Taking technological infrastructure seriously

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PREFACE

In 970AD the Viking king, Harald Blåtand, united the warring tribes of Denmark and Norway, and ushered in a period of relative stability and flourishing. In 2017, the devices that bear his insignia and anglicised name, 'Bluetooth', now stand for a different sort of integration and a new kind of flourishing. The royalty-free, short-range wireless protocol is driving the proliferation of 'wearables' and Internet of Things devices. Unlike other standards in the area of wireless connectivity such as 3G and 4G LTE, Bluetooth stands apart by being comparatively unlitigated and open to all implementers at zero cost. The Bluetooth standard is an example *par excellence* of critical technological infrastructure operating under an open access rule.

But although the technology over Bluetooth is free, it is not public domain. Every time an implementer integrates Bluetooth technology into its devices, it necessarily infringes dozens of patents. Instead of litigating, the technology owners choose to license Bluetooth at zero cost. Why? The team behind another zero cost standard, a royalty-free alternative to MP3, the Opus audio codec, helps explain the reasoning:

> Most of the value of a high-quality standard is the innovation and inter-operation provided by the systems built on top of it. When a few parties have monopoly rights to monetize a standard, that infrastructure stops being so common and everyone else has more reason to use their own solution instead, increasing cost and reducing efficiency.
>
> Imagine a road system where each type of car could only drive on its own manufacturer's pavement. We all benefit from living in a world where all the roads are connected.

There is something convincing about this explanation, but it is an intuition and not a reasoned argument. While zero-cost licensing of technological infrastructure is wide spread, it is still not the norm. Nevertheless, the above intuition comprises a number of important assumptions, which also apply to other models of open access licensing of technological infrastructure, such as the fair, reasonable and non-discriminatory licensing conditions often required by telecommunications standards. These assumptions deserve careful consideration because they seem to cut across ideas central to mainstream economics and IP theory, such as the primacy of private property and exclusive rights in driving innovation. So, what is technological infrastructure and why is it unique? Does it really need special management, and if so, how? What is the role of the law and the courts in designing these management regimes, and what aspects give rise to enforceable rights if and when these regimes break down? This dissertation sets out to answer these questions by investigating access problems to essential intellectual property in technological infrastructure, and the institutions which underwrite them.

Carl Mair
May 2017, The Hague

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LIST OF ABBREVIATIONS

AG	- Advocate General (of the ECJ)
API	- Application Programming Interface
BSA	- Business Software Alliance
CDMA/(3G)	- Code Division Multiple Access (standard)
CJEU	- Court of Justice of the European Union
CPU	- Central Processing Unit
DARPA	- Defense Advanced Research Projects Agency
EC	- European Community (predecessor to the EU)
ECIS	- European Committee for Interoperable Systems
ECJ	- European Court of Justice (a branch of the tripartite CJEU)
EFD	- Essential Facilities Doctrine
EPC	- European Patent Convention
ETSI	- European Telecommunications Institute
ESS	- Evolutionary Stable Strategy (game theory)
F(L)OSS	- Free, (Libre), and Open Source Software
FP7	- Framework Programme 7 (EU subsidy program)
FRAND	- Fair, Reasonable and Non-Discriminatory (standard)
GC	- General Court (of the CJEU)
GPL	- General Public License (open source)
GSC	- Global Standards Collaboration
H2020	- Horizon 2020 (EU subsidy program, or Framework Programme 8)
HD	- Hawk-Dove (game theory)
IC	- Integrated Circuit
ICT	- Information and Communication Technologies
IEEE	- Institute of Electrical and Electronics Engineers
IETF	- Internet Engineering Task Force
IoT	- Internet of Things
IPR	- Intellectual Property Right
ISA	- Instruction Set Architecture
ITU	- International Telecommunications Union
LTE (4G)	- Long Term Evolution (mobile telecom standard)
NAC	- Non-Assertion Clause
NASA	- National Aeronautics and Space Agency
NE	- Nash Equilibrium (game theory)
NPE	- Non-Practising Entity
OEM	- Original Equipment Manufacturer
OS	- Operating System

PD	- Prisoner's Dilemma (game theory)
PMD	- Personal Mobile Device
RF	- Royalty-free (standard)
SEP	- Standards-essential patent
SME	- Small and Medium-sized Enterprise
SoC	- System on a Chip
SSO	- Standard Setting Organisation
TFEU	- Treaty of the Functioning of the European Union
TRIPS	- Trade-Related Aspects of Intellectual Property Rights (treaty)
VM	- Virtual Machine
W3C	- World Wide Web Consortium

INTRODUCTION

The chapters in this book are focused on investigating a single problem: the problem of access to essential intellectual property in high technology, or what this thesis refers to as 'technological infrastructure'.[1] In particular, it focuses on the means by which critical technological infrastructure can and should be accessed and utilised by market participants other than the infrastructure owner.

The starting point for the chapters is first to develop and defend the above as a *problem*, since many traditional theories about innovation and intellectual property ('IP') fail to adequately take account of the social costs associated with exclusive rights over technological infrastructure. Traditional perspectives on the nature of private property often assume (and only sometimes argue[2]) that exclusive rights over technological assets are sufficient to ensure the efficient allocation of resources and technology transfer. It is sometimes overlooked that, even in the economic framework[3] adopted by property theorists, it is *markets* that deliver positive outcomes, *not* individuals: only when individual decision-making is disciplined by supply and demand side substitution does resource allocation *tend* towards optimality.[4] In the case of technological infrastructure, where these constraints are conspicuously absent[5], it is argued that the 'invisible hand' of efficient markets is invisible precisely because it is not *there*.[6] Instead, the IP system may require the helping hand of other innovation institutions in order to arrive at socially advantageous results. These other institutions include competition law[7], government subsidy programs[8], demand-side instruments[9] and business model innovation.[10] It is the interaction between the IP system and these additional institutions, which is the focus of this dissertation.

1. The term 'technological infrastructure' is invented by the author to pinpoint a class of infrastructural assets in high technology that have both infrastructural attributes and implicate intellectual property rights.
2. See for example, the arguments and theories supporting this view given by Edmund W Kitch, 'The Nature and Function of the Patent System' (1977) 20(2) J L & Econ 265 ; Richard A Epstein, 'Why There Is Too Little, Not Too Much, Private Property' (2011) 53 Arizona L Rev 51.; Harold Demsetz, 'Toward a Theory of Property Rights' (1967) 57(2) Am Econ Rev 347.
3. Generally a Neo-Classical model
4. Mark A Lemley, 'The Regulatory Turn in IP' (2012) 36 Harvard Journal Law and Public Policy 109, 109 ("[i]t is important to remember, because it is quite often lost in the rhetoric surrounding these debates, that it is not the case that individual private decision-making is necessarily efficient. It *is* the case, however, that *market* decision-making is generally efficient").
5. In order to qualify as 'technological infrastructure', a technological asset must be a *conditio sine qua non* for market entry and effective competition, as further discussed in chapters 1 and 2.
6. Joseph E Stiglitz, 'Economic Foundations of Intellectual Property Rights' (2008) 57(1776) Duke LJ 1693 ("[o]ne of the important results of my work, developed in a number of my papers, was that the invisible hand often seemed invisible *because it was not there*.")
7. See chapters 1 and 2.
8. See chapter 3
9. Such as public procurement policies, see chapter 4
10. See chapter 5

One contribution of this thesis is to develop a richer notion of intellectual property *failure*[11]: not just the divergences from social optima that have already been widely documented in the form of deadweight losses from monopolisation and related social costs[12], but the large-scale and *systemic* failure and welfare losses caused by the cutting off of access to intellectual property rights which have acquired an 'infrastructural' character to markets. This thesis attempts to integrate this richer notion of IP failure with existing concepts in EU competition law, such as the essential facilities doctrine and the recently developed '*sui generis*' rule in relation to formal technological standards, and combine these with certain core concepts at the heart of intellectual property, such as subject matter exclusions in patent law. The overall conclusion of this thesis is that there are robust legal and economic arguments for requiring intellectual property over critical technological infrastructure to be licensed under open access terms, but that the institutional and private strategic dynamics at stake often require different solutions and economic justifications. For the above reason, this dissertation adopts an approach that can be loosely characterised as involving 'comparative institutional analysis'.[13] Each chapter in this volume attempts to look at the economic and legal reasoning of the infrastructural approach from the perspective of a different institution or under different economic conditions, ranging from competition law (chapters 1 and 2), public R&D subsidies (chapter 3), public procurement (chapter 4), and private ordering and business model innovation (chapter 5). As this thesis has been written according to the rules regulating PhD by articles and chapters, each chapter has been developed first as a stand-alone article, which has then been published, submitted for publication, or presented at an international conference or workshop.[14]

For its legal foundations, this dissertation concentrates predominantly on European Union ('EU') law, in particular its competition law, and patent law in the form of the European Patent Convention ('EPC'). Although the EU situation is the main target of this thesis's analysis, the reasoning and arguments presented herein are in many ways global in scope, and academic literature, case law and Government reports from the United States ('US') also form a key strut of the analysis.

For its economic foundations, this thesis integrates the insights from institutional economics with game theory to take seriously the idea that one of the functions of law[15] in the economy is

11. As opposed to market failure, or Government failure, for example.
12. Benjamin N Roin, 'Intellectual Property Versus Prizes: Reframing the Debate' (2013) 81 U Chicago L Rev 999 3 ("The government awards patents and copyrights to promote innovation, but those monopoly rights can also create deadweight loss, and generally provide imperfect incentives for investing in R&D")
13. Neil K Komesar, *Imperfect Alternatives : Choosing Institutions in Law, Economics, and Public Policy* (University of Chicago Press 1996) ("Komesar, *Imperfect Alternatives*").
14. For sake of clarity, this thesis is a combination of published articles and unpublished chapters.
15. Not just legal rules, but also regulation in the form of architecture. Lawrence Lessig, 'Reply: Re-Marking the Progress in Frischmann' (2005) 89 Minn L Rev 1031.

to cast a 'shadow' across the strategic behaviour of individuals and companies: defining limits and boundaries within which the latter interact, but certainly not determining them with any predictability. Law is considered to only affect behaviour at the margins; within these margins, individuals and companies internalise the risks and penalties of e.g. competition law rules, the existence and enforcement of intellectual property rights, and various direct interventions by Government, in order to structure relationships in the market by private ordering. To try to capture some of the richness of the private ordering within the shadow of legal rules, many of the chapters in this volume draw on the vocabulary and models of game theory, while also relying on the more traditional tools of legal analysis, such as reference to leading cases and the implementation of Government and regional policies. In particular, much of the analysis is focused on the shadows cast by the four institutions identified earlier, and how they interact with private ordering, as well as with each other, to produce the strategic dynamics between private agents.

By taking the infrastructural nature of technological infrastructure seriously, we can recruit a number of powerful arguments from the economics of infrastructure and public goods to show that these resources are best managed under an open access rule: 'if infrastructure, then open access' (the 'infrastructural approach'). The punch line of this thesis is that technological infrastructure needs to be taken seriously by policy-makers when constructing antitrust policies, by ensuring that market-driven technological standards remain open access and able to support downstream productive activity. It needs to be taken seriously by courts, when intellectual property rights are enforced over technological infrastructure and a robust economic theory for abrogating those rights is required. It needs to be taken seriously by Standards Setting Organisations ('SSOs') when cooperatively-set technological standards are developed. And it needs to be taken seriously when governments design subsidy programs and sponsored Research and Development ('R&D') results in technological infrastructural assets.

A central nerve that runs through all the above is that innovation is a system with a number of moving parts. Intellectual property is too often considered the 'flux capacitor' to the economy's DeLorean, even to the extent that patent counts are routinely used as a proxy for innovation in econometric studies.[16] An important side-theme of this thesis is to apply pressure to this assumption. Although this dissertation brushes the outskirts of the related debate over the primacy (or otherwise) of intellectual property rights over the 'public commons' it does not engage this discussion as a central component of the analysis. The literature on this question is dense enough.[17] Instead, the target of this thesis is tightly focussed on the sub-class of

16. See Basberg (1987), "Patents and the Measurement of Technological Change: A Survey of the Literature," Research Policy. Pavitt, Keith (1988), "Uses and Abuses of Patent Statistics," A. F. J. van Raan (ed). Handbook of Quantitative Studies of Science and Technology. Amsterdam: Elsevier Science Publishers.

17. For a thorough (if somewhat dated) summary of this literature, see R. Polk Wagner, 'Information Wants To Be

intellectual property rights that 'read on' to technological infrastructure. In this subclass of assets, there is a striking interdependence between private rights and public commons[18]: one useful way of thinking about the relationship is that intellectual property is both an input and an output of innovative activity. As an output, intellectual property helps to drive private investment towards the development of new technological prospects. When these prospects bear fruit, the protection of the patent grant (for example) enables innovators to sustain pricing strategies which support continued R&D. But intellectual property is also an *input* of innovative activity: high technology markets are distinguished from other kinds of markets in that their dominant use-cases tend to require the formation and maintenance of real and virtual networks. The interoperability standards that underwrite these networks require extremely precise implementations of component technologies. This means that patents that read on to technological infrastructure are in many cases impossible to design around. The upshot of this is that patents which are required to practise standards ('standards-essential patents' or SEPs) do not just *contribute* to the public commons (by e.g. expanding the technological frontier); rather, they often *constitute* the public commons, by serving as necessary inputs for fully functional information technologies. Although this perspective is now widely accepted[19] in relation to cooperatively-set standards emanating from SSOs, the arguments placing de facto standards and pioneering technologies in the same category (of infrastructural assets) have often been weak and underdeveloped. This dissertation hopes to provide powerful economic arguments for viewing these different types of infrastructural assets through the same lens. The end point of these arguments results in an approach to the management of such resources, which this thesis calls the 'infrastructural approach'. The first stage of this approach assesses whether the asset in question is infrastructural, by checking whether it has the required economic and demand-side attributes. If this test is passed, then there is a rebuttable presumption that open access rules should apply in the form of 'if infrastructure, then open access'. This approach is argued to be both descriptive and normative. It is descriptive because it is argued to be derived from the case law of the EU judicature in recent technological infrastructure cases involving both de facto and de jure standards, as well as from the IP system as a whole, which generally excludes infrastructural resources as protectable subject matter. It is normative because it is argued to be the best way of managing such assets, by minimizing social costs and increasing social gains. This last point is an empirical claim, and since empirical claims should ideally be addressed by empirical methods, it is worth briefly defending this thesis's theoretical treatment of the problem. This approach is justified in two main moves. First, while it is agreed that theoretical arguments

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Free: Intellectual Property and the Mythologies of Control' (2003) 103 Columbia L Rev 103(1)

18. Brett M Frischmann, 'An Economic Theory of Infrastructure and Commons Management' (2005) 89 Minn L Rev 917 ("Frishmann, An Economic Theory").

19. See, for example, Daryl Lim, 'Standard Essential Patents, Trolls and the Smartphone Wars: Triangulating the End Game' (2014) 119 Penn State Environ L Rev 1

cannot conclusively make the case for or against an empirical claim, powerful theoretical arguments may be used to establish rebuttable presumptions, as they are in other areas of law.[20] Second, given the current state of the data available and the complexity of the subject matter, robust and systematic approaches to the claim are currently out of reach[21], except perhaps for the "second best" choice of modelling and simulations.[22] In lieu of the above, this thesis makes extensive use of the "third best" choice of using simple game theoretical models for trying to capture some of the complexity involved in trying to efficiently manage infrastructural resources, as discussed below.

One novel approach adopted and developed in chapter 3 of this thesis is to characterise the choice between managing technological infrastructure as a commons (under an open access rule) or under an exclusive rights regime as an 'assurance game' in game theory. Such an approach provides analytical traction as to why the intellectual property regime is often not sufficient in itself to ensure socially-optimal outcomes, and why the operation of other institutions are often required to minimise social cost. Intimately related with the above is the additional side-theme that focuses on the ways in which the market, the public sector, and other institutions have sought to integrate the interests of private right-holders with the public interest that technological infrastructure remains open. The approach to this side-theme is largely drawn from the tradition of law and economics- and its relatively recent offshoot- comparative institutional analysis. From law and economics, this dissertation takes the insight that *incentives* are important: companies with private rights over infrastructural resources care about openness only if market conditions (including the strategic landscape) or the legal rules *mak*e them care. Openness does not evolve from the market out of charity, but is an emergent property of the legal backdrop and the interactions of agents, such as developed in the 'assurance game' approach.

20. Rebuttable presumptions are rules relating to proof for legal arguments. They are frequently used in EU competition law, where presumptions tend to fall on the side of established economic theory (e.g. 'hardcore restrictions' under Art 101 TFEU.) This approach is similar to that adopted by Professor Jorge Contreras in his 'market reliance' model of technological infrastructure, see Jorge L. Contreras 'A Market Reliance Theory For FRAND Commitments and Other Types of Patent Pledges' (2015) Utah Law Review 479, 544: ("In the case of patent pledges, an implementer's ability to enforce a pledge against a patent holder, and to sue for breach of that pledge, should also be subject to a rebuttable presumption of reliance.")

21. My feeling is that it is a problem endemic to all IP scholarship which tries to grapple with empirical-normative questions of how the IP system *should* be. It is also endemic to competition law, and haunts competition regulators, who must make assessments of counterfactuals (comparing either the present or future competitive conditions) with conditions which may obtain when a merger is approved or denied, a pricing strategy continued/halted, or an IP protected resource compulsorily licensed or not.

22. This "second best" option would be to simulate counterfactual realities by use of Agent Based Modelling, e.g. construct a market where infrastructural IP is made available to downstream innovators according to an adjustable 'exclusivity' toggle, and assess social welfare payoffs. I explored this option early on in my research, but was concerned that the amount of time to construct such a model would have made me a specialist in ABM, but might have taken me away from the legal analysis.

The punch line and side-themes of this thesis are developed in the following framework. After this Introduction, the volume is divided into 5 chapters and an overall conclusion. Each of these chapters analyses the interaction between the IP regime and at least one other institution, and assesses the way their operation and interaction affect private ordering. The key concern in each of the chapters is how the particular institution or institutions affect the access terms to technological infrastructure. To this end, an underlying- sometimes implicit, sometimes explicit, framework for the chapters in this volume is Neil Komesar's comparative institutional analysis.[23] Sometimes markets fail to deliver desirable outcomes. Sometimes Governments fail. Sometimes intellectual property and competition law fail too. The important issue is to identify what the objective baseline is that enables us to assess success and failure and to unpack why and under what conditions institutions fail. For the purpose of this dissertation, the normative baseline is the optimal management of technological infrastructure.

Chapter 1, entitled 'Taking Technological Infrastructure Seriously', focuses on how the institution of competition law can modify the strategic landscape and distribution of incentives to help private companies converge on open access licensing with respect to both *de facto* and *de jure* standards. This chapter introduces an 'infrastructural approach' to the problems of *de facto* and cooperative standard-setting in high technology. It reviews recent case law in the area, and attempts to provide robust economic arguments for the maintenance of 'open access' rules over such standards. First, it begins by qualifying such resources as 'technological infrastructure' according to the work of Brett Frischmann and Peter Lee. Subsequently, game theoretical tools are applied to the problem of cooperative standard-setting to demonstrate how the 'quasi-open access' FRAND commitment can constrain strategic behaviour. A legal analysis—including an examination of recent case law about the availability of injunctions—then follows to demonstrate the optimal 'negotiation framework' for the latter commitment to become credible. Finally, the infrastructural approach is expanded to demonstrate how it can elucidate a number of current controversies in high technology markets, where the tension between private ownership and public use of technological infrastructure is at its sharpest. A previous version of this chapter was first presented at the 2013 Asia Pacific Innovation Conference at Taiwan National University and at the 2013 Young Scholars Lab at the European University Institute ('EUI'). The paper benefited enormously from feedback from numerous colleagues and professors at these institutes, especially Prof. Neil Komesar, who was the primary reviewer of the paper at the EUI Young Scholars Lab. An updated version of this paper was published in 2016 in the Utrecht Journal of International and European Law.

Chapter 2, 'Technological Infrastructure and the EU Essential Facilities Doctrine', develops in greater detail the application of the EU competition law rule of the essential facilities doctrine

23. Komesar, *Imperfect Alternatives.*

to *de facto* standards. As the most controversial aspect of the 'infrastructural approach' developed in chapter 1, this chapter focuses on fleshing out the legal and economic analysis with respect to technological infrastructure emerging from the market without the voluntary cooperation between companies nor the granting of a FRAND commitment, as in the closely-related case of cooperatively-set standards. The analysis digs into the details of the Microsoft case as the only EU case to date dealing explicitly with applying ex post open access rules over a privately-owned technological infrastructure. The chapter also briefly considers the current EU Commission investigation into Google's Android Operating System, and the interesting wrinkles this adds to the analysis. This chapter benefited from the commentary and discussion of Prof. Rene Smits of the Dutch Competition Authority (as it then was) and with Dr. Robert Ludding at the University of Amsterdam.

Chapter 3, 'Visible and Invisible Hands', zooms out from the competition law approach developed in the previous chapters and considers the interaction of the IP system with the institution of public (EU) R&D subsidy grants. This chapter constitutes a companion chapter to chapter 1: while that chapter developed the point that certain privately-provisioned knowledge assets may qualify as infrastructural assets, this chapter identifies infrastructural information assets arising in the intersection between public R&D programs and private IP rights. The nub of the argument is that information assets arising like this are unique in ways that have not been given sufficient attention in the literature: they are of sufficient social value to attract a subsidy and yet give rise to protectable inventions or creative works. Taken individually, each of these institutions must have failed to produce the asset, either for reasons of risk, limited private appropriability, or social welfare considerations. This chapter argues that the class of asset that most closely maps to these attributes is likely to be 'infrastructural', deriving its high social value from its status as input to downstream innovation. Due to its status as infrastructure, it is argued that these R&D assets would be most effectively managed under an open access regime, and that European subsidy programs can have a have central role in ensuring this outcome. This chapter is unique in this volume by attempting a highly detailed account of the nature of technological infrastructure and by linking it to certain core concerns of the intellectual property system and the more general notion of 'intellectual infrastructure', of which technological infrastructure is just a subset. This chapter deploys numerous tools from game theory, and develops the ideas of strategic behaviour as an 'assurance game', and 'property traps' as a possible strategic outcome of exclusive rights approaches to technological infrastructure. The game theoretical components of this chapter were presented at the 2016 Satellite Session 'Law and Complexity' at the 2016 Conference on Complexity Systems.

Chapter 4, 'Open Standards and Their Enemies', continues in the vein of the previous chapters by considering the ways legal rules may induce technological infrastructure owners to operate under an open access rule. However, this chapter considers the *demand-side* institution of

Government public procurement policies. It argues that public procurement policies that demand zero-fee or royalty-free patent licensing over standards may backfire by insufficiently considering the strategic landscape of the standard-setting process. The chapter suggests that the rise of the pure-play IP licensing company in the information technology market place may be incompatible with a royalty-free standards policy, as it drastically lowers their incentives to engage in formal standard-setting and the attendant licensing obligations. By limiting such companies' ability to derive revenue from participating in SSOs, open standards policies may (with the best intentions) result in standards being less open, as pure-play IP companies assert their patents after the adoption of the standard- thus shutting down access and jeopardising the standard ex post. A previous version of this chapter was awarded the 2012 Association for Research and Teaching in Intellectual Property ('ATRIP') first prize for original scholarship by a young researcher in intellectual property. It was presented at the 2012 ATRIP conference in Chicago, where comments and criticisms by colleagues and professors helped to improve its quality before eventually being published by the US journal 'IP Theory', in late 2012.

Chapter 5, entitled 'Intel, ARM and Private Ordering Approaches to Technological Infrastructure' considers the institutions of IP management and business model innovation as ways of managing technological infrastructure. It reviews how and why private companies often have incentives to engage in open access licensing even without the threat of competition law enforcement. Its focus is the unique market of CPUs that power the swathe of 'embedded devices' from smartphones to the nascent Internet of Things ('IoT'), and in particular, the approach to intellectual property licensing of the two main contenders there, ARM and Intel. These two companies are both deploying significant resources to become the *de facto* CPU standard and technological infrastructure for both the smartphone market and IoT devices. The companies have very different approaches to managing their IP, which this chapter argues may be a determinative feature in their battle to develop the emerging technological infrastructure. While ARM licenses its IP freely to downstream chip makers, Intel is extremely restrictive of who it licenses its IP to and generally attempts to be the only downstream supplier of its CPU architectures. These differences in IP licensing strategies are also replicated in the software space, where the openness or closedness of selected operating systems may serve to reinforce or undercut the drive towards de facto standardisation of the CPU. This chapter analyses the salient differences in these two broad strategies to IP licensing, and attempts to distil some predictions about how these different approaches will drive the process of technological infrastructure standardisation- in both hardware and software- for the emerging post-PC marketplace. The conclusions shed light on the use of business model innovation as a method for both managing and leveraging the success of technological infrastructure and the 'infrastructural approach'. A previous version of this chapter was the runner-up in the 2016 Google PhD Award organised by the British and Irish Law Education and Technology Association ('BILETA') conference. It benefitted from comments and criticism during the Google PhD Workshop, particularly by professors Abbe Brown (University of Aberdeen) and Daithí Mac Síthigh (Newcastle University).

These five chapters illustrate the many complexities and nuances in the debate over private rights over information technology infrastructure in its various guises, taking into account market conditions, legal rules, and public R&D instruments. All these many guises serve to demonstrate that there is no silver bullet to openness in high technology markets, but that taking technological infrastructure seriously is a good place to start.

CHAPTER 1

TAKING TECHNOLOGICAL INFRASTRUCTURE SERIOUSLY: STANDARDS, ANTITRUST AND INTELLECTUAL PROPERTY

I. INTRODUCTION

At the core of today's high technology markets are networks, both real and virtual.[24] Real networks—links between devices and systems—scaffold the lower levels of information exchanges by ensuring a common hardware platform. Examples of real networks include the mobile communication networks (*e.g.* 3G UMTS, 4G LTE), local area networks (LANs), and the 'network of networks', the Internet. On top of real networks, there may also be networks built around software platforms, which enable users to share and exchange information important to them. These 'virtual networks' are formed by users as they select and utilise software applications, such as word processors, image editing programs, and social media.[25]

To many consumers, the complex pattern of networks that underwrites the success of high technology markets is more or less invisible.[26] Consumers tend to cluster their activity around only a limited number of platforms (network hubs), and markets tend to 'tip' towards dominant solutions.[27] The user experience is therefore often one of seamless interoperability. But the seamlessness of the user experience is sometimes bought at a steep price. Dominant software and hardware companies may utilise their intellectual property rights (IPR) to foreclose competition, and limit consumer choice by isolating competitors from the network or by raising their costs.[28]

In particular, IPR over technological standards (the technical details which define device and software interoperability within a network) may be used anti-competitively. In the case of '*de facto*' standards,[29] which arise from the market due to demand-side efficiencies (network effects), the European Union (EU) Commission and European Courts have elaborated 'exceptional circumstances' whereby dominant companies and standard owners may be

24. Richard N Langlois, 'Technological Standards, Innovation, and Essential Facilities: Toward a Schumpeterian Post-Chicago Approach' (1999) Economics Working Paper 199907 ("Langlois, 'Technological Standards'), 37 <http://digitalcommons.uconn.edu/econ_wpapers/199907/> accessed 14 October 2016 ("[…] 'virtual networks' [are those] in which the connections are not physical but rather in the nature of economic complementarity").

25. For an interesting analysis of the importance of software platforms in industry, see *e.g.,* David S Evans, Andrei Hagiu and Richard Schmalensee, *Invisible Engines: How Software Platforms Drive Innovation and Transform Industries* (MIT Press 2008).

26. Ibid.

27. As will be discussed further in Part II, Section B of this chapter the 'tipping' characteristics of a platform or standard come down to an *empirical* analysis, and should not be inferred *a priori.* Whether or not 'tipping' confers 'infrastructural' status on an asset also depends heavily on the demand-side 'switching costs'. See generally Joseph Farrell and Paul Klemperer, 'Coordination and Lock-in: Competition with Switching Costs and Network Effects' in Mark Armstrong and Robert Porter (eds), *Handbook of Industrial Organization* (Elsevier 2007) ("Farrell and Klemperer, 'Coordination and Lock-in'")

28. Mark A Lemley, 'Intellectual Property Rights and Standard Setting Organizations' (2002) 90 CLR 1889 ("Lemley, 'Intellectual Property Rights'").

29. Jae Hun Park, *Patents and Industry Standards* (Edward Elgar Publishing 2010) 10 (arguing that "[s]ince the standards formed by network effects in markets are not formal standards but represent proprietary technologies that reach a dominant position in the market, they are called informal standards or *de facto* standards").

compelled to license their IPR to downstream competitors under so-called 'open access' rules.[30] The competition law basis for these 'refusal to deal' or 'essential facilities' cases (*e.g., Microsoft,*[31] *IMS*[32]) has generally been motivated by a 'monopoly leveraging' theory under Article 102 of the Treaty of the Functioning of the European Union (TFEU): the refusal to license IPR is seen to work as a 'complementary strategy' to extend a dominant position from an upstream market to one downstream, constituting an exclusionary abuse.[33] More recently, the EU Commission and European Courts have also demonstrated their willingness to intervene in cases of '*de jure*' or 'cooperatively-set standards'.[34] Unlike *de facto* standards, *de jure* standards arise by a process of co-operative standard-setting in formal standard-setting organisations (SSOs).[35] When companies contribute technology for inclusion in a standard, they undertake a commitment to license any standards-essential patents (SEPs)[36] under Fair, Reasonable and Non-Discriminatory' (FRAND) terms. The precise content given to these terms is left to be hashed out by private negotiations between the parties, with the caveat that the framework for the negotiation may require a softening of some of the hard edges of IP law. In particular, recourse to injunctions may be limited. According to the recent EU Commission statements in *Samsung*[37] and *Motorola,*[38] and the Court of Justice of the European Union (CJEU) Judgement in *Huawei v ZTE,*[39] the threat or use of injunctions by the SEP-holder during these negotiations may thwart the process of FRAND bargaining,[40] leading

30. Marina Lao, 'Networks, Access, and "Essential Facilities": From Terminal Railroad to Microsoft' (2009) SMU L Rev 557 ("Lao, 'Terminal Railroad to Microsoft'"), 563 ("the essential facilities doctrine can be a useful tool in ensuring open access and interoperability").

31. Case T-201/04 *Microsoft Corp v Commission* [2007] ECR II-3601 ("*Microsoft Corp v Commission* [2007]").

32. Case C-418/01 *IMS Health GmbH & Co. OHG v NDC Health GmbH & Co. KG* [2004] ECR I-5039 ("*IMS v NDC*").

33. Commission, 'Commission Concludes on Microsoft Investigation, Imposes Conduct Remedies and a Fine' (24 March 2004) Press Release IP/04/382, para 1 (noting that "[t]he European Commission has concluded, after a five-year investigation, that Microsoft Corporation broke European Union competition law by leveraging its near monopoly in the market for PC operating systems […]"). Censuring 'exclusionary abuses' rather than merely 'exploitative abuses' is an enforcement priority of the EU Commission. In this regard, see Commission Guidance on the Commission's Enforcement Priorities in Applying Article 82 of the EC Treaty to Abusive Exclusionary Conduct By Dominant Undertaking [2009] OJ C45/02, para 6 ("[t]he emphasis of the Commission's enforcement activity in relation to exclusionary conduct is on safeguarding the competitive process […]") ('Commission Guidance on Enforcement of Art. 82 EC'").

34. The terms '*de jure*' standard and 'cooperatively-set standards' shall be used interchangeably in this chapter and thesis generally. Strictly, 'cooperatively-set standards' is a broader category as it also includes non-official SSOs such as private consortia and fora, *e.g.,* the Bluetooth SIG <https://www.bluetooth.org/en-us> accessed 14 October 2016.

35. Tim Pohlmann, 'Six Essays on Patenting and Coordination in ICT Standardization' (DPhil thesis, Technical University Berlin 2012) vi ("standards are described as *de jure* standards when they are specified by a formal standard-setting body").

36. See the definition of 'essentiality' according to the European Telecommunications Standard Institute ('ETSI') Rules of Procedure (19 November 2014) art 15(6).

37. *Samsung* (Case AT/39.939) Commission Decision [2014] OJ C350/8.

38. Commission, 'Antitrust: Commission Finds that Motorola Mobility Infringed EU Competition Rules by Misusing Standard Essential Patents' (29 April 2014) Press Release IP/14/489.

39. Case C-170/13 *Huawei Technologies Co. Ltd v ZTE Corp & ZTE Deutschland GmbH* (CJEU, 16 July 2015) ("*Huawei*").

40. *Motorola* (Case AT/39.985) Commission Decision [2014] OJ C344/6. In *Motorola,* these 'un-FRAND' terms also including conditional threats of injunctions if the licensee challenged the essentiality or validity of the SEPs. See also

to the anticompetitive exclusion[41] of competitors' products from the market.[42] As in the case of *de facto* standards, the Commission and CJEU also elaborate 'exceptional circumstances' under which a finding of abuse can be sustained, and simultaneously define a 'safe harbour' within which licensees may negotiate FRAND rates without threat of injunctions, although the precise competition law 'theory of harm' remains uncertain.[43]

This chapter aims to contextualise the recent Commission and CJEU statements in *Huawei, Samsung* and *Motorola* as part of a broader 'infrastructural approach' to technological standards consistent with the *de facto* standards line of cases of *Microsoft* and *IMS.*[44] The nerve of the argument is that despite the different competitive and cooperative processes that give rise to them, both these types of standards perform the economic role of 'technological infrastructure', and function as necessary inputs to downstream production in high technology markets. Achieving such infrastructural status has the potential to create an economic windfall on the supply side and demand side simultaneously by lowering production costs, increasing consumer surplus, and fostering static and dynamic competition, leading to greater product choice and diversity.[45] However, as with traditional indispensable infrastructure, these social and private gains are only fully realised when the essential infrastructural resource is managed under an open access rule.[46] The approach of this chapter is both descriptive and normative. It is argued that despite the differences in the identified 'exceptional circumstances' and the legal rules used, the European approach to both *de facto* and *de jure* standards is underwritten by an implicit concern to ensure open access to technological infrastructure.[47] A two-stage

Press Release IP/14/489.

41. The precise competition law theory of harm is difficult to deduce from the decisions so far. For an overview of possible theories of harm, see *e.g.,* Nicolas Petit, 'Injunctions for FRAND-Pledged SEPs: The Quest for an Appropriate Test of Abuse under Article 102 TFEU' (2013) 9(3) Eur Comp J 677 ("Petit, 'FRAND-Pledged'"). See also Alison Jones, 'Standard-Essential Patents: FRAND Commitments, Injunctions and the Smartphone Wars' (2014) 10(1) Eur Comm J 1 ("Jones, 'Standard-Essential Patents'").

42. *Huawei,* para 52 ("the fact that that patent has obtained SEP status means that its proprietor can prevent products manufactured by competitors from appearing or remaining on the market and, thereby, reserve to itself the manufacture of the products in question.")

43. See Parts IV and V, Sections A of this chapter respectively.

44. Although the CJEU and Advocate-General in *Huawei* worked hard to distinguish the *de facto* standards case law from the operative part of the newly minted *de jure* standards decision, there are a number of essential similarities between the decisions which point to this shared overarching concern. See this chapter Part V for a more detailed discussion.

45. Carl Mair, 'Openness, Intellectual Property and Standardization in the European ICT Sector' (2012) 2(2) IP Theory 52 ("Mair, Intellectual Property"), 55 (arguing that "[t]he benefits of a single dominant standard accrue on both the demand and supply sides simultaneously: software suppliers reduce costs by focusing their production on a single platform; meanwhile, consumers benefit 'from a large installed base that generates lots of software and other complementary goods and services'").

46. Frischmann, 'An Economic Theory', 928.

47. Although the language of 'infrastructure' was not used in *Huawei*, AG Wathelet discusses the concept of 'dependence', which is foundational to this approach. See *Huawei,* Opinion of AG Wathelet, paras 73-74 (pointing to "[…] a relationship of dependence between the intellectual property right holder occupying a dominant position and other undertakings").

'infrastructural approach' is argued to be at the core of this approach, which can be roughly summarised as including (i) an 'infrastructural screening test', followed by (ii) an assessment of the appropriateness of an open access rule. This is the descriptive component. The normative component argues that by making this infrastructural approach explicit it becomes possible to taxonomise the access disputes over SEPs, 'interoperability information' and other privately owned technological infrastructure as part of a wider societal debate[48] about the merits and pitfalls of private control over 'public' infrastructure, whether these are the traditional 'top down' infrastructures of roads, electricity and telecommunications; the (private) cooperatively set infrastructure of, *e.g.*, mobile communications; or the 'bottom up' infrastructures of super-dominant software products, such as operating systems, search engines or social media websites.[49] It is submitted that all these examples of infrastructure share a number of key characteristics that may jeopardise the efficient application of 'property'[50] rules and frustrate the normal process of market bargaining for access.[51] Furthermore, as network products and markets continue to proliferate and take centre stage in the modern economy, the social trade offs involved in private ownership over technological infrastructure are starting to sharpen, as shown by the increasingly regulatory and interventionist tendencies of governments towards companies like Microsoft,[52] Intel,[53] Google[54] and Facebook.[55] Unlike with traditional infrastructure—where access issues have historically been solved by public provisioning or sector-specific regulation—the 'bottom up' provisioning of technological infrastructure presents governments with extremely difficult, if not intractable, efficiency gambles over private incentives and the public interest. By building on the insights of Brett Frischmann, Suzanne Scotchmer and Ian Ayres, and some useful tools from game theory, this chapter develops and defends the utility of an infrastructural approach to technological standards

48. This is a debate of deep historical provenance, and can be traced (in modern times) back at least to the notion of 'conveniences affected with the public interest' in the seventeenth jurisprudential writings of the English jurist Sir Matthew Hale, as discussed in Walton H Hamilton, 'Affectation with Public Interest' (1930) 39(8) Yale LJ 1089 ("Hamilton, Affection with Public Interest"), 1093; this provenance is also briefly discussed in Brett Frischmann and Spencer W Waller, 'Revitalizing Essential Facilities' (2008) 75(1) Antitrust LJ 1 ("Frichmann and Waller, 'Revitalizing Essential Facilities'").

49. At its most capacious, the debate also touches on issues of 'net neutrality' and personal data protection, but these topics are outside the scope of this chapter.

50. 'Property rules' refer to the application of exclusive ownership regimes, which provide owners with near-total discretion to determine access.

51. Derek Ridyard, 'Essential Facilities and the Obligation to Supply Competitors under the UK and EC Competition Law' (1996) 17 ECLR 438, 450 ("free negotiation cannot be expected to provide a satisfactory solution. If the essential facility is indeed a monopoly, the outcome of free negotiation between a monopoly asset owner and a competitive complainant must also be unsatisfactory […]").

52. *Microsoft Corp v Commission* [2007].

53. *Intel* (Case COMP/37.990) Commission Decision [2009] OJ C227/13 ("*Intel* Commission Decision").

54. Commission, 'Antitrust: Commission Sends Statement of Objections to Google on Comparison Shopping Service; Opens Separate Formal Investigation on Android' (15 April 2015) Press Release IP/15/4780.

55. See Samuel Gibbs, 'Facebook's Privacy Policy Breaches European Law, Report Finds' *The Guardian* (London, 23 February 2015) <http://www.theguardian.com/technology/2015/feb/23/facebooks-privacy-policy-breaches-european-law-report-finds> accessed 14 October 2016.

and demonstrates how an open access regime can be efficient and principled in both law and economics.

The chapter will develop the above arguments in the following framework. After this introduction, Part II will unpack the concept of 'technological infrastructure' as used in this chapter. It will begin by introducing the infrastructural approach (Part II, Section A), before applying it to the special case of IP-protected essential 'technological infrastructure' (Part II, Section B). Part III will then focus on the strategic and legal dynamics of standard-setting in high technology. It is divided into three sub-sections. Section A will provide an overview of the relationship between *de facto* and cooperative standards, by making use of tools from game theory to highlight the strategic aspects of standards development, both as a coordination game, and as a prisoner's dilemma (Section B). Section C will then hone in on the (EU) legal status and enforcement of the FRAND commitment in cooperative standard-setting. To this end, it will provide a review of recent cases in the EU, as well as a brief look at some key case law that has emerged internationally. Part IV then zooms in on the recent ECJ case law and Commission statements about the (un)availability of injunctions during FRAND negotiations, in certain conditions. The discussion will focus on the economic and strategic consequences of removing the availability of injunctions during FRAND negotiations. It aims to demonstrate that, in contrast to arguments of commentators who suggest that such an approach is tantamount to non-market price-setting, removing injunctions as a remedy may actually lead to an increase in successful private bargaining over FRAND, due to its 'information-forcing' negotiation framework. Part V is integrative, and attempts to synthesise the legal approaches adopted by the European Courts with respect to *de facto* and *de jure* standards and demonstrate that they form part of a single concern to apply an open access rule to technological infrastructure, thus allowing producers, consumers and society in general to benefit from the 'synergies' and network spillovers which may result. Part VI will conclude.

II. INFRASTRUCTURE THEORY

Although an 'infrastructural' approach to certain type of IPR has arguably been implicit in a number of key legal decisions and academic commentaries for some time,[56] the first explicit development of this perspective was made by Brett Frischmann in 2005. In his paper, 'An Economic Theory of Infrastructure and Commons Management',[57] Frischmann developed the

56. Frischmann and Waller, 'Revitalizing Essential Facilities', 64 (argue that "[...] the EU cases seem to instinctively understand the value of the essential facilities doctrine when applied to infrastructural assets, both physical and incorporeal"). Explicit use of the term 'infrastructure' is also found in a number of EU essential facilities cases such as Case T-158/00 *ARD v Commission* [2003] ECR II-3825 ("*ARD v Commission*"), para 199 ('digital infrastructure'); *Sealink/B&I HolyHead: Interim Measures* (Case IV/34.689) Commission Decision 94/19/EC [1992] OJ L15/8, para 41 ("an essential facility, *i.e.,* a facility or infrastructure…")

57. Frischmann, 'An Economic Theory'.

idea that certain information resources (such as IPR) may share key attributes with traditional infrastructural resources (such as the power-grid or the road system) which qualify them for special management in the public interest. As with traditional infrastructure, Frischmann argued that certain kinds of IP-protected information resources should be managed in a manner that promotes openness over private control. Below, these special attributes of infrastructural resources will be unpacked and explained (Section A) before the special case of IP-protected privately-owned 'technological infrastructure' is developed (Section B).

A. Economic Characteristics of Infrastructure

'Infrastructure resources are intermediate capital resources that serve as critical foundations for productive behaviour within economic and social systems'.[58] Put simply, infrastructure functions as an input to downstream production but is not used up by such production. In order to fulfil this role, infrastructure is characterised as being non-rival,[59] intermediate[60] and generic.[61] Traditional infrastructure is often characterised by two chief attributes: government involvement in its provision and/or management, and its predominantly open accessibility. Governments and the public have both historically recognised that certain resources tend to yield socially optimal outcomes when managed in an openly accessible manner. On the supply side, these socially optimal outcomes have traditionally been explained in terms of the returns-to-scale advantages inherent in natural monopolies, or by the 'public good' status of some infrastructural goods, which inhibits their private provision at socially optimal levels. Government regulation and public provision of such resources was therefore considered to be essential. Although in recent years, many of these resources have undergone some privatisation (*e.g.,* the unbundling of telecommunications networks in many countries), they often still benefit from sector-specific competition policies, which mandate openness and non-discrimination as a condition of their private ownership.[62] One consequence of the push towards liberalisation has been the necessity to develop 'access rules' for the downstream suppliers requesting access to indispensable assets owned by the incumbent (often state-

58. Brett M Frischmann, *Infrastructure: The Social Value of Shared Resources* (OUP 2012) 11 ("Frischmann, *Infrastructure*").

59. Non-rivalry refers to an asset's ability to sustain multiple- sometimes infinite- downstream uses simultaneously.

60. 'Intermediacy' refers to an asset's status as an input rather than as an end product, meaning that demand for the asset is generally a 'derived demand'.

61. 'Genericness' means that the range of final products or services to which the asset may function as an input is very broad, and may be undefined. For another, related definition, see Peter Lee, 'The Evolution of Intellectual Infrastructure' (2008) 83 Washington L Rev 39 ("Lee, The Evolution of Intellectual Infrastructure"), 54: ("(i) the resource is at least partially nonrival; (ii) it derives its primary social value from facilitating downstream productive activity; and (iii) it serves as an input into a wide range of goods and services, including private, public, and nonmarket goods").

62. Natascha Freund and Ernst-Olav Ruhle, 'The Evolution from Sector-Specific Regulation Towards Competition Law in EU Telecom Markets from 1997 to 2011 – Different Effects in Practical Implementation' (22nd European Regional ITS Conference, Budapest, September 2011) <https://ideas.repec.org/p/zbw/itse11/52208.html> accessed 14 October 2016.

sponsored) monopolist. The solution was the adoption of 'open access' terms, which were intended to prevent both exploitative and exclusionary abuse on the part of the monopolist as well as to lower prices, stimulate technological innovation and increase consumer choice.[63] Briefly defined, an open access regime is an access regime implemented by the resource holder(s) or regulator, which permit all potential users to have access to the resource on similar terms.[64] Such rules aim to 'leverage' the (partial) non-rivalry of the resources at stake, in order to realise maximum social spillovers and encourage competition.[65] An open access regime does not imply that resource owners cannot charge for access. The essential component of an open access rule is that the licensing terms guarantee the public availability of the resource in order to sustain 'effective competition'.[66] The meaning of 'openness' may differ depending on what markets are the subject of analysis, the sunk costs involved in the development of the resource, the character of the companies which operate in the market, as well as historical and cultural factors.[67] For example, in telecommunications markets (where sunk costs are high and implementers are often high-value corporations) 'open access' generally permits royalty-bearing licenses negotiated on FRAND terms[68], whereas in software markets (including the Web), the prevalence of cultural factors and open source providers may require royalty-free licenses in order to be compatible with certain wide-spread open source license types, as well as licensing trends and expectations in that market.

An important contribution made by Frischmann to the economic analysis of infrastructure is his focus on the 'demand side' aspects of open access to infrastructural resources, as opposed to the supply side. Indeed, the supply side arguments in support of government management of infrastructural resources fell out of vogue in the late 1970s and early 1980s, triggered in part by the notion that 'government failure' in the management of natural monopolies may lead to greater 'deadweight losses' than the 'market failure' inherent in their deregulation.[69] Frischmann's arguments on the demand side focus on the idea that infrastructural resources

63. For a relatively early EC explanation of the rationale behind unbundling, see Commission Recommendation, 'Unbundled Access to the Local Loop: Enabling the Competitive Provision of a Full Range of Electronic Communication Services Including Broadband Multimedia and High-Speed Internet' COM(2000) 417/EC.

64. But 'open access ' does not mean that access is free: in cases where payment is not integrated into the tax system, other 'tolls' or fees may apply – provided these are 'reasonable' and do not extract the 'strategic value' of the input.

65. Furthermore, an open access rule 'diffuses pressure within both market and political systems to "pick winners and losers" and leaves it to users to decide what to do with the opportunities (capabilities) provided by infrastructure'; Frischmann, *Infrastructure*, 15.

66. This is an inversion of the test for an 'essential facility', as discussed in chapter 2 of this thesis.

67. Jorge L. Contreras 'A Tale of Two Layers: Patents, Standardization, and the Internet' (2016) Denver Law Review 867: ("In contrast to telecommunications technologies, the internet developed along a path that emphasized patents and patent enforcement far less.")

68. Jorge L. Contreras 'A Brief History Of FRAND: Analyzing Current Debates In Standard Setting And Antitrust Through A Historical Lens' 80 Antitrust Law Journal No. 1 (2015) 64-66 (where Contreras traces the early tendencies of patent licensing in telecommunications (the 1956 AT&T decree) as applying an early precursor to the FRAND licensing rule.)

69. See *e.g.*, Richard Posner, *Natural Monopoly and its Regulation* (Cato Institute 1999).

are effectively 'conduits' for downstream value production, serving to scaffold vast positive externalities: value which spills over into society at large without being completely captured by private interests.[70] To illustrate his point, Frischmann gives the example of the traditional infrastructural resource of public highways. By being open access, the public transport network lowers transaction costs on commerce and thus leads to 'scale returns—greater social value with greater use of the resource'.[71] Frischmann argues that the same goes for any resource whose social function is that of a conduit for value production, including in special cases, intellectual property, as discussed in Section B (Part II).

As opposed to the logic of the 'tragedy of the commons',[72] where open access to resources results in negative externalities and competitive exploitation, Frischmann and others[73] argue that infrastructural resources are often characterised by a 'comedy of the commons'[74] or a 'cornucopia of the commons', meaning simply, that greater use may lead to greater gains, such as in the well-known case of network goods subject to the 'positive externalities' of 'network effects'. For example, as a telecommunication network expands to include a greater number of users, all existing users experience a value increase in the asset (as measured by the growth in possible connections to members of their social network). Moreover, this increase in consumer surplus is exponential, according to Metcalf's law.[75] Although networks are a special case since the generated value follows a power law, traditional infrastructures also tend to yield increasing social returns to use: a village's use of a sewage system leads to public health gains; education infrastructure leads to a better informed electorate etc. All these outcomes derive from the 'scaffolding' role of infrastructure: the locus of value creation is downstream of the infrastructural good itself, and its value 'spills over' into a number of 'adjacent and sometimes, completely unrelated markets'.[76] The nub of the above arguments means that essential infrastructural assets attract an economic logic which can be summarised as 'if infrastructure, then open access'.[77]

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70. Yochai Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom* (Yale UP 2006) ("Benkler, *Wealth of Networks*") 153-161.
71. Frischmann, 'An Economic Theory', 928.
72. 'Tragedy of the commons' is the idea that common control of a limited resource may lead to competitive overexploitation. See Garrett Hardin, 'The Tragedy of the Commons' (1968) 162 Science 1243.
73. Carol M Rose, 'Romans, Roads, and Romantic Creators: Traditions of Public Property in the Information Age' (2003) 66 L & Contemp Problems 89, 95.
74. Ibid.
75. Knut Blind *et al.*, 'Interaction Between Standards and Intellectual Property Rights' (European Commission Joint Research Centre 2004) ("Blind *et al*, 'Interaction Between Standards'") 52 ("Metcalf's Law of the Telecoms show(s) the magic of interconnections: connect any number 'n' of machines—whether computers, phones or cars and get 'n squared' potential value").
76. Frischmann, *Infrastructure*, 38. The key economic characteristic which permits such increasing returns to consumption is that of 'non-rivalry'. However, it should be noted that some assets may only be partially non-rival, meaning that the regime must also be designed so as to avoid the negative consequences of partial non-rivalry, such as 'congestion'.
77. Frischmann, 'An Economic Theory', 923 ("if a resource can be classified as infrastructure […] then there are

In modern high technology markets, networks play a central role in value creation and productivity as both producers and consumers leverage the network effects of real and virtual (software) networks to enhance the value of their products and intellectual creations. While the underlying real networks are often regulated and in some sense publicly-provisioned (*e.g.,* telecommunications cables, electricity grid, and the regulation of mobile spectrum),[78] the 'wealth of networks'[79] in high technology is often purely privately-provisioned and managed, such as in the case of software operating systems, applications and web services. As will be shown below, in some cases the intellectual property rights that 'read on' to these networks (and the network interfaces, such as standards) may qualify as essential infrastructural resources, thus demanding special treatment analogous to traditional infrastructure.

B. Privately-Owned Technological Infrastructure

Although the argument for previously publicly-owned facilities being treated as 'essential facilities' and made subject to an open access regime following deregulation is reasonably uncontroversial, the case of fully privately-owned assets being treated the same way has proven more problematic. In particular, the idea that purely privately-provisioned infrastructural assets should be subject to the 'forced-sharing' of an open access regime has provoked vituperative criticism from both academia and some Courts.[80] The literature in this area is dense, but can be usefully summarised as clustering around two nodes. One node of the literature aims to undercut the premise of the infrastructural approach, by arguing that in dynamic environments privately-owned assets rarely fulfil the requirements of infrastructure. It begins by acknowledging that the competitive process in network markets (which characterises high technology) may lead to super-dominant market shares. But it argues that the dominant positions that result only enable innovators to extract 'Schumpeterian rents',[81] since the dominance is time-limited by the pressure of dynamic competition. The crux of the argument is that a static 'snapshot' of the market may very well show that an asset is infrastructural, but that when viewed dynamically, these infrastructural attributes fade away and are replaced by a moving image of constant turmoil: a process of cascading dominance by competitors and new entrants.[82] The second node of the literature is intimately related to the

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strong economic arguments that the resource should be managed in an openly accessible manner").

78. Ken Binmore and Paul Klemperer, 'The Biggest Auction Ever: The Sale of the British 3G Telecom Licences' (2002) 112 Econ J 74.

79. Benkler, *Wealth of Networks*.

80. For an early, though still relevant, summary of the main arguments, see Phillip Areeda, 'Essential Facilities: An Epithet in Need of Limiting Principles' (1989) 58(3) Antitrust LJ 841.

81. Or 'time limited rents' due to early entry, see Giovanni Battista Dagnino, 'Understanding the Economics of Ricardian, Chamberlinian and Schumpeterian Rents – Implications for Strategic Management' (1996) 43(1) Intl Rev Econ 213.

82. This roughly 'Schumpeterian' argument was used by counsel for Microsoft in the EU case; see *Microsoft Corp v Commission* [2007].

first, but focuses instead on the dangers of implementing an open access rule, even if the asset is found to be infrastructural. This argument may even concede that an asset is infrastructural in both static and dynamic senses, but argues that it was only the *ex ante* incentive of exclusive private control, often in the form of intellectual property rights and the corollary ability to restrict competition and charge monopoly prices, which justified the 'infrastructural' investment in the first place. In the words of Justice Scalia in the US Supreme Court 'essential facilities' case of *Trinko*:[83] '[T]he opportunity to charge monopoly prices–at least for a short period–is what attracts "business acumen"'. The argument runs that if private control were diluted *ex post* by a mandatory open access rule, then private companies' incentives to invest in such infrastructural assets would be drastically reduced, curtailing dynamic efficiency and innovation.

Both these arguments are often advanced as deriving *a priori* from economic theory;[84] however, both claims are actually empirical in nature. Whether or not a privately-owned asset performs the role of infrastructure—even under dynamic conditions—is a *factual* inquiry. Although it is true that such factual assessments are prone to significant uncertainty, the legal and economic components of these tests can nevertheless be tuned to include an 'error cost framework',[85] by *e.g.*, raising the threshold needed to support an infrastructural finding so as to avoid type 1 errors.[86] Second, whether an open access rule would in fact negatively impact dynamic efficiency is also an empirical assessment, though one that relies on counterfactual analysis under certainty. An IP-protected infrastructural asset is both an output and an input[87] of research and development (R&D). It may be true that the possibility of exclusive ownership is what sometimes triggers asset-owner to invest. However the availability of that asset as an input also has the capacity to trigger follow-on and downstream productivity. What is required is a balancing of the two dynamic efficiencies,[88] rather than the reliance on the *a priori* assumption that strong intellectual property protection is somehow equivalent to dynamic efficiency. Haunting both these strands of the literature is the ghost of the Chicago School's 'Single Monopoly Profit' argument. This argument holds that the economics of

83. *Verizon v Trinko,* 540 U.S. 398 (2004); see also Part III of the judgment ("[f]irms may acquire monopoly power by establishing an infrastructure that renders them uniquely suited to serve their customers. Compelling such firms to share the source of their advantage is in some tension with the underlying purpose of antitrust law, since it may lessen the incentive for the monopolist, the rival, or both to invest in those economically beneficial facilities.")

84. See Jonathan B Baker, '"Dynamic Competition" Does Not Excuse Monopolization' (2008) Social Science Research Network Research Paper 1285223 ("Baker, 'Dynamic Competition'") <http://doi.org/10.2139/ssrn.1285223> accessed 14 October 2016 (for a good summary and robust critique of this approach).

85. See Frank H Easterbrook, 'The Limits of Antitrust' (1984) 63 Texas L Rev 1 ("Easterbrook, 'Limits of Antitrust'").

86. *i.e.,* the errors which result from unnecessary intervention in a self-correcting market.

87. To some extent, the problem of IPR attaining an infrastructural status is pre-empted by the IP system itself. See Lee, 'The Evolution of Intellectual Infrastructure' 55, which identifies the various 'feedback' mechanisms within trademark law and copyright, and specific subject matter requirements in patent law, as controls against the monopolisation of infrastructural assets.

88. This may well be the purpose of the 'new product'/'technical development' test in *Microsoft;* see in this chapter Parts IV(A) and V(A) below.

monopolies means that upstream infrastructure owners do not have incentives to deny access to downstream companies. Summarily put, it states that the total rents a monopolist could receive from denying access (and reserving the downstream market for itself) and granting access (at the monopoly price access fee) would be the same. One upshot from the heyday of this theory was the crafting of per se legality presumptions for certain sorts of unilateral conduct, and burden shifting onto the plaintiffs.[89] There have been a number of attacks on this theory since its development in the 1950s, focussing on the rare and precise economic conditions that must obtain in order for the point to go through[90], its failure to properly consider dynamic competition, and the fact that it would not prevent the monopolist charging the downstream company supra-competitive and even supra-monopolistic rates.[91]

These arguments and their rebuttals will be developed further in Part V, where it will also be argued that the weight of the literature and economic theory favours a rebuttable presumption of open access with respect to technological infrastructure.

By emphasising that the identification of technological infrastructure is a *factual* inquiry, we also usefully limit the scope of this chapter's thesis. At first glance, it might be tempting to argue that all technological platforms and standards are in some way 'infrastructural', in the sense of being intermediate, generic, and non-rival assets. However, just because an asset has the characteristics to become infrastructural does not yet mean that it has achieved the status of essential infrastructure. What is missing is the consideration of the demand side. In the case of technological infrastructure that arises via the market (*de facto* standards), it is the power of social demand and network effects that transform (for example, patented) high technology assets into indispensable inputs for downstream productive activity. Examples of such *de facto* standards abound in high technology, and include dominant document formats,[92]

89. See, for example, the discussion of the George W. Bush era competition law gudielines which implemented this theory, in Herbert J Hovenkamp, 'The Obama Administration and Section 2 of the Sherman Act' (2010) 90 Boston U L Rev 1611, 1613 ("[t]he Report was extremely tolerant of single-firm conduct, making it extraordinarily difficult to prove a violation in many areas, particularly those involving pricing and refusals to deal.") See 'Competition and Monopoly: Single-Firm Conduct Under Section 2 of the Sherman Act (US Department of Justice 2008) < https://www.justice.gov/sites/default/files/atr/legacy/2009/05/11/236681.pdf > accessed on 14 October 2016.

90. Elhauge, Einer, 'The Failed Resurrection of the Single Monopoly Profit Theory' (February 11, 2010). Harvard Public Law Working Paper No. 10-16. 157 ("the literature shows that the single monopoly profit theory does not hold with or without a fixed ratio, with or without a strong positive demand correlation, and with or without a substantial foreclosure share.")

91. Lao, 'Terminal Railroad to Microsoft' 588 ("the doctrine cannot possibly improve consumer welfare because antitrust law does not bar a monopolist from charging rivals supracompetitive prices for access")

92. *E.g.,* Microsoft's proprietary '.doc.' format, now replaced by the arguably more 'open' '.docx' format.

audio-visual compression codecs,[93] and microprocessor architectures.[94] Such technological infrastructures emerge from the competitive process in network markets, characterised by a 'winner takes all' dynamic. (In some situations (such as discussed in chapter 3), some of these infrastructures may also be characterised as 'general purpose technologies'.)[95] Only in cases where the infrastructural asset has replaced all viable substitutes—and it has become uneconomic for a competitor or new entrant to create an alternative—can the infrastructure be considered 'essential'.[96] In such cases, access to the infrastructural asset may perform the role of a market bottleneck. For example, in *Microsoft* (as discussed in greater detail in chapter 2), downstream networking software companies were found to require access to the upstream Windows operating system 'quasi standard' in order to compete on the networking software market.[97] Furthermore, when the essential technological infrastructure is IP-protected, mandatory open access rules may only apply when the denial of access undermines industry-wide dynamic efficiency, such as by preventing the emergence of a new product or by retarding technical development.[98]

But it is important to stress that not all platforms or standards, nor all consumer markets, have the necessary attributes to transform a technological infrastructural asset into essential technological infrastructure. For instance, if switching costs[99] are low,[100] innovation

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93. *E.g.,* H.264 or MP3 codecs for compressing audio-visual and audio information, respectively. It should be noted that in the EU, copyright-protected 'interface information' in the form of software object code may be legally 'reverse engineered' ('decompiled') for the purposes of interoperability, see European Parliament and Council Directive 2009/24/CE of 23 April 2009 on the legal protection of computer programs ('The Software Directive'), OJ 111/16, 5.5.2009, Art 6(1).

94. See generally the EU Commission's Decision in *Intel* , discussing the dominant PC 'x-86' CPU 'instruction set architecture'.

95. Susanto Basu and John G Fernald, 'Information and Communications Technology as a General Purpose Technology: Evidence from U.S. Industry Data' (2008) FRBSF Econ Rev 1 ("Basu and Fernald, 'Information and Communications Technology'").

96. In the EU, the case law is usefully summarised in the Commission Guidance on Enforcement of Art. 82 EC, para 83 (which reads "[…] an input is indispensable where there is no actual or potential substitute on which competitors in the downstream market could rely so as to counter—at least in the long-term—the negative consequences of the refusal").

97. See *Microsoft Corp v Commission* [2007], para 387 ("[…] Windows represents the 'quasi-standard' for those operating systems"). However, it could also be argued in this case that the true 'standard' was in fact the 'interoperability information' rather than the OS.

98. Ibid, para 647 (stipulating that "the appearance of a new product […] cannot be the only parameter which determines whether a refusal to licence an [IPR] is capable of causing prejudice to consumers within the meaning of Article 82(b) EC. As that provision states, such prejudice may arise where there is a limitation not only of production or markets but also of technical development").

99. See Farrell and Klemperer, 'Coordination and Lock-in'.

100. Commission, 'Mergers: Commission Welcomes General Court Judgment in Microsoft /Skype Merger Case' (11 December 2013) Press Release MEMO/13/1137 <http://europa.eu/rapid/press-release_MEMO-13-1137_en.htm> accessed 4 January 2016 ("[…]if Microsoft started to make PCs users pay for such a product, this would only encourage them to switch to other providers that continue offering their services free of charge […]"). *Microsoft/Skype* (Case COMP/M.6281) Commission Decision [2011] OJ C341/02.

rates are extremely rapid,[101] and/or consumer preferences are fragmented.[102] For the sake of completeness, it should also be noted that private companies who own technological infrastructure may choose to adopt open access rules as part of a business strategy to stimulate technological innovation downstream, even in the absence of any mandatory access rules.[103] Such strategies are often observed in network industries characterised by two-sided markets.[104] For example, an owner of a *de facto* standard in the form of a mobile operating system (OS) may choose to open up its Application Programming Interface (API) to software developers for free or at very low cost, such as in the case of both Apple and Android. By permitting application designers to create and sell applications (Apps) to consumers, the OS owner leverages indirect network effects to increase the value of its upstream infrastructure to consumers. In addition, companies owning 'infrastructural' software libraries or hardware[105] may also choose to adopt open access regimes (such as open source licenses) in order to benefit from indirect value appropriation mechanisms like 'Linus's Law',[106] or to stimulate the dissemination and use of complementary hardware and software, or simply to engage more fully with the open source community.[107] Examples of the latter include royalty-free interoperability standards, which are prevalent in infrastructural technologies related to the Internet or World Wide Web, but which are also gaining a creeping acceptance in other areas of high technology.[108] SSOs in Internet and Web related technologies often have IPR policies, which either strongly prefer or mandate royalty-free ('RF') licensing, such as those of the W3C and the IETF.[109] While the RF nature of these types of standards may relate to the unique cultural and historical forces at play in these communities[110], the success of these standards has 'influenced groups

101. Ibid.

102. If consumers value the small distinctions between products then the market dynamic might not be 'winner takes all'.

103. For a detailed overview of this strategy, see Jonathan M Barnett, 'The Host's Dilemma: Strategic Forfeiture in Platform Markets for Informational Goods' (2011) 124(8) Harv L Rev 1861 ("Barnett, 'The Host's Dilemma'").

104. Jean-Charles Rochet and Jean Tirole, 'Platform Competition in Two-sided Markets' (2003) 1(4) J Eur Econ Assn 990 ("Rochet and Tirole, 'Platform Competition in Two-sided Markets'").

105. Also the case with so-called 'open source hardware', see Eli Greenbaum, 'Open Source Semiconductor Core Licensing' (2011) 25(1) Harv J L & Tech 131 ("Greenbaum, 'Open Source Semiconductor Core Licensing'").

106. Eric S Raymond, *The Cathedral and the Bazaar* (O'Reilly Media 1999) ("Raymond, *The Cathedral and the Bazaar*") 12 ("[g]iven a large enough beta-tester and co-developer base, almost every problem will be characterised quickly and the fix obvious to someone. Or, less formally, 'Given enough eyeballs, all bugs are shallow.' I dub this: 'Linus's Law' [...]"). Indeed, both the W3C and the IETF (two prominent Internet and Web related SSOs) have adopted royalty-free IP policies due to arguments similar to those summarised in this section, cf. Mair,'Intellectual Property', 56-57 ("SSOs... mainly in the context of the Web and the Internet—tend to adopt either non-proprietary standards or standards adopted according to policies mandating RF licensing.")

107. The attribution right of open source licenses allows a form of reputational effects to operate, which can lead to indirect gains for the developers.

108. Such as Bluetooth, see discussion in chapter 4.

109. e.g see Clause 3.1 of the W3C Patent Policy, (available at https://www.w3.org/Consortium/Patent-Policy-20040205/), (" As a condition of participating in a Working Group, each participant (W3C Members, W3C Team members, invited experts, and members of the public) shall agree to make available under W3C RF licensing requirements any Essential Claims related to the work of that particular Working Group.")

110. Jorge L. Contreras 'A Tale of Two Layers: Patents, Standardization, and the Internet' (2016) Denver Law Re-

developing other important standards, such as USB (uniform serial bus) and Bluetooth', to also adopt royalty-free licensing requirements.[111] Although the acceptance of RF licensing of interoperability standards is growing, their acceptance in markets traditionally characterised by royalty-bearing standards is still reasonably low, and may arguably create situations of 'culture clash'[112], as well as enhanced patent assertion risks, when these markets include substantial numbers of 'outsider' non-practising entities ('NPEs')[113], as discussed further in chapter 4.

Finally, even where an infrastructural asset does qualify as an essential infrastructure, access problems may still be addressed by private-ordering solutions, such as patent pools or cross-license agreements.[114] The utility of patent pooling arrangements as SEP access mechanisms has however been brought into question by a number of empirical studies. Even when patent pools have been carefully constructed in line with EU antitrust guidelines concerning technology pools[115], they often present few incentives for companies with high proportions of SEP ownership to join, which can vitiate their market-clearing function. These companies, such as *Qualcomm* in relation to the CDMA standard, often stand to extract more value from SEPs by not being part of a patent pool.[116]

It is only as a last resort, where private-ordering access solutions fail, and the infrastructural asset is truly indispensable to downstream companies, that the asset may attract antitrust scrutiny and the mandatory application of an open access rule. In both the EU and US jurisdictions, 'indispensability' has been understood to mean that, on objective grounds, there is no actual or potential substitute to the contested resource and that the 'denial of access [...]

view 868: ("One of the overarching features of all of these organizations was a distinctly non-commercial culture that valued technical capability over than economic returns")

111.ibid 880

112. For example, when Google released its RF VP8 WebM, web video standard for HTML5, it received a number of patent assertion threats by MPEG-LA, the patent pool responsible for licensing the competing royalty-bearing H.264 codec. See Carl Mair, 'Is the Future Open for Web Video?' (*Leiden Law Blog*, 21 March 2013) <http://leidenlawblog.nl/articles/is-the-future-open-for-web-video> accessed 14 October 2016

113. See chapter 4 discussion and the analysis generally in Jorge L. Contreras 'When A Stranger Calls: Standards Outsiders and Unencumbered Patents' Journal of Competition Law & Economics

114. Adam Mossoff, 'The Rise and Fall of the First American Patent Thicket: The Sewing Machine War of the 1850s' (2009) 53(1) Arizona L Rev 165 ("Mossoff, 'The Rise and Fall'"), 170 ("patent owners have substantial incentives to overcome a patent thicket without prompting by federal officials or judges, and that they can in fact do so through preexisting private-ordering mechanisms").

115. See Communication from the Commission Guidelines on the Application of Article 101 of the Treaty on the Functioning of the European Union to Technology Transfer Agreements, OJ C 89 28.4.2014

116. David B. Yoffie and Andrei Hagiu 'Intermediaries for the IP market.' (2011) Harvard Business School. 7 ("...if a specific firm owns a disproportionate amount of the essential IP in a given sector, it is unlikely to derive much value from joining a patent pool since it can extract more surplus on its own. This is the case of Qualcomm in the wireless communications industry: the company has always refused to join patent pools related to its CDMA technology.")

can reasonably be expected to make competitors' activities in the market in question either impossible or permanently, seriously and unavoidably uneconomic'.[117]

Although the essentiality of some technological infrastructures may be challenged on dynamic grounds using the Schumpeterian argument mentioned earlier, any robust analysis must also take into account that while 'technology' dominance can be limited over time, ownership over technologies often may not be.[118] Fast innovation rates in dynamic markets may drive some technological infrastructures towards obsolescence, but the sequential nature of R&D trajectories[119] often means that patents continue to 'read on' to subsequent generations, and technologies may need to be backwardly-compatible. For example, the current *de facto* standard for PC CPU 'instruction set' architecture- the 'x86 architecture'- has a legacy stretching back over 36 years.[120] The process of 'creative destruction' cannot therefore be used as a blanket justification for refusal to intervene in dynamic markets characterised by persistent intellectual property rights, as a (promptly retracted) 2007 US Department of Justice Guidance Report once seemed to suggest.[121] Such an approach would be tantamount to allowing the IP owner of an essential technological infrastructure to have significant control over the development of the downstream market. It is a pernicious misreading of economic theory to argue that such exclusive control leads to efficient outcomes. Under the neoclassical approach only *market* decision-making leads to optimal outcomes, not individual ones.[122] The core of the infrastructural approach is to enquire into the nature of these hubs of exclusive control. Scholars such as Suzanne Scotchmer and Stephen Maurer have argued that the 'heart' of antitrust's mandatory open access rules (*e.g.,* the essential facilities doctrine) is to leverage the sharing of assets to harness 'synergies', resulting in consumer welfare gains.[123] Put another way, the competitive harm caused by the owners of technological infrastructure

117. For the US formulation, see the case *MCI Commc'ns Corp. v AT&T Co.*, 708 F.2d 1081, 1132–33 (7th Cir. 1983) ("competitor's inability practically or reasonably to duplicate the essential facility"). For the EU formulation see Case C-7/97 *Oscar Bronner GmbH & Co. KG v Mediaprint Zeitungs- und Zeitschriftenverlag GmbH & Co. KG and Others* [1998] ECR I-7791 ("*Bronner*"), Opinion of AG Jacobs, para 65 (quoted in main text).

118. Of course patents only last 20 years, but this is often a very long time compared to the development rate of technological infrastructure .

119. James E. Bessen and Eric S. Maskin, 'Sequential Innovation, Patents, and Imitation' (2000) MIT Department of Economics Working Paper No 00-01 <http://papers.ssrn.com/abstract=206189> accessed 14 October 2016.

120. Paul E Ceruzzi, *A History of Modern Computing* (MIT Press 2003) ("Ceruzzi, *A History of Modern Computing*") 270.

121. Herbert J Hovenkamp, 'The Obama Administration and Section 2 of the Sherman Act' (2010) 90 Boston U L Rev 1611, 1613 ("[t]he Report was extremely tolerant of single-firm conduct, making it extraordinarily difficult to prove a violation in many areas, particularly those involving pricing and refusals to deal.") See 'Competition and Monopoly: Single-Firm Conduct Under Section 2 of the Sherman Act (US Department of Justice 2008) < https://www.justice.gov/sites/default/files/atr/legacy/2009/05/11/236681.pdf > accessed on 14 October 2016.

122. Mark A Lemley, 'The Regulatory Turn in IP' (2012) 36 Harv J L & Pub Pol 109 ("Lemley, 'The Regulatory in IP'"), 109 ("[i]t is important to remember, because it is quite often lost in the rhetoric surrounding these debates, that it is not the case that individual private decision-making is necessarily efficient. It *is* the case, however, that *market* decision-making is generally efficient").

123. Stephen Maurer and Suzanne Scotchmer, 'The Essential Facilities Doctrine: The Lost Message of Terminal Railroad' (2014) 5 California L Rev Circuit 247 ("Maurer and Scotchmer, 'The Essential Facilities Doctrine'").

denying access to downstream companies is the foregone consumer welfare boon, resulting from excess unilateral control over R&D trajectories.[124] This point will be picked up again in Part V.

So far most of the above analysis has focussed on *de facto* standards as technological infrastructure. While the emergence of *de facto* standards can largely be explained by the power of demand transforming the market from the inside out, *de jure* standards gain their essential infrastructure status by a different route. During cooperative standard-setting, companies agree on key infrastructural technologies on which to scaffold their downstream products, such as interoperability protocols and agreed bandwidths of the electromagnetic spectrum. Once these standards are agreed (usually in conjunction with a FRAND commitment, see Part III, Section B), then companies often make 'relation-specific investments […] because e*x post* design decisions are specifically based on the essential technologies selected *ex ante*'.[125] As with the competitive process in relation to *de facto* standards, these relation-specific investments transform the character of the market, and push the agreed standards (and any SEPs) in the direction of essentiality for the downstream markets[126] by creating a 'relationship of dependence between the intellectual property right holder […] and other undertakings'.[127]

Now to sum up. It is important not to oversell the point. Only some IP-protected technological infrastructures have characteristics enabling them to work as bottlenecks to downstream value creation, namely those for which social demand and network effects or relation-specific investments in the context of cooperative standard-setting have eliminated substitutes and where demand has become inelastic due to their status as necessary inputs. These IP-protected resources take on the function of essential technological infrastructure by becoming indispensable, non-rival inputs for downstream value creation and potential bottlenecks for further technological development. Given their role as essential technological infrastructure, they attract the economic logic of the 'infrastructural approach', which demands 'if infrastructure, then open access'. Although it is argued that this approach applies equally to *de facto* and *de jure* standards (see Part V), there are nevertheless some crucial differences between them, which must also sound in the relevant competition law tests. Unpacking the

124. The market failure in this case is caused by the excess 'centralisation' of R&D decision-making power provided by IP rights. As argued by Tim Wu, 'Intellectual Property, Innovation, and Decentralized Decisions' (2005) 92(1) Virginia L Rev 123 ("[e]ven accepting that useful incentives can be created by intellectual property, the effects on decision making suggest a reason to be cautious about the assignment of broad rights. The danger is that centralization of investment decision making may block the best or most innovative ideas from coming to market.")
125. Petit, 'FRAND-Pledged', 7.
126. Commission Guidance on Enforcement of Art. 82 EC, para 83 (reads "requesting undertaking [...] had made relationship-specific investments in order to use the subsequently refused input, the Commission may be more likely to regard the input in question as indispensable.")
127. *Huawei*, para 71 ("[…] creating a relationship of dependence between the intellectual property right holder occupying a dominant position and other undertakings").

strategic components (in relation to standards participation) of these differences will be the focus of Part III.

Below, Part III builds on the distinctions between *de facto* standards and cooperatively-set standards, and deploys game theoretical tools to explain why the latter might be preferred in high technology markets. Section A focuses on cooperatively-set standards as a solution to a 'coordination problem' afflicting standard choice in high technology. Section B then explains why this solution is nevertheless 'unstable' unless standard participants are prepared to make *ex ante* 'FRAND commitments', in order to help solve a 'prisoner's dilemma' problem that emerges *ex post*, after the cooperatively-set standard is adopted. Section C will then take a closer look at the legal nature of FRAND, and the extent to which its legal status makes its function as an *ex ante* commitment 'credible'.

III. FROM *DE FACTO* TO *DE JURE* STANDARDS

The purpose of this section is to take a closer look at the strategic nature of cooperative standard-setting in contrast to *de facto* standards. As mentioned in the previous section, there are some important differences between the two ways technological infrastructure emerge from the market, and these differences have consequences for how they can and should be managed. Section A aims to explain using game theoretical tools why companies in high technology may have incentives to coordinate their standard-setting efforts. Section B then deals with the related question of why cooperative standard setting generally requires *ex ante* FRAND commitments in order to be successful. Once these strategic aspects of cooperative standard-setting and FRAND commitments have been explained, Section C will look into FRAND as a 'creature' of law, including how its legal form attempts to make its status as a commitment 'credible.'

A. Why High Technology Markets Prefer De Jure Standards: Game Theory Approach

When a *de facto* standard emerges from the market—often as the outcome of a 'standards war'—the company that owns the standard reaps an economic windfall, as consumer markets and downstream producers[128] 'tip' their consumption in its direction. The company then goes on to assume a dominant position on the market for the asset, along with the corollaries of

128. Of course, not all *de facto* standard owners are willing to license to downstream producers, but it can happen, especially in cases of pure upstream companies. For example, the ARM CPU architecture has achieved status of *de facto* standard for embedded computing, and is licensed by ARM to downstream producers such as Apple, Qualcomm, Samsung etc; see ARM, 'ARM Processor Architecture' < http://www.arm.com/products/processors/instruction-set-architectures/index.php> accessed 4 January 2016.

volume increases, relative pricing-independence, and a (comparatively) 'easy life'.[129] In fact, in contradistinction to non-network monopolies, the economic bonanza of achieving a standard in a network industry is general: both the demand side and the supply side profit. Consumers may benefit from exponentially increasing network effects according to Metcalf's law; the producer benefits from a larger consumer market, greater commercial certainty, and a single 'platform' on which to focus its production.[130] But the nature of a standards war is that there are also losers. Companies who developed competing standards endure significant sunk costs without payoff. Consumers and producers who backed the 'wrong horse' end up with rapidly depreciating assets, as well as the costs involved in adopting and switching to the winning standard, where possible.

For the losing company, it would have been better to have coordinated with the winning company in advance and agreed on a common standard and to have shared in the windfall, even if that meant agreeing to use a standard 'owned' by the other. Likewise for the winning company: if we assume that the outcome of a standards war is essentially stochastic (an assumption with reasonably strong theoretical backing[131]), then it too would have preferred in advance to have agreed on a common standard and shared in the windfall rather than risk ending up empty-handed. Ending up 'empty-handed' here refers to the worst outcome in the 'game' (also known as the 'sucker's payoff'), where no standard is agreed and the losing company is left with significant sunk costs and no payoff. For example, in the High Definition (HD) audio-visual standards war between HD-DVD and Blu-ray, consumers and producers (including Microsoft Xbox) who bought and sold HD-DVD discs and readers were left with near worthless assets after Blu-ray achieved market traction and became the *de facto* HD standard.[132] However, it was a near thing; the standards war included a number of episodes when HD-DVD significantly outsold Blu-ray.[133] In its subsequent generation of Xbox (Xbox One), Microsoft switched over to the Blu-ray standard, despite the patents being substantially owned by its main downstream competitor in the console space, Sony,[134] meaning that Sony

129. John R Hicks, *'Annual Survey of Economic Theory: The theory of Monopoly' (1935) 3(1)* Econometrica 1, 8 ("[t]he best of all monopoly profits is a quiet life").
130. Mair, 'Intellectual Property'.
131. William Brian Arthur, 'Competing Technologies, Increasing Returns, and Lock-In by Historical Events' (1989) 99 Econ J 116 ("Arthur, 'Competing Technologies'"), 116 ("[w]hen two or more increasing-return technologies 'compete' then, for a 'market' of potential adopters, insignificant events may by chance give one of them an initial advantage in adoptions […]").
132. In 2008, Blu-ray's position was consolidated when Wal-Mart chose to exclusively back the Blu-ray standard over HD-DVD. See Julian P. Christ and André P. Slowak 'Why Blu-ray vs. HD-DVD is not VHS vs. Betamax: The Co-evolution of Standard-setting Consortia', Promotionsschwerpunkt Globalisierung und Beschaeftigung No. 29/2009.
133. See Brian P Cozzarin, William Lee and Bonwoo Koo, 'Sony's Redemption: The Blu-Ray vs. HD-DVD Standards War' (2012) 30(4) Prometheus 377, 384 ("Toshiba launched the HD-DVD player for $936 in 2006 in response to the Blu-ray player introduced in 2003 for $3,815. With the help of a lower price, more HD-DVD players were sold than Blu-ray players").
134. See list of patent licensors in the Blu-ray patent pool at One-Blue, 'Which companies are behind One-Blue?

profited from Xbox sales. The losses, both social and private, involved in Microsoft's loss of the standards war would have been avoided if Microsoft and Sony (and the other stakeholders in the standards war) could have agreed on either one of the standards upfront. It is the purpose of cooperative standard-setting to help companies reach this outcome.

In the taxonomy of game theory, the structure of a 'standards war' is referred to as a 'coordination game'. If only the parties could coordinate their behaviour *ex ante* they would be able to reach the best outcome: a commonly agreed standard (referred to as a 'Nash Equilibrium'[135] in game theory) as opposed to risking ending up at the worst outcome of having no standard at all. The purpose of cooperative standard-setting is to permit the emergence of coordinated market solutions to the problem of achieving a standard, enabling all participating producers (and also, eventually, consumers) to share in the economic windfall. Participants avoid the cost of standards wars and fragmented standards and consumers benefit from increased 'downstream' competition due to interoperability between competing technologies. To elucidate this game more clearly, Figure 1 contains a payoff matrix for the HD-DVD/Blu-ray 'standards war'.[136] The numerical values[137] represent 'producer surplus', and stand in for the players' (in this case either Sony or Microsoft) incentives to select a certain standard. Note that this game has two Nash Equilibria (the underlined values), where the parties agree on a single standard: (i) one where Microsoft agrees to a Sony-owned standard (Blu-ray); and (ii) one where Sony agrees on a Microsoft-owned[138] standard (HD-DVD). If they select different standards, then neither benefits since the market remains fragmented. Naturally, the game is a simplification because it misses the outcome where one party 'wins' the standards war, but it does succeed in capturing the key motivations behind why companies favour cooperative standard-setting in high technology: because the cost of losing the standards war is often significantly greater than the benefit in winning. Although this is not the case in all industries, it is generally the case in high technology markets with complex products.[139]

Can all essential patent holders join the One-Blue licensing program as licensor?' <http://www.one-blue.com/licensors/> accessed 4 January 2016.

135. The strategy that cannot be improved upon given the payoff structure in the game, and taking into account the other players' best moves.

136. All 'standards wars' are generally analysed in the same way. See Richard McAdams, 'Beyond the Prisoner's Dilemma: Coordination, Game Theory and the Law' (2009) 82(2) South Calif L Rev 209 ("McAdams, 'Beyond the Prisoner's Dilemma'").

137. What matters here is the relative values not the absolute numbers, which are arbitrary.

138. Of course there were other stakeholders involved in both standards, but both companies (Microsoft and Sony) had SEPs and both had made relation-specific investments in the relevant standards.

139. This is because the more complex the product, the greater the number of standards that are required to help 'manage' that complexity, and it is difficult if not impossible for companies to anticipate all of these in advance, thus requiring some sort of pre-market coordination; See Gregory Tassey, 'Standardization in Technology-Based Markets' (2000) 29(4-5) Res Pol'y 587 ("Tassey, 'Standardization in Technology-Based Markets'"), 587 ("[t]he complexity of modern technology, especially its system character, has led to an increase in the number and variety of standards that affect a single industry or market").

	HD-DVD	Blu-ray
HD-DVD	1, 3	0, 0
Blu-ray	0, 0	3, 1

Figure 1. The Standards War game (coordination game)

Although not necessarily the best outcome for companies at all times (the best outcome would be to *win* a *de facto* standards war)—cooperative standard-setting represents the best 'risk averse' outcome.[140] As shown in the payoff matrix above, when companies can agree on a standard upfront, they each harvest positive returns [1,3] or [3,1]. By adding the two values together (3+1=4), we also see that the total social welfare (spillovers excluded) is maximised at these two equilibria. These positive returns derive from the agreement 'not to compete' on the upstream market of the standard, allowing companies to instead divert more resources to creating better (interoperable) products downstream across a much wider consumer market. Consumers benefit from this downstream competition of interoperable products by avoiding 'lock in', and by getting a greater diversity and choice of products. As is also shown by the payoff matrix, failure to agree on a standard results in a fragmented market with zero payoffs. Although a zero payoff is not an entirely accurate representation of reality, it should be noted that in high-technology markets complex products often incorporate hundreds of different standards (and, sometimes, thousands of SEPs)[141] so that the consequences of making wrong standards decisions can be drastic. Absent cooperative standard-setting, the multi-faceted and multi-technology devices that characterise current high technology markets would be severely handicapped. In the worst case, failure to adhere to a common standard (and consequent standard fragmentation) leads to lack of product interoperability and complete isolation from both real and virtual networks. From society's perspective, the social cost is also considerable: significant losses in social welfare (lost network effects) due to absence of a common standard.[142]

Having now reviewed the strategic considerations for high technology companies to engage in cooperative standard-setting, it falls to consider why a FRAND commitment generally accompanies such standard-setting. It will be shown in Section B below that the stability of cooperative standard-setting relies heavily on the extent to which strategic behaviour after

140. Companies are generally acknowledged to be more risk adverse than is optimal in any case, see Albert N Link and John T Scott, *Public Goods, Public Gains: Calculating The Social Benefits of Public R&D* (OUP 2010) ("Link and Scott, *Public Goods, Public Gains*") 7 ("most private firms are risk averse (*i.e.,* the penalty from lower than expected returns is weighted more heavily than the benefits from greater than expected returns)").

141. See Jones, 'Standard-Essential Patents', 5 ("at least 250,000 SEPs and non-SEPS are estimated to read on the average smartphone").

142. According to Cottrell, the Japanese computer software industry's failure to settle on a single standard (as compared to the dominant 'Wintel' standard of the US and Europe) contributed towards its slow pace of innovation in the 1980s-1990s; see Tom Cottrell, 'Fragmented Standards and the Development of Japan's Microcomputer Software Industry' (1994) 23 Res Pol'y 143 ("Cottrell, 'Fragmented Standards'").

the standard is adopted is controlled (and seen to be 'credibly' controlled) *ex ante*, by legal commitments.

B. Solving the Ex Post 'Prisoner's Dilemma': The Purpose of FRAND Commitments

As shown in the previous sub-section, cooperative standard-setting is a solution to the 'coordination problem' which afflicts high technology markets: high technology markets require standards, but simply relying on standards to emerge via the competitive process is extremely risky, both for the companies involved and for society. Although cooperative standard-setting might help solve the problem of coordination in achieving a common standard, it also creates the conditions for another strategic game to play out among standard-setting participants: the well-known prisoner's dilemma.

The dilemma takes the following form. Companies who agree to coordinate with others on setting a standard still retain strong incentives to absorb as much of the economic windfall as possible. They may attempt this by 'competing on the merits' in markets 'downstream' of the standard, an outcome which also benefits consumers. Alternatively, and more dangerously, they may do so by attempting to 'capture' the 'upstream' standard once it is agreed, often by asserting intellectual property rights in the form of SEPs. This type of behaviour is referred to as 'patent holdup'[143] or '*ex post* opportunism'[144] in the literature. Such *ex post* opportunism may manifest in the standards' participant either refusing to license its SEPs to competitors once the standard is adopted or by charging excessive licensing fees in an attempt to raise competitors' fixed costs. (As will be discussed in Part IV, the role of injunctions in enabling such threats and pricing strategies is crucial.) The structure of this game is that of a cooperation game or 'prisoner's dilemma' because although both companies are better off not asserting their SEPs over the agreed standard (or not asserting them excessively), each nevertheless has strong incentives to do so, which results in each company attempting to prevent the other from using the standard. The payoff matrix in Figure 2 summarises the essential features of the strategic choices facing the standards' participants after the standard has been adopted. To 'share the standard' refers to the strategy of choosing not to assert IPR (in the form of SEPs) to try to capture the standard, but instead focusing on producing products downstream. 'Assert IPR' refers to the strategy of attempting to 'capture' the upstream standard- by refusing to license SEPs over it (or to charge non-FRAND rates) once the standard is adopted- in order to prevent the standard's use by competitors or to raise their costs. As is clear in the payoff matrix,

143. Carl Shapiro, 'Injunctions, Hold-Up, and Patent Royalties' (2010) 17 ALER 280 ("Shapiro, 'Injunctions'").
144. James D Ratliff and Daniel L Rubinfeld, 'The Use and Threat of Injunctions in the RAND Context' (2013) J Comp. L & Econ 1, 5 ("…these parties find themselves in a prisoners' dilemma–like strategic situation in which they are likely to be worse off unless SEP-holders can credibly commit *ex ante* to restrain their *ex post* opportunism").

both companies would be better off not asserting their IPR- by 'sharing the standard'- (each then has positive payoff of 3; and the total social welfare is 6 (3+3=6, excluding spillovers); but both would like to avoid the 'sucker's payoff' of zero when the other company has a payoff of five. This game structure thus leads to 'Assert IPR' as the dominant strategy for both players, and hence the Nash Equilibrium of the game results in the sub-optimal [0,0] payoff.

	Share standard	**Assert IPR**
Share standard	3, 3	0,5
Assert IPR	5, 0	0, 0

Figure 2. The Prisoner's Dilemma (cooperation game)

The problem with having this prisoner's dilemma sitting on top of the coordination game is that its 'shadow'[145] is visible *ex ante* to all standard-setting participants, who may then refuse to engage in the cooperative standard-setting process *ab initio*, if they assess the risk of *ex post* opportunism as insufficiently managed. In short, the existence of the *ex post* prisoner's dilemma may work to destabilise the formation of cooperative standard-setting *ex ante*.

Because of this problem- recognised very early in the history of cooperative standard-setting-[146] participants are required to give an *ex ante* 'commitment' not to engage in patent holdup or *ex post* opportunism. Such 'commitments' are a well-known solution to prisoner's dilemma problems, although the challenge is in making them 'credible',[147] as will be discussed in Section C below. The commitment usually includes a number of components designed to constrain 'defection', the most important of which are the duty to declare any intellectual property over the standard before it is adopted, and the duty to license the latter on FRAND terms.

In economic terms, the purpose of the above commitments have been understood as an attempt to confine the licensing fees of standards-essential patents to the 'value conferred by the patent

145. The 'shadow of the future' is a concept in game theory that explains how future expectations of strategic encounters can affect the strategies played in present games. It is normally used to explain how cooperation can occur in an iterated Prisoner's dilemma; however, here it is used to explain how a prospective future Prisoner's Dilemma can destabilise coordination in a current coordination game, unless adequately managed.

146. See *e.g.*, the first-reported SSO IPR policy (ANSI 1932) ("[t]hat as a general proposition patented design or methods not be incorporated in standards. However, each case should be considered on its own merits and if a patentee be willing to grant such rights as will avoid monopolistic tendencies, favourable consideration to the inclusion of such patented designs or methods in a standard might be given"), as quoted in Rudi Bekkers and Andrew Updegrove, 'A Study of IPR Policies and Practices of a Representative Group of Standards Setting Organizations Worldwide' (2012) National Academies of Science, 3.

147. Jones, 'Standard-Essential Patents', 6 ("[t]hese parties find themselves in a prisoners' dilemma-like strategic situation in which they are likely to be worse off unless SEP-holders can credibly commit *ex ante* to restrain their *ex post* opportunism").

itself as distinct from the additional value—the hold-up value—conferred by the patent's being designated as standard-essential'.[148] In short, FRAND attempts to ensure that the value of the SEP '*ex post*' remains roughly the same as its value '*ex ante*', stripped of any 'strategic value'.[149] As will be further explained in Section C below, this commitment also attempts to strike a balance between ensuring sufficient incentives for companies to contribute their technology for inclusion in the standard while ensuring its *ex post* openness. From the perspective of SEP-owners, the bargain can be defined as trading some of their unilateral price-setting rights in exchange for greater licensing opportunities, once the standard is adopted.[150] Section C will provide a brief outline of the nature of the FRAND commitment as a 'creature' of law, including its status as a contract, as well as its more complicated relationship with competition law. It will also discuss how the legal character of FRAND attempts to make its status as a commitment 'credible', before setting the stage for Part IV. The latter will engage with the latest European case law on the topic of the availability of injunctions as part of the FRAND negotiation framework (Part IV, Section A), before focussing on the strategic components of the FRAND commitment in operation (Part IV, Section B).

C. Legal Analysis of FRAND Commitment

Before honing in on the legal analysis of the FRAND commitment, it is important to briefly zoom out to glimpse the infrastructural import of the commitment. As with other infrastructural assets, FRAND attempts to approximate an open access regime, but with one crucial caveat. Unlike traditional infrastructure, such as highways and the electricity grid, the technological infrastructure which FRAND attempts to 'regulate' only rarely involves public subsidisation, meaning that the intellectual property system has to 'pick up the slack' by ensuring the private recoupment of (at least) the investment in its development. Because technological infrastructure is by and large privately-provisioned (see Part II, Section B), the FRAND commitment attempts to balance sufficient privately appropriability of the asset to the SEP-holders, while simultaneously ensuring 'access' to the standard implementers. In short, a FRAND commitment, such as the one embedded in the IPR policy of the European

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148. In the words of Richard Posner, as quoted in Joseph Kattan and Chris Wood, 'Standard-Essential Patents and the Problem of Hold-Up' (2013) Social Science Research Network, <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2370113> accessed 14 October 2016.

149. For an opposing view on this position, cf. Damien Geradin, 'Pricing Abuses by Essential Patent Holders in a Standard-setting Context: A View from Europe' (2009) 76(1) Antitrust LJ 329 ("Geradin, 'Pricing Abuses'"), 342 ("[t]he implicit assumption in the *ex post* opportunism claim is that all of the additional value created by the standardization process *improperly* accrues to patent licensors [...] There is no reason to assign all of the rents to one or the other"). For a robust reply to this dissent, see Mark A Lemley and Carl Shapiro, 'A Simple Approach to Setting Reasonable Royalties for Standard-Essential Patents' (2013) 28(2) BTLJ 1135 ("Lemley and Shapiro, 'Simple Approach'"), 1148.

150. Lemley and Shapiro, 'Simple Approach', 1140 ("[...] the FRAND commitment is at its base an agreement not to exercise the full scope of the patentee's rights in exchange for having its technology adopted as an industry standard, likely resulting in increased licensing opportunities").

Telecommunications Standards Institute (ETSI), 'seeks a balance between the needs of standardisation for public use [...] and the rights of the owners of IPRs'.[151]

As mentioned in Section B (Part III), one of the key purposes of FRAND is to solve a 'commitment problem' which afflicts the standard-setting process: once a cooperatively-set standard is adopted the bargaining position of contributing companies to extract very high licensing fees is considerably improved ('surges')[152] due to relation-specific investments and lock-in on the demand side. In order for the standard to be successful, standard-setting participants and implementers must assess the *ex ante* risk of *ex post* opportunism as low otherwise the whole endeavour might unravel. FRAND commitments function as an *ex ante* contractual commitment that contributing companies will not use their increased bargaining power to engage in *ex post* 'unfair', 'unreasonable' or 'discriminatory' licensing practices. However, in order to correctly do its job of preventing such behaviour, and thus ensuring the stability of cooperative standard setting, the FRAND commitment has to be legally 'credible' (enforceable). Part III, Section C(1) below will analyse the legal status of FRAND as both a contract, as well as its relationship with (EU) competition law. Section C(2) will then review the current understanding of its enforceability.

1. Contract or Competition Law Duty?

The legal form of the FRAND commitment is a contract between the IPR owner and the SSO (including its members, as third party beneficiaries).[153] The commitment is normally embedded in an SSO's IPR policy, alongside other complementary duties, such as the obligation for technology submitters to disclose *ex ante* any SEPs reading onto the standard.[154] The latter duty is included to control the risk of so-called 'patent ambush'. This occurs when a participant to cooperative standard-setting 'deceptively' allows an SSO to adopt a standard without declaring its SEPs. It then asserts its SEPs *ex post*, well after it is possible for the SSO to design around them, often demanding inflated royalties, such as in the EU case of *Rambus*.[155]

From a contractual point of view, the FRAND commitment is incomplete.[156] Except for some arguably unhelpful guidance from the EU Commission in its *Horizontal Guidelines* (which

151. See ETSI Policy, Art 3(1).
152. See Judge Posner's decision in *Apple v Motorola,* No. 1:11-cv-08540 (N.D. III. June 22, 2012) (which argues that "once a patent becomes essential to a standard, the patentee's bargaining power surges because a prospective licensee has no alternative to licensing the patent; he is at the patentee's mercy").
153. Roger G Brooks and Damien Geradin, 'Taking Contracts Seriously: The Meaning of the Voluntary Commitment to Licence Essential Patents on "Fair and Reasonable" Terms' in Steven Anderman and Ariel Ezrachi (eds), *Intellectual Property and Competition Law: New Frontiers* (OUP 2011) ("Brooks and Geradin, 'Taking Contracts Seriously'").
154. ETSI Policy, Art 4(2).
155. *Rambus* (Case COMP/38.636) Commission Decision [2009] OJ C30/17 ("*Rambus*").
156. Joshua D Wright, 'SSOs, Frand, and Antitrust: Lessons From the Economics of Incomplete Contracts' (Center for the Protection of Intellectual Property, Arlington, 12 September 2013) ("Wright, 'SSOs, Frand, and Antitrust'") <https://www.ftc.gov/sites/default/files/documents/public_statements/ssos-frand-and-antitrust -lessons-eco-

may be used in contract interpretation),[157] there is very little to help parties determine when a licensing offer is non-FRAND. According to some,[158] the incompleteness of the FRAND contract is a good thing. It is sufficiently capacious to incorporate the complexities of market bargaining, such as cross-licenses, portfolio-licensing, and a number of contingencies, which may only occur after the standard is adopted. These commentators argue that further *ex ante* specification over the meaning of FRAND terms introduces economic, business and legal complexities into the domain of standard-setting, when the latter should remain foremost a technical procedure. This may slow down the standard-setting process and vitiate its utility.[159]

In contrast to those who favour the incompleteness of FRAND, other commentators, and some SSOs, take the position that this incompleteness makes the commitment lack credibility, which increases the risk of *ex post* opportunism in the form of patent holdup.[160] As already discussed, this lack of credibility can be argued to be visible *ex ante* to standard participants, who may then refuse to participate.

Scholars who criticise the contractual incompleteness of FRAND argue that SSOs should adopt policies that require SEP holders to declare their 'most restrictive licensing terms'[161] before the standard is adopted. Then, companies that either fail to disclose their SEPs in a timely matter, or breach their own licensing commitments, should become subject to strong penalties.[162] Despite the recent creation of an EU competition law 'safe harbour' for the inclusion of such terms, only a minority[163] of international SSOs have incorporated terms like the above into their IPR policies. Most SSOs seem content to live with the contractual incompleteness, and leave FRAND negotiations to the private parties.

By leaving the actual content of the FRAND commitment to the negotiation of the private parties themselves, SSOs have made at least three implicit institutional choices. First, that the

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nomics-incomplete-contracts/130912cpip.pdf> accessed 14 October 2016.

157. Depending, of course, on the nature of member state contract laws.

158. See Wright, 'SSOs, Frand, and Antitrust', 2-3 ("[…] incomplete contracts were a predictable and efficient result given the costs associated with identifying all contingencies that might arise during the life of the contractual relationship").

159. Jorge L. Contreras 'Technical Standards And "Ex Ante" Disclosure: Results And Analysis Of An Empirical Study' (2013) Jurimetrics 53(2) 168: (summarising some of the critics' arguments, "modern technology development is too complex and unpredictable to make all pricing decisions before implementation of a particular standard").

160. Maurits Dolmans, 'A Tale of Two Tragedies – A Plea for Open Standards' (2010) 2(2) IFOSS L Rev 115 ("Dolmans, 'Two Tragedies'").

161. Lemley, 'Intellectual Property Rights'.

162. Damien Geradin, 'What's Wrong with Royalties in High-Technology Industries?' in Geoffrey A Manne and Joshua D Wright (eds), *Competition Policy and Patent Law under Uncertainty* (CUP 2011) ("Geradin, 'Royalties in High-Technology Industries'").

163. See *e.g.,* IEEE Standards Association, 'IEEE Enhances Standards Patent Policy to Permit Fuller Disclosure on Licensing' (*BusinessWire,* 30 April 2007) <http://www.businesswire.com/news/home/20070430006298/en/IEEE-Enhances-Standards-Patent-Policy-Permit-Fuller#.U7msxxYeVuY> accessed 14 October 2016.

normal process of market bargaining between parties can lead to a FRAND result. The game theoretical analysis in Section B (Part III) of the prisoner's dilemma, however, applies pressure to this as a possibility—although everything depends upon the nature of the 'negotiation framework', as will be discussed in Part IV. Second, that FRAND determinations should ultimately be made by the Courts in case of disputes.[164] Courts are good at a lot of things, but they are notoriously bad at price-setting, as will also be discussed in Part IV. Third (and very recently), at least one SSO—the ETSI—has also contemplated the role of the competition regulator in the determination and/or enforcement of FRAND by expressly involving the latter in its internal procedures for dealing with non-FRAND licenses.[165] This institutional choice implies that competition issues may indeed form part of the general understanding of FRAND.

Discussion of these three institutional choices: market bargaining, Courts, and competition law will be embedded in the following examination of FRAND 'enforcement', in Section C(2) below. The nerve of this section is to assess the respective role of each of these institutions in the determination of FRAND.

2. Enforcement Issues

As already mentioned, FRAND commitments take the legal form of a contract between the SEP-holder, the SSO, and the SSO Members, as third party beneficiaries. Given this starting point, scholars are divided on how the commitment should be enforced. Some commentators, including Damien Geradin and Roger Brooks,[166] argue that since FRAND is simply a contract, it should be enforced as such, before a court, utilising the normal instruments of contract law. Others, including Philippe Chapatte[167] and Maurits Dolmans,[168] argue that FRAND duties map directly to EU competition law obligations contained in Art 102 TFEU, and should be enforced by the EU competition regulator and Courts on competition law principles. Below, these two positions are dealt with in turn.

a) Contractual Approach

According to advocates of the contractual primacy of the FRAND commitment, its enforcement should be solely a question of contract law. If one party to the FRAND contract alleges that the other is in breach—for example, by demanding 'unreasonable' licensing terms of the licensee—then the latter is entitled to bring an action for breach of contract before the

164. Since very few SSOs have any mechanism for dispute resolution. Note ETSI as a recent exception.
165. See ETSI Policy, Art 8(2).
166. Brooks and Geradin, 'Taking Contracts Seriously'.
167. Phillipe Chapatte, 'FRAND Commitments – The Case for Antitrust Intervention' (2009) 5(2) Eur Comp J 319 ("Chapatte, 'FRAND Commitments'").
168. Dolmans, 'Two Tragedies'.

Courts, perhaps on the basis of an intended third party beneficiary theory.[169] It is then up to the Courts to adjudicate: [170]

> [...] whether the terms offered, taking into account all of the specific circumstances between the parties and prevailing market conditions, fall outside the *range* of reasonableness contemplated by the FRAND commitment.

This position holds that it is conceptual confusion to suggest that what is essentially a matter of civil law should be escalated to the level of competition law simply because both the FRAND commitment and Art 102 TFEU contain clauses related to setting 'fair prices'.[171] Treating the FRAND commitment as equivalent to Art 102 TFEU also introduces a logical problem of the following form. If FRAND is simply a restatement of competition law it makes the existence of a separate FRAND duty essentially redundant (at least in the European context),[172] since it is already embedded in the duties under competition law. All companies which occupy a dominant position in the SEP would already be bound by the duties in Art 102 TFEU. However, if FRAND sets a higher standard of 'unfair prices' compared to the excessive pricing test under Art 102 TFEU, then a breach of FRAND would not lead to liability under Art 102 TFEU (since breaching the FRAND threshold might not yet amount to a breach of the Art 102 threshold) and would have to be enforced by contract anyway. Only in the case where the FRAND commitment is assessed as exactly the same as the duty under Art 102 TFEU would competition law be applicable, in which case the FRAND contract is entirely redundant. Moreover, the argument that the FRAND commitment merely reiterates Art 102 TFEU seems to go against a statement in the 2003 CFI (now 'General Court') case, *ARD v Commission,*[173] where it was held that 'the [...] argument that the [FRAND] commitment is merely the reiteration of a legal obligation under Art 82 EC [now Art 102 TFEU] cannot be

169. Brooks and Geradin, 'Taking Contracts Seriously', 12 ("The intended beneficiaries of a FRAND declaration appear to be any parties who wish to perform actions identified in Paragraph 6 of the ETSI IPR Policy with respect to a standard-compliant product. This includes those who wish to 'manufacture, including the right to make or have made customized components and sub-systems to the licensee's own design for use in manufacture'. The ability of intended third party beneficiaries of a contract to enforce their rights under that contract is well recognized within the Common Law Tradition, while Civil Law jurisdictions provide comparable enforcement rights under (in the case of France, for example) the doctrine of 'stipulation pour autrui'. Fr. Civil Code Art. 1121.") Also see the critical discussion in Contreras, 'Market Reliance' 550

170. ibid

171. Art 102(a) TFEU (reads "directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions", which has similar wording to the 'Fair' component of the FRAND commitment).

172. For the difference in the EU and US approaches to 'excessive pricing', see Michal S Gal, 'Monopoly Pricing as an Antitrust Offense in the U.S. and the EC: Two Systems of Belief about Monopoly' (2004) 49(2) Antitrust Bulletin 343.

173. *ARD v Commission.*

accepted'.[174] Although that case concerned a merger and did not involve an industry standard, it seems to suggest that a FRAND commitment is stricter than the duty not to engage in 'excessive pricing' under Art 102 TFEU. If so, then a breach of FRAND, would not necessarily always be a breach of Art 102 TFEU, although the distinction between the two was never formally elaborated in that case.

It should be noted that when Geradin and Brook's FRAND contractual primacy argument was published in 2010, neither SSO IPR policies nor the European Courts had yet made definitive statements about the legal nature of the commitment.[175] Since that date, (as already mentioned) at least one prominent SSO—ETSI—has recently modified (November 2014) its IPR policy to include internal procedures for dealing with non-FRAND licenses offered by ETSI members. Interestingly, the end point of the ETSI internal procedure includes the 'General Assembly [...] request[ing] the European Commission to see what further action may be appropriate [...]'.[176] This new approach seems to require ETSI members and SEP owners to contractually agree to the involvement of the European competition agency in the monitoring and enforcement of FRAND licenses. In addition to this SSO policy change, the recent CJEU decision in *Huawei* also places pressure on the argument that FRAND is simply a contract devoid of competition law relevance, as will be discussed in Part IV. Although these recent SSO IPR policy changes and the CJEU decision do not entirely destroy the FRAND contractual primacy argument, they do suggest that the FRAND commitment is now understood to be a duty with at least competition law relevance, if not enforcement.[177] A recent (5 April 2017) decision[178] by the English High Court (Chancery Division), in *Unwired v Huawei,* has also shed light on the relationship between FRAND commitments' status under competition law and contract law. Essentially, the decision interpreted FRAND as an enforceable contract[179] under French Law (the law where the SSO, ETSI, was incorporated) since the FRAND commitment 'should be viewed as "public, irrevocable and enforceable" on grounds of public policy, if nothing else.'[180]

174. Ibid, para 242.

175. In any case the contractual primacy of FRAND has never been accepted by German Courts; See Jones 'Standard-Essential Patents' (remarking that 'German courts have regularly held the FRAND licensing declarations do not give rise to contractual obligations, but are declaratory in nature and do not go beyond the competition law based obligation to grant licenses, see eg, *General Instrument Corp v Microsoft Deutschland GmbH* Regional Court of Mannheim, 2nd Civil Division, 2 May 2012, file no. 2 O 240/11').

176. ETSI Policy, Art 8(2)(v).

177. Furthermore, and practically, bringing the enforcement of FRAND within the ambit of competition law may also help with ensuring a more-or-less uniform application of FRAND; something which would be entirely absent in the currently highly fragmented state of EU member state's contract laws.

178. *Unwired Planet International Ltd. v Huawei Technologies Co. Ltd.*, [2017] EWHC 711 (Birss J). (hereinafter: "*Unwired* Judgment"*).*

179. ibid, para 806(1) ("FRAND undertaking to ETSI is a legally enforceable obligation which any implementer can rely on against the patentee.")_

180. Jorge L. Contreras 'A New Perspective on FRAND Royalties: *Unwired Planet v.* Huawei' (2017) (unpublished draft) 3

The Court also held that it was 'not necessary to rely on competition law to enforce the FRAND undertaking'.[181] Furthermore, with respect to the 'content'[182] of FRAND, the Court found that 'the boundaries of FRAND and competition law are not the same. A rate may be above the FRAND rate but not contrary to competition law.'[183] As elaborated further in the case[184]:

> … I hold as a matter of law that the boundary of what is and is not a FRAND rate is different from the boundary of what is and is not an unfair price contrary to Art 102(a). If the rate imposed is FRAND then it cannot be abusive. But a rate can be higher than the FRAND rate without being abusive too.

A non-FRAND rate may give rise to an action in contract[185], but will only give rise to an action in competition law if the rate offered is excessively above a FRAND rate such as to distort competition and 'to disrupt or prejudice the negotiations themselves'[186]. Although this decision is non-binding on the EU judicature or other EU member state Courts, it is likely to be highly persuasive.[187]

For the sake of international comparison,[188] it should be noted *en passant* that in the US breaches of FRAND duties are often filed as breaches of contract,[189] in addition to the occasional 'patent

181. ibid para 806(2)
182. Contreras makes an important distinction between 'process' and content' obligations with respect to FRAND, see Contreras 'Market Reliance' 497 ("These commitments fall into two general categories: commitments to grant licenses on FRAND terms ("Process Obligations"), and commitments as to the license terms that are ultimately granted ("Content Obligations").")
183. *Unwired* Judgment, para 806(3)
184. ibid, para 757
185. However, such an action would only be possible during the negotiation phase. Once the rate is agreed to by the parties, the licensee cannot then re-open the negotiation, since 'if parties agree licence terms then their rights and obligations under the ETSI FRAND undertaking will be discharged and replaced by their contractual rights under the licence'. (see para 155 of the Judgment). It should further be noted that Birss J contemplates that the opening offer of the patentee may well be higher than the actual FRAND rate as it is the process of negotiation which should arrive at FRAND, not the first offer.
186. *Unwired* Judgment, para 765
187. As one of the first national judgements to exhaustively consider the binding ECJ precedent of *Huawei*
188. Additionally, the recently passed amendment to the Japanese Fair Trade Commission (JFTC) is roughly in-line with both the EU and US approach in terms of outcome. However, it differs in its approach, suggesting instead that using patents to block third parties from accessing technology is not 'within the rights' that a patent-holder is permitted to exercise; see JFTC, 'Guidelines for the Use of Intellectual Property Under the Antimonopoly Act' <http://www.jftc.go.jp/en/pressreleases/yearly-2015/July/150708.files/Attachment1.pdf> accessed 14 October 2016.
189. Daryl Lim, 'Standard Essential Patents, Trolls and the Smartphone Wars: Triangulating the End Game' (2014) 119 Penn State Environ L Rev 1 ("Lim, 'Standard Essential Patents'"), 41 ("[t]he remedy for a breach of FRAND commitments is specific performance of the contract").

misuse' claim.[190] Antitrust suits based upon the US 'anti-monopolization' provision of Section 2 Sherman Act (equivalent of Art 102 TFEU) are rarely pursued.[191] This is because:[192]

Unlike EU competition law, exploitative practices (including excessive fees) do not constitute an antitrust offence under US antitrust law.

However, an action under Section 2 Sherman Act has been brought in a case of the Third Circuit Court of Appeals, where the Court held that an intentionally false promise to grant FRAND licenses by one of the parties could be tantamount to 'illegal monopolization' under Section 2 Sherman Act.[193] Other approaches under US law, suggested either by case law or in the literature, have included Section 5 FTC (for deceptive practices)[194], patent misuse[195], breach of contract (on a theory of intended third party beneficiaries)[196], and promissory and equitable estoppel.[197]

b) Competition Law Duty?

An alternative view on the nature of the FRAND commitment is that it is a creature of competition law, and should be enforced as such. Supporting commentators[198] argue that the FRAND commitment maps to Art 102 TFEU, and that its breach should attract antitrust censure.[199] The EU Commission's *Horizontal Guidelines*[200] may be interpreted to support this view: [201]

> [T]he assessment of whether fees imposed for patents in the standard-setting context are unfair or unreasonable, will be based on whether the fees bear a reasonable relationship to the economic value of the patents.

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190. Ibid, 106 ("[p]atent misuse or misuse-like concepts have been invoked in both pre- and post-standardization cases").
191. Urska Petrovcic, 'Patent Hold-Up and the Limits of Common Law: A Trans-Atlantic Perspective' (2013) 50(5) CMLR 1363 ("Petrovcic, 'Patent Hold-Up'").
192. ibid 1375
193. See discussion in Contreras 'Market Reliance', 525
194. Negotiated Data Solutions LLC, No. C-4234, 2008 WL 4407246, at *1 (F.T.C. Sept. 22, 2008).
195. See Lim, 'Standard Essential Patents'
196. J. Gregory Sidak, 'A FRAND Contract's Intended Third-Party Beneficiary', 1 Criterion J. on Innovation 1001 (2016).
197. Robert P Merges and Jeffrey M Kuhn, 'An Estoppel Doctrine for Patented Standards' (2009) 97(1) Cali L Rev 1. Also see discussion in Contreras 'Market Reliance'
198. Chapatte, 'FRAND Commitments'; Dolmans 'Two Tragedies'.
199. Ibid.
200. Commission Guidelines on the Applicability of Article 101 of the Treaty on the Functioning of the European Union to Horizontal Co-operation Agreements [2011] OJ C11/1, 14.1.2011 (hereinafter: "*Horizontal Guidelines*")
201. *Horizontal Guidelines*, para 289.

The footnote to this sentence refers to *United Brands,*[202] a CJEU case under Art 82 EC (now Art 102 TFEU), which forms part of the CJEU's 'excessive pricing' jurisprudence, and defines the latter as a price which 'has no reasonable relation to the economic value of the product'.[203] Not too much should be read into this small footnote in the *Horizontal Guidelines*. However, a plain reading would seem to suggest that the legal test for assessing 'reasonableness' under FRAND is identical to the test under EU competition law. This would mean that breach of a FRAND commitment would be tantamount to a breach of EU competition law, assuming that all the other elements required under Art 102 TFEU are also met.[204] This interpretation, however, goes against the recent decision of Judge Birss in *Unwired,* as already discussed, where it was held that there is clear distinction between breaches of the FRAND obligation and Art 102 TFEU liability. Although Birss 's Judgement is likely to be highly persuasive in its interpretation of EU law, it is not, however, binding on other national Courts in the EU, who may still hold that duties under FRAND and Art 102 TFEU are in fact co-extensive.

Unfortunately, aside from the recent Commission statements in *Samsung* and *Motorola* and the AG's *Opinion* and CJEU Judgment in *Huawei* that deal with the related issue of strategic negotiation for FRAND licenses (covered in Part IV), case law from the EU judicature has not managed to resolve these issues. Advocate General Wathelet in his *Opinion* in *Huawei* makes an oblique reference to the controversy over the legal status of FRAND, when he mentions, in passing: [205]

> [T]he matters at issue in the dispute [...] stem largely from a lack of clarity as to what is meant by 'FRAND terms' and as to the requisite content of such terms, could not be adequately — if not better — *resolved in the context of other branches of law or by mechanisms other than the rules of competition law.*

The emphasised sentence suggests—tantalisingly—that other areas of law, or other mechanisms,[206] might be better suited to resolve these disputes. However, that *Opinion* and the subsequent CJEU Judgment, which substantially affirmed it, were only indirectly concerned with the 'requisite content' of FRAND, *i.e.*, the meaning of, *inter alia*, 'reasonableness' in

202. Case 27/76 *United Brands Company and United Brands Continental BV v Commission of the European Communities* [1978] ECR 207.
203. Ibid, para 250.
204. *e.g.,* such as occupying a dominant position on the relevant market; effect on inter-member state trade; effect beyond de minimus etc.
205. *Huawei,* Opinion of AG Wathelet, para 9 (*emphasis added*).
206. Part IV, Section B argues that the adoption of a liability rule can operate as an 'information-forcing mechanism' to lead to better FRAND licenses.

relation to licensing terms, focusing instead on the question of the use of injunctions during negotiations, as will be discussed in Part IV, Section A.

One EU attempt at addressing the meaning of the 'reasonableness' criterion in FRAND issues arose in 2007 in a case involving *Qualcomm's* licensing terms for its essential patents over the GSM/UMTS 3G standard.[207] In the 2005 US litigation over patents in the same patent family, *Qualcomm* argued that, despite its commitment to F(RAND) terms, 'charging what the market can bear [...] is not anticompetitive or unreasonable'.[208] In Europe, the case was eventually dropped and no determination was made.[209] Other SEP-related cases, such as the 2009 cases of *Rambus*[210] and *IPCOM,*[211] turned on facts related to 'deceptive conduct' leading to 'patent ambush' and the transferability of the FRAND commitment, respectively. Unfortunately, neither case permitted the Commission or the European Courts to make a definitive statement on how to determine the content of the 'reasonableness' element of FRAND.

In this regard, US courts have been more proactive. In the 2013 (breach of contract) District Court lawsuit between Microsoft and Motorola over the reasonableness of Motorola's FRAND royalty requests on the H.264 video compression codec, Judge Robart set down some legal rules for determining the 'reasonableness' of a FRAND royalty. Robart referred to fifteen criteria contained in the well-known US 1970 case for determining 'reasonable royalties'—*Georgia Pacific*[212]—and simply went down the list, expanding or contracting the royalty in line with the various factors to take into account. In that case, the plaintiff (Motorola) requested a rate more than one hundred times the FRAND rate, according to Robart's determination.[213]

In most cases, the international consensus on FRAND determination appears to adopt the understanding that a 'reasonable royalty rate' should, coarsely put, reflect the 'incremental

207. Commission, 'Antitrust: Commission Initiates Formal Investigation against Qualcomm' (1 October 2007) Press Release MEMO/07/389. Although in the EU it was retracted in 2009, see Commission, 'Antitrust: Commission Closes Formal Proceedings Against Qualcomm' (24 November 2009) Press Release MEMO/09/516.

208. Chapatte, 'FRAND Commitments', 320.

209. More precisely: in July 2008, Nokia agreed to withdraw its complaint against Qualcomm in exchange for a 15-year licensing agreement and a payment to Nokia of more than USD 1billion. This (together with another complainant dropping its claims) led the EU Commission to officially close its investigation in November 2009 and to address these issues through the *Horizontal Guidelines.* See Qualcomm, 'Nokia and Qualcomm Enter into a New Agreement' (24 June 2008) Press Release.

210. Commission, 'Antitrust: Commission Accepts Commitments From Rambus Lowering Memory Chip Royalty Rates' (9 December 2009) Press Release IP/09/1897.

211. Commission, 'Antitrust: Commission Welcomes IPCom's Public FRAND Declaration' (10 December 2009) Press Release MEMO/09/549.

212. See *Georgia-Pacific Corp. v United States Plywood Corp., 318 F. Supp. 1116, 166 U.S.P.Q. (BNA) 235 (S.D.N.Y. 1970).*

213. Joseph Kattan, 'FRAND Wars and Section 2' (2013) 27(3) Antitrust 30, 31 ("[i]n the only judicial decision to date to establish a F/RAND royalty rate, the SEP-holder sought a F/RAND rate that was 100 times the F/RAND rate that the court ultimately established for patents related to the Wi-Fi standard").

contribution of the patent to the world'[214] (or at least the next best alternative technology).[215] Although a voluminous legal and economic literature has emerged which goes into the finer points of 'reasonable royalty' calculations[216] for the purposes of FRAND, further discussion of this topic is outside the scope of this chapter (except for some brief observations in Part IV, Section B), as the EU case law is still undecided. The recent English case of *Unwired* did, however, shed some light on acceptable methods of calculating the value of a FRAND license, which may be of persuasive value to the EU courts.[217]

Rather than focus on the specific royalty-rate of a FRAND committed SEP in relation to a specific technology, the European Commission and Courts have been more active in defining the legal contours of the framework in which the FRAND negotiation takes place. In particular, recent EU statements and decisions have focused on the issue as to whether the owner of an SEP may have recourse to injunctions during the negotiations over a FRAND license.

The availability of the injunction remedy has significant consequences for the bargaining positions of parties in a FRAND negotiation.[218] As will be discussed further in Part IV, there are two schools of thought on the desirability of injunctions. Some commentators argue that the threat of injunctions are economically efficient since they enable SEP-holders to extract the 'full value' of their patents and therefore encourages both SSO participation and the continued investment in innovation.[219] Others argue that the threat of injunctions permit SEP-holders to 'hold up' standard implementers and extract 'strategic value' of the SEPs in addition to their market value,[220] consistent with the prisoner's dilemma problem sketched in Section B (Part III).

In what follows, market bargaining for access to an SEP where injunctions are available is referred to as bargaining under a 'property rule', whereas bargaining for access where

214. Mark A Lemley, 'Response: Taking the Regulatory Nature of IP Seriously' (2014) 92 Texas L Rev 107 ("Lemley, 'Response: Taking the Regulatory Nature of IP Seriously'"), 112.
215. Lemley and Shapiro, 'Simple Approach', 1148 (argue that "[t]he incremental value of the patented technology over and above the next-best alternative serves as an upper bound to the reasonable royalties").
216. To this end, the seminal paper of William J Baumol is of enduring relevance, see generally Daniel G Swanson and William J Baumol, 'Reasonable and Nondiscriminatory (RAND) Royalties, Standards Selection, and Control of Market Power' (2005) 73(1) Antitrust LJ 1.
217. *Unwired Judgement*, para 806 (8) ("an appropriate way to determine a FRAND royalty is to determine a benchmark rate which is governed by the value of the patentee's portfolio. That will be fair, reasonable and generally non-discriminatory.") Further discussion of this is outside the scope of this chapter.
218. Lemley and Shapiro, 'Simple Approach', 1143 (concluding that "[i]ntroducing injunctions would drive negotiated royalty rates away from reasonable rates to artificially high ones reflecting the threat of holdup").
219. Wright, 'SSOs, Frand, and Antitrust', 29 ("[*e*]*x post* interpretation of F/RAND commitments to preclude injunctive relief can deprive the parties the benefit of their bargain, undercompensate patent holders relative to *ex ante* expectations, and reduce incentives to innovate and the commercialization of innovation").
220. Lemley and Shapiro, 'Simple Approach', 1143.

damages are the only remedy is referred to as bargaining under a 'liability rule'. As mentioned in Section C(1), the crucial question is whether the process of market bargaining, under property or liability rules, is able to deliver FRAND results which adequately control the risk of *ex post* opportunism. An important component of assessing the outcomes of such bargains is whether the resulting FRAND license strikes the required balance between rewarding the SEP owner and ensuring open access to the technological infrastructure.

Consideration of these issues is the purpose of Part IV, which shall begin by an analysis of the recent CJEU and Commission decisions (Section A), before turning to analyse the FRAND bargaining 'dynamics' under property and liability rules (Section B).

IV. THE DYNAMICS OF BARGAINING UNDER PROPERTY AND LIABILITY RULES

This section aims to review the nature of the FRAND commitment in operation, by assessing the process of FRAND bargaining under property and liability rules. Section A will begin by discussing the recent Commission statements and CJEU case law with respect to the availability of injunctions during FRAND negotiations. It will unpack and examine the economic rationale of the case law as well as offer a (limited) analysis of the applicable competition law theory of harm. Section B will then assess the economic incentives to reach a FRAND outcome under property and liability rule, by analysing the strategic context of the negotiations. It will conclude that the European Commission statements and CJEU Judgment are economically robust, but according to different reasoning than that presented in those cases. Part V will then situate the Commission and CJEU decisions within the broader 'infrastructural approach' of this chapter, and attempt to show how they fit into the existing European case law on *de facto* standards forming part of a unified concern to ensure the openness of technological infrastructure.

A. EU Position on Injunctions in FRAND Negotiations

In April 2014, the Commission adopted its decisions in the cases *Motorola* and *Samsung*. The cases concerned the two companies' separate injunction applications against Apple in the course of a FRAND negotiation about an SEP over the 3G/UMTS standard. The Commission's findings, shared between the cases, were that it is an abuse of a dominant position under Art 102 TFEU, when an SEP-holder applies for an injunction if: (i) it is in a standardisation context; and (ii) an SEP-holder has committed to license the SEP on FRAND terms; and (iii) the licensee is willing[221] to take a license on FRAND terms. It is similarly an abuse of Art

221. Commission, 'Antitrust Decisions on Standard Essential Patents (SEPs) - Motorola Mobility and Samsung Elec-

102 TFEU to use the threat of injunctions in order to induce the licensee not to challenge the validity or essentiality of the SEP. Where the above 'exceptional circumstances' are met, the licensee enjoys a 'safe harbour' against injunctions and injunction threats. According to the Commission, 'the seeking of injunctions can distort licensing negotiations and lead to licensing terms with a negative impact on consumer choice and prices'.[222]

In short, *Samsung* and *Motorola* stand for the rule that the SEP-holder is denied recourse to an injunction where a FRAND negotiation is on-going with a 'willing' licensee. Under such conditions, the negotiation must therefore be carried out under the framework of a 'liability rule'. In case the parties are unable to agree on a FRAND license, then the parties may submit, on the licensee's request, to third party determination of a FRAND rate by a Court or agreed arbiter.

In November 2014, the Advocate General Wathelet delivered his *Opinion* in the case of *Huawei v ZTE.* The facts were similar to that of *Samsung* and *Motorola*, with Huawei applying for an injunction against ZTE's use of an SEP reading onto the 4G/LTE standard after negotiations had reportedly 'broken down'. Wathelet's findings in that case were in substantial agreement with the Commission decisions, except greater detail was given as to what constitutes a 'willing licensee'. In order for injunction applications to amount to a competitive abuse, the licensee must have demonstrated itself to be 'objectively ready, willing and able to conclude a licensing agreement', while not behaving in a 'dilatory manner' in reaction to the SEP-holder's licensing offer. In addition, the SEP-holder must have failed to comply with at least one of the cumulative 'procedural requirements' of the FRAND commitment, such as ensuring to formally notify the licensee of its need to have a license, together with the complete licensing terms and royalty calculations.[223] The licensee is furthermore permitted to respond to the SEP-holder's FRAND offer with a reasonable counter-offer, as well as a request for third party FRAND determination, although the SEP-owner may in the latter case request a bank guarantee.[224]

Though considerably more pithy and seeming sometimes to rely on equitable estoppel[225] principles rather than the strict application of competition law, the CJEU's July 2015 Judgment

tronics - Frequently Asked Questions' (29 April 2014) Press Release MEMO/14/322 ("*i.e.,* companies which, in case of dispute, are willing to have FRAND terms determined by a court or arbitrators (if agreed between the parties) and to be bound by such a determination").

222. Ibid.

223. See *Huawei,* Opinion AG Wathelet (n 25), para 103(2).

224. Ibid, para. 103(3)-(4).

225. See *Huawei,* para 53 (the suspect wording is the phrase 'legitimate expectations' used: "In those circumstances, and having regard to the fact that an undertaking to grant licenses on FRAND terms creates legitimate expectations on the part of third parties that the proprietor of the SEP will in fact grant licenses on such terms, a refusal by the proprietor of the SEP to grant a license on those terms may, in principle, constitute an abuse within the meaning of Article 102 TFEU"). The equitable estoppel approach has also been previously proposed by US scholars as a possible

in *Huawei*, essentially affirmed the findings of the Advocate General. One exception (perhaps only a matter of interpretation) is the licensee's unilateral right to request third party FRAND determination in case of continued disagreement over a FRAND rate. The CJEU Judgment, in contrast to the AG's *Opinion,* seems to make this a matter requiring 'mutual agreement' rather than at the 'licensee's request'. However, if that were the case, one can imagine the potential for negotiations grinding to a halt if the parties continue to disagree over a FRAND rate, and if the SEP-holder (or licensee) refuses to submit to third party determination. In such case, however, it is likely that the dispute would enter the Courts—who would then probably be tasked with the role of such determination.[226]

Aside from the small issue mentioned above, the current law of the EU with respect to the procedural aspects of the enforcement of FRAND commitments can now be said to be definitive. FRAND negotiations must proceed under a liability rule rather than a property rule, so long as the licensee is objectively willing and serious in its intention to conclude a FRAND license. Failure to reach agreement in the above shall lead to third party FRAND determination.

These decisions of the Commission and CJEU are substantially inline with international practice, and there seems to be a growing transatlantic consensus on the point. Although not referring to competition law principles, a United States (US) policy document issued by the USDOJ and US Patent Office in January 2013, stated that:

> [I]n some circumstances, the remedy of an injunction or exclusion order may be inconsistent with the public interest. This concern is particularly acute in cases where an exclusion order based on a F/RAND-encumbered patent appears to be incompatible with the terms of a patent holder's existing F/RAND licensing commitment.[227]

This guidance was 'operationised' in August of 2013, when the (then) US trade representative Michael Froman, struck down (on the request of President Obama) a US International Trade Commission[228] exclusion order against Apple mobile products found to infringe Samsung's SEPs over the 3G standard.[229] Although based on 'public interest' and equity arguments (also

(non-competition law) means to enforce the FRAND commitment; See *e.g.,* Robert P Merges and Jeffrey M Kuhn, 'An Estoppel Doctrine for Patented Standards' (2009) 97(1) Cali L Rev 1.

226. Unless of course, it becomes a competition law issue, due to the SEP owner's meeting of the criteria contained in the case.

227. US Department of Justice and US Patent & Trademark Office, 'Policy Statement on Remedies for Standards-Essential Patents Subject to Voluntary F/RAND Commitments' (8 January 2013) 6 <http://www.uspto.gov/about/offices/ogc/Final_DOJ-PTO_Policy_Statement_on_FRAND_SEPs_1-8-13.pdf> accessed 14 October 2016.

228. The ITC is a quasi-judicial body tasked with ruling on disputes over US imports.

229. Disapproval of the U.S International Trade Commission's Determination in the Matter of Certain Electronic

endorsed by the landmark US case of *eBay v MercExchange*)[230] rather than competition law principles, the effect is the same. The availability of injunctions during FRAND negotiations is severely circumscribed. Market bargaining over FRAND rates should occur in the shadow of a liability rule, as a property rule may lead to suboptimal (public interest, consumer welfare) outcomes.

On 3 November 2015, the first post-*Huawei* case law was decided, where the Court had the opportunity to apply the *Huawei* criteria. The German case of *SISVEL v Haier*[231] was the first EU national case to apply the ratio of *Huawei* to the question of the availability of injunctions in FRAND negotiations. The case concerned the defendant's ('Haier')[232] defence against SISVEL's injunction application for infringement of its SEPs over the 3G UMTS standard. Haier, using the same defence as ZTE in the *Huawei* case, argued that the SEP-owner's FRAND commitment disabled it from applying for an injunction. However, Haier's defence was rejected and SISVEL's injunction was granted, due to the dilatory behaviour of Haier in responding to SISVEL's FRAND offer. This case demonstrates that Courts (at least in Germany) do not view the *Huawei* decision as a 'get out of jail free card' for SEP-infringers, but will only deny injunctions if the conditions laid down in the *Huawei* 'safe harbour' are strictly adhered to. Likewise, in the recent English case of *Unwired,* where Birss J held that 'an implementer who does not negotiate fairly is not a willing licensee and may ultimately be subject to an injunction.'[233]

Further consequences of these recent cases will be discussed again briefly in Section B (Part IV).

Having now summarised the latest EU case law on the availability of injunctions during FRAND negotiations, the contours of the bargaining framework for reaching FRAND licenses are reasonably clear. However, the legal and economic rationales behind bargaining under a liability rule for FRAND remain underdeveloped. Moreover, the CJEU's theory of competition law harm seems poorly founded. In so far as it considered the matter at all, the CJEU appeared to base its theory of harm upon 'monopoly leveraging': [234]

Devices, Including Wireless Communications Devices, Portable Music and Data Processing Devices, and Tablet Computers, Investigation No. 337-TA-794', available at <https://ustr.gov/sites/default/files/08032013%20Letter_1.PDF> accessed 3 April 2017

230. *eBay Inc. v MercExchange L.L.C*, 547 U.S. 388 (2006).

231. *SISVEL Wireless Patent Portfolio v. Qingdao Haier Group*, Case 4a O 93/14, Düsseldorf Regional Court (3 November 2015).

232. The German entity of the Chinese *Qingdao Haier Group*.

233. *Unwired* Judgment, para 160

234. *Huawei,* para 52

> [T]he fact that that patent has obtained SEP status means that its proprietor *can prevent products manufactured by competitors from appearing or remaining on the market and, thereby, reserve to itself the manufacture of the products in question* [...][added emphasis].

The emphasised language, particularly the phrase 'reserve to itself' in relation to a downstream market, is generally indicative of the application of a monopoly leveraging abuse. The difficulty of trying to impose a monopoly leveraging theory on the facts of *Huawei* (and SEP/ injunction cases in general) is that it would require treating the injunction application as a 'refusal to license', as per the *de facto* standards line of cases like *Microsoft.* However, treating an injunction application as a 'refusal to supply' completely overlooks the strategic element of such applications in a FRAND negotiation, where the injunction (or threat of one) is usually a complementary strategy in order to extract higher licensing fees, according to patent-holdup theory. It also glides over the fact that Huawei's injunction application was lodged only *after* it had already made an offer to ZTE, which ZTE rejected. To consider these facts as amounting to a 'refusal to supply' would require Huawei's initial offer to have amounted to a 'constructive refusal', by being so out of the orbit of what is reasonable that it was an effective denial of access.[235] Although similar on its face, a constructive refusal is a different abuse under Art 102 TFEU, than one of excessive pricing. While the former is an 'exclusionary' abuse, the latter would be an exploitative abuse, and would likely need to meet the legal test set down in *Unwired.*[236] However, no reasoning fleshing out this distinction or suggesting a finding of constructive refusal was present in the *Huawei* judgment.

Despite the possible 'monopoly leveraging' language of the CJEU quote, it might also be possible to sustain a theory of harm based on 'margin squeeze' where the injunction (either threat or application) functions as a complementary strategy to achieve the main strategy of raising the prices on ZTE's inputs (4G/LTE SEPS) in an attempt to exclude ZTE from the market.[237] However, the law around margin squeeze is currently in some disarray, given the recent *Teliasonera* case[238] and the difficulty of integrating it with the *Guidance Paper on*

235. See Commission Guidance on Enforcement of Art. 82 EC, para 79 ("[c]onstructive refusal could, for example, take the form of [...] the imposition of unreasonable conditions in return for the supply.")
236. *Unwired* Judgment, para 765 ("an offer which is so far above FRAND as to act to disrupt or prejudice the negotiations themselves...")
237. As discussed below, margin squeeze is treated as an 'exclusionary abuse' under EU competition law .
238. Case C-52/09 *Konkurrensverket v TeliaSonera Sverige AB* [2011] ECR I-0527.

Art 82EC.[239] In addition, the required analysis of 'equally efficient competitor' was completely absent from the CJEU Judgement.[240]

An alternative possibility which avoids the difficulties of trying to force the facts of *Huawei* into the shoes of existing case law is to zoom out from the specific legal rules of either 'monopoly leveraging' or 'margin squeeze' and focus on general principles. According to Alison Jones:

> [...] it might be preferable to rely on these lines of cases more generally as indicating that when identifying an abuse the EU courts look for evidence: (i) of whether the conduct at issue falls within the scope of competition on the merits; and, where it does not; (ii) of whether anticompetitive effects, actual or potential, can be demonstrated.[241]

This approach would effectively make the specific legal rules in *Huawei* amount to the identification of a *sui generis* abuse.[242] Given the difficulty in aligning *Huawei* with existing case law, this position has some support. However, it is the purpose of Part V to attempt to integrate the *Huawei* decision with the overall approach of the *de facto* standards case law, by delineating an 'infrastructural approach' to technological infrastructure.

Leaving further discussion of the competition law components of the *Huawei* decision to Part VI below will now push on with the economic analysis. The key economic consequence of *Huawei* is on its effect on the bargaining framework for the FRAND negotiation, by removing the availability of injunctions when the licensee is within the defined 'safe harbour'. Section B and subsequent subsections will focus on analysing the effect of this by doing a comparative analysis of FRAND bargaining under property and liability rules. It will be shown that by removing injunctions from the negotiation toolbox of SEP-holders, the credibility of the FRAND commitment is strengthened. Introducing the 'threat' of third party FRAND

239. Nicolas Petit, 'Theories of Self-Preferencing Under Article 102 TFEU: A Reply to Bo Vesterdorf' (2015) Social Science Research Network 1("Petit, 'Self-Preferencing'"), 8
<http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2592253> accessed 14 October 2016 ("[s]ince the adoption of *TeliaSonera*, antitrust experts have fretted over the interpretation of the judgment. A possible reading of the ruling of the CJEU in *TeliaSonera* is that once a dominant firm has *voluntarily* chosen to supply a customer, it can no longer refuse to deal, and this notwithstanding the fact that the restrictive conditions of the essential facilities doctrine may not be fulfilled [...]"). This post-*TeliaSonera* view conflicts with the old view, which treated margin squeeze analogously to refusal to supply, see Jones, 'Standard-Essential Patents' (in which "[t]he Commission also treats margin squeeze analogously with refusal to deal in its Guidance Paper").

240. Commission Guidance on Enforcement of Art. 82 EC, para 80 (arguing that "a dominant undertaking may charge a price for the product on the upstream market which, compared to the price it charges on the downstream market, does not allow even an equally efficient competitor to trade profitably in the downstream market").

241. Ibid, 20.

242. Petit, 'Self-Preferencing' ("an increasingly popular proposition is to view the seeking of injunctions for FRAND-pledged SEPs as a *sui generis* abuse, subject to a novel substantive standard").

determination may function to 'force' information from the SEP-holder about its true valuation of the SEP, helping to keep royalty rates 'reasonable'.[243]

B. Bargaining in the Shadow of Legal Rules: 'Property' v 'Liability Rules'

Below, the comparative 'information forcing' potential of injunctions and liability rules to allow parties to arrive at a FRAND rate is assessed. The analysis will conclude that while the threat of injunctions may lead to *supra*-FRAND licensing demands, a liability rule has the ability to force information from the parties to arrive at more accurate SEP valuations. Using tools from bargaining theory, it will be shown that the threat of 'outsourcing' the FRAND determination contingent on failure of the parties to agree may lead to more FRAND-like valuations.

1. FRAND Bargaining under Injunctions v Liability Rules

When companies bargain over the value of an SEP, the transaction cost at issue is that of 'private information'.[244] Both the SEP-holder and the potential licensee have strategic incentives to hide their true valuation of the resource. SEP-holders would like to inflate the value of the SEP, while licensees wish to decrease it to the minimum amount possible. In a competitive or quasi-competitive market (such as does not usually exist in the context of SEPs), both sides of the transaction would be disciplined by possible substitution on the demand side (other buyers) and supply side (other sellers). The market acts as an information-forcing mechanism, revealing a valuation of the asset closer to its actual incremental value.[245] But where demand is inelastic as in the case of SEPs, there are few constraints to force the private information about value from the SEP-holder, and the value may reflect instead the 'strategic value', especially in the case where injunctions are available.

According to bargaining theory,[246] the availability of an injunction in this context may function as a 'threat point', enabling the SEP-holder to make the licensee internalise the potential losses of a successful injunction in its decision to accept the offered licensing fee ('patent holdup').[247] Commentators who argue against the availability of injunctions during

243. Lemley and Shapiro, 'Simple Approach', 1143 ("[e]xplicitly ruling out injunctions will tend to steer bilateral negotiations towards a reasonable royalty rate").

244. Ian Ayres and Eric Talley, 'Solomonic Bargaining: Dividing a Legal Entitlement to Facilitate Coasean Trade' (1995) 104 Yale LJ 1027 ("Ayres and Talley, 'Solomonic Bargaining'"), 1030 ("[p]rivate information is a particularly pernicious form of transaction cost, especially in legal contexts […] In such contexts, self-interested bargainers have a strong incentive to misrepresent their private valuations so as to capture a larger share of the bargaining 'pie'").

245. However, not all SEPs may have viable (*ex ante*) alternatives; see Geradin, 'Pricing Abuses'.

246. Lemley and Shapiro, 'Simple Approach', 1143 ("the outcome of bilateral negotiations is governed by the threat points of the two parties […]").

247. Shapiro, 'Injunctions', 283 ("[t]he right to obtain an injunction thus gives the patent holder the power to hold up an infringing firm that has made specific investments to design, manufacture, and sell the infringing product […]").

good faith FRAND negotiations often present a variation of the above argument that injunctions basically facilitate unilateral supply-side price setting, which may be inefficient, as well as anticompetitive under EU law. But it is important to note that an argument *against* injunctions does not translate into an argument *for* a 'liability rule'. That would be to commit what Harold Demsetz elsewhere has called the 'Nirvana fallacy'.[248] What is required is a comparative analysis between bargaining in the shadow of injunctions against bargaining in the shadow of a liability rule.[249] This is the purpose of the following sub-sections.

2. Bargaining in the Shadow of Injunctions: Dynamic Constraints?

There are at least two main arguments in favour of the availability of injunctions in a FRAND context against a willing licensee. First, that the problem of 'patent holdup' in FRAND licensing negotiations is significantly oversold. This argument states that there is no or little empirical evidence that 'patent holdup' is a problem and that taking away SEP-holders' rights to injunctions is an unnecessary solution to a non-existent problem.[250] The second argument for the continued availability of injunctions in FRAND negotiations is that SEP-holders are in fact constrained in important ways from engaging in patent holdup.

Taking the arguments in order, it is true that the empirical literature is undecided on the problem of patent holdup. Some commentators remark wryly that 'if patent holdup is slowing innovation, it is slowing it down to perhaps the fastest rate in human history'.[251] High technology markets characterised by high patent concentrations and standards, which are candidate industries for patent holdup problems, have witnessed dramatic and continued price declines and rapid innovation rates. However, as patent holdup naysayers admit,[252] even if the above is true, such a finding cannot support the thesis that patent holdup does not have an adverse effect on innovation, because the counterfactual remains unobserved. One can still argue innovation rates and price decreases would have been faster *but for* patent holdup. Patent holdup is difficult to empirically assess because it tends to operate in the opaque negotiating rooms of private bargaining, and only enters the Courts on the margin. Given this empirical problem, it is not possible to take this argument much further. Instead, one must resort to economic analysis of the private incentives to engage in patent holdup. This is the second

248. Harold Demsetz, 'Information and Efficiency: Another Viewpoint' (1969) 12(1) J L & Econ 1 ("Demsetz, 'Information and Efficiency'").
249. The seminal paper highlighting this distinction is Calabresi, Guido and Melamed, A. Douglas, 'Property Rules, Liability Rules, and Inalienability: One View of the Cathedral' (1972). Faculty Scholarship Series. Paper 1983.
250. J Gregory Sidak, 'Holdup, Royalty Stacking, and the Presumption of Injunctive Relief for Patent Infringement: A Reply to Lemley and Shapiro' (2007) 92 Minnesota L Rev 714.
251. Alexander Galetovic, Stephen Haber and Ross Levine, 'Patent Holdup: Do Patent Holders Holdup Innovation?' (2014) Hoover IP[2] Working Paper Series No 14011 <http://hooverip2.org/wp-content/uploads/ip2-wp14011-paper.pdf> accessed 14 October 2016.
252. Ibid.

argument of patent holdup naysayers: that SEP-holders are dynamically constrained from engaging in patent holdup.

One important dynamic constraint that has been argued to operate in the domain of standard-setting comes in the form of 'reputational effects' in the technological trajectory of standards: [253]

> [b]ecause standards evolve over time, and many high technology standards pass through multiple versions, any unreasonable pricing or abuse of market power can be punished in future iterations of the standard.

This argument suggests that standard-setting participants treat the standard-setting process as a 'repeated prisoner's dilemma game', rather than the 'single shot' game outlined in Section B (Part III). The argument runs: players have the ability to 'punish' patent holdup behaviour in subsequent rounds by refusing to include the technology of those 'behaving badly' in subsequent generations of the standard. To advocates of this view, the 'threat point' of a patent injunction would only rarely be utilised, as SEP-holders have incentives to set licensing fees at rates acceptable to licensees in order to avoid punishment in later standard-setting rounds.

But this 'dynamic constraint' argument is vulnerable to a number of attacks. First, unlike the case of showing that patent holdup has or has not a negative effect on innovation, this argument makes an empirical claim which is easily rebutted. One simply needs to show that there are cases where parties cannot agree on a FRAND license.[254] There are many examples of the latter, including the cases cited involving Apple, Samsung, Motorola, Microsoft, Qualcomm – most of the big players in high technology markets today.

An additional point against the effectiveness of 'reputational effects' in constraining licensing behaviour takes stock of the number of players in the standard-setting 'game', which may have a dilutive effect on the constraint. The standard-setting game is one with often hundreds of participants. For example, the 3G Partnership Project (3GPP)—the telecoms SSO 'mothership' uniting six SSOs under its umbrella—has more than 400 individual members.[255] It is difficult to see how SEP-holders' selective patent holdup of a few competitor companies might have really negative reputational effects sufficient to constrain behaviour.

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253. Damien Geradin, 'Abusive Pricing in an IP Licensing Context: An EC Competition Law Analysis' (12th Annual Competition Law and Policy Workshop, Florence, June 2007) 20-21.

254. Of course, this could also be due to the licensees being systematically 'unreasonable' as opposed to the SEP-holder.

255. See the 3PP Membership List:
<http://webapp.etsi.org/3gppmembership/Results.asp?Member=ALL_PARTNERS> accessed 4 January 2016.

Finally, one may also challenge the underlying premise of the argument that the standard-setting process is in fact a repeated game. Although it is impossible to challenge the fact that standards do require repeated interactions between participants, it is often the case in technological standards that succeeding generations of a standard build on the platform of previous generations, and often require backward compatibility.[256] This may mean that SEPs in one generation continue to 'read on' to succeeding ones, although the overall share in SEPs owned by any one company may rise or fall.[257] This would mean that even if SEP-owners have acquired a 'bad reputation', it would be extremely difficult, if not impossible, to remove their SEPs from the technology without jeopardising the integrity of the standard. Furthermore, it might also be the case that repeat offenders may simply have the best technology, meaning that isolating them from engaging in standardisation would lead to inferior standards. For example, Qualcomm has been involved in a number of FRAND-based litigations, but nevertheless remains in the top two[258] contributors of SEPs to wireless standards. Although none of these arguments kill the dynamic constraint argument, they do weaken the position that reputation has a disciplining effect on hold-up behaviour.

Having now addressed the arguments of empirical poverty and dynamic constraints that are generally deployed by those in favour of retaining the availability of injunctions in FRAND negotiations, we turn to assess the arguments for and against adopting a liability rule.

3. Bargaining in the Shadow of a Liability Rule or Third Party Determination

By removing the availability of injunctions in negotiations with an 'objectively willing' licensee in a FRAND context, the usual 'property rule' underlying patents is replaced by what amounts to a 'liability rule'. According to the recent *Huawei, Samsung* and *Motorola* decisions, when negotiating parties cannot agree on FRAND terms, they will generally have the option to submit to a neutral third party to determine the FRAND rate.[259] Following the CJEU *Huawei* decision, if they cannot agree on a third party arbiter, it is likely the dispute would be submitted to the Courts. Another way of viewing the above is that the parties are forced to negotiate a FRAND license in the shadow of third party FRAND determination, as will be discussed in Section B(3)(a).

256. For further detailed discussion on other ways SEP-holders may evade dynamic constraints, see Maurits Dolmans, 'Standard Setting – The Interplay with IP and Competition Laws' in Hugh C Hansen (ed), *Intellectual Property Law and Policy* (vol 11, Hart Publishing 2010) ("Dolmans, 'Standard Setting'").
257. For example, Qualcomm has less SEPs over the 4G LTE standard (as a percentage of the total) than it had over the 3G/UMTS, see 'Why Qualcomm's Royalty Rate Will Continue To Decline' (*Forbes*, 10 June 2014) <http://www.forbes.com/sites/greatspeculations/2014/06/10/why-qualcomms-royalty-revenue-will-continue-to-decline/> accessed 4 January 2016.
258. Just behind LG Electronics for 4G/LTE SEPs, see Elizabeth Woyke, 'Identifying The Tech Leaders In LTE Wireless Patents' (*Forbes,* 21 September 2011) <http://www.forbes.com/sites/elizabethwoyke/2011/09/21/identifying-the-tech-leaders-in-lte-wireless-patents/> accessed 4 January 2016.
259. In practical terms, such an adjudication process may be essentially indistinguishable from damage assessment following infringement.

There are at least two economic[260] arguments against such a curtailment of the SEP-holder's IP rights. First, that negotiating in the shadow of a liability rule (or third party determination) may lead to reverse-holdup, (otherwise known as 'hold-out'), where the licensee gains *too much* bargaining power. This may lead to licenses that are non-FRAND because they are *too cheap*, thus harming dynamic efficiency. Second, that even if injunctions may lead to 'excessive pricing', outsourcing price determination to a 'market mimicking' mechanism such as the Courts or a neutral third party, will lead to inefficient and inaccurate pricing, perhaps meaning that the 'cure is worse than the disease'.[261]

a) Problems of Reverse Holdup; Information-Forcing under a Liability Rule

In order to assess whether reverse holdup may be a problem under a liability rule, it is necessary to review the strategic position of the licensee in such a negotiation. Failure of the negotiating parties to agree on a FRAND rate will most likely lead to third party rate determination. This means that the licensee's 'threat point' is one of relegating FRAND determination to a third party.[262] In most cases, there would be significant legal costs (not to mention wasted time) associated with this eventuality. There would also be significant transaction costs associated with the uncertainty of such a process. However, it is likely that both the legal and transaction costs would be apportioned *symmetrically* across the bargaining parties: both parties would have to retain counsel and neither would be able to predict the outcome of the FRAND determination process in advance. Furthermore, as the recent German case of *SISVEL v Haier* and the English case of *Unwired* demonstrate, Courts may still grant injunctions to SEP-owners in circumstances where the *Huawei* conditions are not fulfilled. It would therefore be unreasonable to argue that the *Huawei* rule is somehow licensee-friendly, as the licensee's obligations under *Huawei* seem to be interpreted narrowly. In conclusion, the threat point available to a licensee under a liability rule would most likely be insufficient to create a reverse-holdup scenario in FRAND negotiations.

Moving on to the second argument about the inefficiency of third party FRAND determination, it is true that non-market mechanisms are notoriously poor at simulating market price setting. This is because 'price' is a signal that results from the interaction of

260. There are also legal arguments—as reviewed in *Huawei*—which turn on the right to property, and access to the Courts.

261. Stanley M. Bessen 'Why Royalties for Standard Essential Patents Should Not Be Set By The Courts' (2016) 15(1) Chic.-Kent J. Intellect. Prop. 28 ("[A]s a practical matter, it will be extremely difficult for a court to implement the "hypothetical, bilateral negotiation under the RAND obligation" that Judge Robart indicates "logically will lead to a royalty rate that both parties would have found to be reasonable.")

262. Jones, 'Standard-Essential Patents', 25 ("the removal of an unfettered right to seek an injunction does not automatically create a risk of Type 1 errors and mean that implementers are free to infringe SEPs with impunity and hold-out against patentees. If the parties cannot agree on FRAND terms, having reached an 'impasse', the patentee may request a court (or arbiter) to order the infringer to pay damages in respect of past infringement and/or to pay an on-going royalty for future licensed use").

a vast array of different factors, summarised by economists as 'demand' and 'supply'. Such factors constitute 'information', which is extremely costly to procure and difficult to integrate by non-market entities. Because of this, non-market price-setting is generally avoided by the Courts and spurned by the private sector, unless no market-based price-setting mechanism is available. However, the poverty of market-mimicking mechanisms can be leveraged to reach efficient outcomes under a liability rule, as explained below.

Since both parties to a FRAND negotiation have an interest in avoiding the uncertainty of third party adjudication, they each have incentives to reveal their true valuations during negotiations. Under the threat of third party determination in case of failure to agree on a FRAND rate (and the resulting extra costs, time, and unpredictability), rational bargainers may choose to shed their 'strategic valuations' and make offers closer to the actual incremental value of the SEP. This is because both parties will attempt to simulate the price-setting behaviour of a hypothetical third party arbiter in their own valuations, and each would attempt to make offers of the (respective) maximum and minimum amounts that could be accepted by the other party.[263] The SEP-owner may have extra incentives to offer a 'reasonable' FRAND rate, as third party determination would then limit its flexibility in negotiations with other parties in future negotiations, due to the 'non discriminatory' limb of the FRAND commitment.[264] By shedding strategic valuations and moving closer to what the parties can reasonably accept, the parties can be said to be revealing their 'private information' over the true valuation of the asset.

According to the work of a number of scholars including Mark Lemley,[265] Ian Ayres[266] and Rochelle Dreyfuss,[267] the transaction costs associated with the uncertainty of third party price determinations may actually (in fact, admittedly perversely)[268] function as information-forcing mechanisms, and the latter may gain in efficiency as the transaction costs are perceived to increase. When the price-setting body is perceived as particularly unpredictable, costly and

263. Ayres and Talley, 'Solomonic Bargaining', 1032 ("[u]nder a liability rule regime, a nominal entitlement owner has an incentive to reveal truthfully whether her valuation is above or below the damage amount").

264. In *Unwired,* Birss J held, however, at para 806(9) that the non-discrimination obligation is not "hard edged", and that it would only be suseptible to competition law enforcement where the differences in price would "distort competition between the two licensees"

265. Mark A Lemley, 'Contracting Around Liability Rules' (2012) Stanford Law and Economics Olin Working Paper No 415, 113 <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1910284#%23> accessed 14 October 2016 (stating that "[f]ar from discouraging bargaining, if anything, the denial of an injunction in a patent case appears more conducive to settlement than its grant").

266. Ian Ayres and Paul Klemperer, 'Limiting Patentees' Market Power Without Reducing Innovation Incentives: The Perverse Benefits of Uncertainty and Non-Injunctive Remedies' (1999) Yale Faculty Scholarship Series Paper 1256 <http://digitalcommons.law.yale.edu/fss_papers/1256> accessed 14 October 2016.

267. Rochelle C Dreyfuss, 'Varying the Course in Patenting Genetic Material: A Counter-Proposal to Richard Epstein's Steady Course' in Fred Scott Kieff (ed) Perspectives on Properties of the Human Genome Project (Elsevier 2003).

268. See Lemley, 'Liability Rules', 474-475.

slow,[269] parties have even stronger incentives[270] to reveal their 'true' valuations in order to avoid submitting to such a process.

Empirical data on settlements in the shadow of liability rules compared to property rules, show that the former often have a higher number of settlements.[271] Though the empirical data is not so far conclusive, it does lend weight to the information-forcing character of bargains conducted in the shadow of liability rules, and suggests that FRAND rates may be more forthcoming under a liability rule (and the threat of third party determination) compared to a property rule. As Lemley and Shapiro put it: '[s]o long as the arbitration procedure itself is unbiased, bargaining in the shadow of binding arbitration will tend to lead to reasonable rates'.[272]

Now to sum up. It has been argued above that FRAND bargaining under a liability rule has distinct advantages over bargaining in the shadow of an injunction. These advantages include reducing incentives for *ex post* opportunism due to the information-forcing potential of the threat of third party price-setting. These incentives may furthermore increase as the unpredictability, cost, and time for such a procedure increase.

By removing injunctions from the negotiation toolbox of SEP-holders, the EU Commission and Courts have recognised that market bargaining under a property rule may lead to sub-optimal results when the asset at stake is an essential infrastructural asset, such as a FRAND-committed SEP. By removing the availability of injunctions in such cases, the FRAND commitment gains credibility as the risk of *ex post* opportunism is reduced. This result may help to encourage the process of cooperative standard-setting since the prisoner's dilemma of *ex post* patent holdup would be perceived as credibly controlled (see Part III, Section B).

V. INTEGRATING THE INFRASTRUCTURAL APPROACH

It is well established in EU competition law that antitrust concerns can trump the exclusivity of an intellectual property right only in 'exceptional circumstances' and where the alleged anticompetitive use of the right is not 'objectively justified'. The 1968 case of *Parke & Davis*

269. Ibid, 475 ('the uncertainty of outcome is enough to cause risk-averse parties to settle rather than chance a bad outcome').
270. See Ayres and Talley, 'Solomonic Bargaining', 1026-1027 ("[i]ndeed, the inability of a court to tailor a damages award and the existence of litigation costs can often improve the ability of the parties to reach a consensual, efficient agreement on their own terms, not those dictated by the underlying liability rule [...]").
271. Lemley, 'Liability Rules', 475 ("[f]ar from discouraging bargaining, if anything, the denial of an injunction in a patent case appears more conducive to settlement than its grant."). Lemley also quotes empirical data that 31.25% of cases under liability rule cases settle compared to 16% under an injunction.
272. Lemley and Shapiro, 'Simple Approach', 1148.

v Probel[273] established the principle that the 'special protection' given by a patent is not an infringement of competition law unless its exercise 'degenerates' into an abuse of that protection. The 'very subject matter' of the 'special protection' was later defined in the 1988 case of *Volvo v Veng*[274] to be the right to exclude 'third parties from manufacturing and selling or importing, without its consent […]', though it left the door open for a finding of abuse in case of the 'arbitrary refusal to supply' or excessive pricing. In line with this early case law, the Commission's Guidance on the enforcement of Article 82 EC (now 102 TFEU), starts from the position that dominant undertakings 'should have the right to choose its trading partners and to dispose freely of its property'.[275] A series of more recent CJEU and General Court cases have elaborated on the 'exceptional circumstances' required to motivate a finding of 'refusal to supply' in relation to an intellectual property right, culminating in the 2007 *Microsoft* decision of the General Court. In that case, which substantially endorsed the framework established in the earlier cases of *IMS* and *Magill,* the following cumulative conditions were considered sufficient (but not necessary) [276] to justify a finding of a 'refusal to supply' and abuse of dominant position in relation to IP: first, that the refusal relates to a product or service indispensable to an activity on a secondary market; second, that it prevents the emergence of a new product or technical development[277] for which there is potential consumer demand; third, that it is such as to exclude any effective[278] competition on a secondary market; and fourth, that it is not objectively justified.[279]

Since this test has been substantially used to motivate compulsory licenses and open access to IP covering *de facto* standards, it would have seemed to be the natural competition law approach to cooperatively-set standards as well. However, both the AG Wathelet and the CJEU were careful to distinguish the *de facto* standards cases from the *de jure* standard case at issue in *Huawei:* [280]

> [I]t must be pointed out, as the Advocate General has observed in point 70 of his Opinion, that the particular circumstances of the case in the main proceedings *distinguish that case from the [de facto standards] cases which gave rise to the case-law... by the fact that the patent at issue is essential to a standard* established by a standardisation body […]. [emphasis added]

273. Case 24/67 *Parke, Duvis & Company v Probel and others* [1968] ECR 55.
274. Case 238/87 *AB Volvo v Erik Veng (UK) Ltd* [1988] ECR 6211.
275. See Commission Guidance on Enforcement of Art. 82 EC, para 75.
276. 'Sufficient' but not 'necessary', since the case states that the 'exceptional circumstances' were not exhaustive.
277. *Microsoft Corp v Commission* [2007], para 665.
278. Ibid.
279. Ibid, para 139.
280. *Huawei*, para 48

The AG and the CJEU were also careful to distinguish the German case law of *Orange Book,*[281] which the referring Court considered relevant on the same grounds.[282] In distinguishing the cases, the AG made the observation that 'it is only natural that, in those circumstances [of a *de facto* standard], the patent owner will have greater negotiating power than in the case of an SEP the owner'.[283]

It is submitted that the CJEU was correct to support a distinction between *de jure* and *de facto* standards. However, it is argued that the ground for the distinction can be more precisely defined. To briefly preview the argument below, the nub of the distinction should derive from the greater difficulty and uncertainty in identifying essential technological infrastructure in *de facto* standards cases compared to *de jure* standards cases. Using Easterbrook's 'error-cost framework' (see Part II, Section B), the increased likelihood of committing type 1 errors in relation to *de facto* standards should demand a more robust and exhaustive 'infrastructural screening' test than that of *de jure* standards. However, once qualified as essential technological infrastructure, then the application of an open access rule should follow unless there are very good reasons to counsel against. The underlying logic of the infrastructural approach can thus be summarised as 'if infrastructure, then open access'. This approach can be decomposed into two steps, including (i) an 'infrastructural screening test', followed by (ii) an assessment of the appropriateness of an open access rule, as will be discussed in detail below in relation to *de facto* and *de jure* standards.

In the case of the purely 'bottom up' technological infrastructure of *de facto* standards, the 'essential facilities' test was used to 'screen' for the infrastructural character of the asset and assess the merits of an open access rule, and can be divided into two parts. First, the 'essentiality' and *sine qua non* status for effective competition can be said to go towards determining whether the asset is truly infrastructural. This is a *factual* inquiry. Only if the asset cannot be reproduced and if denying access to it would seriously harm effective competition can it be considered 'infrastructural'. Its attributes of being non-rival, intermediate and generic (see Part II, Section A) are implied by its function as an input; however the 'non-rivalry' assessment may also sound in the second part of this analysis: assessing the merits and conditions of applying an open access rule given the asset has been found to be infrastructural. The IP-specific test of the 'new product' or 'technical development' can be seen to form part of the assessment of whether an open access rule is appropriate: it is only in cases where denial of access would harm dynamic efficiency (the emergence of a new product or technical development) that an open access rule would be a principled approach. Otherwise, the Schumpeterian arguments (summarised in Part II, Section A) in favour of strong, exclusive intellectual property protection would likely

281. *Orange Book Case* (2009) KZR 39/06 (GFCJ).
282. *Huawei*, para 48.
283. Ibid.

tip the balance against an open access rule. Finally, an open access rule may also be challenged by 'objective justifications', such as where, for example, the infrastructural asset is not truly non-rival and sharing access may lead to *e.g.,* congestion problems.[284] From a competition law perspective, the consumer harm of 'monopoly leveraging' in a *de facto* standards case is identified as the loss of the 'new product'/technical development', referred to in *Microsoft* as loss of 'consumer choice'.[285]

In the case of *de jure* technological infrastructure, the infrastructural status of the SEPs need not go through the exhaustive 'essential facilities' style 'infrastructural 'screening test', since the 'quasi-top-down'[286] and cooperative approach of *de jure* standard-setting raises fewer risks of misidentifying essential infrastructure. Compared to *de facto* standards, the risk of type 1 errors is less in relation to *de jure* standards. *De jure* standards are considered technological infrastructure (almost) by definition, as they create a 'relationship of dependence between the intellectual property right holder…and other undertakings'.[287] The legal analysis in *Huawei* can be seen to focus purely on the equivalent of the second part of the 'essential facilities' analysis:[288] *i.e.* the conditions under which the application of an open access rule is appropriate. Since the basis of the open access rule was the *ex ante* FRAND contractual commitment, and since SEPs only attained their infrastructural status by virtue of this commitment,[289] it is the bargaining conditions around this duty which are the Court's focus. As explained earlier, the nub of the Court's decision on this point was that an open access rule to SEPs should apply unless the licensee's approach to the negotiation is not 'objectively willing', or otherwise in bad faith. Where these elements are absent, then the parties must conduct their negotiation under the shadow of a liability rule, which amounts to the application of an open access rule. The 'essential facilities'-style 'objective justification' as a means to challenge the application of open access would not be available in a *de jure* standards case, as such considerations should have been internalised before the SEP-holder committed to a FRAND contract. The consumer harm in the case of *de jure* standards under the *sui generis Huawei* test seems to be dual: that there will be harm in patent hold up risk (leading to exclusion of competitors, and loss of

284. Also referred to as a 'dirty public good', such as highways or some telecom networks. In cases of pure IP (as information) resources, however, such as SEPs, these arguments would not bite.
285. The reduction in 'product choice' due to monopoly leveraging was the identified 'consumer harm' in *Microsoft Corp v Commission* [2007].
286. Quasi top down because the standards do not 'emerge' from the market via competition, but are agreed *before* the products hit the market.
287. *Huawei*, para 71.
288. However, AG Wathelet emphasised in his *Opinion* that a SEP-holder cannot be simply assumed to occupy a dominant position for the purposes of Art 102 TFEU. Therefore, this will need to be shown before it can be assumed that an alleged SEP is indeed 'infrastructural'; *Huawei*, Opinion AG Wathelet, para 57 ("[…] the fact that an undertaking owns an SEP does not necessarily mean that it holds a dominant position within the meaning of Article 102 TFEU, and that it is for the national court to determine, on a case-by-case basis").
289. *Huawei*, para 51 ("[…] the patent at issue obtained SEP status only in return for the proprietor's irrevocable undertaking, given to the standardisation body in question, that it is prepared to grant licences on FRAND terms").

consumer choice),[290] and also that the 'risk that confidence in the standard setting process will be undermined'.[291] This second element of harm links to the strategic considerations of standard-setting developed in Sections A and B (Part III), and the fact that the risk of patent holdup can cause the coordination conditions for *de jure* standards to unravel,[292] due to the frustration of the 'legitimate expectation' of FRAND licensing.[293]

A useful way of summarising the 'infrastructural approach' outlined above is contained in Figure 3. As shown there, the approach is characterised by two main steps: 'an infrastructural screening test', followed by an assessment of the appropriateness of an open access rule. In the third box on the right, the suggested theory of harm motivating the competition law intervention is also included.

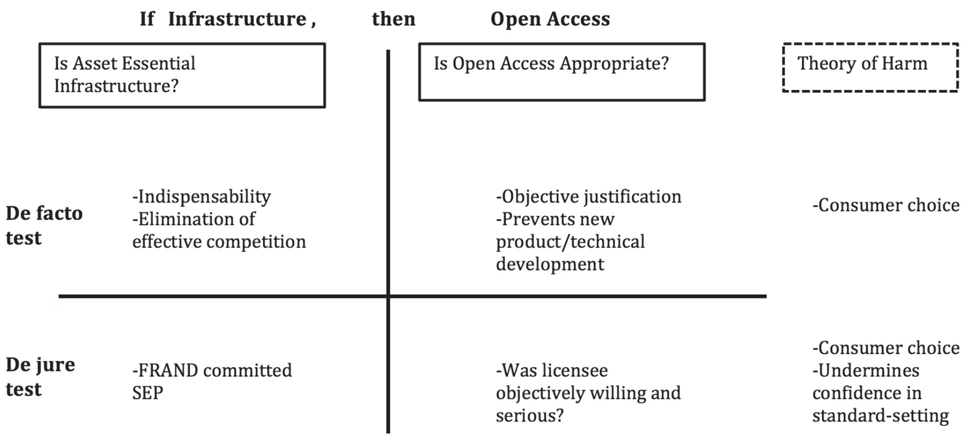

Figure 3. The two stage infrastructural approach

To sum up, the *de jure* and *de facto* standards cases are unified by an infrastructural approach to the underlying technological infrastructure, of the default form 'if infrastructure, then open access'.[294] In *de facto* standards cases (such as *Microsoft*) the risk of type 1 errors counsels for a robust 'infrastructural' screening test before the application of an open access rule. However 'objective justifications' (*e.g.,* congestion) and 'dynamic efficiency' (absence of a new product/

290. Ibid, para 52.
291. Jones, 'Standard-Essential Patents', 26.
292. See Part III, Sections A-B and the argument about the 'shadow' of the Prisoner's Dilemma being visible to coordinating companies in *de jure* standard setting.
293. *Huawei*, para 53 ("an undertaking to grant licenses on FRAND terms creates legitimate expectations on the part of third parties that the proprietor of the SEP will in fact grant licenses on such terms").
294. Frischmann, 'An Economic Theory', 923 ("if a resource can be classified as infrastructure […] then there are strong economic arguments that the resource should be managed in an openly accessible manner").

technical development) arguments may still be recruited to defend against application of an open access rule. In *de jure* standard cases, the 'infrastructural screening test' is foregone due to the inherently essential infrastructural nature of cooperatively-set standards. The analysis instead focuses on the 'open access' conditions. To this end, an open access rule is applied by default unless the licensee is shown to not be objectively willing, or otherwise behaves in bad faith during the FRAND negotiation.

Viewed in the above way, the 'essential facilities' test can be seen as just one legal approach to ensuring the open access of essential technological infrastructure- and one which is tuned to the difficulties of mandating access to purely 'bottom up' technological infrastructure. The *de jure* standards test is another, perhaps *sui generis,* test (see Part IV, Section A) to the same problem, although tuned to the issues of cooperative standard-setting. Both tests are unified by the overall two-stage 'infrastructural approach'.

VI. CONCLUSION

As high technology markets have become central to economic production, modern economies have undergone a profound shift in the provisioning systems of essential infrastructure. While traditional infrastructures retain their crucial importance for scaffolding social value creation, technological infrastructures in the form of real and virtual networks have arisen via bottom-up and industry-coordinated processes to take centre stage. As these technological infrastructures swell to include greater proportions of social activity, the trade-offs between their private ownership and the public interest in their 'open access' and management are sharpening. The regulatory attention attracted by such companies as Google,[295] Facebook,[296] Microsoft[297] and Intel[298] is symptomatic of the increasing tension between these companies' private ownership of key technological infrastructures and the latters' inherently public role.

It is submitted that the infrastructural approach endorsed by this chapter may have some role to play in helping to identify the nerve centres of the debates over private ownership and public interest. The two-stage approach of first 'screening' for infrastructure, then assessing the utility of the open access rule can be used to assess whether exclusive private control over an essential technological infrastructure is justified. The infrastructural approach[299] may then

295. See Commission, 'Antitrust: Commission Sends Statement of Objections to Google on Comparison Shopping Service' (15 April 2015) Press Release MEMO/15/4781.
296. See Gibbs, 'Facebook's Privacy Policy Breaches European law, Report Finds'.
297. *Microsoft Corp v Commission* [2007].
298. *Intel* Commission Decision.
299. It should be noted that some scholars strongly disagree with identifying *e.g.*, companies like Google as being treated as 'essential facilities'. As should be clear, the approach endorsed by this paper does not depend on the application of the essential facilities directly, but on the wider 'infrastructural approach'. In any case, see Bo Vesterdorf, 'Theories of Self-Preferencing and Duty to Deal - Two Sides of the Same Coin?' (2015) 1(1) Comp L & Pol Debate 4,

go on to craft legal *sui generis* rules (such as, arguably, in *Huawei*) that recognise the importance of continued private investment, while bringing the interests of social welfare into the mix, and attempting to tune the legal tests to the uncertainties of market intervention.

By mandating 'open access' over essential technological infrastructure in certain well-defined cases, competition law is merely reinstating the 'lost message' of the early case law, that 'antitrust law should not discard beneficial synergies that require sharing'.[300] Although today's high technology markets generate new and interesting *facts*, the *principle* that privately held 'conveniences affected with the public interest'[301] may be restrained from taking 'arbitrary or excessive duties' has very deep roots within the law. Taking privately-owned technological infrastructure seriously as 'infrastructure' sits firmly in this legal tradition, as well as representing a step towards greater openness, dispersion of unjustified control, and competition in today's high technology markets.

8 ("Google's position is not comparable with that of an infrastructure service, such as a port or telecommunications utility that represents a necessary access point to the market for which there is no alternative"). However, Vesterdorf's position that the essential facilities doctrine is inapplicable to Google is robustly challenged by Nicholas Petit. He argues that Vesterdorf's view is unduly narrow and cannot be sustained by the case law; see Petit, 'Self-Preferencing', 10-15.

300. Maurer and Scotchmer, 'The Essential Facilities Doctrine' ("[t]he lost message is that antitrust interventions must not discard beneficial synergies that require sharing. This common thread goes a long distance to unifying the cases on both sides of the Atlantic. We anticipate that the doctrine will gain renewed importance, since the digital economy is a new source of synergies").

301. Hamilton, 'Affection with Public Interest', 1093 (reads "a man who 'for his own private advantage' sets up a wharf or a crane 'may take what rates he and his customers may agree'; but at a wharf unto which all persons must come to unlade or lade their goods 'there cannot be taken arbitrary or excessive duties,' but 'the duties must be reasonable and moderate.' The reason is that "now the wharf and the crane and other conveniences are affected with a public interest, and they cease to be *juris privati* only").

CHAPTER 2

TECHNOLOGICAL INFRASTRUCTURE AND THE EU ESSENTIAL FACILITIES DOCTRINE

I. INTRODUCTION

As chapter 1 has discussed in detail, competition policy has an important role to play in structuring strategic behaviour in the market. When private companies self-organise access regimes to technological infrastructure or attempt to use intellectual property strategically to block access or extract monopoly rents, their behaviour reflects their internalisation of both the legal and business risks in the marketplace. This behaviour occurs in the shadow cast by legal rules. One important function of good legal rules is to structure private incentives to track socially-optimal outcomes, as described in chapter 1's 'infrastructural approach'. Although referred to frequently by name in that chapter, the 'essential facilities doctrine' ('EFD') component of this approach was not developed or analysed in significant detail. This omission was for two main reasons. First, the focus of chapter 1 was to develop and defend the 'infrastructural approach' in general, by integrating the case law and economic arguments as applied to *de facto* and cooperative standards. Given the existing literature already applying the infrastructural approach to the EFD[302], the core contribution of chapter 1 was to bring cooperatively-set standards within the same framework. Second, the EFD remains a controversial doctrine, both in the EU and the US, meaning it requires individual and detailed treatment on its own terms. That is the purpose of this chapter.

A core carry-over insight from chapter 1 is that the proliferation of both real and virtual networks in the modern economy has led to increasing reliance on privately-provisioned technological infrastructures. As the reach of these infrastructures spills over into derivative markets and the scope of the rights over them expands due to network effects, they have attracted increasing regulatory attention due to exclusive ownership creating access problems[303], self-preferencing issues[304], or privacy concerns.[305]

In regard to competition law-related problems, which includes both access issues and self-preferencing, the EU Commission has recently launched a number of investigations against Alphabet Inc, the holding company of the Google software giant.[306] In so far as these charges

302. Frischmann and Waller, 'Revitalizing Essential Facilities'.
303. In the EU Commission's Google AdSense investigation, Google has been charged with blocking its potential or actual competitors from being able to advertise on third party websites using Google AdSense ("[t]he Commission has also sent a Statement of Objections to Google on restrictions that the company has placed on the ability of certain third party websites to display search advertisements from Google's competitors.") See Commission, 'Antitrust: Commission Takes Further Steps In Investigations Alleging Google's Comparison Shopping And Advertising-Related Practices Breach EU Rules' (14 July 2016) Press Release IP/16/2532.
304. Vesterdorf, 'Theories of Self-Preferencing and Duty to Deal - Two Sides of the Same Coin?'; Petit, 'Theories of Self-Preferencing Under Article 102 TFEU: A Reply to Bo Vesterdorf'.
305. See Letter from Article 29 Data Protection Working Party to Mr. Larry Page, CEO of Google Inc. (23 September 2014), Ref. Ares(2014)3113072 -23/09/2014 <http://ec.europa.eu/justice/data-protection/article-29/documentation/other-document/files/2014/20140923_letter_on_google_privacy_policy.pdf>.
306. For an overview of recent EU investigations into Google, see <http://ec.europa.eu/competition/elojade/isef/

are defensible under EU competition law, a number of legal scholars have argued that the most likely legal rule to be applied is the Art 102 TFEU essential facilities doctrine.[307]

This chapter examines the EFD in both its legal and economic dimensions, by focusing on leading EU cases in the area. Specifically, it will confine the core of its analysis to the 2007 Court of First Instance (now General Court, hereafter 'GC') decision on *Microsoft,* due to the fact the latter is the only EFD decision to date to exhaustively consider the competition law issues around *de facto* technological infrastructure[308] in a network industry. The main focus of this chapter will be to try to determine to what extent the EFD shaped the reasoning of the Court in this case. It will include a general examination of the main nerve-centres of the field: the relation between competition law and intellectual property rights; the special characteristics of high technology industries; and the 'public good'[309] and 'infrastructural' nature of privately owned *de facto* technological standards. Discussion of these issues will be situated within the following. After this Introduction, Part II will be divided into two sections; the first section will look at the factual and legal background of the case; the second section will then engage a detailed examination of the EFD in the abstract. This will provide the intellectual tools and theoretical touchstones necessary for Part III and IV. In Part III the GC's reasoning will be analysed 'blow by blow' to see to which extent the EFD was actually applied. Part IV will then provide a commentary, arguing that the EFD (albeit, a 'revamped' EFD) did play a major role in shaping this case's outcome, and furthermore, for good legal and economic reasons. The relevance of the key economic and legal elements of this decision for the recent EU Commission's antitrust investigation into Google's Android mobile OS will also be briefly discussed before offering a brief conclusion.

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case_details.cfm?proc_code=1_40099> accessed 29 October 2016

307. For a critical view, see Vesterdorf, 'Theories of Self-Preferencing and Duty to Deal - Two Sides of the Same Coin?'; for the rebuttal, see Petit, 'Theories of Self-Preferencing Under Article 102 TFEU: A Reply to Bo Vesterdorf'.

308. Of course, the phrase 'de facto technological infrastructure' was not used in this case. Instead, this case concerned de facto technological standards. Chapter 1 of this thesis attempted to show how de facto standards are a subset of technological infrastructure.

309. See Link and Scott, *Public Goods, Public Gains* for a definition of 'public good', effectively one which is non-rivalrous and non-excludable.

II. BACKGROUND: LEGAL AND ECONOMIC

A. Factual and Legal Background

1. The origin of the complaint against Microsoft and the Commission Decision

The Commission's investigation into Microsoft's alleged abuses of its dominant position was triggered by a complaint by Sun Microsystems Inc. ("Sun") on 10 December 1998. The complaint stated that Microsoft's refusal to supply 'inter-operability information'[310] to its Windows Operating System ('OS') prevented Sun's networking software from being able to successfully interoperate with Windows, and thus prevented it from viably competing on the work-group server operating systems market, in breach of Art 82 ECT [now Art 102 TFEU[311]].

The Commission decision[312], adopted on 24 March 2004, detailed two abuses: firstly, the one outlined in Sun's complaint, which was found by the Commission to form 'part of a general pattern of conduct'[313] to weaken competitors and eliminate them from the market, and second, Microsoft's tying of its Windows Media Player to its Windows client PC OS. Only the first of these two abuses will be considered in this chapter.

The remedies and fines ordered by the Commission included the disclosure of the requested interoperability information[314] to Microsoft's competitors in the secondary market, and a fine of EUR 497,196,304.[315]

2. Microsoft's action before the GC

The case before the GC constituted Microsoft's appeal of the Commission decision. Microsoft sought to get the orders annulled or, alternatively, the fine substantially reduced. The crux of Microsoft's argument was that the requested interoperability information was the subject of IPRs, and that an order to license would interfere with these rights[316]. Furthermore, Microsoft argued that the legal criteria for compulsory licensing were not met in this case.

310. *i.e.,* the technical information necessary to enable competing work group server OS to be compatible with the Windows OS platform. In particular, the version of Windows at issue is Windows 2000.
311. Treaty of the Functioning of the European Union
312. *Microsoft* (Case COMP/C-3/37.792) Commission Decision 2007/53/EC [2007].
313. Ibid, para 573. This point is important as Art 102 TFEU protects 'competition' per se, not a competitor. If Sun was the only victim of Microsoft's behaviour (and if it had no harmful effects on consumer welfare) then Art 102 would likely not have been triggered.
314. To be precise, Microsoft was ordered to disclose: 'complete and accurate specifications for the protocols used by Windows work group servers in order to provide file, print and group user administration services to Windows work group networks.' Commission *Microsoft* Decision, para 999
315. In subsequent proceedings focussing on non-compliance with the 2004 Decision, this fine was increased to EUR 860 million, see Case T-167/08 *Microsoft Corp v Commission* (27 June 2012) ECLI:EU:T:2012:323.
316. Ibid, para 111.

B. EFD in the abstract: legal and economic foundations

The purpose of this section is to come to grips with the EFD as it appears in the economic and legal literature and judicial decisions in the EU. The status of the EFD in the United States ("US")- the legal 'home land' of the doctrine- will also be considered. This inquiry will then function as the touchstone for the analysis of the GC decision in the following analytical Part.

1. Legal foundations of the EFD: the EU context

It is important to note at the outset that the EFD has never been expressly referred to in any European Court of Justice decision to date. Although the preponderance[317] of academic literature recognises the existence of the doctrine, there is also a vocal strain who argue that the EFD is not part of European law.[318] Many of these critics argue that the so-called 'essential facilities' cases were decided according to a traditional 'refusal to supply' analysis, and that the EFD adds nothing new.[319] Proponents of the EFD argue that although not express, the EFD was implicit in the reasoning of these cases. Indeed, Attorney-General ("AG") Jacobs when analysing the so-called "EFD case-law" in *Bronner*[320] stated that these cases could either be 'understood as an application of the essential facilities doctrine, or more traditionally, as a response to a refusal to supply goods or services.'[321] While some EFD proponents view these two lines of cases as representing separate legal rules[322], this chapter will follow the Commission's stance[323] and that of Cyril Ritter's[324] in viewing the EFD as a sub-set of 'refusal to supply'.

One powerful proponent of the EFD is the European Commission. The first use of the EFD in the European Community ("EC") was in the Commission decision *B&I Pipe Line Plc. v*

317. Barry Doherty, 'Just What Are Essential Facilities?' (2001) 38 CMLRev 397, 404 ("Doherty, 'Just What Are Essential Facitilies?'"); Maurer and Scotchmer, 'The Essential Facilities Doctrine', 5; J Gregory Sidak and Abbott B Lipsky Jr., 'Essential Facilities' (1999) 51(5) Stan L Rev 1187 ("Sidak and Lipsky, 'Essential Facilities'"); Lao, 'Terminal Railroad to Microsoft'; Carl Mair, 'Taking Technological Infrastructure Seriously : Standards, Intellectual Property and Open Access' (2016) 32 Utrecht J Intl & Eur L 59.

318. Doherty, 'Just What Are Essential Facilities?', 397 ("…it has been said that the doctrine has become an empty label and, in turn, has fostered a misleading approach to antitrust analysis and leads to judging by 'catch phrase'…")

319. Ibid, 435.

320. *Bronner, Opinion of AG Jacobs.*

321. Ibid, para 65.

322. Arutyun Arutyunyan, 'Intellectual Property Law vs. Essential Facility Doctrine. Microsoft vs. Commission' (2008) 4 Proceedings of the Institute for European Studies, IES Proceedings 167, 175-176.

323. See Commission Guidance on Enforcement of Art. 82 EC, where the EFD is classified as a sub-category of 'refusal to supply', para 78.

324. Cyrill Ritter, 'Refusal to Deal and "Essential Facilities": Does Intellectual Property Require Special Deference Compared to Tangible Property' (2005) 28(3) World Comp: L & Econ Rev 281 ("Ritter, 'Refusal to Deal'"), 285 ("… the [EFD] line of cases [is] a sub-set of the 'refusal to deal' category")

Sealink.[325] In that decision, the Commission laid out the principles underlying the EFD in European law[326]:

> the owner of an essential facility which uses its power in one market in order to protect or strengthen its position in another related market, in particular, by refusing to grant access to a competitor…infringes Art [82].

As mentioned in this case, a crucial aspect of the EFD is that access to the 'essential facility' is a *conditio sine qua non* for competitors to be able to enter the market. These general principles underlying the EFD have since been refined, itemised, and extended by subsequent Commission decisions and GC and ECJ judgments. Besides the test of 'essentiality' (since refined by *Bronner*), the application of the EFD also requires that the refusal to supply is 'likely to eliminate all competition'[327] in the secondary market; and in the special case[328] of IP, 'prevent the development of the secondary market to the detriment of consumers'[329] by stopping the emergence of a 'new product'. Furthermore, there must also be an absence of 'objective justification' on the part of the dominant undertaking.[330]

a) The EFD in its wider context: function and origin

As a legal concept under Art 102 TFEU, the EFD's function is to restrain the abuse of market power by dominant undertakings. In order for the EFD to be applied, all the usual requirements of Art 102 must be met, such as: the demonstration of dominance; an effect on inter-Member State trade[331], and the finding of an abuse.[332] The EFD is thus not an extension

325. *Sealink v. B&I* (Case IV/34.174) Commission Decision [1992] OJ L378.
326. As quoted in J Temple Lang, 'The Principle of Essential Facilities in European Community Law- The Position since Bronner' (Notes for lecture, Copenhagen, September 2000).
327. *Bronner*, para 41. This requirement was modified by the *Microsoft* case to 'effective competition', see Bo Vesterdorf, 'Article 82 EC: Where do we stand after the Microsoft judgement?' (2008) Glob Antitrust Rev 1, 8 ("this shift from elimination of all to elimination of effective competition appears to have at the same time rendered the conditions for finding an infringement of Article 82 EC [now 102 TFEU] less strict by loosening the conditions for finding an abuse in these situations".
328. Referred to as 'exceptional circumstances' in the case law, see Joined Case C-241 & Case 242/91P, *Radio Telefis Eireann (RTE) and Independent Television Publications Ltd (ITP) v Commission of the European Communities (Magill TV Guides),* Commission Decision [1995] ECR I-743, para 49 ('…the exercise of an exclusive right by the proprietor may, in exceptional circumstances, involve abusive conduct.') "
329. *IMS v NDC,* paras 48-49.
330. Lang, 'The Principle of Essential Facilities in European Community Law', 6.
331. A *de minimus* rule also applies here, such that the effect must be more than 'negligible', see Commission Guidelines On the Effect On Trade Concept Contained in Articles 81 and 82 of the Treaty [2004] OJ C101/07 27.4.2004 ("[t]he effect on trade criterion confines the scope of application of Articles 101 and 102 TFEU to agreements and practices that are capable of having a minimum level of cross-border effects within the EU.")
332. In the case of the EFD the abuse is exclusionary, rather than exploitative.

of the usual scope of Art 102 TFEU.[333] The doctrine addresses a particular category of abuses by a particular kind of dominant undertaking: the restriction of access to an essential input by an undertaking which owns that input. The usual category of undertakings which meet these requirements is the so-called ‘natural monopoly’.[334] Natural monopolies are characteristic of ‘network industries’, where the impossibility (or extreme difficulty or inefficiency[335]) of reproducing a facility or ‘infrastructure’ logically (and logistically) leads to one undertaking having control over it. A classic example is given by the facts of *Terminal Railroad Association*[336], the 1912 US case which first pioneered the EFD. In that case, a group of entrepreneurs owned the only railroad bridge crossing the Mississippi river and prevented competitors from accessing it. The Court ordered mandatory and non-discriminatory access, reasoning that such access was essential for competing undertakings to pursue their commercial activities. In recent history, natural monopolies such as this have often been publicly-owned or regulated[337], however such facilities are increasingly the subject of deregulation and privatisation, in order to ‘lower prices, stimulate technological innovation and increase consumer choice’.[338]

Although the argument for previously publicly-owned facilities being treated as ‘essential facilities’ following deregulation is reasonably uncontroversial[339], the case of fully privately-owned assets being treated the same way has proved more problematic.

2. Economic foundations of the EFD: the issue of efficiency

Generally, allowing private undertakings to decide with whom they trade and deal is a key ingredient of effective competition. [340] Economic theory suggests that such behaviour may lead to efficient outcomes. However, sometimes this freedom may lead to market distortions. This is particularly true in the case of dominant undertakings with large market power, who may act with a degree of independence from the market. Undertakings with large market

333. Lang, ‘The Principle of Essential Facilities in European Community Law’, 36.
334. Sidak and Lipsky, ‘Essential Facilities’, 1220; Mair,‘Taking Technological Infrastructure Seriously’.
335. See *Bronner*, Opinion of AG Jacobs (“only in cases in which the dominant undertaking has a genuine stranglehold on the related market. That might be the case for example where duplication of the facility is impossible or extremely difficult owing to physical, geographical or legal constraints or is highly undesirable for reasons of public policy. It is not sufficient that the undertaking’s control over a facility should give it a competitive advantage.”)
336. *United States v. Terminal R.R Ass'n of St Louis,* 224 U.S. 383 (1912).
337. Mair, ‘Taking Technological Infrastructure Seriously’.
338. Commission, ‘Unbundled Access to the Local Loop’.
339. James Turney, ‘Defining the Limits of the EU Essential Facilities Doctrine on Intellectual Property Rights: The Primacy of Securing Optimal Innovation’ (2005) 3(2) Nw J Tech & IP 179, 183 (“… the application of the essential facilities doctrine to intellectual property rights can perhaps be justified when the research and development was publicly funded in formerly nationalized industries. In such cases an essential facilities doctrine can aid market liberalization. However, the regulator must be cautious if applying the same principles when the property right has been privately financed.”)
340. See Commission Guidance on Enforcement of Art. 82 EC, para 75 (“[w]hen setting its enforcement priorities, the Commission starts from the position that, generally speaking, any undertaking, whether dominant or not, should have the right to choose its trading partners and to dispose freely of its property.”); Langlois, ‘Technological Standards’.

power are not disciplined by market forces to the same extent as smaller companies, meaning that stupid, greedy or short-sighted behaviour may go unpunished by the market.[341] By going unpunished, such behaviour may lead to economic outcomes that produce social cost or forgo substantial social benefits, such as synergies or spillovers. In the case of dominant undertakings with exclusive rights over an essential resource to downstream competition, refusing to grant access may lead to underdevelopment of the downstream market. But this may not always be the case, as the exclusivity of the resource may actually drive investment and innovation by the resource owner which would be eroded under an open access regime. From an economic standpoint, deciding whether to mandate access to a privately held resource is essentially a question of balancing various kinds of efficiencies, in particular allocative (or 'static' efficiency) and dynamic efficiency. The first measure relates to 'static' resource allocation across one time period, where 'all available…resources are allocated to their highest valued use among all market participants'[342] The second measure refers to resource allocation across several periods, and focuses in particular, on optimal resource allocation for the creation of innovation. It is generally accepted that the conditions for the latter type of efficiency often result in a diminution of the competitive conditions to the detriment of static efficiency[343]. In the area of EC merger control, the Commission has accepted a so-called 'efficiency defence' for the creation of large market concentrations, and this may include dynamic efficiency considerations.[344] In EU competition law, these efficiency assessments centre on the notion of 'consumer welfare'.[345] The EU Commission and judicature therefore accept, in principle, that efficiencies may be 'traded off' against each other, provided the overall effect on consumer welfare is likely to still be positive (perhaps in the middle or long run[346]). It is precisely this 'trade off' of efficiencies which provides the rationale for the *de jure* monopolies of IPRs:[347]

341. Lemley, 'The Regulatory Turn in IP', 109-110 ("[b]ut market decision-making is efficient largely because when stupid, greedy, or shortsighted people in the private sector make poor decisions, they are overthrown by people who make correct decisions. For private decision-making to produce efficient decisions, there must be a competitive market.")

342. Christian R Fackelmann, 'Dynamic Efficiency Considerations in EC Merger Control: An Intractable Subject or a Promising Chance for Innovation' (2006), University of Oxford, Centre for Competition Law and Policy Working Paper L-09/06 ("Fackelmann, 'Dynamic Efficiency'"), 9; Demsetz, 'Information and Efficiency'; Amy Kapczynski, 'The Cost of Price: Why and How to Get Beyond Intellectual Property Internalism' (2012) 59 UCLA L Rev 970 ("Kapczynski,'The Cost of Price'") <http://digitalcommons.law.yale.edu/fss_papers> accessed 14 October 2016; 'Antitrust Enforcement and Intellectual Property Rights: Promoting Innovation and Competition' (US Department of Justice & Federation Trade Commission 2007).

343. Due to the argued link between market power and R&D investment. The balance is, however, fine. 'While concentrations present a risk to innovation, they also have the potential to increase innovative output…' see Fackelmann, 'Dynamic Efficiency', 1.

344. Although these are notoriously difficult to assess, see Fackelmann, 'Dynamic Efficiency', 23.

345. Essentially 'consumer welfare' is the same as 'consumer surplus'. However this measure is fraught with difficulty and the Commission and EU judicature are not entirely consistent in its applications. This issue will be discussed again in Part IV of this paper. See Kati J Cseres, 'The Controversies of the Consumer Welfare Standard' (2007) 3(2) Competition L Rev 121 ("Cseres, 'Consumer Welfare Standard'"),124.

346. Ibid, 25.

347. Ritter, 'Refusal to Deal', 298.

the loss in static efficiency brought about by higher prices and reduced supply is the 'price we pay today for tomorrow's unrestricted innovation'.[348] In the context of the restriction of access to IPRs by a dominant undertaking, two questions immediately arise: first, what if the loss in static efficiency exceeds the gain in dynamic efficiency?; second, what if the firm-level incentives to innovate are outweighed by the loss in dynamic efficiency industry-wide? In the case of the first question, a well-calibrated IP system should be an answer to the underlying concern. As discussed in chapter 3 of this thesis, a core component of this calibration centres on the scope of the regulatory choice over what information subject matters fall within the IP regime compared to the public domain.[349] If this choice is poorly made, then competition law does not have any scope for intervention[350] since it may only question the exercise of a right, not its existence.[351] In the case of the second question (i.e. that the exercise of the IPR reduces industry-wide dynamic efficiency), then assuming that reduced consumer welfare is the result, it would seem that there are the *necessary* conditions for competition law intervention. However, assessing the *sufficient* conditions for mandating access to a privately-owned resource is a much more difficult question. We will now examine the complexities of these efficiency 'trade-offs' with respect to the private property rights of IPRs in more detail, beginning with a general analysis of monopolies.

a) Monopolies: *de facto* and *de jure*

According to one influential economic school, it is the lure of monopoly status (and the monopoly rents which accompany it), which provides the vigour to drive companies to continue to invest in innovation.[352]'*De facto* monopolies'- or 'dominant' undertakings[353]- are therefore tolerated by competition law, provided their large market power is not put towards anti-competitive, exploitative or exclusionary ends.[354] The ambit of competition

348. Hans Ullrich, 'Expansionist Intellectual Property Protection and Reductionist Competition Rules: A TRIPS Perspective' (2004) 7(2) J Intl Econ 401, 425.

349. As discussed further in Part II, Section B of chapter 3, determining this scope relies on an 'infrastructural approach' to information assets.

350. Although this is the 'official line' (see infra), some comentators see the Court's scepticism about the existence of the IP right (in this case, copyright) over the TV Guide in the case of *Magill* as the real motivation behind the decision in that case.

351. TFEU, art 345 states that "[t]he Treaties shall in no way prejudice the rules in Member States governing the system of property ownership." This has been interpreted by the ECJ to mean that competition law (*i.e.,* Art 102 TFEU) can only enquire into the use of intellectual property, not its existence.) See Case 238/87 *AB Volvo v. Erik Veng (UK) Ltd* [1988] ECR 6211.

352. The school of 'Schumpeterian economists', see Michael L Katz and Howard A Shalanski '"Schumpeterian" Competition and Antitrust Policy in High Tech markets' (Fall/Winter 2005) 14(2) Competition 47. See also Langlois, 'Technological Standards', 21 ("...one could argue that to prohibit a firm from exploiting the benefits of a legally acquired monopoly is to discourage the very sort of briskly competitive behaviour that is fundamental to economic efficiency."); Joseph Schumpeter, *Capitalism, Socialism, and Democracy* (Routledge 2003) (Schumpeter, *Capitalism, Socialism and Democracy*); Mair, 'Taking Technological Infrastructure Seriously'.

353. In fact, the economic concept of a 'monopoly' in which one firm owns 100% of market share is extremely rare. The real subject of this section is the 'super-dominant' firm, or the 'quasi-monopoly'

354. Such 'abuses' of market power are defined in Art 101, 102 of TFEU

law's tolerance for monopolies may arguably stretch as far as allowing monopoly pricing, although this is widely debated within the EU.[355] Nevertheless, dominant undertakings are charged with a 'special responsibility not to engage in conduct that may distort competition'[356]. This duty aims to curtail the extent to which such an undertaking may flex its considerable (and often, undisciplined) market power. The economic rationale behind this can be made clearer by considering the following sketch of the economics behind the EFD. The freedom to contract permits undertakings to choose their business partners. However, absent good economic reasons[357] like, inter alia, capacity restraints, refusing to supply downstream undertakings would seem irrational behaviour for a monopolist since it would forgo potential monopoly rents, at least under the single monopoly profit theory of unilateral conduct, discussed in chapter 1.[358] If the monopolist constitutes the sole upstream supplier of an input for downstream undertakings (and no other supplier is possible) then the monopolist is known as an 'upstream bottleneck': if it cuts off supply (or fails to supply in the first place), the secondary market is terminated. In contrast to the usual exercise of monopoly power which just sets the *terms* of access (e.g., monopoly pricing), this scenario entails the cutting off of access altogether. In this context, such refusal to supply can be seen as 'an instrument to achieve another purpose'[359]. One possible purpose could be that the monopolist wishes to leverage its upstream monopoly to the downstream secondary market to capture all the monopoly rents[360] not just in a static sense, but also in a *dynamic* sense, by raising entry

355. In US antitrust law, monopoly pricing, as such, is not prohibited, see Gal, 'Monopoly Pricing', 5 "...the Sherman Act was early on interpreted as prohibiting only exclusionary conduct that created or maintained a monopoly, rather than the monopolistic status or its exploitation". The EC, however, has a rule about 'excessive pricing' (derived in part from Art 102(a) TFEU on 'unfair prices'), which may be interpreted as referring to monopoly pricing. It is defined as a price which has 'no reasonable relation to economic value' (as per *General Motors v Commission* (26/75) [1975] ECR 1367, para 12. However, the Commission has been a bit reticent in the application of this rule. Furthermore, in high-technology industries with large sunk R&D costs, prices will always be higher than in competitive markets (where marginal cost equals marginal revenue) because undertakings try to recoup their fixed costs). The difficulty in assessing costs in high-technology industries, and whether or not prices are consequently 'excessive' may also be a reason for the Commission's reticence. See Damien Geradin, 'The Necessary Limits To the Control of 'Excessive Prices' By Competition Authorities – A View From Europe' (2007) Tilburg University Legal Studies Working Paper, 8 <http://ssrn.com/abstract=1022678> accessed 14 October 2016.
356. Case 322/81 *Michelin v Commission* [1983] ECR 3461, para 57.
357. Under the EFD test in EU, these are labelled 'objective justifications'.
358. This argument is known as the 'single monopoly profit' argument, and derives from the so-called Chicago School of Economics. See Einer Elhauge, 'Tying, Bundled Discounts, and the Death of the Single Monopoly Profit Theory' (2009) 123(2) Harvard L Rev 399.
359. This is the language used in the DG Competition Discussion Paper on the Application of Article 82 to Exclusionary Abuses (Brussels, December 2005).
360. On a 'Chicago School' reading of monopoly economics, this behaviour is still irrational since the total monopoly rents it could extract on the secondary market would be the same whether it monopolised it (and extracted them itself) or received the rents via the undertakings in that market paying monopoly prices for the input. However, it is rational behaviour if 'for one reason or another, the upstream firm may be unable to extract from the downstream competitors all the monopoly rents in the downstream chain' in Luis M Cabral, *Introduction to Industrial Organization* (The MIT Press, 2000), 79. However, it is submitted that this criticism overlooks the dynamic effects of controlling a resource which extend to altering the market structure and controlling entry, rather than just the extraction of monopoly rents.

barriers for new entrants.[361] This may negatively affect dynamic competition in two ways; first, by cutting off the stream of product variety which may derive from a competitive marketplace; second, by weakening the incumbent's incentives to innovate by removing the 'Schumpeterian' dynamic constraint of firm entry.[362] Effectively, this refusal to supply 'allows it to affect the structural conditions it faces rather than merely allowing it to maximise a fixed pie of profit.'[363] In summary, by foreclosing the secondary market and thus eliminating competition, the dominant undertaking may decrease consumer welfare by, *e.g.,* decreasing the product variety, and perhaps also its own incentives to innovate[364], as well as raising entry barriers for the operation of dynamic competition.[365] Essentially, the entire downstream value chain would be jeopardised by such a refusal to supply, in the same way chapter 1 of this thesis described in relation to standards-essential patents over cooperative standards.[366] The social cost involved in limiting or curtailing access to such assets therefore also includes the foregone social value and spillovers that could have resulted from the foregone downstream value creation.[367] This is the economic nub of the EFD mandating access to the dominant undertaking's assets.[368]

Furthermore, refusal to grant access to an essential facility in *high technology markets* can have economic effects which are exacerbated by forces such as network effects[369] and 'switching costs'.[370] As discussed in chapter 1, these demand-side effects can drive the entrenchment of small market advantages into a game of 'winner takes all', where leading technologies may acquire the character of 'technological infrastructure'.[371] The IPR 'reading on' to such infrastructure may then be considered essential facilities under the EFD, and as further discussed below.

361. Thus diminishing the dynamic constraint of firm entry, which can help keep the incumbent innovating.
362. Schumpeter, *Capitalism, Socialism, and Democracy*; Mair, 'Taking Technological Infrastructure Seriously'.
363. Langlois, 'Technological Standards', 22.
364. This depends, *inter alia*, on the character of the innovation: Cabral, *Industrial Organization*, 298 ("[i]ncumbent firms have a greater incentive than entrants to perform R&D toward a gradual innovation. If, however, there is uncertainty regarding the threat of entry or if the innovation is sufficiently drastic, then outsiders may have a greater incentive to perform R&D than incumbents.")
365. Baker, 'Dynamic Competition'.
366. Mair, 'Taking Technological Infrastructure Seriously'.
367. Maurer and Scotchmer, 'The Essential Facilities Doctrine',
368. Ibid, 250 ("antitrust interventions must not discard beneficial synergies that require sharing").
369. Lao, 'Terminal Railroad to Microsoft'; Benkler, *The Wealth of Network*; Nicholas Economides, 'Antitrust Issues in Network Industries' in Ioannis Kokkoris and Ioannis Lianos (eds), The Reform of EC Competition Law (Kluwer 2008) ("Economics,'Antitrust Issues in Network Industries'"); George L Priest, 'Rethinking Antitrust Law in an Age of Network Industries' (2007) John M. Olin Center for Studies in Law, Economics, and Public Policy Research Paper No. 352 ("Priest, 'Rethinking Antitrust Law'").
370. 'Switching costs' are the costs faced by a consumer changing from one high-tech product to another, such as *e.g.*, having to learn how to use a new interface from scratch. Farrell and Klemperer, 'Coordination and Lock-in'.
371. Mair, 'Taking Technological Infrastructure Seriously'; Frischmann and Waller, 'Revitalizing Essential Facilities', 63 ("...the EU cases seem to instinctively understand the value of the essential facilities doctrine when applied to infrastructural assets, both physical and incorporeal").

b) IP as an essential facility

As will be discussed in much greater detail in chapter 3 of this thesis, IP is distinguished from traditional property in two main respects: its intangibility and its 'public good' character.[372] These attributes make IP (or the information that IP protects) especially vulnerable to exploitation by free riders.[373] In high technology industries, the costs of R&D leading to a successful innovation may be very high.[374] In order for rational undertakings to attempt to innovate the rewards have to be high, and moreover, immunised from the free rider effect. This is argued to be the function of an IP regime[375]: the allocative inefficiency of monopoly power is traded off against its purported positive dynamic efficiency effects[376]. The argument against treating IPRs as essential facilities under the EFD thus centres on the fact that:[377]

> ...especially in high-technology markets where rewards drive innovation...[i]f those rewards are taken away, the innovation will likely decline, and in the long run consumers will suffer.

However, as shown in the above section, if this incentive system is too 'strong' (in the sense of providing too much protection for the monopolist/IPR-holder) it can result in sub-optimal industry-wide dynamic efficiency, undermining the *raison d'etre* of the right in the first place. In the relevant context of a two-market analysis[378] in high-technology industries, this can

372. Meaning its non-rivalry and non-excludability (except by legal means), see chapter 3 of this thesis for more detail.

373. The 'free-rider effect' is where 'market participants obtain the benefits of a good without contributing to its cost of production' see Dina Kallay, *supra* note 47, p 13. See also the prisoner's dilemma argument developed in Part III, Section C(2) of chapter 3 of this thesis.

374. Sidak and Lipsky, 'Essential Facilities'; Areeda, 'An Epithet'; Geradin, 'Pricing Abuses'.

375. This argument essentially takes the form of a prisoner's dilemma argument, however chapter 3, Part III, Section C(2) also develops an 'assurance game' model of the purpose of IPR, as initially developed in Shubha Ghosh, 'Patent Law and the Assurance Game: Refitting Intellectual Property in the Box of Regulation' (2005) 18(2) Canadian JL & Juris 1315.

376. This is only achieved under an optimal IPR system, and is rarely attained. See Mark A Lemley and Brett M Frischmann, 'Spillovers' (2007) 100(2) Columbia LJ 101 ("Lemley and Frischmann, 'Spillovers'"); Michael W Carroll, 'One Size Does Not Fit All: A Framework for Tailoring Intellectual Property Rights' (2009) 70(6) Ohio St LJ 1361 ("Carroll, 'One Size Does Not Fit All'"); Kapczynski, 'The Cost of Price'.

377. Sergio Baches Opi, 'The Application of the Essential Facilities Doctrine to Intellectual Property Licensing in the European Union and the United States: Are Intellectual Property Rights Still Sacrosanct?' (2001) 11(2) Fordham IP, Media & Entertainment LJ 409, 470. This logic has also been echoed by Justice Scalia, as already quoted in chapter 1 of this thesis, and is re-quoted here for convenience, *Verizon v Trinko*, 540 U.S. 398 (2004), see Part III of the judgment ("[f]irms may acquire monopoly power by establishing an infrastructure that renders them uniquely suited to serve their customers. Compelling such firms to share the source of their advantage is in some tension with the underlying purpose of antitrust law, since it may lessen the incentive for the monopolist, the rival, or both to invest in those economically beneficial facilities.")

378. The operation of the EFD typically requires identification of both a primary (upstream) and secondary (downstream) market, see Commission Guidance on Enforcement of Art. 82 EC, para 76 ("[t]ypically competition problems arise when the dominant undertaking competes on the 'downstream' market with the buyer whom it refuses to supply. The term 'downstream market' is used to refer to the market for which the refused input is needed in order

be due to a couple of different but intimately related reasons as already discussed: the loss of incentives to innovate due to reduced competition or (threat of) firm entry[379], and the loss of product diversity from complementary or follow-on innovations. Consider the scenario where the upstream monopolist/IPR-holder is the only supplier of a certain industry-wide de facto technological standard. If this standard is sufficiently wide-spread and generic it could be said to have the character of 'infrastructure'[380]; a character which would be further entrenched by forces which mark high-technology products, such as network effects[381] and switching costs[382]. Certainly, it would function as a technological 'bottleneck' for the downstream undertakings. Cutting off access to this standard by exercising an IPR (or refusing to provide it in the first place) would effectively foreclose the secondary market, enabling the IPR-holder to leverage its monopoly to this market and alter the dynamic competitive conditions. This behaviour may have the effect of reducing industry-wide dynamic efficiency. As developed in the GC *Microsoft* decision (see discussion in Part III), denying access to the technological infrastructure can be described as limiting 'technical development' generally, by retarding follow-on innovation in markets requiring the latter as a necessary input.[383] The reasoning here depends on the peculiar nature of high-technology industries, and of the software industry in particular (which demands a high degree of standardisation due to interoperability requirements). The pattern of development in these industries, rather than being a series of radical jumps in technology, has historically been one of 'rapid sequential innovation, re-use, and re-combination of components and strong network effects that privilege interoperable components and products'[384]: one where undertakings modify and improve the products of their predecessors (or competitors)[385]. While some IP protection may provide the incentives to innovate in the first place, it is argued by a number of scholars[386] that overly strong IP

to manufacture a product or provide a service. This section deals only with this type of refusal.")

379. Also called Arrow's 'Replacement Effect', see Jonathan B Baker, 'Beyond Schumpeter vs. Arrow: How Antitrust Fosters Innovation' (2007) 74 Antitrust LJ 575.

380. For an argument along these lines see the US case *Berkey Photo Inc v. Eastman Kodak co.*603 F.2d 263 (2d Cir. 1979): a competitor in the camera film production secondary market to the Kodak camera company sued for technical information relating to its latest model of camera on the grounds that Kodak had established a universal standard. See Langlois, 'Technological Standards', 5-6.

381. 'Network effects' occur when the attractiveness of a product is reinforced by the number of users due to 'direct' effects: increased technical support for the product; 'indirect' effects: a larger array of spin-off applications. Mair, 'Intellectual Property'.

382. Farrell and Klemperer, 'Coordination and Lock-in'.

383. Mair, 'Intellectual Property'.

384. Julie E Cohen and Mark A Lemley, 'Patent Scope in the Software Industry' (2001) 89(1) California L Rev 1.

385. This characteristic of the software industry also has some bearing on the 'new product' criterion of the EFD. This will be discussed in Part III of this chapter.

386. Thorsten Kaseberg, *Intellectual Property, Antitrust and Cumulative Innovation in the EU and the US* (Hart Publishing Ltd 2012); Mark A Lemley, 'Economics of Improvement in Intellectual Property Law' (1996) 75 Texas L Rev 989 ("Lemley, 'Economics of Improvement'"); Baker, 'Dynamic Competition'.

protection which encumbers this natural incremental process might lead to technological stagnation.[387] Bessen and Maskin put the point this way[388]:

> A firm that patents its product in a world of sequential and complementary innovation can prevent its competitors from using the product (or sufficiently similar ideas) to develop further innovations. And because these competitors may have valuable ideas not available to the original firm about how to achieve such innovations, the patent may therefore slow down the pace of invention.

While this is essentially an argument for weaker patent rights in the software industry (in terms of 'scope'[389] and perhaps raising the bar on patentability in general), it could be argued that the point gains even more force where the IP-protected product constitutes a technological infrastructure and is a 'bottleneck' for secondary market software developers. In this case, the dynamic efficiency concerns of the IP-protected product may be outweighed by those of the market (or industry) as a whole. This is therefore the type of case in which competition policy and, the EFD in particular, could intervene to realign the dynamic efficiency balance towards a socially optimal outcome.

c) The EFD as a special case of refusal to supply

So far this chapter has refrained from distinguishing the EFD from the general category of 'refusal to supply'. This is because, although there exists a purported EFD line of case-law, the cases are often 'dry and under-theorized'[390] and lack any detailed economic rationale behind the application of the rules. Nevertheless, some commentators claim to have discovered some plausible, if implicit, conditions for the judicature's use of the EFD.[391] Since this topic forms the main part of the ensuing analysis and commentary of the next part, this section attempts only a very brief preview. In essence, (and as developed and defended already in chapter 1) the EU judicature's 'instinctive understanding' of an essential facility is that of a resource with 'infrastructural' characteristics, which supports 'significant downstream positive externalities'[392], strong network effects, and has 'natural monopoly' attributes.[393] All

387. Indeed the following authors argue that precisely this happened in the 1980's after the introduction of strong patent rights in the software industry, see Bessen and Maskin, 'Sequential Innovation', 2.
388. Ibid, 4.
389. Ibid, 2: ("For industries like software or computers, theory suggests that imitation may promote innovation and that strong patents (long-lived patents of broad scope) might actually inhibit it")
390. Frischmann B and Waller SW, 'Revitalizing Essential Facilities', 63.
391. In the near-equivalent case of the US, see Lao, 'Terminal Railroad to Microsoft', 558 ("though these cases are somewhat undertheorized, they are in fact based on sound, if unarticulated, principles.")
392. Ibid, 578.
393. Ibid, 582, 595

these attributes map to the definition of 'technological infrastructure' developed in chapter 1 of this thesis. Part III of this chapter will attempt to unpack them from the legal reasoning used in the *Microsoft* case and develop the argument in greater detail in relation to *de facto* technological standards.

Having now assessed the key economic and legal arguments surrounding the EFD, we are in a position to analyse the *Microsoft* case to determine to which extent the doctrine was utilised in the Court's reasoning.

III. THE COURT'S REASONING: TO WHAT EXTENT WAS THE EFD APPLIED?

Before we begin this analysis: first some preliminary remarks. It is important to reiterate the point that the EFD was never expressly mentioned in the *Microsoft* case. As explained in Part II, Section 2(b) of this chapter, that does not rule out the EFD having been applied implicitly. This section will dig into the legal and economic underpinning of the decision in *Microsoft* by making use of the analytical tools developed in Part II. In particular, the infrastructural approach of the EFD as proposed by Waller and Frischmann and suggested by them to be the CJEU's 'instinctive understanding' of the EFD, will be a constant theme in this analysis. The commentary in the following section will again address and justify this approach, and attempt to highlight the application of the two-stage 'infrastructural approach' identified in chapter 1. The final part of this section will then briefly develop the same arguments in relation to the Commission's recent investigation into Google's Android.

A. The structure of the GC's reasoning

The first task the Court set itself was to determine the 'exceptional circumstances' under which to assess whether Microsoft's refusal to supply was an abuse under Art 102 TFEU. After having considered the array of circumstances put forward by the Commission, including some not formally recognised by the case-law[394], the Court settled on the frameworks established in *IMS* and *Magill* as a first course.[395] Although some commentators consider these cases as quintessential EFD IPR cases, it is the details and character of the Court's reasoning which will shed light on whether this was a traditional 'refusal to supply' analysis or application of the EFD. The elements of the *IMS/Magill* framework as they were used in the Court's reasoning will now be examined.

394. Arguing that the 'circumstances' recognised in the case-law were not exhaustive (see para 303 of the GC *Microsoft* decision) the Commission proposed, *inter alia*, that the supply of interoperability information is a matter of particular concern to the Community since it is the subject of the Directive 91/250.

395. *i.e.,* if these circumstances were found not to be present, then the Court would consider the other circumstances.

1. Indispensability of the interoperability information and the 'elimination of competition'

The Court accepted the Commission's proposed approach to assess the indispensability of the interoperability information (hereinafter the "information") at issue, which consisted of two parts. The GC's reasoning is structured around, first, determining what degree of interoperability is necessary in order for Microsoft's competitors in the work-group server operating system market ("work group server OS") to viably remain, and second, to assess if the information requested by Microsoft's competitors ("the competitors") and refused by Microsoft was indispensable to achieve that aim. Due to the extremely close link between the 'indispensability' criterion and the 'elimination of competition' criterion suggested by the first stage of this approach, these two elements will be considered together in what follows.

The first part of this approach involved complex technical and economic assessments that cannot be set out here. However, it is the character of the GC's reasoning that is of interest, and this can be summarised simply. Essentially, the Court considered two possible types of interoperability between the 'Windows domain architecture' ("Windows") and the competitors' work group server operating systems: 'one-way' (when all the features of the work group server OS can be accessed from a Windows client OS), or 'two-way' (when in addition to the latter, non-Windows work group servers may also communicate with Windows client and server OS). The two-way type of interoperability is of a higher degree of compatibility with Windows, and would allow non-Windows work group OS to interact with the Windows 'domain architecture' on an 'equal footing'[396] with Windows work group server OS. (One-way interoperability information was already available to competitors.) When reasoning whether one-way or two-way interoperability was necessary to maintain effective competition on the secondary market, the GC's analysis focussed on Microsoft's position in the upstream market of client PC OS, and the consequences of this position for competitors in the downstream market of work group server OS.

In the upstream market of client PC OS, the GC observed that Microsoft's dominant position displayed 'extraordinary features'[397]. In particular, Microsoft Windows had a market share of more than 90%, which functioned as a 'quasi-standard'.[398] Furthermore, Microsoft itself, in light of its market share, could be considered a 'quasi-monopoly'[399], which had, moreover, managed to 'impose the Windows domain architecture as the *de facto* standard for work group computing'.[400] Since Windows was the effective 'technological standard' for PC client OS, it was necessary for competitors' work group OS to interact with it. However, one-

396. *GC* Judgment, para 374
397. Ibid, para 387.
398. Ibid.
399. Ibid, para 775.
400. Ibid, para 392.

way interoperability would only allow this to occur efficiently in the case of competitors' work group *client* OS. In the case of non-Windows work group OS *servers* interacting with Windows client OS, the lack of interoperability would cause several 'technical glitches' that would erode efficiency, compromise security, and diminish overall productivity[401]. This lack of 'interoperability with the Windows domain architecture has the effect of reinforcing Microsoft's competitive position on the work group server [OS] market'[402] by inducing consumers to buy the Windows work group OS in favour of its competitors. Under the criterion of 'elimination of competition' (which was loosened in this case to 'elimination of *effective* competition')[403], the Court assessed the empirical evidence for the extent of this inducement by examining the evolution of market shares of the competitors' *vis-à-vis* Microsoft in the secondary market. Microsoft was found to have undergone a 'rapid and significant growth'[404] in its market share by 40% over six years[405] at the expense of its competitors, in particular, Novell[406]. Microsoft's [then] current market share of at least 60%, coupled with its strong growth and the strong network effects present in the industry (such as the fact that 'a very high number of technicians possess skills specific to Windows operating systems[407]) led the GC to conclude that the 'refusal at issue entailed the risk of elimination of competition.'[408] The GC thus concluded that both the first stage of the 'indispensability' test and the 'elimination of competition' criteria were fulfilled in this case. Another way of putting this point which the GC used, was to say that 'non-Microsoft work group server OS must be capable of interoperating with the Windows domain architecture on an equal footing with Windows work group OS if they are to be marketed viably on the market':[409] full interoperability with Windows is indispensable for Microsoft's work group server OS competitors to remain on the market.

The second part of the Commission's approach for the indispensability test was given extremely limited assessment. In short, the GC concluded that since none of Microsoft's other 'recommendations or solutions made it possible to achieve the high degree of interoperability... required'[410], Microsoft had not demonstrated that this standard of interoperability information was *not* indispensable.

401. Ibid, para 415.
402. Ibid, para 422.
403. Ibid, para 139.
404. Ibid, para 567.
405. Ibid, para 570.
406. Ibid.
407. Ibid, para 619.
408. Ibid, para 620.
409. Ibid, para 421.
410. Ibid, para 435.

The GC thus concluded that the two-way compatibility standard was the correct degree of interoperability required to maintain *effective competitio*n on the secondary market, and its provision to Microsoft's competitors was *indispensable* to achieve that aim. It is clear from the above reasoning that the Court came to this conclusion in recognition of the fact that Microsoft Windows is the 'technological bottleneck' through which the downstream market of non-Windows work group OS must pass. Given Windows' status as a *de facto* standard for client PC OS, it would be impossible for the secondary market to remain competitively viable without full Windows interoperability.

In a real sense, then, it is not the interoperability information *per* se that is indispensable, it is 'open access' to the Windows platform that the information unlocks. To say that this access is 'indispensable' is tantamount to saying that the interoperability information that unlocks it is an 'essential facility'. Microsoft Windows' position as a *de facto* standard gives it several features characteristic of infrastructure as identified by Waller and Frischmann, such as: it can be consumed non-rivalrously, and 'social demand for the resource is driven primarily by downstream productive activity that require the resource as an input'[411]. It is submitted that both these statements are manifestly true about Microsoft Windows, the first being obvious[412] given the public good nature of information goods, and the second shown to be true almost by the definition of the role of an operating system: it is not the OS itself that consumers demand, but the applications and programs (i.e. the downstream functionalities) that the OS permits them to use. Another way of putting this is that the Windows platform supported significant downstream positive externalities by virtue of its 'scaffolding' upstream role. Furthermore, the GC's constant reference to the strong direct and indirect network effects associated with the Windows OS platform served to underscore and further entrench its infrastructural character, where Microsoft Windows' status as '*de facto* standard' for work group computing enabled it:

> to determine to a large extent and independently of its competitors, the set of coherent communications rules that will govern the *de facto* standard for interoperability in work group networks.[413]

It is submitted that these special features of the market emphasised by the Court shows that the rationale behind the GC's reasoning was that the Windows OS had achieved infrastructural status with regard to downstream work-group OS products. Given this finding of Windows OS as technological infrastructure, the interoperability information was found to be a *sine qua*

411. Frischmann and Waller, 'Revitalizing Essential Facilities', 12.
412. In the sense that individuals using their own operating systems do not limit the use of the operating system by other individuals.
413. *GC* Judgement, para 392.

non for effective market entry and downstream competition, making it an essential facility. As discussed in chapter 1, the above components of the EFD constitute the 'infrastructure screening' aspects of the two-stage infrastructure approach. By demonstrating the indispensability of the interoperability information and the fact that denial of access chokes of effective competition, the market 'scaffolding' role of the asset is proven to conform to technological infrastructure. However, merely identifying the interoperability information as infrastructural is not yet sufficient to warrant an open access rule. The economic consequences of compulsory licensing must still be accessed from an efficiency point of view. This is the purpose of the remaining two components of the EFD: the 'new product test' and objective justifications.

2. Prevention of the emergence of a 'new product' and lack of objective justifications

Since the interoperability information in question is most likely[414] covered by IPRs, Microsoft's refusal to grant a license to the competitors must be shown to have 'prevented the development of the secondary market to the detriment of consumers'.[415] In other words, the denial of access to the essential facility must have resulted in consumer harm. The 'new product test' as discussed in the context of IMS/Magill can be seen to function as a proxy for this consumer harm by standing in as a proxy also for dynamic efficiency. The 'development' which was prevented must moreover be shown to constitute 'not mere duplicates...but new goods or services not offered by the owner for which there is potential consumer demand'.[416] The Court's interpretation of this element was one of the most controversial issues in its analysis.[417] The focus of the criticism is on the word 'new', and whether the Court's assessment of the types of non-Windows work group OS which would have resulted from access to the full interoperability information would have met this exacting standard. The fourth *IMS/ Magill* criterion, the absence of 'objective justifications', will be discussed in conjunction with this element for reasons that will become clear.

The 'new product' test is a problematic one. As mentioned, in effect, it stands in as a 'proxy' balancing test for 'weighing...the interest in protection of the intellectual property right and the economic freedom of its owner, on the one hand, and the interest in protection of

414. Ibid, para 313. It was unsure whether the information at stake was a 'trade secret' or an IPR, as although copyright of course applies automatically to software, not all interface information is considered copyrightable subject matter, see discussion on the 2016 Electronic Frontier Foundation, 'Oracle v Google' <https://www.eff.org/cases/oracle-v-google> accessed 13 October 2016.
415. *IMS v NDC,* para 48.
416. Ibid, para 49.
417. Ariana Andreangeli, 'Case T-201/04, *Microsoft v. Commission,* Judgment of the Grand Chamber of the Court of First Instance of 17 September 2007' (2008) 45(3) Common Market L Rev 863 ("Andreangeli, 'Case T-201/04 Judgment"), 882.

free competition on the other'.[418] If we unpack this sentence by AG Tizzano[419] from *IMS* in terms of the *economic* rationales behind 'the interest in protecting the IPR' and the 'interest in protecting free competition', we arrive at a balancing act between efficiencies described in Part IV, Section B. This test might be more clearly conceptualised as a balancing act between the dynamic efficiency produced by protecting the IPR at issue and the dynamic efficiency (industry wide) produced by its compulsory licensing, in the sense of liberating it as an input to the competing undertakings downstream, If we follow AG Tizzano's explanation of the purpose of the 'new product' test, we have to agree with at least one economic commentator, that it is indeed a very 'bad proxy of the parameter the Court seeks to test'.[420] An economically robust application of this test would require an accurate measure of the innovation rate in the first case as against the second case in order to see which was greater. As the present test stands it does nothing of the kind. For instance, even if a refusal to license does block a 'new product' for which there is potential consumer demand, it does not follow that consumers as a whole would be better off if compulsory licensing was granted: the loss of the incentive to innovate by the IPR-holder might still outweigh the potential consumer benefit gained by the 'new product'.[421] Moreover, there are difficulties surrounding the definition of 'new' that cause further trouble since it is 'a continuous rather than a discrete variable'.[422] There is also the fact that, as already mentioned in Part IV, section B, innovation in the software industry is characterised by rapid sequential and complementary innovation, which builds incrementally on previous innovations.

It is perhaps in awareness of the above points (or at least the untidiness of the economic reasoning) that the Court relaxes the strict interpretation of 'new product' and chooses to rest its analysis on whether Microsoft's refusal to license the interoperability information limited the 'technical development' in the secondary market:[423]

> …the appearance of a new product…cannot be the only parameter which determines whether a refusal to licence an [IPR] is capable of causing prejudice to consumers within the meaning of Article 82(b) EC. As that provision states, such prejudice may arise where there is a limitation not only of production or markets but also of technical development.

418. AG Tizzano, *IMS v NDC,* para 62.
419. Ibid.
420. Francois Leveque, 'Innovation, Leveraging and Essential Facilities' (2005) 28(1) World Competition 76
421. This argument was in fact developed by Microsoft under the 'objective justification' element of the EFD, where it suggested that unless its exclusivity would be protected it would lose incentives to invest. The reply by the GC on this point (discussed below) can therefore be seen as its response to this argument as well.
422. Francois Leveque Innovation, Leveraging and Essential Facilities' 75
423. GC Judgment para 647.

The Court relies on the wording of Art 102 (b) TFEU to support this interpretation.[424] On the basis of this test, the Court finds that the work group server OS that would be developed if the 'obstacle of insufficient interoperability was removed would be differentiated from Microsoft's product, offering innovative features which would be distinguished from those systems with respect to parameters which consumers find important.'[425] Microsoft's refusal to licence its IP thus meant that technical development in the secondary market was impaired. The harm to consumers was characterised as the loss of the choice of these other (differentiated) non-Windows work group server OS[426], and also the indirect harm caused by the 'impairment to the effective competition structure' brought about by Microsoft's refusal to supply the information.[427]

Interestingly, the efficiency-balancing act which is argued to be the proper rationale behind the 'new product test' (the 'economically robust' test described in the preceding paragraphs) is identical to the disputed 'new test'[428] which Counsel for Microsoft claimed the Commission illegitimately used to evaluate its 'objective justification'[429] for not licensing its interoperability information[430]:

> [T]he Commission considered that a refusal to communicate information protected by [IPRs] constituted an infringement of Article 82 EC if, all things considered, the positive impact on the level of innovation in the whole industry outweighed the negative impact of the dominant undertaking's incentives to innovate.

Since Microsoft's objective justification for not licensing its IPR over the interoperability information was the circular reason that it would 'eliminate incentives to invest in the creation of future intellectual property'[431], (i.e. the 'interest' the 'new product' test is meant to balance) the fact these two tests are analogous in this instance is not surprising. The GC

424. Art 102(b) TFEU ("…limiting production, markets or technical development to the prejudice of consumers").
425. GC Judgment para 656.
426. Ibid, para 652.
427. Ibid, para 664.
428. Counsel for Microsoft argued that this 'new test' was legally defective: ("…new test, which is legally defective and marks a radical departure from the tests defined in the case-law") ibid, para 669.
429. As stated earlier in this chapter, objective justifications can function as an affirmative defence to charges of illegally refusing competitors access to essential facilities under Art 102 TFEU, see Commission Guidance on Enforcement of Art. 82 EC, para 28 ("[i]n the enforcement of Article 82, the Commission will also examine claims put forward by a dominant undertaking that its conduct is justified. A dominant undertaking may do so either by demonstrating that its conduct is objectively necessary or by demonstrating that its conduct produces substantial efficiencies which outweigh any anti- competitive effects on consumers.")
430. GC Judgment Para 669-670
431. Ibid, para 689.

stated, however, that this 'new test' was never applied by the Commission[432], and in any event, Microsoft's 'objective justification' was rejected out of hand as being inconsistent with the '*raison d'etre* of the [IPR] exception'[433] and as 'vague and theoretical'. In conclusion, the GC found that the 'new product' element (albeit, somewhat revamped as 'technical development') was met in this case, and furthermore, there was an absence of 'objective justification'.

It is submitted that the Court's reasoning in the above exemplifies, as in the previous section, an application of the EFD in the form of the two-stage infrastructural approach. First, the Court screened for the infrastructural attributes of the asset, by making findings on indispensability and elimination of effective competition. Second, the Court assessed with an open access rule would in fact lead to greater industry-wide dynamic competition compared to the lose in Microsoft's private incentives to innovate.

The Court's relaxation of the 'new product' criterion has been argued by commentators[434] to go against the standard *IMS/Magill* interpretation of the element. However, a close reading of the *IMS Judgment* and particularly the *Opinion* of AG Tizzano at least makes this point debatable. [435] Whether it was or was not a novel approach, it is submitted that it was certainly a more principled approach both on economic and legal grounds. On economic grounds, 'technical development' is a more nuanced category that is perhaps more suited to the incremental nature of innovation in high technology industries, particularly the software industry, than the 'radical' innovation implied by 'new product' test. This is so particularly when the 'essential input' is a technological standard (or the 'access key' to such a standard like the interoperability information). Unless software companies can enter the market in the first place (at least in some form) it would be impossible to get a sense of the various niches of potential consumer demand. It is only by competition in that market, and in the struggle for market share, that undertakings can radiate out into exploring new avenues of innovative possibility. It is from this process of vigorous dynamic competition that innovation comes. 'New products' –in the sense of 'radical' innovations- would only come about after this initial exploratory phase, of which access to the 'infrastructure' would be the *condition sine qua non.* For this reason the slightly weaker 'technical development' test functions as a more nuanced substitute. It is the GC's 'instinctive understanding' of the importance of Windows as an infrastructure for sustaining these downstream externalities that, it is submitted, represents the application of the EFD in this case as opposed to a traditional 'refusal to supply'. Furthermore, on legal

432. Ibid, para 710.

433. Ibid para 690.

434. Andreangeli, 'Case T-201/04 Judgement', 884.

435. Christian Ahlborn, David S Evans and A Jorge Padilla, 'The Logic & Limits of the "Exceptional Circumstances Test" in Magill and IMS Health' (2004) 28(4) Fordham Intl LJ 1109, 1120 ("[a]dvocate General Tizzano thus considered that IMS Health's refusal to license could only be considered abusive if it prevented the emergence of "new" products or services. However, his view of what might constitute a "new product" in the downstream market could be read *rather expansively, because taken literally it could include minor improvements on existing products*") (italics added).

grounds the 'technical development' test coupled with the 'consumer harm' sub-element is a better proxy to the efficiency-balancing act which underlies the 'new product' rule. This is because 'technical development' is a better description of the incremental innovation process in many high technology industries, and thus is more likely to capture the dynamic efficiency loss (industry wide) associated with the refusal to license the IPR. These arguments will be developed in greater detail in the commentary below, which will also briefly consider the recent Commission investigation into Google's Android OS.

IV. CONCLUSION

A. Commentary

It is the contention of this chapter that the EFD was the guiding legal rule behind the GC's decision in the *Microsoft* case. By unpacking the Court's reasoning in this case, an underlying infrastructural approach to the problem of access to IP-protected essential facilities was identified and defended, leading to the open access rule of a compulsory license, or as stated in the decision: '…[Microsoft] is required to license its 'server/server' communication protocols so that they can be implemented in directly competing server operating systems.'[436] This overall approach of 'if infrastructure, then open access' is consistent with the economic and legal reasoning developed in detail in chapter 1.

Reaching the above conclusion required a detailed inquiry into the economic and legal rationales underlying the purpose of the EFD, as well as the conditions under which the EU judicature has purportedly sanctioned its use in previous cases. This chapter has followed the 'infrastructural' approach to understanding the EFD, and views this as the 'instinctive understanding' of the doctrine as utilised by the CJEU. As a distinct subset of the general category of 'refusal to supply', the EFD concerns a resource which is characterised as supporting significant downstream positive externalities, the social value of which is more important than the resource itself; involves strong network effects; and like a 'natural monopoly', is for whatever reason, impossible (or economically unreasonable) to reproduce.

The interoperability information enabling non-Windows work group server OS to be fully compatible with the Windows domain architecture met all the above criteria. However, it is important to note that the interoperability information merely functioned as the 'access key' to unlock full Windows compatibility, and that it was Windows OS itself which was the true technological infrastructure in this case. Since Windows had become the *de facto* 'quasi standard' PC client OS, it functioned as the 'technological bottleneck' through which all the derivative markets, products, and thus positive externalities, flowed. In many important ways,

436. GC Judgment Para 673.

by achieving the status of technological infrastructure, Windows had become a privately-owned standard with a public-utility character. It is submitted that the bulk of antitrust concerns which involved Microsoft[437] centred on this tension between its simultaneous public/private character, and the risk that the panoply of ancillary markets may 'inexorably move towards a "homogenous" Microsoft solution'[438]. This seems to be true, certainly, of the derivative markets involving Internet search engines, Media playing software, and the present case of work group server operating systems.[439] Not all these cases involve the EFD, but the infrastructural nature of the Windows operating system is a central issue of each of them.

The question, put in its most extreme form, is essentially to what extent can the private owner of a technological infrastructure use its formidable market power to determine the character of the derivative markets by favouring its own products at the expense of competitors, or by other means. EU competition law's answer is centred on the notion of 'consumer harm'; however, a purely economic approach might favour a dynamic efficiency appraisal. One important and difficult question is whether these two measures are analogous, or more interestingly, whether they can be reconciled. According to one commentator, 'it is generally accepted that a business conduct which makes consumers worse off in terms of price, output and quality makes the competitive process worse off' and attracts competition law liability.[440] However, the measures of 'price', 'output' and 'quality' are 'static' efficiency measures that lack the dynamic element. A strict enforcement of such a standard would always attach more importance to consumers' short-term gains as opposed to tolerating some losses for the sake of innovation increases. However since dynamic efficiency gains are effectively second-period allocative efficiency gains resulting from first-period innovations, taking a middle or long-term view of consumer welfare might be more appropriate. By focussing on 'product variety' in this case and the concept of consumer 'choice' as a contributor to consumer welfare, the GC has attempted to incorporate some of these dynamic elements into its assessment of consumer harm. This 'speculative' or 'hypothetical' notion of harm, though criticised by commentators, is submitted to be the best approximation of the true economic efficiencies at stake due to the counterfactual nature of lost innovation[441]. The 'technical development' criterion used by the Court serves to identify and specify precisely what this 'loss' is in terms of an actual product or products. However, as these elements stand together, they fail to adequately take into account the loss of incentives to innovate by the IPR-holder, since the test only looks at whether the

437. William H Page and Seldon J Childers, 'Antitrust, Innovation, and Product Design in Platform Markets: Microsoft and Intel' (2012) 78 Antitrust LJ 363.
438. Harry First, 'Controlling the Intellectual Property Grab : Protect Innovation, Not Innovators. Public Interest' (2003) 38 Rutgers LJ 365, 3
439. Such as were considered in the 'tying' elements of this case, not dealt with in the present chapter.
440. Cseres, 'Consumer Welfare Standard', 136.
441. See the discussion of counterfactuals discussed in Part III, Sections A-C.

refusal to licence prevents technical development.[442] As in the scenario of a 'new product', it could well be the case that the dynamic efficiency gains of this 'technical development' are less overall than the loss in incentives to innovate brought about by compulsory licensing of the IPR, such that on balance, consumers are not harmed by the refusal to licence. Indeed, the Court did consider this side of the equation under the 'objective justification' criterion, but its analysis was supplementary, and explicitly not part of any 'new' test.[443] It is submitted that if consumer harm is to be given the detailed assessment it requires, just such a balancing act should be incorporated into this legal rule, either under the 'technical development' element (as implied by AG Tizzano), or under the assessment of consumer harm itself.

The recent EU Commission investigation into Alphabet Inc's abuse of dominant position with respect to Google's Android Mobile OS provides an opportunity to test some of the economic and legal arguments first raised by Microsoft.

B. EU Commission's Investigation into the Android mobile OS

When Google purchased Android OS in 2005, the smartphone market was still underdeveloped. Apple's iPhone release was still 2 years off (2007), and the dominant devices were running highly impoverished operating systems such as Symbian and Blackberry OS. Eleven years later, Android now makes up more than 80% of smart device OS's in the EU, with Apple trailing far behind.[444]

In the Commission's Statement of Objections[445], Google has been charged with, inter alia, 'tying' the supply of its OS with the mandatory pre-installation of certain key software applications, such as Google Search and Google Chrome, as well as preventing customers from 'forking' (developing competing Android-based OS's). In the case of Microsoft case, such mandatory tying was considered anticompetitive due to the chilling effects on the downstream application market.[446] However, Android is distinguished from Microsoft's Windows by its unique 'open source' status.

One fascinating wrinkle in the Google Android investigation is that Android, unlike Microsoft, is 'open source software'.[447] What this means is that device makers have the

442. Lao, 'Terminal Railroad to Microsoft'.
443. *GC* Judgement, para 710.
444. Zach Epstein, 'Apple's Mobile Market Share Sees Big Drop In May As Android Skyrockets' (*BGR*, 2 June 2016) <http://bgr.com/2016/06/02/apples-mobile-market-share-sees-big-drop-in-may-as-android-skyrockets/> accessed 14 October 2016.
445. Commission, 'Antitrust: Commission Sends Statement of Objections to Google on Android Operating System and Applications' (20 April 2015) Press Release IP-16-1492.
446. This 'tying' component of the Microsoft decision was not considered in this chapter, since it falls outside the legal rule of the EFD and is a separate legal basis.
447. For a detailed discussion of the special attributes of open source software, see chapter 4 of this thesis.

theoretical ability to create their own Android-based OS's independent of the version offered by Google (referred to as 'forking'). Such a possibility would have the effect of neutralising any real dominance that Google has in the mobile OS market, and considerably weaken Google's alleged 'tying' strategy as well as its ability to engage in 'self-preferencing' behaviour.[448]

However, the Commission's 'Statement of Objections' claims that Google has prevented its customers from forking Android, by use of an 'Anti-fragmentation Agreement'. Although presented as a means of maintaining interoperability and cohesion in the Android ecosystem, the Commission views this Agreement as an illegitimate restriction of competition under as it prevents the emergence of competing Android-based mobile OS's.

Despite the meagre details provided by the Commission's Factsheet[449], the legal argument against Google will almost certainly be based upon 'abuse of dominant position' under Art 102 TFEU. Unlike the still on-going Google online search case, which seems to be formulated in terms of ‹self-preferencing›, the Android case presents facts much closer to the Microsoft case.

As with the Microsoft case, it is possible to develop the argument that super-dominant software platforms (such as Android) play an analogous economic role to 'infrastructure', by serving as conduits for downstream value creation. As with traditional infrastructure, there are compelling legal and economic reasons for these platforms or 'technological infrastructures' to operate under 'open access' rules. Such rules would mean that all downstream companies (including the infrastructure owner) are given equivalent access terms to the upstream platform, unless there are very good (and objective) reasons not to. As stated in chapter 2, an open access regime does not imply that resource owners cannot charge for access. The essential component of an open access rule is that the licensing terms guarantee the public availability of the resource in order to sustain 'effective competition'.

The strength of Google's legal arguments against the abuse of dominance charges under Art 102 TFEU will likely depend upon how well it can formulate its reasons not to operate under an open access rule. Certainly, its first response will be to dispute its dominant position, given the dynamic constraint of Apple's iOS as well the open source nature of Android. It may also make the affirmative defence that its control over forking and App pre-installations (to prevent 'fragmentation' across the Android 'ecosystem') is ultimately in the consumers'

448. See the discussions of this type of behaviour as having EU antitrust (or not) dimensions under Art 102 TFEU with respect to a separate Google investigation related to its advertising practices in Vesterdorf, 'Theories of Self-Preferencing and Duty to Deal'; Petit, 'Theories of Self-Preferencing Under Article 102 TFEU'.
449. Commission, 'Antitrust: Commission Sends Statement of Objections to Google on Android Operating System and Applications – Factsheet' (20 April 2016) Press Release MEMO-16-1484.

interests. This last point (depending as it does on Android's open source status) would also help to distinguish the case from the otherwise very similar facts of Microsoft.

As open source software continues to deepen its role in today's high-technology markets, this case will no doubt have resounding consequences throughout the industry. One possible outcome would be to weaken Google's hold over its flagship Android mobile OS, and pave the way for a flood of competing Androids forked by both downstream (and perhaps) upstream device makers and software companies. Whether this serves to sharpen the Google product (by competition) or simply create interoperability problems (by fragmentation) will be keenly observed by both legal scholars and technologists. However, the legal and economic rules established in the *Microsoft* case will likely play a determinative role in this case.

C. Overall conclusion

In conclusion, this chapter has argued that the EFD played a significant role in shaping the GC's decision in this case, albeit using a slightly modified *IMS/Magill* framework, utilizing the underlying two-stage 'infrastructural approach' outlined in chapter 1. We have shown that the renovation of the 'new product' element made by the Court is a development in the sensitivity of this test particularly suited to high technology industries, and software in particular, and moreover is justified on both economic and legal grounds. The Court's 'infrastructural' approach to Microsoft's refusal to supply helped to signal that we were dealing with the application of the EFD as opposed to a traditional refusal to supply analysis. This chapter has also identified some remaining problems with the legal rule underlying the EFD, and has made some suggestions which might help ground the doctrine on a firmer economic rationale for future cases, such as the recent (currently) on-going investigation into Google's Android mobile OS, in which the *Microsoft* case will no doubt play a pivotal role.

CHAPTER 3

VISIBLE AND INVISIBLE HANDS: IP, SUBSIDIES AND OPEN ACCESS IN THE EU INNOVATION SYSTEM

I. INTRODUCTION

The previous two chapters have focussed on a qualification of 'technological infrastructure' that encompasses *de facto* and cooperatively-set interoperability standards. *De facto* standards have been described as emerging from the market due to demand-side network effects. Cooperatively-set standards emerge via a different process, becoming entrenched by horizontal agreements and specific investments made by competitors. Both these forms of technological infrastructure have been argued to fall under an 'infrastructural approach' to the enforcement of EU competition law.

The present chapter focuses on a third category of technological infrastructure: 'pioneering' inventions (or 'general purpose technologies') that result from publicly subsidised Research and Development ('R&D') programs. The chapter examines why an exclusive rights approach to the management of R&D outputs (such as in the European 'transplant' of the US 'Bayh Dole' regime[450]) may lead to suboptimal social welfare outcomes. It proposes that rather than relying on the ex post application of EU competition law to ensure the openness of technological infrastructure, the subsidy system itself can structure incentives to drive knowledge resource management regimes towards open access outcomes, such as royalty-free or FRAND licensing. The key to this proposal has two features. First, that where subsidised R&D results in IP-protectable outputs, these outputs are highly likely to qualify as technological infrastructure. Second, that the best way of managing this technological infrastructure is to create strong incentives for the subsidy recipient to make these outputs open access, for example, by ramping up available subsidy intensities, even where the output is 'close to the market'.[451] This proposal embodies a variation of the 'infrastructural approach' of the previous chapters, by recommending changes to the institution of subsidy grants, so that the rule, 'if infrastructure, then open access', becomes institutionally entrenched.

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450. The 'European transplant of Bayh-Dole' refers to the default allocation of IP rights to the subsidy recipient, as set down in Regulation (EU) No 1290/2013 of The European Parliament and Of The Council of 11 December 2013 Laying Down The Rules For Participation And Dissemination In "Horizon 2020 - The Framework Programme For Research And Innovation (2014-2020), Article 41
("Ownership Of Results: Results shall be owned by the participant generating them.")

451. Currently, close to market activities (e.g prototyping) R&D projects max out at 70% of the total costs for large companies. See, <http://ec.europa.eu/competition/state_aid/modernisation/rdi_framework_faq_en.pdf> accessed April 20 2017 One interesting issue is whether or not the subsidy caps in State Aid or H2020 apply at all if the access regime is royalty-free. The Communication from the Commission Framework for State Aid for Research and Development and Innovation (C(2014) 3282), Article 19(a) would seem to suggest not, as it would not then be considered an 'economic activity'. However, it is quite clear that the caps would apply if the IP is licensed under the open access regime of 'FRAND 'licensing.

The above arguments are developed in three main moves. After this introduction, the first move (Part II) lays the groundwork. It begins by developing the concept of an 'innovation institution'. It then introduces and explains the approach of 'comparative institutional analysis' which will be used to guide the argument. The subsequent subsection develops the key concept of 'intellectual infrastructure', its close relationship to open access licensing, as well as the concepts of 'scientific infrastructure' and 'technological infrastructure'. It explains why the mixed subsidy/IP Bayh-Dole regime is likely to give rise to information assets of this character. The second move (Part III) begins by digging into the economic foundations of intellectual property, including deploying some useful tools from game theory to highlight the regulatory nature of the IP system, such as the 'assurance game' and the problem of 'property traps' in high technology. The nerve of this part is to apply pressure to the idea that an exclusive rights regime is the best institution for stimulating the transfer and commercialisation of technological infrastructure, such as is assumed by the Bayh-Dole model of allocating sponsored R&D results (and any IP) to the subsidy recipient. The third move (Part IV) distils the insights from the previous section into policy recommendations by first briefly reviewing the EU subsidy regime as it now is, then offering a simple approach to ensure greater openness with respect to technological infrastructure. This approach takes the form of ramping up R&D subsidy intensity in cases where subsidy recipients make their outputs available on open access terms.

II. GROUNDWORK: ORIENTATING THE ARGUMENT

A. Innovation Institutions and Comparative Analysis

Innovation institutions can be conceptualised as any economic mechanism that organises incentives in order to encourage R&D and commercialisation.[452] But this definition immediately begs the question: why does innovation need to be encouraged? The textbook answer to this question recruits the concept of 'market failure' to do the heavy lifting: that the unaided market's allocation of resources diverges from what is socially optimal to drive investment in R&D. There are at least two arguments commonly used to explain the market failure of information production: the spillover argument (as already briefly discussed in the introduction) and uncertainty.

1. Spillovers

As developed in the work of Harold Demsetz, the spillover argument is analytically identical to the more familiar 'public goods' argument.[453] The public goods argument runs that

452. Daniel Jacob Hemel and Lisa Larrimore Ouellette, 'Beyond the Patents-Prizes Debate' (2013) 92(2) Texas L Rev 303.
453. Demsetz, 'Information and Efficiency'; Brett M Frischmann, 'Evaluating the Demsetzian Trend in Copyright

since R&D outputs[454]- mostly information goods- are non-excludable and non-rivalrous, their private appropriability can be weak[455], resulting in relatively weak private incentives to invest.[456] The value that is not appropriated by the company engaging in R&D enters society in the form of spillovers[457]: unintended third party benefits that are not factored into an individual's decision to engage in information production. As already mentioned, although R&D spillovers are difficult to measure accurately, their value to the economy has been calculated econometrically at several times that of the private value appropriated by the company engaging in the R&D.[458] This extra value shakes out micro-economically, by driving efficiency gains across an industry[459]; and macro-economically, by contributing to economic growth,[460] making them a central goal of policies addressing the innovation system.

The upshot of the 'spillovers' argument is that since a company's R&D investment decisions only focus on the appropriable *private benefits* and not the wider *societal benefits* of R&D, the 'invisible hand' of the unaided market fails to align the privately optimal level of R&D investment with that which is socially optimal: spillovers are less than what they could be because R&D investment is less than what it could be.[461] In other words, the reason why the invisible hand may sometimes be invisible in information production, is because in the unaided market it is often simply not there.[462] The invisible hand may require the 'helping hand' of bespoke innovation institutions, such as IP and subsidies, whose design and purpose is to help private incentives track socially optimal goals.

As will be discussed in more detail in Section B and also in Part III, intellectual property is a form of 'socially created property', which is designed to create artificial scarcity in information by permitting exclusion. [463] This artificial scarcity allows innovators to internalise

Law', (2007) 3(3) Rev L & Econ 2.

454. R&D outputs are here considered as all the intangible outputs that result from R&D, including know-how and intellectual property.

455. Teece, 'Profiting from Technological Innovation'.

456. Ibid.

457. Frischmann and Lemley, 'Spillovers'. See also Gerald A Carlino and Jake Carr, 'Clusters of Knowledge: R&D Proximity and the Spillover Effect', (2013) (Q3) Business Rev 11.

458. Griliches, 'The Search For R&D Spillovers'.

459. Ibid.

460. Robert M Solow, 'Technical Change and the Aggregate Production Function' (1957) 39(3) Rev Econ & Stats 312 ("Solow, 'Technical Change'"). See also J Doyne Farmer and Francois Lafond, 'How Predictable is Technological Progress?', (2016) 45 Research Policy 647 ("Farmer and Lafond, 'How Predictable is Technological Progress?'")("[t]echnological progress is widely acknowledged as the main driver of economic growth").

461. Phedon Nicolaides, 'The Economics of Subsidies for R&D: Implications for Reform of EU State Aid Rules' (2013) 48(2) Intereconomics 99 ("Nicolaides, 'The Economics of Subsidies for R&D'").

462. Joseph E Stiglitz, 'Economic Foundations of Intellectual Property Rights' (2008) 57(1776) Duke LJ 1693 ("[o]ne of the important results of my work, developed in a number of my papers, was that the invisible hand often seemed invisible *because it was not there*.")

463. *i.e.,* in contrast to the 'natural right' arguments which often motivate real property. See Edward L Rubin, 'The Illusion of Property as a Right and Its Reality as an Imperfect Alternative' (2013) Wisconsin L Rev 573 ("Rubin,'The

a greater proportion of the value of spillovers, which can then function as incentives for R&D investment. At its core, the IP system constitutes a *regulatory choice* as to what types of information should be protected and what cannot and represents a 'social bargain' of high complexity: IP should only attach to information that would not otherwise be produced (or disclosed) but for the IP[464], and which has high social value; and where such social value (in the form of spillovers) is *enhanced* by the exclusivity provided by IP, rather than diminished by it. In short, the driving force of the IP system is the creation of social value, and it is designed 'to benefit the public as a whole', rather than individual inventors.[465] Hitting this sweet spot is a difficult task, and a substantial literature has emerged which focuses on cases where the IP system fails to meet these conditions, leading to unjustified social cost.[466] Where IP-protected information assets also constitute intellectual infrastructure, these shortcomings may be exacerbated further, as discussed in Part III.

The institution of R&D subsidies attempts to solve the spillover problem in a different way. By providing for greater relative value appropriation via the ex ante grant of (a percentage) of R&D costs. Again, there is a complex bargain at the heart of the subsidy system: that subsidies should only be granted where the innovation is of high social value, and only when the market cannot produce the information asset on its own, or where the terms of access to the asset would be sub-optimal if the market were to produce it.[467] One key condition under which subsidies may be an optimal institutional choice is when the desired information asset fails to be produced by reason of high risk or uncertainty, as discussed below.

2. Uncertainty

Information production may be hampered by 'uncertainty'. This argument takes a different tact from the spillover argument, by suggesting that the divergence between private and social levels of *risk aversion* leads to chronic underinvestment, even where value appropriation mechanisms (such as IP) may be present. [468] The concept of uncertainty may be further decomposed into 'risk' (where the uncertainty is known and can be roughly calculated[469]) and

Illusion of Property'"), 578 ("[w]ith respect to intangibles or socially created property, such as a patent or a government position, the pattern emerges once again with clarity, since these kinds of property are generally brought into existence by explicit governmental action. In all these cases, property—the private ownership of resources—was a government policy designed to achieve specific and identifiable purposes…")

464. Or produced in socially sub-optimal levels.

465. Contreras, 'Market Reliance' 486 ("The patent system as authorized by the U.S. Constitution is endowed with a public character: "To promote the Progress of Science and useful Arts." Its primary purpose is not to reward individual inventors, but to benefit the public as a whole.")

466. See the discussion in Benjamin N Roin, 'Intellectual Property Versus Prizes: Reframing the Debate' (2013) 81 U Chicago L Rev 999.

467. As discussed further in Part II, Section A(2) and in Part II, Sections B(3) and (4)

468. Link and Scott, *Public Goods, Public Gains.*

469. Mariana Mazzucato, The Entrepreneurial State (Demos 2011) 49-50 for discussion of risk and uncertainty.

'Knightian[470] uncertainty' (where the uncertainty cannot be known because of the uniqueness of the project[471]). Depending on the market structure,[472] this divergence between the level of private and socially optimal risk aversion may lead to a bias in private investment away from radical innovation and towards incremental innovation. Alternatively, radical innovation may still go ahead but only under conditions where the ex post revenue streams are assessed as extremely high, such as has been argued by Joseph Schumpeter and proponents of 'dynamic competition'[473], as in the case of *de facto* standards 'wars' (see Section B(3)).

In cases where risk and uncertainty prove an insurmountable obstacle to private R&D, the 'risk gap' may be addressed by public R&D subsidies, which aim to cover (a percentage of) the total costs in order to help make R&D go through which otherwise might not.[474]

Given the challenges to innovation institutions posed by both spillovers and uncertainty, the task of incentivising R&D often involves an institutional choice of some form, for example, between the market (IP) or direct Government involvement (subsidies). The tool of comparative institutional analysis can help in clarifying the various costs and benefits involved in these different innovation institutions.

3. Comparative institutional analysis

In general, the innovation institutions identified above operate by narrowing the gap (whether financial or risk) between the privately and socially optimal levels of R&D. But the way these two innovation institutions operate is very different; involve different costs, benefits and trade-offs; and often derive their raisons d'etre from divergent economic theories on the nature of innovation and efficiency. Each of these institutions furthermore has well-known draw-backs.

In the case of IP, which attempts to reinstate the 'invisible hand' of market forces, these drawbacks relate to the fact that propertising information (particularly of an infrastructural character[475]) may lead to monopoly pricing, the potential choking of downstream and cumulative innovation[476] and the creation of intellectual property anti-commons in the form

470. Ibid. Deriving from the name of economist, Frank Knight.
471. Ibid, 42.
472. There is a dense literature on the effect of market structure on incentives to invest in R&D, see for example the concept of "Arrow's replacement effect", as discussed in Daron Acemoglu and Dan Vu Cao, 'Innovation by Entrants and Incumbents' (2010) National Bureau of Economic Research NBER Working Papers 16411 <http://www.nber.org/papers/w16411.pdf> accessed 14 October 2016.
473. Baker, 'Dynamic Competition'; Arthur, 'Competing Technologies'.
474. Commission Communication on the framework for State aid for research and development and innovation [2014] OJ C198/01, 21-23.
475. See discussion in section B below.
476. Paola Giuri and Salvatore Torrisi, 'Cross-Licensing, Cumulative Inventions and Strategic Patenting', 5th Annual Conference EPIP Association, Maastricht, 20-21 September 2010) ("Giuri and Torrisi, 'Cross-Licensing'").

of, inter alia, 'patent thickets' caused by the strategic use of IP.[477] In addition, an IP system may bias creative and inventive activity towards outputs which are more easily commercialisable and away from both basic research and high risk (and uncertain) R&D, with high social value but limited (risk-discounted) private appropriability. The use of IP as a vehicle for technology transfer also has well-known deficiencies, in many cases stemming from a faulty analogy between real property and IP. The technology transfer aspect of IP is generally understood to motivate the Bayh-Dole regime in relation to subsidised R&D. Part III of this chapter hones in on this aspect by deploying useful tools from game theory.

The draw-backs associated with R&D subsidies take a different form. While theoretically capable of incentivising R&D without engendering social deadweight losses as well as being able to target high risk/uncertain R&D, subsidies may suffer resource allocation problems due to information poverty.[478] Unlike the IP system, which is able to harness the price system as a conduit for demand signalling and other crucial R&D investment decision-making information, the allocation of subsidies is generally subject to the very 'visible hand' of centralised decision-making and agenda-setting. The centralisation of R&D resource allocation decisions is therefore more likely to involve both false negatives and false positives, leading to 'crowding out'[479] of private investment, the risk of 'double-subsidisation', as well as distortionary directional R&D incentives.[480]

Importantly, these two institutions do not operate as viable substitutes in all cases, but have preferred scopes of application. In cases where the IP system is thought to operate well, subsidies may be distortionary or have negative wealth distribution effects.[481] Likewise, in cases where subsidies are deemed necessary, the IP system may lead to unjustified dead-weight losses and losses in dynamic efficiency caused by access problems. But these two institutions do not merely function as 'imperfect *alternatives*'; they may also, in some cases operate as *complements*.[482] As already mentioned, under both the US Bayh-Dole Act and its European transplants, IP arising from subsidised R&D are allocated to the subsidy recipient. The effect of this IP allocation is that the private party gets exclusive rights over an information

477. Georg von Graevenitz, Stefan Wagner and Dietmar Harhoff, 'Incidence and Growth of Patent Thickets: The Impact of Technological Opportunities and Complexity' (2013) 61(3) J Indus Econ 521 ("von Graevenitz, Wagner and Harhoff, 'Incidence and Growth of Patent Thickets'").
478. Demsetz, 'Information and Efficiency', 12 ("[h]ow would such a system produce information on the desired directions of investment and on the quantities of resources that should be committed to invention?")
479. Néstor Duch-Brown, José García-Quevedo and Daniel Montolio, 'The Link between Public Support and Private R&D Effort: What Is the Optimal Subsidy?' (2010) Institut d›Economica de Barcelona Working Papers 2011/12.
480. Paul A David and Bronwyn H Hall, 'Heart of Darkness: Modeling Public–Private Funding Interactions Inside The R&D Black Box' (2000) 29 Research Policy 1165 ("David and Hall, 'Heart of Darkness'").
481. Nancy Gallini and Suzanne Scotchmer, 'Intellectual Property: When Is it the Best Incentive System?' (2001) Economics Working Paper E01-303.University of California, Berkeley ("Gallini and Scotchmer, 'Intellectual Property'").
482. One key question that will be considered in Parts 2 and 3 is the extent to which such complementary use may compound or mitigate the drawbacks in the two institutions.

asset that it would otherwise not have even been able to produce, but for the subsidy. The economic logic underlying this complementary use of IP and R&D subsidies is driven by a technology transfer story of the function of IP. Essentially, policy makers side-step the usual incentivisation argument in support of IP and invoke the argument that the subsidy recipient (often a private company, but also universities and research institutions[483]) would likely make more productive use of the information asset than either Government ownership or its commitment to the public domain. In the first case (Government ownership of resulting IP), the argument runs that IP risks languishing in filing cabinets, like the ninety-five per cent of patents recorded on US Government files before the passing of the Bayh-Dole Act in 1980.[484] In the second case (commitment to the public domain), the assets may simply disappear from view once committed to the public domain, due to information problems and the lack of any one company's incentives to bring the assets to market, or as put by Rebecca Eisenberg: the public domain may become 'a treacherous quicksand pit in which discoveries sink beyond reach of the private sector'.[485]

The literature on the relative merits of the Bayh-Dole regime compared to a regime where R&D outputs are committed to the public domain or otherwise made open access, is dense, but ambiguous and inconclusive.[486] It is therefore widely acknowledged that in the context of information production, legislators and policy makers must enter the world of "second best" solutions and imperfect institutional alternatives (or complements).[487] Furthermore, imperfections in a particular innovation institution do not necessarily argue for the legitimacy or primacy of an institutional alternative. To move from the identification of imperfections

483. Originally Bayh-Dole Act applied to SME's and non-profits only, but then under President Reagan it was extended to all companies, regardless of size. See Ronald Reagan, 'Memorandum on Government Patent Policy' (The American Presidency Project 18 February 1983) <http://www.presidency.ucsb.edu/ws/?pid=40945> accessed 13 October 2016.

484. Wendy Schacht, 'The Bayh-Dole Act: Selected Issues in Patent Policy and the Commercialization of Technology' (2012) Congressional Research Service <https://www.fas.org/sgp/crs/misc/RL32076.pdf> accessed 16 September 2016, 2 ("[p]rior to 1980, only 5% of government owned patents were ever used in the private sector although a portion of the intellectual property portfolio had potential for further development, application, and marketing. The Bayh-Dole Act was constructed, in part, to address the low utilization rate of these federal patents."); David C Mowery and Bhaven N Sampat, 'The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other OECD Governments?' (2005) 30(1) J Tech Transfer 115. Also see the US Bayh-Dole Act, as codified in US law at 94 Stat. 3015, and in 35 U.S.C. § 200-212, and as implemented by 37 C.F.R. 401.

485. Rebecca S Eisenberg, 'Public Research and Private Development: Patents and Technology Transfer in Government- Sponsored Research' (1996) 82(8) Virginia L Rev 1663 ("Eisenberg, 'Public Research and Private Development'"), 1664.

486. Michael Sweeney, 'Correcting Bayh-Dole's Inefficiencies for the Taxpayer' (2012) 10(3) Nw J Tech & IP 295 ("Sweeney,'Correcting Bayh-Dole's Inefficiencies for the Taxpayer'"); Eisenberg, 'Public Research and Private Development'; Rebecca S Eisenberg and Arti K Rai, 'Bayh-Dole Reform and the Progress of Biomedicine' (2003) 662(1) Law and Contemporary Problems 289 ("Eisenberg and Rai, 'Bayh-Dole Reform'"); Samuel Loewenberg, 'The Bayh–Dole Act: A Model For Promoting Research Translation?' (2009) 3 Molecular Oncology 91.

487. Carroll, 'One Size Does Not Fit All', 1391 ("[t]hus, uniform patents and copyrights are second-order second best, or, in other words, a second-best solution nested within the second-best solution of intellectual property rights"); Komesar, *Imperfect Alternatives*.

in one institution to the conclusion that therefore a different institution should be preferred commits what Harold Demsetz has referred to as the “nirvana fallacy”.[488] What is required is a comparison of the two different institutions against some base-line objective,[489] according to the framework developed by Neil Komesar.[490]

In the present chapter, the two institutions of exclusive IP (in the form of Bayh-Dole) and open access licensing (in the form of either royalty-free or FRAND) will be assessed in relation to how well they manage the resource of intellectual infrastructure against the base-line objective of ensuring technology transfer.[491] This is the purpose of Parts III and IV of this chapter. Before that analysis can begin, it is first necessary to elucidate the concept of intellectual infrastructure in detail, and to defend its uniqueness as an information asset.

B. Intellectual infrastructure

1. Background

a) Defining Intellectual Infrastructure

According to the work of Brett Frischmann and Peter Lee, when a resource is non-rival, generic, and derives most of its social value from downstream uses, it may be classified as infrastructural. This definition has both supply and demand side components. On the supply side, the asset must be able to support multiple simultaneous uses (often across different markets)- i.e. it must be ‘non-rival’; and it must be ‘general purpose’ or generic (in the sense of having relative independence from end use).

In many ways, the requirement of ‘genericness’ maps to the level of abstraction according to which an information resource is defined. [492] Casually formulated, the more abstract an

488. Demsetz, ‘Information and Efficiency’.
489. Frischmann and McKenna, ‘Comparative Analysis’, 4 (“[c]omparative institutional analysis presumes some objective and evaluates different institutions in terms of their ability to accomplish that objective. ”)
490. Ibid.
491. It should be pointed out that in the case of intellectual infrastructure, the concept of ‘technological transfer’ has a very special meaning: not just the dissemination of the technology as an end-product, but also its productive use in the innovation system, serving to scaffold downstream innovation. See Frischmann and Waller, ‘Revitalizing Essential Facilities’, 13 (“infrastructure resources are intermediate goods that create social value when utilised productively downstream and that such use is the primary source of social benefits. In other words, while some infrastructure resources may be consumed directly to produce immediate benefits, most of the value derived from the resources results from productive use rather than consumption. ”)
492. However, intellectual infrastructure often exhibits a ‘fractal’ character: it can be built up of indispensable components on lower levels of abstraction which also function as necessary inputs. Since access to each of the lower-level components functions as a bottle-neck to the higher-level generic infrastructure, they may also need to operate under an open access rule. The term ‘fractal’ is used here to refer to the ‘recursive’ nature of intellectual infrastructure, meaning that such assets may exist at different levels of abstraction. For discussion of this attribute of infrastructural assets see Frischmann, *Infrastructure*, 276 (“the infrastructure concept [seems] to have a fractal nature when applied

information asset is, the greater the potential number of downstream uses; while the closer the asset becomes to an implementation, its use gradually becomes identified with a single use.[493] If an idea or technology feeds in as an input into a wide range of downstream uses (whether within a single market or research space or multiple ones[494]) then it is most likely generic[495]. Due to its ability to feed into a range of possible uses, a resource's genericness may also give rise to high social value in the form of spillovers. However, as Frischmann observes[496]:

> although infrastructure may generate substantial social welfare ; rather it is the functional nature of the resource and the manner in which it generates social value that matters.

The genericness and high social value of an information resource are necessary but not sufficient to identify it as critical infrastructure;[497] it must also perform the function of infrastructure *in fact.* In economic terms, a candidate asset for an infrastructural asset must exhibit *derived demand*, [498] meaning that downstream users require the asset as an input for their own productive activities. This was a key component of the 'infrastructure screening test' developed in chapters 1 and 2. Examples of intellectual infrastructure include generic ideas, scientific discoveries, and technological innovations that form part of the cumulative cultural and informational 'backdrop' that feeds into society's socio-cultural and technological production systems.[499] Put like this, the concept of intellectual infrastructure seems to be a very rich idea. In fact, this conceptualisation of intellectual infrastructure links up with the literature on cultural evolution and theoretical biology[500], as well as economic arguments for

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to intellectual resources because you could identify infrastructure at various scales…")

493. Frischmann, *Infrastructure*.

494. Frischmann and Waller, 'Revitalizing Essential Facilities.'

495. It is, however, important to distinguish between widespread use of a single input in the same use-case compared to widespread use of a sinlge input in many different use cases. Both may be considered generic, but a lot will turn on the particular facts of the resource's use.

496. Frischmann, *Infrastructure*, 278.

497. In fact, highly specific inventions (such as may be disclosed in a patent) can have high social value due to the more generic teaching embedded inside, which feeds back into the public domain, see R. Polk Wagner, 'Information Wants To Be Free: Intellectual Property and the Mythologies of Control' (2003) 103 Columbia L Rev 103(1) ("Wagner, 'Information Wants To Be Free'"), 1005 ("[t]his information may not be embodied in any product or service, but instead might consist more generally of ways of viewing problems, adaptations of old or unrelated principles, a promising direction of research, or the identification of new uses for materials").

498. Sidak and Lipsky, 'Essential Facilities', 1215 ("[t]he demand for use of the facility is a derived demand based on the underlying demand for the end product").

499. Frischmann, *Infrastructure*, 260 ("[t]he cultural environment as infrastructure has an intergenerational dimension. Each generation is blessed beyond measure with the intellectual and cultural resources it receives from past generations; each generation experiences and changes the cultural environment and passes it on to future generations").

500. For example, see Kim Sterelny, *The Evolved Apprentice: How Evolution Made Humans Unique* (MIT Press 2012) ("Sterelny, *The Evolved Apprentice*") xii: ("…human cognitive competence is a collective achievement and a collective legacy; at any one moment in time, we depend on each other, and over time, we stand on the shoulders of not a few

the freedom of speech.[501] But the richness of this concept does not prevent it from being defined precisely enough so as to be useful for legal and economic analysis. Chapters 1 and 2 discussed in detail the legal and economic tests for assessing *de facto* and cooperatively-set technological standards as infrastructure. By and large, these tests are tuned to focus on the *function* of these resources within productive systems rather than simply checking boxes of infrastructural attributes. These tools provide lawyers and economists with the analytical traction required to define and apply 'infrastructure screening' tests in legally and economically meaningful ways.

Importantly, while clearly encompassing both de facto and de jure standards as intellectual infrastructure, the above understanding also embraces pioneering inventions or 'general purpose technologies'. General-purpose technologies[502] are technological innovations that are so fundamental that they can lead to 'discontinuities'[503], which completely reshape markets and sometimes economies. Steam engines[504], electricity[505], and computation[506] are examples of the latter. As developed in Section B(3) below, this category of intellectual infrastructure is a likely output of subsidised R&D.

Having established the scope of the intellectual infrastructure concept, it is necessary to explain in greater detail its relationship to open access licensing regimes, by briefly rehearsing and extending the arguments already developed in chapters 1 and 2.

b) Intellectual infrastructure and open access licensing

In an ideal world, all intellectual infrastructure would be publicly provided and available at zero cost[507], as in the case of much traditional infrastructure. Although this holds true for a subset of intellectual infrastructure (that which falls outside the IP system, see discussion at B(3) below), it is not possible in the real world, as it would require the Government to

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giants but of myriads of ordinary agents who have made and passed on intact the informational resources on which human lives depend".)

501. Yochai Benkler, 'Free As the Air to Common Use: First Amendment Constraints on Enclosure of the Public Domain' (1999) 74 New York U L Rev 354 ("Benkler, 'Free As the Air to Common Use'").

502. Lipsey, Carlaw and Bekar, 'Economic Transformations'.

503. Or radical changes in the trajectory of technological or market evolution. Philip Anderson and Michael L Tushman, 'Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change' (1990) 35 Administrative Science Quarterly 604; Michael L Tushman and Philip Anderson, 'Technological Discontinuities and Organizational Environments' (1986) 31(3) Administrative Science Quarterly 439.

504. Nicholas Crafts, 'Steam as a General Purpose Technology: A Growth Accounting Perspective' (2004) 114(495) Econ J 338.

505. Petra Moser and Tom Nicholas, 'Was Electricity a General Purpose Technology?' (2004) 94(2) Amer Econ Rev 388.

506. Basu and Fernald, 'Information and Communications Technology'.

507. Arrow, 'Economic Welfare and the Allocation of Resources for Invention', 614-615: ("The cost of transmitting a given body of information is frequently very low. If it were zero, then optimal allocation would obviously call for unlimited distribution of the information without cost.")

harvest and synthesise an impossible amount of information. The market- and competition in particular- is required as a 'discovery procedure'.[508] For this reason, the market operates in liberal democracies- both with respect to certain types of traditional infrastructure and some information assets (in the form IP)- as a procedure for coming up with novel solutions. As discussed in Section III, the downside of this mechanism with respect to IP is that the scope of IP laws is a regulatory choice and therefore most likely to be full of type I and II errors. Because of this, society relies on the interaction of other institutions, such as competition law, with the IP system to ensure that information markets operate efficiently. Chapters 1 and 2 of this thesis argued that the role of competition law in opening up IP can be explained according to an 'infrastructural approach': ensuring the public availability of critical infrastructural IP where such availability is essential to sustain effective competition and innovation.

By keeping infrastructure open (via either royalty-free or FRAND licensing[509]), neither IP right holders[510], nor Government, nor other mechanisms of top-down decision-making[511] get to exclusively determine downstream productive uses via denial of access or arbitrary setting of access terms.[512] Instead, open access permits a 'bottom up' process, whereby individual decision-makers can self-select their downstream productive uses of the infrastructural asset, permitting the emergent complexity and unpredictability of innovation systems.[513] Tim Wu develops this argument with respect to intellectual property in general, where he argues for a 'polyarchal' rather than a 'hierarchal' approach to patents –suggesting that patent scopes should be narrowed or patent eligibility requirements raised, so as to allow a greater flourishing of innovation.[514] To this end, the work of Mark Lemley reminds us that it is a fallacy to assume that an individual right owner will always pursue the most productive uses of its information asset:[515] Economic theory states that *markets*, not individuals, generally make efficient decisions, where the cost of stupidity, greed or short-sightedness is elimination

508. See generally F. A. Hayek, 'Competition as a Discovery Procedure' (1968), republished in The Quarterly Journal of Austrian Economics Vol. 5, No. 3 (Fall 2002): 9–23
509. See the FRAND discussion in chapter 1.
510. Tim Wu, 'Intellectual Property, Innovation, and Decentralized Decisions' (2005) 92(1) Virginia L Rev 104, ("In general, broad rights or rights held by a limited number of parties promote a hierarchical decision architecture. Conversely, diffuse rights or non-assignment of rights leads to the market default: polyarchical decision making architectures, where any firm or individual may decide to undertake a new project.")
511. Such as *e.g.*, IP owners acting as gate-keepers to entire markets or research spaces.
512. Frischmann and Waller, 'Revitalizing Essential Facilities', 18 ("[o]pen access eliminates the need to rely on either the market or the government to "pick winners" or uses worthy of access. On one hand, the market picks winners according to the amount of appropriable value generated by outputs, and consequently output producers' willingness to pay for access to the infrastructure. On the other hand, to subsidise production of public goods or non-market goods downstream, the government needs to pick winners by assessing social demand for such goods based on the social value they create.")
513. David C Colander and Roland Kupers, *Complexity and the Art of Public Policy : Solving Society's Problems from the Bottom up* (Princeton University Press 2016); Tim Wu, 'Intellectual Property, Innovation, and Decision Architectures' (2005) University of Chicago Public Law & Legal Theory Working Paper No. 97.
514. Tim Wu, 'Intellectual Property, Innovation, and Decentralized Decisions' 101.
515. Lemley, 'The Regulatory Turn in IP'.

from the market. But a market requires demand and supply side substitutability in order to operate. As will be shown later in this section, these conditions are often absent in the case of intellectual infrastructure.

The preference for open access in relation to infrastructural resources also goes some way to explaining the dominant provisioning mechanism of traditional infrastructure. By being publicly provided, most traditional infrastructure is able to remain open access[516] without the need for assuring private appropriability of the value created. Even in the case of the liberalisation of Government-owned assets, a condition of letting market forces operate is often the implementation of open access rules by regulatory bodies.[517] In the case of intellectual infrastructure, the situation is more complex. Ownership over information is determined by the scope of intellectual property laws. The line between what may or may not be protected under intellectual property laws maps (to a vast extent) the line between genericness and specificity that also motivates the identification of infrastructure. By consequence, it also traces the contours of the regulatory choice over the preferred provisioning mechanism for categories of information resources: those information assets which fall under IP have been selected to be provided by the market, whereas information falling outside IP is left to the operation of other institutions, such as subsidies, prizes or indirect value appropriation mechanisms.[518] But despite this regulatory choice, the boundary between what society chooses to be propertised and what should remain in the public domain as intellectual infrastructure is messy and constantly litigated. Indeed, the boundary between what is generic and abstract and what is sufficiently specific to be protected has been at the core of a number of landmark IP cases, including the granting of patents over software,[519] gene sequences[520], and business models[521], as shown by the recent US Supreme Court case of *Alice v CLS Bank*.[522] In an Amicus Curia Brief to the Court in that case, Jack Lerner implicitly endorsed an infrastructural approach, which links the 'genericness' of the information asset to its infrastructural function:

516. As stated in chapter 1, 'open access' does *not* mean that infrastructural resources have to be zero cost: as with highway tolls, a fee can be charged; the crucial point is that it is publicly available and open indiscriminately to all comers on similar terms.
517. Mair, 'Taking Technological Infrastructure Seriously'.
518. Gallini and Scotchmer, 'Intellectual Property'; Mair, 'Intellectual Property', 59-62.
519. Bessen and Maskin, 'Sequential Innovation'.
520. Geertrui Van Overwalle (ed.) *Gene Patents and Collaborative Licensing Models: Patent Pools, Clearinghouses, Open Source Modls and Liability Regimes* (Cambridge University Press 2009).
521. Stefan Wagner, 'Business Method Patents in Europe and Their Strategic Use: Evidence From Franking Device Manufacturers' (2006) Munich School of Management, University of Munich Discussion Paper 2006-15 <https://epub.ub.uni-muenchen.de/1265/1/Wagner_bmp.pdf> accessed 14 October 2016.
522. See discussion in Jack Lerner, Brief of Public Knowledge: Alice Corporation Pty. Ltd. v. CLS Bank International and CLS Services Ltd. (2014) USC Legal Studies Research Papers Series No. 14-7 <http://ssrn.com/abstract=2405553> accessed 8 August 2016.

> Being the basic tools of innovation, abstract ideas must remain available to the public; to do otherwise would impede innovation more than promote it.

For the purposes of this chapter, information assets that are infrastructural but fall outside the IP regime are referred to as 'scientific infrastructure'. Intellectual infrastructure that falls within the IP system is referred to as 'technological infrastructure.' One useful way of viewing the relationship between IP and infrastructure is to imagine IP as a system with a number of 'safety valves' labelled 'infrastructure' attached. These valves serve to ensure that property rights are either: a.) not granted over intellectual infrastructure in the first place (such as limited by subject matter requirements for IP eligibility), or, b.) if they are granted, that they are managed in an open access manner (as enforced by competition law or other institutions). Of course, both of these valves are notoriously imperfect and are subject to both Type I and Type II errors.[523]

2. Scientific infrastructure

The 'safety valve' of subject matter requirements includes (in the field of patent law, for example) that the information resource does not fall into one of the excluded categories of subject matter. These categories exclude from being considered an 'invention', inter alia, the following: discoveries, scientific theories, mathematical methods, aesthetic creations, schemes, rules and methods for performing mental acts.[524] Most of these excluded subject matters can be qualified as 'scientific infrastructure', since they may also function as indispensable, non-rival inputs for the further development of both scientific and technological progress.[525] From an economic perspective, perhaps the key attribute of these subject matter exclusions is their 'genericness': despite being discoveries or breakthroughs in their own right (and thus surely worthy of incentivisation), they are fundamentally tools or inputs for the creation of more scientific knowledge. Irrespective of which philosopher of science one subscribes to, the creation of scientific knowledge is universally acknowledged to be a cumulative and self-feeding process: scientific theories or discoveries open new research pathways or eliminate old ones, which then produce new scientific theories or discoveries, and so on.[526] In the case of this 'scientific infrastructure', the 'social bargain' embodied in IP- trading private value

523. In particular, patent laws may be over-inclusive: granting property rights over poorly-defined or abstract inventions, as discussed in Part II, Section B(3).
524. See European Patent Convention, art 52. <https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar52.html>.
525. Lee 'The Evolution of Intellectual Infrastructure', 42 ("[i]n trademark, copyright, and patent law, raw materials such as generic words, abstract ideas, and natural principles constitute "intellectual infrastructure " that is not eligible for individual ownership.")
526. See generally Karl Popper, *Conjectures and Refutations* (2nd edn, Routledge 1963) and Thomas S Kuhn, *The Structure of Scientific Revolutions* (Otto Neurath, 2nd edn, University of Chicago Press 1970).

appropriation for social spillovers- tips in the direction of openness over exclusivity: the social-value of openness and free exchange and reuse is intuitively regarded[527] as significantly greater than the counterfactual case of propertisation. In place of patents[528], the generation of scientific knowledge is generally incentivised by reputational effects within the university system[529], Government R&D subsidies, and prizes. [530] Similarly to patents, in the creative industries copyright law excludes the application of copyright to 'ideas', which should remain 'free as the air to common use',[531] as well as, in the case of software, ostensibly 'infrastructural' components of software programs such as application programming interfaces[532] (APIs), logic, or algorithms.[533]

In the case of scientific research itself, the existence of patents over scientific infrastructure underlies one of the most controversial debates in intellectual property today, with a number of commentators decrying the creation of knowledge 'anti-commons'[534] and patent thickets[535] which hamper scientific progress. In addition to patents over scientific infrastructure, publishers' 'pay walls' have also traditionally limited access to scientific publications and have consolidated concerns over knowledge anti-commons.[536] Perhaps in response to concerns

527. The author is not aware of any systematic study on this.
528. Though, there is continued debate out the scope of patentable subject matter when it comes to science, particularly biotechnology, see for example, Charlie Schmidt, 'Negotiating the RNAi Patent Thicket' (2007) 25 Nature Biotechnology 273.
529. Rochelle Cooper Dreyfuss, 'Double or Nothing: Technology Transfer Under the Bayh-Dole Act' (2013) NYU Law and Economics Research Paper No. 13 ("Dreyfuss, 'Double or Nothing'"), 54 ("[r]eputational rewards come from publishing early and sharing materials; the commitment to communitarianism ensures that good work is available to continually push the frontiers of knowledge forward.")
530. In many ways, the above description of the relationship between scientific infrastructure and the IP system is idealised. In practice, subject matter exclusions over scientific discoveries have not prevented the careful drafting of patent claims in relation to, for example, gene sequences, or other biotechnological discoveries and inventions. See European Parliament and Council Directive 98/44/EC of 6 July 1998 on the legal protection of biotechnological inventions and Patrick Van Eecke et al., 'Monitoring and Analysis of Technology Transfer and Intellectual Property Regimes and Their Use' (European Commission DG Research 2009).
531. Benkler, 'Free As the Air to Common Use'.
532. See *Google vs Oracle* case Oracle Am., Inc. v. Google, Inc., 750 F.3d 1339 (Fed. Cir. 2014) cert. denied 135 S. Ct. 2887 (2015); see also Joe Mullin, 'Google Beats Oracle – Android Makes "Fair Use" of Java APIs" (arsTechnica, 27 May 2016) <http://arstechnica.com/tech-policy/2016/05/google-wins-trial-against-oracle-as-jury-finds-android-is-fair-use/> accessed 13 October 2016. In the EU, interfaces are also exempted from the general ban on reverse engineering or decompilation of object code into source code, see Article 6 of the Software Directive.
533. 'The Software Directive' 2009/24/EC, at recital 11 ("[i]n accordance with this principle of copyright, to the extent that logic, algorithms and programming languages comprise ideas and principles, those ideas and principles are not protected under this Directive.")
534. Michael Heller, 'The Tragedy of the Anticommons: Property in the Transition Form Marx to Markets' (1998) 1111(3) Harv L Rev 621.
535. Carl Shapiro 'Navigating the Patent Thicket: Cross Licenses, Patent Pools and Standard-Setting' in Adam B. Jaffe, Josh Lerner and Scott Stern, *Innovation Policy and the Economy 1* (The MIT Press 1998) ("Shapiro, 'Navigating the Patent Thicket'").
536. Jorge L. Contreras 'Confronting the Crisis in Scientific Publishing: Latency, Licensing and Access' (2013) 53 Santa Clara Law Review 491 and Alex Mayyasi, 'Why is Science Behind a Paywall' (Gizmodo, 13 May 2013) <http://gizmodo.com/why-is-science-behind-a-paywall-504647165> accessed 14 October 2016.

about the growing access problems to scientific infrastructure, a very recent initiative by the European Union is now requiring all scientific publications that have received EU funding to be fully open access by 2020.[537]

3. Technological infrastructure

Technological infrastructure can arise from the market in at least three ways. First, as discussed in detail in chapters 1 and 2 of this thesis, a technological innovation or dominant design can achieve wide-spread adoption in a market due to the demand-side effect of network externalities.[538] Technological convergence and the requirements of interoperability can drive both supply and demand sides within a market to settle on a single solution to a particular technological requirement. These market forces can then transform the asset from being a specific product to an abstract 'standard'. For example, when the Windows operating system ('OS')[539] was first introduced in 1985 it was simply one among many operating systems, including UNIX and OS/2. However, its success in the marketplace among both consumers and suppliers (in particular, its tight coupling to the x-86 chip architecture[540]), led to its specific features being abstracted away into a 'standard': it exposed a richer API[541] to application developers, who then developed various 'killer' apps, leveraging the economics of two-sided markets to drive both consumer and supplier adoption. This led the Windows OS to become the *de facto* standard for PC operating systems, a position it still retains, (though increasingly tenuously[542]) to this day. Crucially, the supply-side components of genericness and non-rivalry were already inherent in the concept of an operating system[543], but it was the market success and network effects which drove it to its infrastructural status. The success of Windows also resulted in the demise of competing operating systems.[544]Indeed, the risks inherent in dynamic competition for 'generic' technological assets (and the stochastic process by which the market selects 'winners'[545]) has contributed to the emergence of the second

537. Nadia Khomami, 'All Scientific Papers To Be Free By 2020 Under EU Proposals' (*The Guardian*, 28 May 2016) <https://www.theguardian.com/science/2016/may/28/eu-ministers-2020-target-free-access-scientific-papers > accessed 14 October 2016.
538. Farrell and Klemperer, 'Coordination and Lock-in'; Arthur, 'Increasing Returns and the New World of Business'.
539. Although up until the release of Windows XP, MS Windows was actually a graphical 'shell' for the underlying MS-DOS OS.
540. Mair, 'Taking Technological Infrastructure Seriously'. Also see final chapter of this thesis for more detailed discussion of the x-86 architecture.
541. Application Programming Interface, or the set of functions and procedures that allows programmers to write software for a particular platform. A rudimentary was already available since the beginning of MS-DOS, but these were later greatly expanded in subsequent versions.
542. See the final chapter of this thesis for more detailed discussion on this point.
543. Barnett, 'The Host's Dilemma'.
544. This point could be debated, as in many ways Windows was unique in being a user-friendly home OS for private citizens. Its main competitor was actually its predecessor, MS-DOS, rather than UNIX, which retained its use for scientific, commercial and computation-intensive use-cases.
545. Arthur, 'Competing Technologies'.

way in which technological infrastructure can arise - the process of cooperative standard-setting. As described in chapter 1, the requirement of interoperability in technology markets combined with the high stakes and probabilities of losing standards wars, has created strong incentives for companies to cooperate on upstream infrastructural assets in order to compete in a shared downstream market of interoperable products.[546] Companies agree ex ante to define a standard, which is then implemented in specific products downstream.[547] Both these examples of *de facto* and cooperatively-set standards meet the definition of intellectual infrastructure, by being generic, non-rival information resources which feed into and sustain significant downstream value creation, as argued for in detail in chapters 1 and 2. However, unlike scientific infrastructure, these information assets are built up of components that usually fall squarely[548] within protectable IP subject matter, making them 'technological infrastructure' according to the definition of this thesis. While their economic functions may be generic, their constituent components are highly specific. For this reason the access regimes to both *de facto* and *de jure* standards have caused significant controversy and attracted antitrust intervention (including the *ex ante*[549] and *ex post*[550] application of competition law), and are only recently starting to find a semblance of organisation.[551]

The third way technological infrastructure can arise from the market derives from the nature of the IP system itself, particularly patents. The case of 'first inventor patents' or 'pioneering patents' refers to patents that are the first contribution to a technological area. Often these patents are necessarily broad because the technological area is still in its infancy and poorly defined. Famous historical examples of pioneering patents may include Watson's 1769 high-pressure steam patent[552], early solutions to technical problems of the sewing machine[553], and Edison's patent over incandescent lighting.[554] These examples of pioneer patents were all extensively litigated and are often cited as cases where the granting of over-broad patents

546. Mair, 'Intellectual Property'.
547. Jones, 'Standard-Essential Patents'.
548. This is generally the case because technologies included in standards are derived from the technological frontier, and so are often novel, inventive, and have industrial application (the criteria for patentability under the EPC, sections 54, 56 and 57).
549. Ex ante competition law regimes include the *Horizontal Guidelines and* Commission Regulation (EU) No 316/2014 of 21 March 2014 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to categories of technology transfer agreements and *Communication from the Commission Guidelines on the Application of Article 101 of the Treaty on the Functioning of the European Union to Technology Transfer Agreements*, OJ C 89 28.4.2014
550. *i.e.,* the essential facilities doctrine or the 'infrastructural approach' developed in Mair, 'Taking Technological Infrastructure Seriously; Petrovcic, 'Patent Hold-Up'; Lemley and Shapiro, 'Simple Approach'; Geradin, 'Pricing Abuses'.
551. Unified into the 'Infrastructural Approach' suggested by chapter 1 of this thesis.
552. George Selgin and John L Turner, 'Strong Steam, Weak Patents, or the Myth of Watt's Innovation-Blocking Monopoly, Exploded' (2011) 54(4) J Law & Econ 841.
553. Mossoff, 'The Rise and Fall'.
554. Arthur A Bright Jr., *The Electric-Lamp Industry: Technological Change and Economic Development from 1800 to 1947* (MIT 1949) 88–91.

significantly retarded follow-on innovation,[555] making them prime candidates for technological infrastructure as well as 'general purpose technologies'. It is important to underline the essential difference between broad patents constituting technological infrastructure and the case of *de facto* standards discussed first in this section, as the two may be easily confused. *De facto* standards achieve their infrastructural status mainly due to effects on the demand-side, i.e. network effects and 'tipping'. In many cases, there is a certain amount of stochasticity in the market's selection of a 'winner' from a standards war[556], as often the true value of a *de facto* standard is the fact that there is a standard at all, rather than the specific features of any one.[557] In the case of pioneering patents constituting technological infrastructure, this is not the case at all: the patent usually embodies a radical innovation that is a significant contribution to the state of the art. If follow-on innovators demonstrate a relatively inelastic demand for the technological infrastructure, it is not due to 'lock-in' caused by switching costs (as is often the case in *de facto* standards), but by the fact the pioneering patent is a genuinely radical innovation which has no substitutes, and is often of broad scope. In markets of complex technologies, genuine radical innovations are often a synthesis of pre-existing component technologies[558], which may implicate dozens if not hundreds of essential patents in order to practice the pioneering invention, such as *e.g.,* wireless charging (implicating patents over wireless protocols, magnetic resonance and batteries)[559], or 3-D printing (implicating patents over *e.g.,* plastics, semiconductors and robotics).[560]

The issue of patent scope with respect to pioneering patents is a difficult one[561], as it goes to the heart of patent theory.[562] Some patent systems (for example, the German Patent Act and

555. For discussion of Edison's incandescent lighting patent see Wu 'Intellectual Property, Innovation, and Decentralized Decisions'.
556. Stan J Liebowitz and Stephen E. Margolis, 'Path Dependence, Lock-In, and History' (1995) 11(1) J L Econ & Org 205; Arthur, 'Competing Technologies'; Mair, 'Taking Technological Infrastructure Seriously'.
557. Consider an operating system as discussed in chapter 2. The value of an operating system inheres more in its downstream 'application ecosystem' rather than in the specific attributes of the OS itself which may interest only the specialist. Also see chapter 1 of this thesis for more detail on this point, as well as the Preface, which quotes a similar argument from the OPUS organisation.
558. Willam B Arthur, 'The Structure of Invention' (2007) 36(2) Research Policy 274, 285: ("[i]nvention is not an event signaled by some striking breakthrough…In the end the problem must be solved with pieces – components – that already exist (or pieces that can be created from ones that already exist). To invent something is to find it in what previously exists.")
559. LexInnova, 'Wireless Power: Patent landscape Analysis', WIPO (2015) <http://www.wipo.int/export/sites/www/patentscope/en/programs/patent_landscapes/documents/lexinnova_plr_wireless_power.pdf> accessed 13 October 2016.
560. '3D Printing: a Patent Overview Report' (UK Intellectual Property Office, 2013) <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445232/3D_Printing_Report.pdf> accessed 13 October 2016.
561. Merges and Nelson, 'On the Complex Economics of Patent Scope'; John R Thomas, 'The Question Concerning Patent Law and Pioneer Inventions' (1995) 10 Berkeley Tech LJ 35.
562. Which in some ways attempts to channel incentives towards radical innovations or technological 'prospects', Edmund W Kitch, 'The Nature and Function of the Patent System' (1977) 20(2) J L & Econ 265 ("Kitch,'The Nature and Function of the Patent System'").

French patent law) [563] have specific rules regarding follow-on innovation to such patents, which include mandatory licensing in the form of 'dependency licenses'. [564] However, not all jurisdictions provide for such licenses, meaning that the issue of access to pioneer patents may have to be dealt with by the ex post operation of competition law as argued in chapters 1 and 2 of this thesis.[565] Part IV of this chapter develops an alternative approach to these options in the context of subsidised R&D by including ex ante rules/incentives within the structure of the subsidy grant.

As will be argued below, information outputs under a subsidised R&D regime are more likely than the IP-enhanced market to give rise to such general purpose technologies and intellectual infrastructure, leading to pioneering patents and generating specific problems relating to the mixed IP/subsidy provisioning system. Developing these arguments is the nub of Section B(4) below. Parts III and IV will then explain how the institutions of IP and subsidies may have a role to play in ensuring the openness of such technological infrastructural involving pioneering IP.

4. Technological infrastructure arising under a subsidised R&D regime

The three ways technological infrastructure can arise from the *unaided* market have been summarised above, but there is an additional way technological infrastructure can emerge, which is a variation of the third category of pioneering inventions: when the market mechanism of IP is 'enhanced' by an R&D subsidy. Much has already been written about the interaction of R&D subsidies and IP in the context of the Bayh-Dole regime.[566] However, insufficient attention has been given to the nature of the information assets that are likely to arise from this interaction. This is surprising because it is clear without much inspection that IP assets arising from subsidised R&D are a unique class of assets, distinguished from market-driven information assets along a number of axes. First, R&D subsidies operate in the a space where both the competitive market and the IP system fail to deliver the goods, such as under conditions where the desired output approximates a pure public good, or where R&D investments are prone to excessive risk or 'Knightian uncertainty'.[567] As discussed in Section A(2), the institution of R&D subsidies is often recruited to operate with the IP system in order to stimulate the emergence of high risk/uncertain[568] 'radical' innovations. R&D subsidies

563. See e.g. *Patentgesetz,* 16 December 1980 , <http://www.wipo.int/wipolex/en/text.jsp?file_id=401424> accessed 13 October 2016.
564. Kaseberg, *Intellectual Property*, 122. ("...one 'internal' IP solution provided under, for example, the German Patent Act and the French law on improvements on patented inventions is a compulsory license in the form of a dependency license.")
565. Ibid.
566. Mowery and Sampat, 'The Bayh-Dole Act of 1980'; Sweeney 'Correcting Bayh-Dole's Inefficiencies for the Taxpayer'; Eisenberg and Rai 'Bayh-Dole Reform'; Eisenberg 'Public Research and Private Development'.
567. Mazzucato, *The Entrepreneurial State* (2011).
568. Commission, 'Framework For State Aid For Research and Development and Innovation' (Communication)

would likely be unavailable for mere incremental innovations, as risk and uncertainty would be low, and the projected social value of incremental R&D projects would also be unlikely to attract a subsidy.[569] A well-working subsidy system generally prioritises projects with large 'external effects' (i.e. high social value in the form of spillovers, (see Section A(1)) and that yield outputs which are generic. As Nicolaides argues[570]:

> Knowledge of more general nature or with multiple applications tends to be neglected. Yet, it is probably this type of knowledge that is more valuable to society at large. It appears reasonable that society should subsidise to a larger extent knowledge with larger external effects.

In the above excerpt, Nicolaides suggests that generic information assets with high social value are worthy subsidy targets. Given the nature of both scientific and technological research trajectories, R&D outputs are only likely to be of a 'general' rather than a 'specific' nature in cases where a research or technical area is relatively or completely novel.[571] In cases where IP is also available over the R&D outputs, then the latter are likely to be both high risk/uncertain and generic. As discussed in 1.2(iii), such radical innovations would likely give rise to general purpose technologies implicating 'pioneer patents'. These attributes provide the supply-side conditions for the R&D outputs to be qualified as potential technological infrastructure. The demand-side conditions (i.e. that the information resource actually performs the role of scaffolding downstream productivity) also depends on whether the resource is substitutable. Under European competition law, a crucial component of the test for whether an asset is infrastructural to a market or market(s) is whether access to it is a *conditio sine qua non* for effective competition. According to Advocate-General Jacobs in *Bronner*:[572]

> I do not rule out the possibility that the cost of duplicating a facility might alone constitute an insuperable barrier to entry. That might be so particularly in cases in which the creation of the facility took place under non-competitive conditions, for example, partly through public funding. (added emphasis)

C(2014) 3282, 21-23.
569. Nicolaides, 'The Economics of Subsidies for R&D'.
570. Ibid.
571. See also Thomas Kuhn's 'normal' science versus 'revolutionary' science dichotomy, in *Kuhn, The Structure of Scientific Revolutions.*
572. *Bronner*, Opinion of AG Jacobs (emphasis added).

Although as far as the author is aware, the above situation has not been a feature of any recent competition law cases[573], it is reasonable to infer that the public subsidisation of an IP-protected, generic information resource would create a rebuttable presumption that the latter is non-duplicable by the private sector. This would mean that access to it is a *sine qua non* for follow-on innovation. Furthermore, on the demand-side it is not necessary under European competition law for the information resource to currently function as a necessary input to downstream companies in order to be qualified as infrastructural: 'it is sufficient that there is demand from potential purchasers and that a potential market for the input at stake can be identified'.[574] Given the above, and the analysis on pioneering patents in Section B(3), it is argued that the R&D outputs arising from the mixed IP/subsidy regime of Bayh-Dole are likely to be qualified as technological infrastructure.[575]

The above theoretical argument is also supported by some empirical data, which suggests that the role of public money in the innovation system is generally associated with reducing the risk and uncertainty of pioneering, radical innovation.[576] As argued by Mariana Mazzucato, empirical evidence demonstrates that[577]:

> …from the development of aviation, nuclear energy, computers, the internet, the biotechnology revolution, nanotechnology and even now in green technology, it is, and has been, the state not the private sector that has kick-started and developed the engine of growth, because of its willingness to take risk in areas where the private sector has been too risk-averse.

The US Defense Advanced Research Projects Agency' ('DARPA') explicitly endorses the mission statement of 'taking on risk, and high risk in pursuit of high payoff'[578] (as well as

573. State-sponsored monopolists or regulated monopolies (such as recipients of state aid or Services in the General Economic Interest, which are transitioning towards liberalisation) have traditionally been the main targets of the EFD in both the EU and US. See Frischmann and Waller, 'Revitalizing Essential Facilities' 8 ("The best cases for the essential facilities model typically involve the denial of access to infrastructure and networks, particularly in the context of regulated industries in transition"). It should be noted that in relation to SGEIs, the EU competition laws only apply in so far as 'the application of such rules does not obstruct the performance, in law or in fact, of the particular task assigned to them'. See *Joined Cases* C-115/97 Brentjes [1999] [ECR I-6025. In cases where an SGEI has been given an exclusive task, therefore, it is unlikely that the language quoted above in *Bronner* could be used in order to require compulsory licensing under the essential facilities doctrine.
574. Guidance on Article 82 EC [now 102 TFEU], para 79.
575. It is not suggested that Art102 TFEU would actually apply in such cases (State Aid rules would probably supercede), but just for the sake of analysis, such assets would likely meet the requirements under AG Jacob's reasoning in *Bronner*.
576. Mazzucato, *The Entrepreneurial State, 21-23*.
577. Ibid, 23.
578. DARPA, 'Our Research' <http://www.darpa.mil/our-research>.

often adopting an open access licensing approach, as will be discussed in Part III, Section B). In addition, a cursory look at the European Framework Programme 7 subsidised R&D projects also supports the hypothesis that such projects generally do have a pioneering flavour, with project titles ranging from 'musculoskeletal robot development'[579], to 'nanocomputing building blocks with acquired behaviour'.[580] Although one cannot discount the possibility that a certain amount of 'gaming' of the European subsidy programme is taking place (see discussion in Part IV), the novelty and inventiveness of such projects will also undergo an additional layer of scrutiny when patents over the outputs are filed.[581] As we are concerned here only with subsidised R&D that *does* result in patents, it is reasonable to infer that such patents will be in some sense 'pioneering' patents of broad scope. Such patents are therefore likely to belong to the class of technological infrastructure, in the sense of being required inputs for follow-on innovation in the subsidy target area.

As already mentioned, the Bayh-Dole regime as implemented in European R&D subsidy policy allocates all resulting IP to the subsidy recipient. The key question confronted by the remaining parts of this chapter is whether or not such a regime of exclusive rights allocation is the best resource management strategy for such assets. Section B(1) developed the argument that technological infrastructure and open access licensing are intrinsically linked due to social welfare considerations. However, this point needs further development in order to go through, as the economic arguments supporting exclusive rights as both an incentivisation mechanism and as a mechanism for efficient technology transfer are deeply entrenched in traditional information economics and innovation theory.[582]

It is the task of Part III to engage in a detailed analysis of the economics of IP, aiming to apply pressure to a number of key struts, as they apply generally and also in the specific case of technological infrastructure, including revealing the inherently regulatory nature of IP by using tools from game theory. Part IV will then unpack in greater detail the economics behind subsidies with respect to the same. Part V will then conclude.

III. THE INSTITUTION OF INTELLECTUAL PROPERTY

579. CORDIS, 'A Framework For Musculoskeletal Robot Development' (MYOROBOTICS –FP7-ICT-2011-7) <http://cordis.europa.eu/project/rcn/102206_en.html> accessed 14 October 2016.
580. CORDIS, 'FP7:FET Proactive Initiative: NANO-SCALE ICT DEVICES AND SYSTEMS', <http://cordis.europa.eu/fp7/ict/fet-proactive/nanoict_en.html> accessed 14 October 2016.
581. It is submitted that this second layer of screening of the inventiveness of subsidised information outputs would help control the private gaming of the subsidy system, at least with respect to subsidised projects yielding registrable intellectual property rights.
582. See e.g. Kitch, 'The Nature and Function of the Patent System' (1977); Epstein, 'What Is So Special about Intangible Property?'; Harold Demsetz, 'Toward a Theory of Property Rights' (1967) 57(2) Am Econ Rev 347.

The purpose of this Part is to assess exclusive intellectual property rights as an institutional arrangement for managing technological infrastructure. In order to do this, first the economic foundations of IP as a 'spillover' internalisation mechanism will be unpacked (Section A). Section B then focuses on IP as a mechanism for technology transfer, by looking into the commonly-held idea that exclusive rights and discrete propertisation drive dissemination of information assets via the vehicle of commercialisation. Section C then kicks off the critical approach, by putting pressure on the 'IP as property' model by deploying game theoretical tools.

A. Intellectual Property and Spillovers

From an economic perspective, the instrumental purpose of intellectual property is to increase the level of socially beneficial spillovers by creating a mechanism for innovators to privately appropriate a greater proportion of the value of their inventions and creations. In essence, spillovers and private appropriation (incentivisation) are two sides of the same coin. By granting innovators a time-limited[583] intellectual property right over their inventions and creations, innovators benefit from enforcing exclusivity over their information assets. Nevertheless, spillovers still persist under the latter: only, they tend manifest around the 'edges' of the IP right, for example, in the form of patent design-arounds, and in the 'signalling' effect of IP[584] – the market learns that something is possible if only because somebody else has done it.[585]

Spillovers may also be generated by the imperfections of the IP system. As will be discussed in Section C, IP is unlike real property, where possession itself can be leveraged to enforce exclusivity without always requiring public intervention.[586] The intangible and fugitive nature of IP means that IP holders rely on public intervention (in the form of the courts) in order for their rights to be activated at all.[587] Infringers can often get away with 'ripoffs' due to, for example: producing ripoffs in quantities which fall below the efficient threshold for IP owners to seek judicial remedies, legal carve-outs for 'fair use' and 'experimental use' doctrines[588], or simply by avoiding detection[589]. The fact that IP requires public intervention in order for the right to be activated is a key component of the critique of the 'property model'

583. In addition to all these types of spillovers, it should also be noted that once the IP right expires, of course, it then enters the public domain and is freely available as in information input to other innovators.
584. Clarisa Long, 'Patent Signals', (2002) 69 U Chicago L Rev 625.
585. Wagner, 'Information Wants To Be Free' (2003); Arrow 'Technical Information', 649: ("[t]he appearance of a product on the market automatically conveys information; if nothing else, the information that the product can be produced. The existence of the product is a signal that the product can be produced.")
586. Rubin,'The Illusion of Property'; Lemley, 'Response: Taking the Regulatory Nature of IP Seriously'.
587. Unless of course technical measures to ensure exclusivity are used in the case of digital goods, such as are permitted under Art 6 of the 'Information Society Directive' 2001/29/EC.
588. See Part II, Section B(1) 'Intellectual Infrastructure'.
589. Mark A Lemley, 'Ignoring Patents' (2008) 19 Mich St L Rev 19 ("Lemley, 'Ignoring Patents'").

of IP developed in Section C(1) below, which aims to situate IP as market regulation rather than property.

It is clear then that despite the instrumental purpose of IP to work as an 'appropriability mechanism', spillovers still persist- and remain, in many ways, a core motivation behind IP.[590] Rather than being at odds with the development of a rich and diverse public domain and 'information commons', some IP scholars[591] argue that a strong IP system actually helps to promote the latter. The argument runs that unless innovators are granted the kind of legal exclusivity provided for by IP, the default position would be to keep inventions and creations secret[592] (in so far as they are created or invented at all[593]) rather than to disclose them to the public (see also Section C(1) for a game theoretical analysis of these dynamics).[594] By ensuring that innovators can still appropriate value from their innovations notwithstanding public disclosure, the IP system helps to liberate information assets from the darkness of invention journals and laboratories and bring them out into the light of public inspection- where they can give rise to the spillovers identified above.

Despite the rough alignment between private appropriation and socially valuable spillovers described above, the institution of IP still embodies a significant tension between private value appropriation and social welfare. This tension is often characterised as society having to engage in a trade-off between 'static' and 'dynamic' efficiencies. The term 'static efficiency' refers to the single-period maximising pareto-efficient conditions for the pricing and quantity of the information embedded in the IP. The work of Kenneth Arrow in his classic 1962 paper, *Economic Welfare and the Allocation of Resources for Invention*[595], established (and proved mathematically) the modern consensus that the price that ensures efficient allocation is equal to marginal cost, which in the case of an information asset, is zero.[596] By inducing 'artificial scarcity' of knowledge assets, the IP system facilitates the violation of this first-order efficiency condition and replaces it with the 'second order' condition of maximising

590. Lemley and Frischmann, 'Spillovers'.
591. Wagner, 'Information Wants to Be Free'.
592. Shubha Ghosh, 'How to Build a Commons: Is Intellectual Property Constrictive, Facilitating, or Irrelevant?' in Charlotte Hess and Elinor Ostrom (eds), *Understanding Knowledge as a Commons: From Theory to Practice*' (MIT Press 2007), 216-219; also see Wagner, 'Information Wants to Be Free' (on his "Type III information", which is not appropriable but which stimulates further indirect information production).
593. A traditional model of IP suggests that without the existence of intellectual property laws, certain categories of creations and inventions may not be invented or created at all.
594. But the usefulness of such disclosures is often not as high as one might like, see Lisa Larrimore Ouellette, 'Do Patents Disclose Useful Information?' (2012) 25(2) Harv J Law & Tech 545.
595. Kenneth J Arrow, 'Economic Welfare and the Allocation of Resources for Invention' in National Bureau for Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors* (Princeton University Press 1962).
596. Because the reproduction of information requires no resources, except indirectly (in the form of the materials used, if any, for information transfer). This is also one of the outcomes of the First Fundamental Theorem of Welfare Economics, which sets marginal cost to price.

'dynamic' efficiency' - the incentives to engage in technological innovation. A compelling, if heterodox[597], early justification for this static/dynamic efficiency trade-off derives from the work of Joseph Schumpeter, who suggested in his book *Capitalism, Socialism and Democracy*[598], that IP such as patents have a 'propelling' effect, despite the loss of static efficiency:

> the protection afforded by patents…is…on balance a propelling and not an inhibiting factor.

Schumpeter supported this claim by appealing to his novel vision of the economy as one in constant 'turmoil', continuously revolutionised from within by risk-taking entrepreneurs vying to assign each other to oblivion with the next technological innovation. Powering Schumpeter's radical vision of the entrepreneurial economy are supra-competitive profits in the form of monopoly rents, which pick up the bill for the heavy R&D investments required to drive innovation. The concomitant deadweight losses which society sometimes pays due to monopoly pricing is in exchange for the continued inventive and creative effort expended by the monopolist – who must keep on running, as it were, in order to stay still.[599] The inventive and creative effort is argued to shake out in spillovers that enter the economy both micro-economically (in the form of process and product enhancements) and macro-economically (in the form of economic growth.)

Appeals to theories of dynamic competition such as those developed by Schumpeter above are regularly used to justify concentrations of power within markets characterised by high innovative activity.[600] While these arguments often have some purchase in relation to some high-technology products, they encounter difficulty when deployed in support of exclusive rights over products with infrastructural attributes. In the case of most resource types, including IP-protected resources, this 'dynamic competition' model can function well since private decisions may be driven towards optimal social outcomes due to actual supply side substitution (or the threat of the same) and elastic demand. The common conception that IP generally leads to monopoly or supra-competitive pricing is false in many cases due to the dynamic disciplining effect of firm entry.[601] If the asset owner is greedy or stupid, other suppliers can push them from the market and buyers can switch suppliers, or choose not to purchase the asset at all.[602] Under such conditions, top down decision-making with regard to

597. Because this model went against traditional economic model that high market concentrations were not good for the economy.
598. Schumpeter, *Capitalism, Socialism, and Democracy*.
599. Also referred to as the 'Red Queen Effect'. Daron Acemoglu, Gino Gancia and Fabrizio Zilibotti, 'Competing Engines of Growth: Innovation and Standardization', (2012) 147(2) J Econ Theory 570.
600. Ibid; Economides, 'Antitrust Issues In Network Industries'; Priest, 'Rethinking Antitrust Law'.
601. See useful summary in Langlois, 'Technological Standards'.
602. Lemley, 'The Regulatory Turn in IP', 109-110 ("[b]ut market decision-making is efficient largely because when

resources is in a sense 'democratised' into emergent 'market decisions'. However, in the case of technological infrastructure, these trade-offs start to sharpen. In such cases, not only is the resource non-substitutable (or non-duplicable[603]) but the demand manifested by downstream companies becomes inelastic:[604] if downstream markets and competition are to exist at all, access to the resource is required; IP becomes a barrier to entry that cannot be justified by dynamic social welfare concerns.[605]

Technological infrastructure in the form of *de facto* standards, cooperatively-set standards, and pioneering inventions are unique in how they affect the marketplace because they exist, in many ways, *outside* of the market. In the language of spillovers: technological infrastructure is a locus of considerable potential downstream value creation and spillovers due to its scaffolding role, but this also makes it a target for anticompetitive behaviour which attempts to internalise those spillovers. Where there is value creation, there is also the opportunity for value appropriation. Since spillovers and private value appropriation are two sides of the same coin as argued in the beginning of this section, it is often the target of strategic behaviour to capture it with private rights, as argued in the following Section B on technological transfer, and in Section C(3) on 'property traps'.

As will be discussed further below, while the existence of IP is often conflated with the economic justifications for real property and efficient markets (and therefore, with the idea that private incentives track optimal social goals), their use may lead to situations of 'IP failure'[606] in relation to infrastructural assets. While competition law casts a shadow over technological infrastructure emerging as both *de facto* and cooperatively-set standards (as discussed in chapters 1 and 2), pioneering inventions which emerge via subsidised R&D presents an opportunity to apply another approach, by creating incentives for open access within the structure of the subsidy grant itself. Ex ante regulation is generally to be preferred over ex post enforcement because it allows private companies the opportunity to self-organise and pre-empts the social costs associated with type 1 and 2 enforcement errors.[607]

As further developed in Section C and Part IV of this chapter, it is suggested that the subsidy system can operate to ensure open access over technological infrastructure, by restructuring incentives ex ante via modifications to the subsidy grant policy. Before that argument

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stupid, greedy, or shortsighted people in the private sector make poor decisions, they are overthrown by people who make correct decisions. For private decision-making to produce efficient decisions, there must be a competitive market.")

603. See discussion in chapter 1.2(iii)

604. This is of course a factual issue and must be shown to hold true case by case.

605. 'Objective justifications' is a possible defense in such cases, but requires demonstration that exclusivity and denial of access increases social welfare compared to an open access scenario. Microsoft case. See discussion in chapter 2.

606. *i.e.,* not market failures but IP failures, in terms of achieving its social goals – which is to stimulate innovation

607. Easterbrook, 'Limits of Antitrust'.

is developed, it is important to assess the prevalent economic theories surrounding the technology transfer function of IP in more detail.

B. Technology Transfer Function of IP

In the context of the US Bayh-Dole Act and its European transplants, it is the use of IP as an efficient technology transfer mechanism (both for licensing and improvement), which is the overriding justification for the private allocation of outputs arising out of subsidised R&D.[608] In the US context, the motivation behind the private allocation of sponsored R&D results (as opposed to liberating them to the public domain or retaining Government ownership) has been described as follows:

> If the results of federally-sponsored research were to be rescued from oblivion and successfully developed into commercial products, they would have to be patented and offered up for private appropriation.

In the European R&D subsidy programmes- such as Framework Programme 7 and Horizon 2020- the private allocation of IP also embeds the assumption that 'the technology will be transferred and immediately used by the entity that can create most value out of it.'[609]

A central strut of this approach as applied to IP makes the claim that where knowledge assets are brought within the property system, decisions over resource allocation are decentralised and distributed among the market participants. This combination of 'decentralisation' and property rights enables innovators to harness the information signals from the price system into their investment decisions about where to direct their resources.[610] According to Paul Goldstein[611], unless information products are brought under a property regime, innovators would be left 'blind' to market forces, by being 'depriv[ed] of the signals of consumer preference that trigger and direct their investments'[612], and will be unable to efficiently allocate their resources. This point goes to the utility of IP in ensuring the directional efficiency of R&D efforts. This position is also often buttressed by the observation of some IP scholars that the exclusive nature of these IP rights helps to parcel out the information resources in efficient

608. Dreyfuss, 'Double or Nothing', 53 ("[t]he expectation was that industry would adapt the advances, find applications, create new businesses and jobs, enhance productivity, and improve social welfare.")
609. Mario Cisneros, 'EU State Aid Policy: A Model to Assess Intellectual Property Rights and Knowledge Dissemination in R&D Cooperation' (European Commission 2014) 12 <http://ec.europa.eu/competition/consultations/2013_state_aid_rdi/cisneros_mario_en.pdf> accessed 4 August 2016.
610. Friedrich A Hayek, 'The Use of Knowledge in Society' (1945) 35(4) Am Econ Rev 519.
611. As quoted in William Fisher, 'Theories of Intellectual Property' in Stephen Munzer (ed), *New Essays in the Legal and Political Theory of Property* (Cambridge University Press 2001) 183.
612. See ibid, 183("[t]o stop short of these ends would deprive producers of the signals of consumer preference that trigger and direct their investments".)

'bundles', which aids in the process of technology transfer – ensuring that the resources are allocated to their most productive uses without incurring excessive transaction costs.[613]

Prominent defenders of this model of IP as property include Edmund Kitch[614], Richard Epstein[615] and Harold Demsetz.[616] While recognising the incentive effect of IP, these scholars, in their different ways, tend to emphasise the function of IP as a technology transfer mechanism. According to Kitch[617], a patent operates much like a 'prospect' in mineral mining, where the resource owner retains exclusive control and is able to manage and direct the applications of, and access to, the resource. This sole control over the resource allows society to avoid wasteful duplicative R&D investments[618], as well as helping to organise follow-on innovation investments. By owning exclusive rights over an information resource, the IP owner gets to act as 'gate keeper' over the resource and society gets to avoid a 'tragedy of the commons' of resource underinvestment.[619] Epstein adds to this argument by stressing the primacy of exclusivity in facilitating 'the cooperation between any two or more parties by allowing for the division of property rights and coordination of labor on whatever terms and conditions they see fit'.[620] In short, for Epstein, part of the power of the exclusive nature of IP is (perhaps paradoxically) in permitting the resource owners' choice when not to be exclusive: in furnishing the tools to encourage cooperative behaviour.[621] For Epstein, the problems associated with the emergence of scientific and technology 'anticommons' are caused by too little rather than too much propertisation, as property rights and their technological transfer function go hand in hand.[622] Harold Demsetz adds an extra gloss to this approach by situating the propertisation of knowledge resources within an overall theory of property evolution, and arguing that the propertisation of information assets helps to reduce social cost and increases

613. F. Scott Kieff, 'Property Rights and Property Rules for Commercializing Inventions' (2001) 85 Minn L Rev 697.
614. Kitch, 'The Nature and Function of the Patent System'. Michael Abramowicz, 'The Danger of Underdeveloped Patent Prospects' (2007) 92 Cornell L Rev 1065.
615. Epstein, 'What Is So Special about Intangible Property?'.
616. Demsetz 'Information and Efficiency'; Demsetz, 'Toward a Theory of Property Rights'; Harold Demsetz, 'Barriers to Entry' (1982) 72(1) Amer Econ Rev 47.
617. Kitch, 'The Nature and Function of the Patent System'.
618. But it may also lead to wasteful 'patent races', see the seminal article Christopher Harris and John Vickers, 'Patent Races and the Persistence of Monopoly' (1985) 33(4) J Indus Econ 461.
619. Although often not applicable to knowledge goods because of their non-rival nature, Kitch has resurrected the argument in his prospect theory by arguing that lack of exclusive control over the resource would lead to underuse of the asset. Lemley, 'Economics of Improvement' ("Kitch makes an analogous argument: that the private incentive to improve and market an invention will be less than the social value of such efforts unless the patent owner is given exclusive control over all such improvements and marketing efforts.") This idea has been empirically challenged in Merges, 'On the Complex Economics of Patent Scope' (1990)
620. Epstein, 'What Is So Special about Intangible Property?'
621. Ibid.
622. Ibid, 49 ("The second limitation that attaches to the basic system of property rights deals with the ability to use contractual devices for the purposes of exchange or cooperation. Exchange and cooperation normally increase the size of the pie and thus are welcome."); Richard A Epstein, 'Why There Is Too Little, Not Too Much, Private Property' (2011) 53 Arizona L Rev 51.

social value, by making such resources 'tradable' in the Coasean sense.[623] In Demsetz's 1969 paper *Information and Efficiency: Another View Point*[624] (drafted as a response to Arrow's classic 1962 paper[625]), Demsetz argues that as positive spillovers increase, there is pressure on the property system to expand to privatise information goods so as to internalise the spillovers. Since the pattern of spillovers changes in relation to technological developments, it is often argued by neo-Demsetzians[626] that as today's information economy expands, more propertisation is needed of the information space.[627] One powerful interpretation of the actual mechanism at play relies on the idea that information products without clearly defined rights engender high transaction costs and thus inefficiency, leading to social cost. This social cost is signalled in both the political system (perhaps by lobbying[628]) and via the Courts (in disputes over misappropriation) to lead to the evolution of property rights in hither-to under-propertised areas.[629] The greater internalisation of the social benefits of information goods by innovators facilitated by the IP system is argued to realign private benefits with social benefits and therefore leads to more innovation, better and more efficient technology transfer, and greater spillovers. The latter effect is due to the fact that spillovers are often an increasing geometric function of R&D investment, rather than an arithmetic one.[630] This account of the evolutionary development of IP will be discussed and critiqued in greater detail in Section C.

All the above reasoning is underwritten by the intuition that IP facilitates technology transfer via the vehicle of commercialisation. The Bayh-Dole regime as adapted by the EU subsidy regime attempts to recruit this technology transfer component of IP by allocating exclusive rights to the subsidy recipient. However, as argued in Section A above, although IP-driven technological transfer may work well for a large number of IP-protected information assets, the arguments cannot be imported whole-sale into all categories of information goods, as IP-protected technological infrastructure presents special difficulties. In particular, the IP-driven technology transfer as commercialisation argument presents a model that is essentially top-down: the access decisions are made on the supply side rather than the demand side. The deficiencies of this approach and the arguments for open access were already discussed

623. Brett M Frischmann and Alain Marciano, 'Understanding the Problem of Social Cost' (2014) Cardozo Legal Studies Research Paper No 435 <http://doi.org/10.2139/ssrn.2445819> accessed 14 October 2016.
624. Demsetz, 'Information and Efficiency'.
625. Kenneth J Arrow, 'Economic Welfare and the Allocation of Resources for Invention'.
626. *E.g.,* Kieff, 'Property Rights and Property Rules'.
627. Ibid.
628. Robert P Merges, 'From Medieval Guilds to Open Source Software: Informal Norms, Appropriability Institutions, and Innovation' (2005) Social Science Research Network <http://www.ssrn.com/abstract=661543> accessed 14 October 2016.
629. According James E Krier, 'Evolutionary Theory and the Origin of Property Rights' (2009) 95 Cornell L Rev 139, 142 ("Krier, 'Evolutionary Theory'") ("Demsetz's idea of the actual progress is something like they result from 'gradual changes in social mores and in common law precedents,' themselves to some degree the product of 'legal and moral experiments'-'hit-and-miss procedures' that select in favour of cost-minimizing approaches").
630. Mair, 'Taking Technological Infrastructure Seriously'.

in Part II, Section B and will not be rehearsed again here. But it should be underlined that the Bayh-Dole approach to IP allocation may still retain some force even with respect to technological infrastructure if it is conclusively shown that IP released under open access terms is somehow underutilised compared to those released under an exclusive IP regime. It is submitted that although this position may have been justified in 1980s, when the Bayh-Dole Act came into force (and perhaps even for the subsequent two decades), there are now a range of modern technology transfer mechanisms which exist that have been shown to function admirably for the dissemination of open access resources. For example, with respect to open source software, there are a number of online repositories where developers can both post, download and modify source code, such as Github[631] and Source Forge.[632] These online repositories enable downstream users to search and browse existing repositories, including by category type, programming language, or industry. Far from needing to be 'rescued from oblivion' by exclusive IP rights, these open access software products are universally available, easily searchable, and expanding every day.[633]

The model of making open source software available in a single repository has been so successful that it has also become the model for the dissemination of some key publicly-subsidised software products as well as scientific results, at least in the US. The US 'Defense Advanced Research Projects Agency' ('DARPA') created its 'DARPA Open Catalog' in 2014[634], which is a portal for the release of both open source software and peer-reviewed publications (as well as experimental results) that emerge from sponsored R&D. [635] Historically, DARPA has also been a source of radical innovations released on open access terms, such as the early foundations of the Internet and interactive voice recognition software.[636] Recent open source projects released on DARPA's Open Catalog include powerful facial recognition software[637], as well as tools for improving security, and managing and analysing large data sets.[638] As already argued in Part II, Section B, all these R&D outputs tend to have a strong pioneering character, which makes them candidates for being qualified as technological infrastructure. By making the IP over these radical innovations open access, DARPA can be seen attempting to amplify the social impact of its publicly-subsidised R&D. DARPA's approach has recently also been followed up by NASA's parallel open access repositories.[639]

631. See GitHub <https://github.com/>.
632. See SourceForge <https://sourceforge.net/>.
633. James Boyle 'Open Source Innovation, Patent Injunctions, and the Public Interest' (2012) 388 Duke L & Tech Rev 30; Merges, 'From Medieval Guilds to Open Source Software'.
634. PHYS ORG, 'DARPA Open Catalog Makes Agency-Sponsored Software and Publications Available To All' (5 February 2014) <http://phys.org/news/2014-02-darpa-agency-sponsored-software.html>
635. DARPA, 'Open Catalog' <http://opencatalog.darpa.mil/>. Rather than holding the repositories, open catalog lists the projects and provides links to *e.g.*, github.
636. Johnny Ryan, *A History of the Internet and the Digital Future* (Reaktion Books 2010).
637. http://www.itl.nist.gov/iad/humanid/feret/feret_master.html.
638. See eg. 'XData', DARPA, 'Open Catalog' <http://www.darpa.mil/program/xdata>
639. NASA, 'NASA-Funded Research Results' <https://www.nasa.gov/open/researchaccess> accessed 14 October

Despite DARPA's and NASA's initiatives in ensuring the open access of key sponsored technological infrastructure, the economic arguments for open access over IP as a technology transfer mechanism are still far from mainstream. Nevertheless, open access approaches to infrastructural technologies continue to grow in the private sector, with a number of leading companies such as Twitter[640], Google[641], Tesla[642], Toyota[643] 'pledging' various key patents to be licensed for free without threat of litigation.[644] For example, Elon Musk's electric car start-up, Tesla Motors Inc (which, incidentally, has been a recipient of a reported 4.9 Billion USD[645] in R&D subsidies and other public sector financial aid) recently kicked-off its 'All Our Patents are Belong to You' [646]initiative. This patent 'non assertion pledge' essentially grants competitors a royalty-free patent license to its core technology patents, despite the company still being in a non-profitable phase of its development.[647] The economic logic behind Tesla's open access pledge seems to be the idea that (much like open source software[648]) competitors' use of its infrastructural technology will help with consumer acceptance, expand the market generally, and drive follow-on innovation from which the economy as a whole (and Tesla) will benefit,[649] by driving microeconomic and macroeconomic spillovers.

The above examples of open source software, DARPA's and NASA's open repositories, and Tesla's open patents pledge all apply pressure to the notion that exclusive IP rights are an essential component of technological transfer, at least with respect to infrastructural technologies. It is the purpose of the next section to continue this critique of exclusive IP rights by taking on the central idea driving the efficiency-based justifications for IP: that IP behaves like real property. It begins by deploying game theoretical tools to analyse the 'property' arguments as applied to IP in the work of scholars like Epstein, Goldstein and

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2016.

640. Adam Messinger, 'Introducing the Innovator's Patent Agreement' (*Twitter*, 17 April 2012) <https://blog.twitter.com/2012/introducing-the-innovator-s-patent-agreement> accessed 14 October 2016.

641. Google , 'Open Patent Non-Assertion Pledge' <https://www.google.com/patents/opnpledge/pledge/>.

642.Elon Musk, 'All Our Patent Are Belong To You' (*TESLA*, 12 June 2014) ("Musk, 'All Our Patent Are Belong To You'")<https://www.tesla.com/blog/all-our-patent-are-belong-you> accessed 14 October 2016.

643. Charlie Osborne, 'Toyota Pushes Hydrogen Fuel Cell Cars With Open Patent Portfoli' (*ZDNet*, 6 January 2015) <http://www.zdnet.com/article/toyota-pushes-hydrogen-fuel-cell-cars-with-open-patent-portfolio/> accessed 14 October 2016.

644. Jorge L Contreras, 'Patent Pledges' (2015) 47(3) Ariz St L J 543.

645. Jerry Hirsch, 'Elon Musk's Growing Empire is Fuled By $4.9 Billion in Government Subsidies' (*Los Angeles Times*, 30 May 2015) <http://www.latimes.com/business/la-fi-hy-musk-subsidies -20150531-story.html> accessed 14 October 2016.

646. Elon Musk, 'All Our Patent Are Belong To You'.

647. According to Musk, Tesla will not be profitable until 2020. Dana Hull and John Lippert, 'Musk Says Tesla's China Sales Fell, No Profit Until 2020' (*Bloomberg*, 14 January 2015) <http://www.bloomberg.com/news/articles/2015-01-14/musk-says-tesla-s-china-sales-fell-no-profit-until-2020> accessed 14 October 2016.

648. Musk, 'All Our Patent Are Belong To You'.

649. Ibid, ("[t]echnology leadership is not defined by patents, which history has repeatedly shown to be small protection indeed against a determined competitor, but rather by the ability of a company to attract and motivate the world's most talented engineers. We believe that applying the open source philosophy to our patents will strengthen rather than diminish Tesla's position in this regard").

Demsetz and as discussed in Sections A and B above. It is divided into three sub-sections, including a discussion of game theory and the evolution of property; game theory and the special case of IP; and the emergent strategic dynamics of the latter in the form of 'property traps' over technological infrastructure. It will conclude that the core nature of IP is more closely allied to market 'regulation' rather than a natural right, and that this finding erodes the efficiency assumptions underwriting much IP scholarship favouring exclusive rights, particularly as they relate to technological infrastructure. This insight then feeds into Part IV, which considers the role of R&D subsidies in guiding optimal outcomes under a subsidised R&D regime, which allocates exclusive rights to the subsidy recipient.

C. Exploring Intellectual Property as Property

Having now unpacked both the spillovers justification for IP as well its function as a technological transfer mechanism, the below sub-sections aim to apply pressure to an assumption which underwrites both these arguments: that IP behaves like property.[650] By drawing on the recent work of Shubha Ghosh and Mark Lemley, as well as some useful tools from game theory, it will be argued that IP is really a form of market regulation. By understanding IP as regulation rather than property, it can be viewed as an imposition on the market rather than as something that emerges organically from it. This is not simply a point about nomenclature: it also means that the assumptions related to efficiency and optimality that generally accompany market and property-based arguments do not apply with the ease that property right theorists often suggest. Rather, as with all regulation, the shoe is on the other foot: the efficiency of IP should be proven as compared to the unaided market. Sections A and B above have already placed pressure on the efficiency of exclusive IP as a management regime in relation to technological infrastructure with respect to both its spillover and technology transfer functions. The sub-sections below provide further ballast to these arguments by taking on the core economic foundation of Demsetz's evolutionary argument, as briefly developed in sub-section B above. The argument begins with a game theoretical account of property evolution, then discusses the particular problems this account has with intellectual property. It then moves onto examine the unique difficulties the property approach encounters with respect to technological infrastructure, such as property traps.

1. Game theory and the evolution of property

The previous sub-sections developed a brief sketch of the quasi-naturalistic theory of IP evolution of Harold Demsetz. This theory has been extremely influential as a powerful economic justification and description of the instrumental role of IP as a spillover internalisation mechanism. The nub of Demsetz's argument is that 'private property rights…

650. Rubin, 'The Illusion of Property'.

emerge to enable the internalisation of externalities as the value of resources increases and technologies and markets emerge to make internalisation less costly (more beneficial).'[651] Although often treated in the literature as being a robust 'evolutionary' explanation of the emergence of the institution of property[652], Demsetz's origin story is incomplete as it must presuppose the existence of the State to enforce property rights. A more powerful approach would be to start from the baseline of the interaction between individual agents over how to manage access to a resource, and attempt to derive the notion of property directly from there. Indeed, part of the power of philosophical arguments for private property as a 'natural right' is the latter's ability to be derived from the pre-State 'state of nature'.[653] In relation to real property, this project has been recently attempted in a compelling way by a number of publications in the field of evolutionary game theory, in particular by the independent work of Herb Gintis[654] and Brian Skyrms.[655]

These theorists, both of whom integrate evolutionary game theory with findings from behavioural economics regarding the 'endowment effect'[656], conceptualise property rights as emerging from an iterated N-person Hawk-Dove (HD) game. The HD game refers to two strategies that individuals can adopt when they contest over a resource: to back down (Dove) or defend aggressively (Hawk). If we assume that one of the players is the 'owner' of the resource, then it can either opt to defend against an ownership contest, or relinquish it to the intruder. The intruder can either choose to back down against a defensive owner or engage in battle. If both back down, then the two share the resource (i.e. Dove/Dove). If both opt to act aggressively (Hawk/Hawk), then they risk injury or death, or prohibitive costs. The numerical payoffs in the matrix at Figure 1 below aim to capture the *relative* outcomes of agents adopting particular strategies. Under normal conditions of a symmetric HD game, there are two pure-strategy equilibria.[657] The Nash equilibria, referred to as the 'private property equilibrium' (3,1) and 'anti-private property equilibrium'[658] (1,3) are as underlined in the payoff matrix below.

651. Frischmann, 'Evaluating the Demsetzian Trend'.
652. Krier, 'Evolutionary Theory', 39: ('Harold Demsetz's *Toward a Theory of Property Rights,* despite its many well-known shortcomings, has been the "point of departure for virtually all efforts to explain changes in property rights " since its publication some forty years ago.')
653. Jeremy Waldron, *The Right to Private Property* (OUP 1990).
654. Herbert Gintis, 'The Evolution of Private Property' (2007) 64(1) J Econ Behavior & Org 1.
655. Brian Skyrms, *Evolution of the Social Contract* (CUP 1996) pp 76-79; Brian Skyrms, *The Stag Hunt and the Evolution of Social Structure* (CUP 2004); Brian Skyrms, *Social Dynamics* (OUP 2014).
656. Daniel Kahneman, Jack L Knetsch and Richard H Thaler, 'Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias' (1991) 5(1) J Econ Perspectives 193.
657. There is also a 'mixed strategy' equilibrium, but it will not be covered here.
658. This equilibrium has however seldom been observed in a state of nature. However it has been formally shown that 'the anti-private property equilibrium again has a lower average payoff that the private property equilibrium, so it will be disadvantaged in a competitive struggle for existence'. See Gintis, 'The Evolution of Private Property'.

	Hawk	Dove
Hawk	-1, -1	3, 1
Dove	1, 3	2, 2

Figure 1: Hawk Dove game as a model of private property evolution

If one assumes the endowment effect as an exogenous factor[659], then the symmetry in the payoff matrix is broken and owners are more likely to commit resources to defending a resource than intruders are in contesting it, provided the value of the resource is lower than the costs of fighting for it[660], or (V(resource)<<C(contest)). This means that the 'private property equilibrium' would constitute a dominant strategy and would tend to dominate a population given the symmetry-breaking exogenous factor of the endowment effect. A general two-prong strategy of 'deference to possessors' and 'protecting what one possesses' would likely emerge from the game (referred to as the Bourgeois strategy) as an evolutionarily stable strategy (ESS).[661] However, as the value increases or the costs decrease, then it is increasingly likely that individuals will choose to duke it out over high-value resources: the coercive power of the State is required to raise the intruders' costs in these cases in order to prevent the emergence of Hobbes's state of nature – the n-person Hawk-Hawk equilibrium, or 'a war of all against all'.[662] Demsetz's evolutionary theory of property would suggest that the State's decisions to recognise and enforce property rights occurs when a.) the State receives signals of social cost (number of battles/disputes over resources), and b.) the costs of instituting a property regime are less than the benefits (such as also in the case of some rivalrous common resources not captured by the HD game[663]).

The above game-theoretical analysis is a plausible way of explaining the emergence of State-enforced property rights in evolutionary terms. However, it does have some significant limitations when applied to IP, which also applies pressure to Demsetz' evolutionary account in relation to information resources as discussed below.

2. Game theory and IP

The model sketched above only seems to apply to tangible property since it assumes that possession is roughly equal to ownership and that the resource is rivalrous and excludable.

659. *i.e.,* an extra factor which affects strategy choose outside of the payoff profiles. Gintis, 'The Evolution of Private Property' 6, ("Similarly, the value of the ownership is taken as exogenous")
660. Here the cost is symmetrical for both the resource owner and invader
661. Krier, 'Evolutionary Theory'; Skyrms, *Social Dynamics,* 140.
662. Gintis, 'The Evolution of Private Property', 18 ("[t]he true value of modern private property, if the argument in this paper is valid, is fostering the accumulation property even when $\pi_g > (1 + \beta)\pi_b(1 - c)$. It is in this sense only that Thomas Hobbes may have been correct in asserting that life in an unregulated state of nature is "solitary, poor, nasty, brutish, and short.")
663. Hardin, 'The Tragedy of the Commons', 1243–48.

In the case of intangible knowledge goods, these assumptions do not hold. In particular, in a 'state of nature' knowledge goods cannot be possessed[664], nor are they rivalrous nor excludable.[665] Instead, once a knowledge good is made public, private ownership is expensive to individually enforce (adopt Hawk strategy) as enforcement must also comprise 'monitoring costs' in addition to the costs involved in trying to prevent ripoffs[666], whatever these may be. In an unregulated state of nature (pre-IP law), these factors increase the costs of the resource owner defending its ownership, meaning that the inequality of V>>C which underlay the HD game may change signs to V(resource)<< C(contest). The change in this inequality leads to a well-understood 'game-switch' in game theory, resulting in the transformation of the HD game structure into a 'prisoner's dilemma' ('PD') or 'public goods game'. This game is generally thought to apply to knowledge goods, and is often used as the justification for IP in the form of the 'free rider argument'.[667] If one modifies the stakes from protecting a resource to creating a resource ('innovate') and intruding on a resource to ripping it off ('imitate'), then we get the PD payoff matrix (fig. 2), where the strategy of 'imitate' always dominates innovating, since companies who choose to imitate the outputs of innovators get access to the resource at zero cost without having to undergo the sunk costs of R&D:

	Innovate	**Imitate**
Innovate	2, 2	.5, 3
Imitate	3, .5	1, 1

Figure 2: prisoner's dilemma model of IP

The structure of this game has been of vital and continued interest to economists and property theorists as its only Nash equilibrium (Imitate/Imitate) is one where private interests lead to a pareto-inferior result (1,1), violating the notion of the 'invisible hand' – where private interests align with the pareto-optimal result (2,2).[668] As a consequence, PD games are generally argued to require public intervention to modify the payoff structure to resemble something closer to an 'invisible hand' game: the Government introduces IP law to modify the costs of imitation so that V<<C, either returning the game back to an HD game, or creating an 'invisible hand' game[669], where 'innovate' becomes the dominate strategy. This result is

664. Except perhaps by secrecy. This option is discussed later in this sub-section.
665. These attributes derive from the knowledge's status as a 'public good'
666. It is important to underline the fact that for this example these costs only include costs associated with trying to enforce ownership over knowledge assets in a 'state of nature', so does not include the costs involved in mobilisation of state apparatus, such as *e.g.*, initiating legal proceedings etc.
667. Epstein, 'What Is So Special About Intangible Property?'; Krier, 'Evolutionary Theory'; Kieff, 'Property Rights and Property Rules'; Tansey *et al.*, 'Patent Agression'.
668. McAdams, 'Beyond the Prisoner's Dilemma'.
669. Samuel Bowles, *Microeconomics : Behavior, Institutions, and Evolution* (Russell Sage Foundation 2004).

often used as an economic motivation to justify the institution of intellectual property. This intuition is echoed by Demsetz, where he asks us to:[670]

> Consider the problems of copyright and patents. If a new idea is freely appropriable by all, if there exist communal rights to new ideas, incentives for developing such ideas will be lacking. The benefits derivable from these ideas will not be concentrated on their originators…

Essentially, Demsetz is arguing that the 'imitate/imitate' equilibrium will dominate in a world where innovators are not given the right to appropriate directly from their innovations, such as in a world with poorly-enforced IP laws or in a pre-IP 'state of nature'.

However, the PD model of knowledge resources as sketched above, while a useful tool and often used as a justification for IP[671], is also a gross simplification of the actual game played. The quoted paragraph from Demsetz in the excerpt above and the outcome of the PD game, seem to suggest that before the advent of IP law, knowledge goods were simply not produced. Clearly, this result is false. Knowledge goods *were* produced, but they were produced in contexts where the knowledge was tightly controlled and managed. These often took the form of private arrangements, outwardly resembling modern trade secret law, although often much more draconian, such as in the glass-blowing guilds of medieval Venice.[672] The 2-strategy PD payoff matrix can therefore be modified to include a third strategy of 'keeping secret', as the available options are not dichotomous but actually trichotomous. Following on from the work of Ghosh[673], once this extra option is included (and the relative payoffs suitably modified) it becomes clear that rather than being a 2-strategy PD game, the pre-regulated 'state of nature' of knowledge assets was rather more like an 'assurance game' or 'Stag Hunt'. [674] Below (fig. 3), the essence of this game is captured by constructing a pay-off matrix where two players have the choice of either keeping the knowledge asset secret or disclosing it.

670. Demsetz, 'Information and Efficiency', 359.
671. Adam D. Moore, 'Intellectual Property and the Prisoner's Dilemma: A Game Theory Justification of Copyrights, Patents, and Trade Secrets' (August 17, 2016). Available at SSRN: https://ssrn.com/abstract=2825252
672. See generally, Merges, 'From Medieval Guilds to Open Source Software'.
673. Ghosh, 'Patent Law and the Assurance Game'
674. Ibid; Skyrms, *The Stag Hunt*.

	Innovate (disclose)	Keep secret
Innovate (disclose)	5, 5	3, 4
Keep secret	4, 3	3.5, 3.5

Figure 3: assurance game as a model of IP

In this game there are two equilibria, one 'payoff' dominant (Innovate/Innovate) and one 'risk dominant' (Keep secret/Keep secret). If the players begin the game by mutually selecting identical equilibrium strategies then neither has any incentive to change strategy. Although both players would of course be better off if they both selected the payoff dominant strategy of Innovate (disclose), this strategy is risky since if the other player chooses to keep secret, then the Innovate player's payoff would be less than if it also chose to keep secret. Under uncertainty, therefore, players are likely to settle on the pareto-inferior Keep secret/Keep secret equilibrium. The role of intellectual property law has been argued to function as a regulation for driving agents' behaviour towards the socially optimal but risky NE of Innovate/Innovate, with the assurance that their disclosures will be protected. Another way of putting this is that IP laws provide the players with the *assurance* that disclosures will be protected such that players can trust each other not to free ride on each other's innovations, but that unlike the PD game, *secrecy*, not imitation is the dominant choice in an uncertain world.

It has been argued by some scholars that this conceptualisation of the role of IP is a more accurate portrayal than the prisoner's dilemma, at least with respect to patents.[675] The 'assurance game' structure of IP law has been elaborated in detail in the work of Shubha Ghosh, who along with recent work by Mark Lemley[676], argues for a reconceptualization of IP away from the traditional 'property' model and towards a model where it has a role as 'market regulation'.[677] But although this concept of IP may provide a richer and deeper analysis than the normal PD game, it still doesn't escape the criticism mentioned at the beginning of this section, which argued that the regulatory nature of IP introduces all kinds of errors and inefficiencies into its economic foundations. By moving away from IP as a property 'right' functioning as a cornerstone of free markets, it is seen instead to be an intervention into the operation of these markets in pursuit of a regulatory goal. It puts defenders of IP into a position faced by all other proponents of regulations, in having to assess: [678]

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675. Ghosh, 'Patent Law and the Assurance Game'.
676.Lemley, 'Response: Taking the Regulatory Nature of IP Seriously'; Lemley, 'IP and Other Regulations'; Ghosh, 'Patent Law and the Assurance Game'.
677. Ghosh 'Patent Law and the Assurance Game', 327 ("[u]nder the terms of the assurance game , the purpose of law is not to punish copying, but to create a set of rules within which participants will do the right thing because of the assurance that others will reciprocate. The assurance of reciprocity is the basis for the well-regulated marketplace") ; Shubha Ghosh, 'Patents and the Regulatory State: Rethinking the Patent Bargain Metaphor after Eldred', (2004) 19(4) Berkeley Tech LJ 1315.
678. Lemley, 'Response: Taking the Regulatory Nature of IP Seriously'.

> whether an IP rule is worth the cost depends, as it does with any other regulation, on whether the benefits we get from that rule (presumably increased or higher- quality innovation or creativity) are worth the costs.

Here it is important to pause to absorb the essential differences between conceptualising real property as a Hawk-Dove game and IP as an assurance game. It is clear that in the case of the HD game with respect to tangible resources, it is possible to construct a 'naturalistic' evolutionary scenario where (given the endowment effect) private property emerges endogenously from the market as a privately and socially efficient solution to the problem of conflict over resources, or 'social cost', which can be signalled to the legislature and courts and taken into account to drive propertisation decisions. Even the exogenous institution of State-enforced property rights can be seen to help internalise these costs (or 'externalities' in the language of Demsetz') by serving to regulate 'edge cases' of high value resources, which might otherwise be worth fighting for, giving rise to social cost.[679] In the case of knowledge goods in the assurance game (or indeed the PD game), there is no equivalent of a 'social cost' signal driving the dynamics of intellectual propertisation. This is because the social cost of not having an IP regime or an insufficient one is not signalled to the legislature by observable increases in 'battles', or competitive exploitation[680] as in the case of real property, but comes about, presumably, by less disclosures and innovation. Crucially, the *absence* of something does not produce a signal, but is in fact only a hypothetical or counterfactual 'social cost'.

This simple comparison between real property operating under a HD game and IP operating under an assurance game (or even a PD game) has an important consequence for evolutionary theories of IP: that the IP regime could not evolve naturalistically from the interplay between private actors, but is always an exogenous imposition on the market. This means that unlike real property, the dynamics of IP expansion cannot easily be explained by social cost internalisation and efficiency but should look for other likely explanations.[681] In practice it would be extremely difficult to distinguish between IP laws which are legitimate responses to (a counterfactual assessment) of social cost and IP laws which result from special interest, or "public choice". This means that the evolutionary aspects of 'Demsetz's descriptive thesis [might actually] best describe public choice dynamics' rather than the dynamics of evolution towards a more 'innovation enhancing' IP system in response to social cost signals.[682] Denuded

679. Gintis, 'The Evolution of Private Property'.
680. Also referred to as negative externalities. These social costs may also arise through *e.g.,* 'tragedy of the commons' situations'.
681. See discussion infra
682. Frischmann, 'Evaluating the Demsetzian Trend in Copyright Law', 4 ("[t]hat is, Demsetz's descriptive thesis best describes public choice dynamics, at least in the field of intellectual property. As the value of intellectual resources increases and new technologies and markets emerge, the pressure of special interests to create and extend private

of its 'organic' or evolutionary justifications, the IP system can be viewed as an institution imposed on the market rather than growing out of it. The key point is that the economic forces driving the dynamics of IP expansion and development cannot be derived from efficiency considerations as Demsetz argues, but may instead be the product of minoritarian bias and the growing influence of private concerns.[683]

Of course, like many regulations, IP also has upsides: in particular, where IP-protected resources exist in competitive markets (whether static or dynamic) it has the attribute of being able to stimulate bottom-up, self-directed innovation.[684] However, its downsides include the fact that its conceptualisation as 'property' as opposed to market regulation means that it tends to treat all resources alike even if they have very different characteristics and effects on the market. This 'one size fits all' criticism of IP is not new[685], but it is submitted that its consequences have not yet been completely worked through for the case of intellectual infrastructure. Specifically, as already argued in Section A, the high spillover potential of technological infrastructure attracts companies to try to appropriate this value by filing, claiming and asserting patents over it. This can lead to highly complex strategic situations where companies find themselves forced to adopt aggressive IP strategies just to retain the freedom to operate and access to technological infrastructure. Jonathan Barnett has referred to such sub-optimal strategic situations as 'property traps'. Below, this additional strategic aspect of IP with respect to technological infrastructure will be examined, before turning to Part IV, which attempts to show how the subsidy system can help mitigate these outcomes in the context of these assets arising from subsidised R&D.

3. Property traps

The above two sub-sections focussed on applying pressure to the arguments that IP behaves like property, by demonstrating fallacies in Demsetz's evolutionary approach to the propertisation of the information space. Instead of the traditional model of IP as a subset of property (as an institution which evolves organically from the market in response to social cost) it was argued that IP behaves a lot more like market regulation. As an *intervention* in free markets, as opposed to a pre-condition for them, IP is prone to all the usual errors and

property rights likewise increases."). Of course, nobody can deny that IP is the product of historical evolution, as IP laws have precursors stretching back to renaissance Italy, see Patentgesetz von Venedig, <http://www.wolfgang-pfaller.de/venedig.htm>.

683. Some scholars see the development of modern IP laws in seventeenth century England in the form of the Statute of Monopolies and the Statute of Anne as a turning point in the transition from feudalism to capitalism by providing private sector greater control over resources. This thesis endorses this view, but stresses the point that excessive private ownership of resources can also lead towards inefficiencies and negative wealth distribution effects as much as excessive public ownership.

684. Mair, 'Taking Technological Infrastructure Seriously'; Mair, 'Intellectual Property'.

685. Carroll, 'One Size Does Not Fit All'.

inefficiencies which plague market impositions. This sub-section highlights the problem of 'property traps', as they apply particularly to technological infrastructure.

The term 'property trap' describes the scenario where the strategic environment 'traps' companies into having to adopt an exclusive rights strategy to technological infrastructure, even when an open access approach would be both privately and socially optimal.[686] Property traps have been observed empirically[687] as associating particularly with technological infrastructure due to strong incentives for private appropriation of the enormous spillovers they produce.[688] Stated simply, a property trap may arise as a strategy of accumulating and asserting IP over technological infrastructure (hereafter: 'strong property' strategy) because it is the best response to an environment where at least one company is adopting this strategy. To pursue an open access strategy (patent non-assertion, hereafter 'open access' strategy) in such an environment would lead to the worse outcome for both the technological infrastructure owner(s) and its follow-on innovator(s) since they would be blocked from using their own assets as well unable to strategically respond to companies using the strong property strategy.

From a game theoretical perspective, the 'strong IP' strategy constitutes the risk-dominant Nash equilibrium because the players have little[689] incentive to deviate from it in an environment of high infringement risk and the concomitant risk of litigation and legal costs.[690] This would mean that companies who adopt a strong property approach would have a higher relative payoff when playing against open access strategy adopters. Interestingly, this result also means that strong property players dominate open access players even though the 'strong property' approach may be more costly (in terms of IP acquisition, monitoring and enforcement costs).

The structure of this game is identical to the assurance game identified in the preceding section, since although the 'payoff' dominant strategy of open access/open access maximises both private and social interests, the nature of the high-risk strategic environment drives players towards the risk-dominant equilibrium of strong property/strong property. Interestingly, the nature of the strong property strategy also has some dynamic feedback effects: when

686. Jonathan M Barnett, 'Property as Process: How Innovation Markets Select Innovation Regimes' (2009) 119 Yale LJ 384 ("Barnett,' Property as Process'"), 384 ("…[the] "property trap" effect where, under high coordination costs, the regime selection mechanism is prone to fail: litigation risk and associated transaction cost burdens drive innovators to over-consume state-provided property rights").
687. Gavin Clarkson and David DeKorte, 'The Problem of Patent Thickets in Convergent Technologies' (2006) 1093 Annals of the New York Academy of Sciences 180; von Graevenitz, Wagner and Harhoff 'Incidence and Growth of Patent Thickets'; Mossoff, 'The Rise and Fall'.
688. For example, in regard to cooperatively-set standards, see Timothy S Simcoe, 'Private and Public Approaches To Patent Hold-Up in Industry Standard Setting' (2012) 57 Antitrust Bulletin 59, 64 ("patents declared to SSOs were four to seven times more likely to be litigated than a typical patent with the same age and technology class.")
689. Assuming coordination costs for negotiating a cooperative solution are too high.
690. Barnett, 'Property as Process'.

companies adopt the strong property strategy, the logic of the interaction drives increased patenting behaviour and patent acquisition in order to play the strategy, further propertising the technological area and intensifying the strategic risk, entrenching the strategy and the sub-optimal equilibrium. Below (fig. 4) the payoff matrix for this game is shown, including the two underlined Nash equilibria.

	Open access	**Strong property**
Open access	4,4	1, 3
Strong property	3,1	2, 2

Figure 4: IP management regime choice and the assurance game model.

It is important to note that the assurance game payoff matrix embeds the concept of 'path dependence': if the game begins by companies adopting a 'strong property' starting point, then companies will have no incentive to swap strategies to open access. However, if the companies begin by assuming a starting strategy of open access then the companies likewise have no incentive to switch strategies. Therefore, if companies find themselves playing a strong property strategy, then the underlying dynamics make the 'strong property' NE an 'efficiency' or 'property' trap.

In order for one player to switch strategies from a Strong Property approach to an Open Access it is clear that she must first go through a 'payoff trough', which means that a strategy switch is very unlikely. As a result, open access strategies are highly unlikely to emerge from the market by market forces alone, or at least not without a concerted effort by a number of players to solve what is essentially a coordination problem.[691] In the case of cooperative standards, chapter 1 of this thesis has explained the instrumental role of competition law enforced FRAND commitments to solve an intimately related problem.[692] The behaviour of companies like Tesla, and the other companies mentioned in Section B which adopted 'patent pledges' is another way companies attempt to 'truncate' the strong property strategy, by creating initial conditions of 'open access' such that the payoff dominant NE can get a foothold in the market.[693] Part IV of this chapter will argue that having incentives for open access licensing built into the structure of subsidy grants will also help to move private strategic behaviour in a technological area towards the payoff dominant open access/open access equilibrium with respect to infrastructure arising via subsidised R&D.

691. Mair, 'Taking Technological Infrastructure Seriously'; McAdams, 'Beyond the Prisoner's Dilemma'.

692. In that chapter, the problem of ex post openness of a standard was described as a prisoner's dilemma rather than an assurance game. Both points of view are justifiable, and the solutions are similar: an intervention to change the payoff structure to reach a cooperative solution.

693. Also referred to as 'indirect truncation' in Barnett, 'Property as Process'.

Now to sum up. The fact that technological infrastructure functions as a nexus of downstream value creation and spillovers makes it attractive to private companies seeking to appropriate and internalise value. However, companies still have the choice of selecting a payoff dominant open access strategy or a risk dominant strong IP strategy. One of the prevailing strategies in high technology markets is the strong IP strategy, which has tended to self-reinforce in some markets as a 'property trap' due to path dependence and high risk. The easiest way for companies to drive strategic behaviour towards the open access equilibrium via private ordering is to trigger this dominant strategy at the outset, as evidenced by Tesla's open patent pledge and the growing prevalence of patent pledges by technology companies. Public solutions to arriving at an open access solution include the ex post operation of competition law, which casts a 'shadow' over the private ordering behaviour of companies, nudging them towards cooperative solutions.[694] A third possible solution explored in Part IV below is to include incentives ex ante in the structure of subsidy grants to drive private companies to adopt open access solutions with respect to technological infrastructure arising out of subsidised R&D.

IV. R&D SUBSIDIES AND TECHNOLOGICAL INFRASTRUCTURE

The nub of this part of the chapter is to demonstrate how the EU subsidy system under Horizon 2020 can be modified in an economically robust way to help ensure the openness of technological infrastructure arising under subsidised R&D projects. Part II examined why R&D outputs arising from subsidies are likely to have infrastructural attributes. Part III then explored in detail why a resource management approach of exclusive intellectual property rights is a poor way of ensuring efficient use of these unique resources. The game theoretical components of the above analysis also demonstrated how external institutions to IP may be necessary to help nudge companies towards the payoff dominant open access equilibrium in the management of technological infrastructure. Below, the role of the EU subsidy grant system will be examined as one such institution, by looking in detail at key components and economic motivations behind this innovation institution, as well as its complex interaction with IP.

As discussed in previous sections of this chapter, public R&D subsidies are often directed at high risk R&D projects with high potential social value and spillovers. Since subsidies are very much a 'visible hand' in the market place, the real world application of subsidies may (much like IP) lead to a subversion of their intended purpose, or at least to unexpected effects. The imperfections of the institution of R&D subsidies have been studied in detail, and a sizable

694. Mair, 'Taking Technological Infrastructure Seriously'.

economic literature has arisen exploring the many dimensions of 'subsidy failure', including, shirking, crowding out, and distortionary directional R&D incentives. [695]

Despite the existence of this critical literature, subsidies continue to attract significant resources from public coffers. This is true even, or especially, for the 'free-market-oriented' United States, where one third of all R&D is funded by government or the non-profit sector.[696] Many commentators in the European Union have regarded the US's innovative success with envy, and have ascribed at least some of the US's economic success to its public policy around R&D subsidies.[697] Recent EU policy initiatives which aim to transplant the US approach to the EU (whether explicitly or implicitly) include a new legislative agenda on the public procurement of R&D services, and a refreshed- and well-heeled[698]- R&D subsidy program, Horizon 2020. A key element in all these initiatives is the allocation of any IP arising out of the R&D to the private party subsidy recipient, a policy which closely tracks the similar US Bayh Dole approach. Part IV, Section D below will closely examine and critique this policy using the insights harvested from the discussion of IP in Parts II and III, in particular the game theory approach which conceptualises the socially-optimal outcome (open access/open access) as an assurance game requiring 'encouragement'.

Before engaging that analysis, some basics. Section A will outline the key economic arguments for R&D subsidies as an alternative, or complement to the institution of IP. This analysis will focus on the importance of subsidies in correcting the 'blind spots' of an IP regime, where the 'invisible hand may be invisible because it's not there'. Section B will then briefly summarise the main areas of 'subsidy failure', including information problems and private sector gaming. Section C will then narrow its focus on the specifics of the H2020 grant system, before Section D develops the relationship between open access rules and the subsidy grant. Part V then concludes.

A. Economic Justifications for Subsidies

As with IP, one of the core concepts underlying the theoretical understanding of R&D subsidies is 'spillovers'. After the pioneering 1890 work of Alfred Marshall[699], which first

695. David and Hall, 'The Heart of Darkness'; Nicolaides, 'The Economics of Subsidies for R&D'.
696. Kapczynski, 'The Cost of Price'.
697. 'Pre-commercial Procurement of Innovation: A Missing Link in the European Innovation Cycle' (March 2006) ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/pcp/precommercial-procurement-of-innovation_en.pdf accessed 14 October 2016.
698. The budget of the H2020 program is nearly 80billion Euros. Commission, 'Factsheet: Horizon 2020 Budget' (25 November 2013) <http://ec.europa.eu/research/horizon2020/pdf/press/fact_sheet_on_horizon2020_budget.pdf> accessed 14 October 2016.
699. As discussed in Adam Jaffe, 'Economic Analysis of Research Spillovers: Implications for the Advanced Technology Program' (1996) Brandeis University and National Bureau of Economic Research <http://www.atp.nist.gov/eao/gcr708.htm> accessed 14 October 2016.

identified and discussed the concept 'knowledge spillovers', Arthur-Cecil Pigou has been credited with one of the earliest robust economic analyses of their effects. In his book *The Economics of Welfare*[700], Pigou puts his finger on the issue of R&D spillovers, stating that often R&D outputs are:[701]

> of such a nature that they can neither be patented nor kept secret, and, therefore, the whole of the extra reward, which they at first bring to their inventor, is very quickly transferred from him to the general public…

While recognising the importance of patent laws to align social and private investment optima where R&D outputs are eligible for such protection[702], Pigou's primary solution to the problem of spillovers was one of direct government intervention in the form of 'bounties' (or "extraordinary encouragements"; now called 'subsidies').[703] The economic purpose of such subsidies was considered to be aimed at 'shift[ing] the recipient-firm's marginal cost to the right (pushing its innovation effort theoretically up to a level that closes the gap between the private level and the "socially optimal level" of R&D".'[704] Pigou's understanding of the relationship between the role of IP and R&D subsidies appears to be one of complementarity: where knowledge outputs can be brought within an appropriability regime such as IP or patents, then this may serve to 'bring marginal private net product and marginal social net product more closely together';[705] however, where knowledge outputs fall outside a private appropriability regime, then social welfare will be increased if society applies a subsidy. For Pigou, it seems to go without saying that the two institutions of IP and subsidies operate in different (if not mutually exclusive) spaces: subsidies apply where IP fails; and where IP successfully operates, subsidies would seem to be unnecessary. This perspective of the relationship between IP and subsidies will be further unpacked and developed in Part IV Section D.

700. Arthur Pigou, *The Economics of Welfare* (4th edn, Palgrave Macmillan and Co. 1932).
701. Ibid, 139.
702. Ibid, ("[t]he patent laws aim, in effect, at bringing marginal private net product and marginal social net product more closely together. By offering the prospect of reward for certain types of invention they do not, indeed, appreciably stimulate inventive activity, which is, for the most part, spontaneous, but they do direct it into channels of general usefulness").
703. Ibid, 166 ("[i]t would still be possible, however, to defend a system of bounties to industries in general, the funds for which should be collected by some kind of lump-sum taxation, by arguing that the sum total of effort and waiting devoted to industry could be increased with advantage to economic welfare.")
704. David, Hall & Toole, 'Is public R&D a complement or substitute for private R&D? A review of the econometric evidence' (2000) Research Policy 29 497–529
705. Ibid.

Although almost a century old, Pigou's economic justification for subsidies is still one of the most widely-cited and robust in the literature.[706] The argument has since acquired a number of layers of added sophistication, including a more nuanced theoretical and empirical elaboration.[707] Under a static analysis, subsidies qualify as a simple 'wealth transfer' from society to producers: tax money is given to producers to invest in R&D, which raises their amount of R&D investment. This is justified by the argument that somewhere in the R&D process lurks a 'multiplier effect': i.e. that the amount of social welfare lost in the wealth transfer results in a net social welfare payoff down the line, which exceeds the cost. The key to this argument again rests in the concept of 'spillovers', which are assumed to be an *increasing* function of R&D investment.[708] Econometric analyses roughly support this contention, as discussed in Part II of this chapter.[709]

The intuitive explanation for the multiplier effect of R&D investment (and thus the economic justification for subsidies) is that the knowledge outputs which 'spill over' are used *productively*,[710] such as by giving rise to outputs which trigger (or operate as inputs into) follow-on innovation. But it must be noted that the high spillovers used to justify the application of subsidies in the first place are purely conjectural: the social demand is not signalled because the R&D has not yet been performed, and thus they derive from hypothetical cases constructed by (counterfactual) economic models.[711] Of course, using counterfactual economic models to direct public policy does not necessarily weaken the resulting policy where no other information is available, however, it does underline an important distinction between the 'bottom up' system of IP (which responds to actual social demand), and the 'top down' system of R&D subsidies (which follows centralised agenda-setting) with respect to the directionality of R&D. [712]

Although it seems reasonable that society should privilege the funding of R&D with higher spillovers,[713] it is very difficult for the subsidy provider to know this information in advance.

706. Lemley and Frischmann, 'Spillovers' 106 ("With the notable exception of Pigou, economists don't much care about pecuniary externalities, reasoning that wealth transfers "within" the market— that is, externalities mediated by the price mechanism—result in offsetting private costs and benefits.")
707. Mainly these elaborations focus on different ways of controlling the negative and riskier aspects of subsidies which give rise to unjustified social cost
708. One such mulitplier effect of 'network externalities' is discussed in detail in Mair, 'Taking Technological Infrastructure Seriously'.
709. Griliches, 'The Search for R&D Spillovers'.
710. *i.e.,* as inputs to further downstream innovation.
711. According to the Framework for state aid for research and development and innovation,
recital 67 ("counterfactual analysis: the change of behaviour has to be identified by comparing what the expected outcome and level of intended activity would be with and without aid. The difference between the two scenarios shows the impact of the aid measure and its incentive effect").
712. This is the root cause of the 'information problems' of R&D subsidies identified in Part III Section A(3) of this chapter.
713. Nicolaides, 'Economics of Subsidies for R&D', 7. It appears reasonable that society should subsidise to a larger

In the EU subsidy program H2020, this problem is addressed by using a proxy best described as 'proximity to market', as will be discussed in the next sub-sections.

One of the most controversial aspects of R&D subsidies concerns the risk of 'crowding out' private investment.[714] Crowding out occurs when the subsidy system faultily targets an R&D area where private incentives are already sufficient for investments to go ahead, leading to a substitution of public funding for private funding, and wasted public expenditure. This may happen, for example, where the IP system and the nature of the knowledge outputs targeted are sufficient in themselves to ensure private appropriability, as discussed in more detail in Section B below. Crudely formulated, there is an inverse relationship between the efficacy of the IP system in stimulating the targeted R&D and the necessity for public R&D subsidies. However, there are nevertheless a number of cases where despite the efficacy of the IP system in stimulating R&D, a subsidy system may still be desired to operate alongside it, such as in cases of high risk/uncertainty or where the IP system would lead to too much internalisation of desirable spillovers. Briefly summarised, these cases of desirable mixed subsidy/IP may include the following cases: (i) where high appropriability via an IP regime translates into lower social spillovers due to monopoly pricing or access problems (*e.g.,* Watson's steam engine patent and the explosive advance in steam engine use and innovation after its expiry[715]). This can occur in situations where the R&D output is a technological infrastructure or a general-purpose technology; (ii) it is also possible that eminently patentable inventions with high social value (notwithstanding the patent monopoly) may fail to go ahead due to private sector risk aversion, as discussed in Part II, Sections A and B.[716] In such cases, R&D subsidies may play an important role, where the private sector (including venture capital) markets are sub-optimally risk-averse; (iii) in addition, it should not be forgotten that just because IP protection is available, companies may nevertheless choose *not* to avail themselves of it in order to actively encourage spillovers via opting out of the exclusive rights regime[717] and attempting to create an open access equilibrium in the assurance game. The subsidy system may also play an important role in incentivising such behaviour, as will be discussed in detail in subsequent sub-sections; (iv) finally, the IP system has in in-built (and intended) bias towards commercialisable creations and inventions at the expense of more generic R&D outputs. Subsidies may help to correct this bias by also rewarding creations and inventions that fall

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extent knowledge with larger external effects.

714. According to the Communication From The Commission Framework For State Aid For Research And Development And Innovation, C(2014) 3282, recital 62 ("R&D&I aid can only be found compatible with the internal market if it has an incentive effect. An incentive effect occurs where the aid changes the behaviour of an undertaking in such a way that it engages in additional activities, which it would not carry out or it would carry out in a restricted or different manner without the aid. The aid must however not subsidise the costs of an activity that an undertaking would anyhow incur and must not compensate for the normal business risk of an economic activity")

715. See the target argument of George Selgin and John L Turner, 'Strong Steam, Weak Patents'

716. Link and Scott, *Public Goods, Public Gains.*

717. Barnett, ' Property as Process '; Barnett, 'The Host's Dilemma'.

outside the scope of desirable IP targets. Given the above points, it should be reasonably clear that the institution of R&D subsidies is not always a substitute for IP, but can, under certain conditions, operate fruitfully in tandem with it.

B. Subsidy Failure

As is clear from the above analysis, the award of R&D subsidies to private companies hinges on the subsidy provider's assessment of the social value of the R&D. The problem with this approach is that it lacks the decentralisation of the private sector, where the invisible hand of the price system is able to convey information to companies investing in R&D. This approach suffers from the information problems that beset all non-market interventions: it is extremely difficult for non-market institutions to sufficiently integrate information signals about social demand and spillovers, without actually being a market entity. In particular, the subsidy system is vulnerable to private sector gaming: where applicants for subsidies 'puff up' the potential social value of their R&D projects in order to receive funding. Instead of assessing projects by proven social demand as in the case of the private sector, the 'visible hand' of the subsidy provider is responsible for defining the R&D domains of high social value[718], and a number of panels and 'experts' have the duty of screening proposals from the private sector to assess whether they qualify for funding within each domain. Superficially, this award process is not unlike that performed by examiners at the patent office, except subsidy reviewers are less highly trained, the award dispute system less highly developed, and the examination reports are not publicly available. Furthermore, unlike the subsidy review process, the patent system has an inherent mechanism for dealing with the risk of false negatives: all patent applications, whether successful or not, are published to the public domain within eighteen months. This means that even if a patent application is falsely assessed as unpatentable by an examiner, the essentials of its 'teaching' are nevertheless disclosed to the public, who can then make of it what it will. By contrast, failed subsidy applications are not put into the public domain, meaning that spillovers from false negatives do not enter society.

However, even given a perfectly objective and stream-lined proposal review process, centralised decision-making over R&D subsidies will still likely give rise to significant errors.[719] But putting aside the issue of false negatives, which are notoriously difficult to study in either institution[720], subsidy programs have attracted a burgeoning literature on

718. In the US SBIR system (https://sbir.nih.gov/review/selection-process), this is referred to as 'program priorities'. In the EU H2020, it is divided into 3 pillars (excellent science, industrial leadership, societal challenges), with a number of specialised sub-programmes.

719. It is also difficult to know the relative number of false positive and false negatives in this system. In patent system false negatives less of a problem (in terms of social welfare) since the information goes to public domain anyway via publication of patent applications.

720. Mark A Lemley, 'Rational Ignorance at the Patent Office' (2001) 95(4) Nw U L Rev 1.

the problem of false positives, otherwise known as the crowding out of private investment, as already briefly discussed in Section A above. Crowding out is a concern from a social welfare perspective because it involves a wealth transfer from the tax payer to the producer, but without a multiplier effect: the R&D itself might still have a multiplier effect, but it is not causally related; instead it is more like a 'windfall.' Where IP is also available to the producer- and allocated by default, under the EU 'Bayh Dole' regime- then social welfare also takes a hit in the form of the dead weight loss of (potentially) monopoly pricing. The issue of crowding out and the related one of 'double subsidisation' (discussed further in Section C below) have triggered a raft of scholarship on subsidy design, some of which may have influenced the EU H2020 program, as will be discussed below, where the mechanism of 'proximity to market' is perhaps one solution to minimise the social cost of poorly-targeted R&D subsidies.

C. EU H2020 and Proximity to Market

As mentioned in Section A, the EU H2020 subsidy program (in line with EU State Aid rules) utilises a 'proximity to market' criterion as a rough proxy for the 'spillovers' to private appropriability ratio.[721] Essentially, the more basic and generic the R&D is, the greater is its potential for spillovers, and the higher the subsidy intensity it attracts from the granting agency. Although it is not presented in these terms, it is submitted that the H2020 system of determining subsidy intensity (i.e. the percentage of total costs eligible to receive public funding) embeds a strong recognition of the infrastructural attributes of generic R&D. The more generic the R&D output is (and thus the greater the value of spillovers) the greater the available subsidy intensity it attracts (e.g. 100% for basic research). Likewise, the closer the R&D project is to the market and the less generic it is, the less the available subsidy intensity (50% for Industrial research for a large enterprise), as shown below (fig. 5).[722]

Aid for R&D projects	Small enterprise	Medium-sized Enterprise	Large enterprise
Fundamental research	100 %	100 %	100 %
Industrial research	70 %	60 %	50 %

Figure 5: Subsidy intensity and market proximity.

The proximity to market rule also helps to avoid 'crowding out' and 'double subsidisation': the public liability decreases in tandem with the subsidy intensity, which decreases as the possibility for private appropriability goes up. Since the tax payer has already subsidised the

721. See Annex II (maximum Aid Intensities) of *The Commission Framework For State Aid For Research And Development And Innovation*.
722. Table derived from information at Ibid.

R&D investment, the fact the subsidy beneficiary may also have the opportunity to charge the tax payer monopoly prices for accessing the R&D output (via the IP system) means there is the chance the producer gets to offset its innovation costs twice. This risk may be less where the object of the subsidy is to overcome excess risk-aversion and inertia in the market, although this caveat is very hard to accurately assess.[723] Turning subsidy intensity down and according subsidy recipients IP rights over R&D outputs may well be one way of limiting direct public cost, but as Part III argued, it does not necessarily lead to greater technology transfer. Indeed, exclusive rights over technological infrastructure resulting from sponsored R&D may lead to the inefficient management of knowledge resources.

So far, the analysis has only focused on the economic reasons behind why subsidy intensity is turned down where it starts to enter the domain where IP operates. Little has been said on why subsidy intensity is turned up when IP fails to be effective, such as where the R&D output gets further away from the market. In explaining the latter, it will be shown that 'proximity to market' is a bad criterion for deciding subsidy intensity. By examining closely the economics behind spillovers, IP and subsidies developed so far in this chapter, it is argued that the key point should be the extent to which the R&D output can be used as a productive input to further knowledge creation, *i.e.*, its potential as an economic 'multiplier' – an asset which sustains downstream value creation. This analysis involves a switch in focus from the supply-side to the demand-side, and will begin by looking deeper into the deceptively obvious fact that basic scientific research should attract a subsidy intensity of 100%.

D. Infrastructural knowledge and open access

1. Basic research

More than eighty per cent of US basic R&D is funded by the government and non-profits.[724] This figure seems very high, (particularly given the free-market rhetoric of the US) until one asks the question: who else would fund it? Basic scientific research generally falls squarely outside the IP regime.[725] Scientific theories, including mathematical theorems, and algorithms are expressly excluded from patentability under most patent laws. Likewise under copyright law, 'ideas' are not protectable, only 'expressions'. In both these IP regimes, legislators have circumscribed, if perhaps messily in some cases[726], the types of intellectual creations which should remain in the public domain and 'part of the storehouse of all men'.[727] Although never

723. Putting a monetary value on risk or uncertainty is always a matter of guess work
724. Kapczynski, 'The Cost of Price'.
725. See discussion in Part II, Section B(2).
726. The boundaries of IP protection are constantly litigated.
727. As quoted in Lee, 'The Evolution of Intellectual Infrastructure'.

explained in the legislation itself[728], there seems to be a general repugnance in both case law and academic commentary to the idea that fundamental truths, principles, and discoveries in nature could be owned. According to Suzanne Scotchmer, the reason why basic R&D is publicly sponsored rather than privately sponsored is "that the benefits of basic research are hard to appropriate by private parties",[729] but there seems to be more to it than that: if scientific theories and principles were susceptible to IP (or otherwise substantially privately[730] funded), research outputs would likely be strongly biased towards outputs with 'observable and appropriable returns'[731] rather than generic, fundamental research with unobservable immediate application.

And here is the nub. It is not the case that the output of basic research has high spillovers because of its low appropriability (i.e. because of the absence of an appropriability regime such as IP); rather, the social returns on any direct appropriability mechanism for basic scientific outputs would be likely dwarfed by its social costs[732]. This is because scientific research outputs are not so much discrete outputs as *constituents* and inputs for the framework for doing further scientific research. It constitutes the framework both for further scientific research and, *inter alia*, technological evolution.[733] In short, it has the function of intellectual infrastructure. In this sense, the value of basic research to society is the social value it supports downstream, in its productive use for further knowledge creation, as well as in its role as an input into technological progress. Since the main value of science is in its status as a *productive* resource[734], economic theory and the social bargain favour an open access regime to research outputs, which guarantee the widest dissemination possible. In addition, open access eliminates directional incentives with respect to the resource, and permits all-comers to determine their own uses rather than the price system (under an IP market system).[735]

To sum up, the reason why basic research is subsidised 100% in most public subsidy systems is plausibly due to its extremely high social value as an *infrastructural* resource, relative paucity and undesirability of available private appropriability mechanisms, and strong open access preference (in order to ensure its functioning as infrastructure). As will be discussed below, certain knowledge assets in technology may also share many of these attributes. Indeed, it will be submitted that the key attribute of basic research that singles it out for unique treatment is its infrastructural character rather than anything special about scientific knowledge, and

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728. See discussion of intellectual infrastructure Part II, Section B(1).
729. As quoted in Frischmann, *Infrastructure*, 308, fn 181.
730. Meaning for a profit, NGO and nonprofits do not count here.
731. Ibid, Frischmann, *Infrastructure.*
732. E.g. monitoring costs, enforcement costs and also social cost of lost innovation
733. The relationship between basic science and technoloy is however a complex one, see Donald Stokes *Pasteur's Quadrant: basic science and technological innovation* (Brookings Institute Press, 1997)
734. Not necessarily in an economic sense, but as in the sense of scaffolding *further* research.
735. Kapczynski, 'The Cost of Price'.

that this attribute is shared by other types of resources, such as the case of technological infrastructure, as described in Parts II and III of this chapter, and further developed below.

2. Technological infrastructure and subsidies

It is the purpose of this sub-section to integrate the insights from Parts II and III, and the arguments presented so far in Part IV. It attempts to defend the position that technological infrastructure shares many commonalities with basic research, which suggest that public policy should be oriented to encourage open licensing regimes, especially when such resources are eligible for the private allocation of exclusive IP protection.

The economic and legal literature on high technology innovation and markets has long identified important commonalities between basic science and certain types of technological resources.[736] These commonalties have ranged from the identification that progress in both domains is fundamentally 'cumulative' in character, to the application of philosophy of science perspectives (in particular, that of Thomas Kuhn) to aid the understanding of technological progress.[737] One essential insight in this respect is the way in which 'dominant' designs within an industry can scaffold significant follow-on innovation, feeding back on the design and making it a 'standard', or infrastructural to an entire market, such as in the case of de facto standards and general purpose technologies. It is well recognised in intellectual property and competition law scholarship that 'infrastructural assets' such as these pose unique problems to the innovation system.[738] Standardisation bodies, antitrust authorities, and private companies have all adopted various formal and informal tools to deal with this problem. The core of the point is that, like basic science R&D outputs, the vast amount of social value of technological infrastructure is generated downstream of the asset, in its productive uses. Since the purpose of public R&D subsidies is to generate social value with the minimum cost to society's scarce resources, subsidy programs are designed to proactively 'dial up' subsidy intensity where spillovers are high and appropriability mechanisms are inadequate. In the case of technological infrastructure, however, the 'proximity to market' criterion means that companies which intend to generate infrastructural assets might be forced to rely on an underperforming IP institution as the means of resource management (see Part III).

It is submitted that instead of looking to the existence of a private appropriability mechanism when judging 'proximity to market' and thus subsidy intensity, a preferred approach would be to place more weight on how to open the resulting R&D outputs in practice. As argued in Part II, such subsidised R&D outputs are highly likely to have attributes of technological

736. Discussions of Kuhn's revolutionary science vs normal science and the similarity to that of working within a dominant design and working towards a new one. See Arthur, 'The Nature of Technology'
737. See generally Philip Anderson and Michael L Tushman, 'Technological Discontinuities and Dominant Designs'
738. Frischmann and Waller, 'Revitalizing Essential Facilities'; Wagner, 'Information Wants to Be Free'; Rubin, 'The Illusion of Property'; Barnett, 'Property as Process'

infrastructure, even when they are close to market (and subject to the lower subsidy intensity). By allocating IP to subsidy recipients in such a context, the management of such resources risks degenerating into the 'strong IP' sub-optimal equilibrium identified in Part III as well as relying on the 'top down' (and not necessarily efficient) decisions of the resource owner, who would be undisciplined by market forces. One powerful way of avoiding this outcome would be for the H2020 subsidy program to explicitly 'dial up' subsidy intensity even for 'close to market' R&D outputs, provided the outputs are licensed on an open access basis, such as royalty-free or FRAND terms.[739] As shown in Part III, in the subsection on technology transfer, there are a range of modern technology transfer mechanisms which do not rely on exclusive rights in order to get the generated resource to market. In the case of software, an open access approach might require the outputs to be licensed under open source terms. In the case of other technological outputs, perhaps FRAND conditions would suffice. A cursory empirical study by the author of FP7 software projects found no statistically significant difference between subsidy intensities of FP7 software projects licensed on open source terms compared to closed source.[740] By making a distinction in the available subsidy intensity grant between exclusive and open access R&D outputs with respect to technological infrastructure, the EU subsidy system could also aid private companies in reaching the payoff dominant open access equilibrium, leading to avoidance of social cost and greater spillovers.[741] Since the overarching economic goal of subsidies is to tap into the economics of the multiplier effect and increased social value, such an approach is also consistent with the underlying policy of the H2020 system.

As Paul Romer has said, "to speed up growth, it is not enough to increase spending on research and development. Instead, an economy must increase the total quantity of inputs that go into the process."[742] Although Romer's point may hold for all types of inputs, it is surely particularly true with respect to infrastructural assets. By liberating the outputs of sponsored R&D, particularly in software products (which are easily transferred), the EU could follow

739. Where the licensing regime is FRAND, then the subsidy intensity may however be less than royalty-free since FRAND may still create barriers to access.
740. Data was requested from DG Research. Data was processed by the author to only include software deliverables. Software deliverables with language suggesting 'open source' or 'open licensng' was then separated from non-open source or non 'open' software deliverables, to create two sets of FP7 software projects. The means between the two groups' subsidy intensities was then compared using statistical tools and found not to be statistically significant.
741. Furthermore, such distinction would not fall foul of EU State Aid law since although such sponsorship would most likely fall into the category of 'development' rather than basic research, the State Aid Guidelines would consider the open source licensing of R&D outputs to be 'non-economic' and thus would fall outside the application of the usual State Aid rules. See Commission Communication on the framework for State aid for research and development and innovation [2014] OJ C198/01 at rectial 19 ("The Commission considers that the following activities are generally of a non-economic character: (a)… wide dissemination of research results on a non-exclusive and non-discriminatory basis, for example through teaching, open-access databases, open publications or open software.") (*bold* added)
742. Paul M. Romer 'Should the Government Subsidize Supply or Demand in the Market for Scientists and Engineers' (2001) Innovation Policy and the Economy, Vol 1

the lead of DARPA and NASA in fostering a vibrant bottom-up eco-system of self-directed innovators.

V. CONCLUSION

In conclusion, this chapter has attempted to shed light on an arguably under- acknowledged source of technological infrastructure in the economy: sponsored R&D. It is argued that sponsored R&D in technological areas is likely to have a pioneering flavour due to the market failures of uncertainty and risk. When pioneering inventions are linked with an assessment of high social spillovers (such as would attract subsidy grants), then the R&D outputs that result are argued to map fairly robustly to the class of 'technological infrastructure'. Under the default regime of Bayh-Dole (and its EU transplants, such as the IP clauses of the H2020 framework), the task of technological transfer is left to the subsidy recipient who has exclusive rights over the R&D outputs. By using tools from game theory, it is suggested that an exclusive rights regime over technological infrastructure is unlikely to give rise to socially optimal results. The nature of the game played by innovators in high technology is described to be a 'stag hunt' or 'assurance game'. It is shown how such a game is sensitive to government policies which incentivise open access over exclusive control. One simple policy that may help achieve this end is explored, in the shape of dialing up subsidy intensity in response to the ex ante open licensing commitments of subsidy recipients, either on royalty-free or FRAND terms. Adopting simple policy prescriptions such as this may help guide the invisible hand of private resource allocation decisions towards social optima by serving to institutionalise the infrastructural approach of 'if infrastructure, then open access'. This approach helps liberate key technological infrastructural assets to the bottom-up process of innovation-niche exploration, without the top-down control of either Government agenda-setting or IP right holders.

CHAPTER 4

OPEN STANDARDS AND THEIR ENEMIES: THE PUBLIC DEMAND-SIDE APPROACH

I. INTRODUCTION

The punch line of this chapter is that public intervention in intellectual property markets to try to ensure the openness of technological infrastructure can sometimes lead to unexpected, and undesirable, effects. In particular, it focuses on the use of Government public procurement policies as a lever to push software suppliers to implement royalty-free open standards in their software products. Rather than focussing on the tool of competition law as discussed in chapters 1 and 2, or rules around the grant of public subsidies as examined in chapter 3, this chapter focuses on the demand-side mechanism of public demand as manifested by public procurement. Unlike the instruments examined in these other chapters, the tool of public demand is argued to alter the strategic behaviour of companies in a different way, one which is less amenable to private-ordering solutions. Instead, as will be examined, sub-optimal strategic behaviour could actually be exacerbated rather than dampened, by the adoption of aggressive 'royalty free' open standards public procurement policies.

Interoperability standards form a key part of the microeconomic infrastructure of today's high-technology ICT industries.[743] By facilitating compatibility between products and systems[744], interoperability standards scaffold the growth and proliferation of networks, both real and virtual[745]: they enable machine-to-machine interaction (as in the case of protocols); permit programs to 'speak' to one another (as in the case of interfaces), and allow information exchange between different applications and platforms (as in the case of document formats or structured data standards).

Since networks are becoming increasingly central to the modern economy[746], the character of the standards which underwrite them have attracted a growing amount of attention due to their role as technological infrastructure.[747] (see chapters 1-3 of this thesis). In particular, the eyes of lawyers, economists and policy-makers have been drawn to the way in which intellectual property rights ('IPR') over interoperability standards can result in technological bottlenecks, leading to reduced competition and the potential for consumer harm.[748] The

743. GM Peter Swann, 'The Economics of Standardization: Final Report for Standards and Technical Regulations Directorate' (*Manchester Business School* 11 December 2000) ("Swann, 'The Economics of Standardization'") 21 and generally.
744. Tim Simcoe, 'Open Standards and Intellectual Property Rights' in Henry Chesbrough, Wim Vanhaverbeke and Joel West (eds) *Open Innovation: Researching a New Paradigm* (OUP 2008) 162-163.
745. 'A 'virtual network' is 'a network in which participants are linked together by their
economic complementarity and adherence to common technological standards rather than by physical interconnection.', see Langlois, 'Technological Standards', 4.
746. See generally Benkler, *The Wealth of Networks*.
747. See chapters 1-3 of this thesis for greater elaboration of this concept. For the sake of a more targetted analysis, this chapter will continue to use the term 'interoperability' or 'technological' *standard* rather than *infrastructure* , as the grain of analysis of this chapter is on the differences between two different licensing approaches to these standards.
748. See generally Lemley, 'Intellectual Property Rights', 1900 ("[w]hile standardization has great economic value in

root of this concern stems from the uneasy reconciliation of two aspects of interoperability standards: that they should both incorporate leading-edge technology[749] as well as be generally available and accessible for implementation. The aspects fit uncomfortably together because the technological frontier is often occupied by intellectual property: 'inventive' and 'novel'[750] technological features which are attractive to standard-setting organizations (SSOs) may be covered by IPR such as patents, which provide their holders with the right to exclude.[751] Although the European Union (EU) issued a revised set of *Horizontal Guidelines*[752] in 2011, which aimed to encourage SSOs to adopt IPR policies that mandate licensing on Fair, Reasonable and Non-Discriminatory (FRAND) terms, a number of European stake-holders (including governments) have advocated a further opening up of interoperability standards in the form of mandatory royalty-free (RF) licenses.[753] This tendency to require RF licensing of essential[754] IPR over interoperability standards has provoked condemnation by some powerful private sector software vendor lobbying groups[755] as well as by some traditional formal SSOs.[756] Despite already been reasonably wide-spread in certain technology markets (see chapter 1), the critics of RF licensing argue that the mandatory applicability of this licensing regime in

many markets, group standard setting also poses some potential threats to competition").

749. Janice M. Mueller, 'Patent Misuse Through The Capture of Industry Standards' (2002) 17 Berkeley Technology LJ 623, 649 ("[i]ndustry standards often encompass proprietary technology, including technology already patented or the subject of pending patent applications. This is not surprising because one would expect an industry standard to be built upon novel and nonobvious advances in technology rather than upon whatever is available in the public domain.")

750. For the patentability of inventions in Europe (and some other third countries) according the European Patent Office, see European Patent Convention, arts 52-57 <http://www.epo.org/law-practice/legal-texts/html/epc/2010/e/ma1.html> accessed 14 October 2016.

751. Deriving from the so called 'property rule' of IPR. The rule relating to actual damages for infringement of IPR is called the 'liability rule'. See Fred Scott Kieff, 'On the Economics of Patent Law and Policy' in Toshiko Takenaka (ed), *Patent Law and Theory: A Handbook of Contemporary Research* (Edgar Elgin Publishing Ltd 2008) 5.

752. See Commission, 'Guidelines on the Applicability of Article 101'.

753. In particular, during the consultation over the revised European Interoperability Framework, where the *European Committee for Interoperable Systems* (ECIS) advocated a RF licensing regime for 'open standards ', see infra, note 44

754. See the definition of 'essentiality' according to the European Telecommunications Standard Institute ('ETSI') Rules of Procedure (19 November 2014) art 15(6). ""ESSENTIAL" as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR…"

755. See the leaked letter from the Business Software Alliance (composed of, inter alia, Microsoft , Apple, Adobe) in the context of the revision of the *European Interoperability Framework*: (Brussels, 7 October 2010) <http://fsfe.org/projects/os/bsa-letter-ec.pdf> accessed 14 October 2016 ("[w]e urge you to vigorously advocate the language be amended to include an express endorsement of technologies made available on...FRAND terms, which will allow European innovators who own patents and other...IP...to participate in standards setting...")

756. Juan Carlos López Agüí, chairman of the Joint Presidents' Group (JPG) of European ICT and electronics standards bodies CEN, CENELEC and ETSI, reportedly wrote the UK cabinet in response to their new procurement policy which mandated use of RF interoperability standards. ("The definition of 'open standards '...used by the UK government, is on a road towards excluding standards from the majority of the most important standards bodies... from being used in UK public procurement ."). See Mark Ballard, 'International Alarm Rings Over UK ICT Policy' (*ComputerWeekly* 13 May 2011) <http://www.computerweekly.com/blogs/public-sector/2011/05/international-alarm-rings-over.html> accessed 14 October 2016.

public procurement fails, inter alia, because by taking the reward component out of the IP regime, the result will be interoperability standards which are less innovative and less widely-used than standards adopted accorded to a FRAND IPR policy.[757] Conversely, RF licensing policy supporters argue that although essential IPR-holders will lose the ability to appropriate value directly from their IP under an RF regime, they may nevertheless still benefit indirectly via harnessing the immense network effects associated with getting technology to read onto a standard, which can be leveraged to drive demand for complementary assets.[758] In addition, RF licensing supporters argue that an RF regime enables the fuller participation of open source software suppliers[759] in the market for implementers, which will increase competition and the uptake of the standard.[760]

At least part of the debate over IPR and interoperability standards centres around which approach to IP licensing deserves to wear the epithet, 'open standards'- a 'slogan' with no fixed meaning, but which carries strong political force.[761] While it is not the purpose of this chapter to vindicate a definition of 'open standards' which is royalty-free, this chapter aims to apply pressure to one key argument of FRAND licensing supporters against RF interoperability standards: that RF standards are necessarily less innovative than their royalty-bearing equivalents. However, at the same time as supporting the notion that RF standards may be as innovative as their FRAND equivalents, this chapter will also highlight their increased vulnerability to patent litigation from companies excluded by a royalty-free IPR licensing policy, such as pure IP companies. This chapter will conclude that 'openness' comes at a cost and that stake-holders must be prepared to fight both strategically in terms of IP management and perhaps also on a policy-level for changes to the patent system generally.

These arguments will be structured in the following framework. Part II will begin by providing a brief background to the issues, including a short summary of the positions of SSOs, Member

757. For example the Business Software Alliance ('BSA') argued against the UK government's RF open standards definition in their new procurement guidelines: "BSA strongly supports open standards as a driver of interoperability; but we are deeply concerned that by seeking to define openness in a way which requires industry to give up its intellectual property, the UK government's new policy will inadvertently reduce choice, hinder innovation and increase the costs of e-government ." quoted by Andy Updegrove, 'Do Royalty-Free Standards Stifle Innovation?' (ConsortiumInfo, 4 March 2011 ("Updegrove, 'Do Royalty-Free Standards Stifle Innovation?'")<http://www.consortiuminfo.org/standardsblog/article.php?story=20110304122357355> accessed 14 October 2016

758. Such as e.g. compatible software and hardware sold by the standard owner. See ibid; Dolmans, 'Standard Setting'.

759. Throughout this article, 'open source' will be taken to refer to 'free software' as well. Technically, the distinction between the two is that the latter utilises only so-called 'copyleft' licensing practices and must meet the strict requirements promulgated by the Free Software Foundation ('FSF'), see the definition here <http://www.gnu.org/philosophy/free-sw.html> accessed 14 October 2016.

760. See Updegrove, 'Do Royalty-Free Standards Stifle Innovation?'

761. The term 'open standards ' is used frequently in political discourse, but seldom defined in a consistent way, if at all. For its use in 'political' discourse, for example, Neelie Kroes, then European Commissioner for Competition Policy, see Commission, 'Being Open About Standards' (10 June 2008) Press Release SPEECH-08-317.2008.Web. 19 July 2011.

State public procurers, and the open source software community. Part III will then attempt to show how SSOs with an RF IPR licensing policy can still attract participants, including significant holders of relevant IP, in order to produce innovative standards. Part IV will outline the risks associated with a RF IPR policy, focusing mainly on the challenges brought about by decreased participation in standard-setting. Part V will briefly outline some potential remedies to these challenges, as well as some policy considerations. Part VI will conclude.

II. BACKGROUND

From a competition policy perspective, an interoperability standard is simply a technological feature- or set of features- which competitors have agreed not to compete on in order to share in the 'network effects'[762] and economies of scale associated with the existence of a single dominant standard.[763] The benefits of a single dominant standard accrue on both the demand and supply sides simultaneously[764]: software suppliers reduce costs by focusing their production on a single platform[765] meanwhile consumers benefit 'from a large installed base that generates lots of software and other complementary goods and services'.[766] While fragmented standards have been shown to retard innovation[767], cooperatively-set interoperability standards are key innovation-enablers in today's high-technology industries by, inter alia, giving companies' R&D expenditures an important degree of certainty in what is otherwise a highly uncertain and dynamic world.[768]

Given their pivotal role as technological infrastructure, interoperability standards have the potential to become innovation choke-points if IPR over them are abused in order to exclude competitors or to charge 'excessive prices'. To this end, both SSOs and public sector procurers aim to regulate the exercise of IPRs in some way. SSOs do this by requiring their members

762. These effects are divided into two categories: 'direct' and 'indirect'. Direct network effects are predominantly a feature of real networks , and occur when users are identified with components', and simply means that the utility any adopter derives from a network is an increasing function of the number of adopters. Indirect network effects are simply the positive effects which the development of the downstream markets for complementary products (and services) have on the upstream technical platform. See generally Nicholas Economides, 'Competition Policy in Network Industries: An Introduction' in Dennis W. Jansen (ed), *The New Economy and Beyond: Past, Present Future* (Edward Elgar Publishing Ltd 2006).
763. According to Tom Cottrell, the Japanese computer software industry's failure to settle on a single standard (as compared to the dominant 'Wintel' standard of the US and Europe) contributed towards its slow pace of innovation in the 1980s-1990s, see Cottrell, 'Fragmented Standards', 143-174.
764. See Langlois, 'Technological Standards', 37.
765. According to Annabelle (quoting West), a 'platform is an architecture of related standards…'. See Annabelle Gawer, Towards a General Theory of Technological Platforms' (DRUID Summer Conference, 16 June 2010), 13.
766. See Langlois, 'Technological Standards', 37.
767. See the already mentioned example of the Japanese software industry in 1980s-1990s, See generally Cottrell, 'Fragmented Standards'.
768. Swann, 'The Economics of Standardization', 21.

to sign up to their IPR policies.[769] These policies usually include a duty to declare ex ante during standard formation any essential IPR over a standard as well as either mandating or requesting commitments on how the IPR will be exercised ex post in the market.

A. Formal and Informal SSOs IPR policies

In the case of formal SSOs, these commitments usually entail FRAND licensing of essential IPR, which may either be binding[770] or simply a request to do so[771], as discussed briefly in chapter 1. Some formal SSOs have publicly repudiated the notion that standards should be mandatorily licensed on a royalty-free basis.[772] The *Global Standards Collaboration* (GSC) - an international body comprised of the major SSOs from all over the world[773]- adopted a resolution (*Resolution GSC-13/22*) condemning mandatory RF IPR licensing. The GSC observed, 'that there is a trend in some user communities and some standards development organizations in support of patent policies which enforce compensation-free provisions for standards implementers with respect to SSO IPR policies'. The GSC then *resolved* to:

> strongly voice their opposition to policies that mandate compensation-free licensing provisions.

In contrast to formal SSOs, informal SSOs such as fora and consortia, however- and mainly in the context of the Web and the Internet- tend to adopt either non-proprietary standards or standards adopted according to policies mandating RF licensing.[774] According to Tim Berners-Lee, the current head of the World Wide Web Consortium (W3C), and inventor of the Web[775]:

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769. Although the term 'policies' is used here as a catch-all, there are significant differences in the legal forms of these commitments. For a summary and comparison of these policies in a number of dominant SSOs, see Contreras, 'Market Reliance', 516.

770.For example, VITA (VMEbus International Trade Association) has a mandatory (F)RAND IPR policy combined with compulsory essential patent disclosures http://www.vita.com/home/VSO/Disclosure2011.html (last accessed 19 July 2011).

771.ETSI 'encourages' FRAND licensing of essential IPR: see ETSI 6.1; ETSI Guide on IPRs, January 25, 2007, available at http://www.etsi.org/WebSite/document/Legal/ETSI_Guide_on_IPRs.pdf, section 2.1.1. ('Members are encouraged to make general IPR undertakings/declarations that they will make licenses available for all their IPRs under FRAND terms and conditions related to a specific standardization area and then, as soon as feasible, provide (or refine) detailed disclosures.')

772. ETSI, Resolution GSC-13/22, 23-25, (IPRWG) *Intellectual Property Rights Policy* September 2008.

773. Including most of the national standardisation bodies from Asia, North America and the EU.

774. See the W3C Patent Policy (5 February 2004) <http://www.w3.org/Consortium/Patent-Policy-20040205/> accessed 14 October 2016. See also the IETF IPR Policy, 'Intellectual Property Rights in IETF Technology' (March 2005) <http://www.ietf.org/rfc/rfc3979.txt> accessed 14 October 2016.

775. Tim Berners-Lee (head of *W3C* and inventor of the Web). Tim Berners-Lee, 'Long Live the Web: a Call for Continued Open Standards and Neutrality,' (*Scientific American* 22 November 2010) <http://www.scientificamerican.com/article.cfm?id=long-live-the-web> accessed 14 October 2016.

> Open, royalty-free standards that are easy to use create the diverse richness of Web sites…Openness also means you can build your own Web site or company without anyone's approval. When the Web began, I did not have to obtain permission or pay royalties to use the Internet's own open standards, such as the well-known transmission control protocol and Internet protocol (TCP/IP). Similarly, the Web Consortium's royalty-free patent policy says that the companies, universities and individuals who contribute to the development of a standard must agree they will not charge royalties to anyone who may use the standard.

Berners-Lee's model of the bottom-up, decentralised dispersion of control over the innovative process has strong analogies to the desired end-point of the 'infrastructural approach', as developed in chapters 1-3, and in particular, chapter 5 of this thesis (which also provides a way of visualising this model). Unlike formal SSOs in telecommunications (which are the main constituents of the GSC), Web and Internet-related standards fora and consortia often have strong cultural and historical reasons for adopting RF licensing models.[776]

B. Member State Public Procurement IPR Policies

In the context of public procurement, Member States often set criteria for what standards can be accepted as part of the software they procure. Increasingly, Member States are opting for standards which are licensed on a RF basis, as the highly controversial example of the United Kingdom procurement policy demonstrates.[777]

The reasons for Member States to adopt RF IPR licensing policies with respect to the standards implemented in the software they procure generally relate to the following concerns: [778]

776. See generally, Contreras 'A Tale of Two Layers'

777. See the 2015 UK Open Standards Principles Policy Paper ("…rights essential to implementation of the standard, and for interfacing with other implementations which have adopted that same standard, are licensed on a royalty free basis that is compatible with both open source"). See also UK Cabinet, 'Procurement Policy Note – Use of Open Standards when specifying ICT requirements', Action Note 3/11 31 January 2011 http://www.cabinetoffice.gov.uk/sites/default/files/resources/PPN%203_11%20Open%20Standards.pdf (last accessed 29 July 2011)
However, this policy was withdrawn in November 2011; see
http://www.cabinetoffice.gov.uk/sites/default/files/resources/20111130_PPN%2009_11%20Open%20Standards.pdf 14 October 2016.

778. See the withdrawn UK Cabinet 'Procurement Policy Note', ibid, 'Background', at point 4

> Government assets should be interoperable and open for re-use in order to maximise return on investment, avoid technological lock-in, reduce operational risk in ICT projects and provide responsive services for citizens and businesses.

The three most important goals are interoperability (in the sense of data exchange between citizens, businesses and other government departments); re-use (i.e. that the standard will continue to be supported in the future); and the avoidance of lock-in (i.e. that there are a diversity of software suppliers able to implement the standard). The last issue of lock-in has been one of real concern for Member State government departments who have often found themselves unable to switch from their current (usually Microsoft-based) information systems to competing systems (often open source), due to lack of interoperability.[779] Indeed, many Member State procurement policies expressly mention that royalty-free 'open standards' are required in order to permit open source software suppliers to make use of them as well.[780]

C. Interoperability Standards and Open Source Software Implementation

The inability of some[781] open source software to implement royalty-bearing interoperability standards derives from restrictive licensing terms in certain open source licenses. In particular, the GNU General Public License (GPL) family of licenses are incompatible with any royalty-bearing conditions which attach to interoperability standards. The specific clause is found at section 7 of the GPL v2, and has been nick-named, the 'Liberty or Death clause'.[782] For good reason: any extra restrictions such as patent royalties which prevent users from exercising the freedoms in the license remove the right to continued distribution of the software.[783]

779. As in the case of the German foreign office, which was 'forced', after some experimentation with some open source software providers, to revert back to Microsoft due to 'interoperability problems', see http://www.osor.eu/news/de-interoperability-forces-foreign-office-to-proprietary-desktop (last accessed 19 July 2011.

780. See *The Netherlands in Open Connection: An action plan for the use of Open Standards and Open Source Software in the public and semi-public sectors*, available at 'The Netherlands in Open Connection' (Ministry of Economic Affairs) <http://www.whitehouse.gov/files/documents/ostp/opengov_inbox/nl-in-open-connection.pdf> accessed 14 October 2016, 6

781. Not all, for example the permissive BSD and MIT licenses would have no such conflict

782. See Fsfe, 'Transcript of Richard Stallman at the 2nd International GPLv3 Conference' (21 April 2006) <http://fsfe.org/projects/gplv3/fisl-rms-transcript.en.html#liberty-or-death> accessed 14 October 2016.

783. GPL v2, section 7: 'If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you… they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.'

The GPL-style family of licenses covers around 65% of all open source projects currently on the market.[784] Furthermore, if we review the main types of software packages- both proprietary and open source- available on the market, often the main rival to the commercial software product is an open source product covered by a GPL-style license.[785] For instance, the main alternatives to the dominant MS Office suite, are the two office suites, OpenOffice.org[786] and LibreOffice (covered by the LGPL). One of the main alternatives (in terms of market share[787]) to the dominant Microsoft Windows PC operating system is Linux (covered by GPL v2). Likewise MySQL (covered by the GPL) is a popular open source database which competes with Oracle's commercial offering.[788]

III. RF INTEROPERABILITY STANDARDS AND INNOVATION

Although the open source community has been among the most vocal supporters of RF interoperability standards, strong supporters also exist among traditional ICT companies. In particular the *European Committee for Interoperable Systems* (ECIS) is composed of members 'such as IBM, Oracle and Nokia, [and] are among the most innovative information and communications technology (ICT) companies on the planet and include owners of some of the largest patent portfolios in the ICT sector'.[789] During the consultation for the revised *European Interoperability Framework*[790] v2, the ECIS supported an open standards definition which included an RF IPR policy:

> to be fully open, a software interoperability specification may not be encumbered with running intellectual property ("IPR") royalties.

784. Although the percentage of open source projects licensed under the GPL-family of licenses is currently in decline, as much as by 24% in previous years in the popular open source respoitory GitHub, http://www.zdnet.com/article/the-fall-of-gpl-and-the-rise-of-permissive-open-source-licenses/
785. Rishab A Ghosh, 'Open Standards and Interoperability Report: An Economic Basic for Open Standards'(FLOSS-POLS MERIT University of Maastricht 2005), 8-9.
786. However it should be noted that Openoffice.org's transfer from Oracle to the Apache Foundation may mean the next release will be under the Apache 2 license rather than the LGPL.
787. See NetMarketshare, 'Analytics Without the Bots' <http://marketshare.hitslink.com/operating-system-market-share.aspx?qprid=8&qpcustomd=0> accessed 14 October 2016.
788. *i.e.,* Oracle pursues an 'open core' model in relation to MySQL.
789. See ECIS, 'ECIS Statement on the Proposed New European Interoperability Framework' (13 October 2010) <http://ecis.eu/documents/ECISStatementreEIF13.10.10.pdf> accessed 14 October 2016.
790. The purpose of the (non-binding) *EIF* is to provide an 'overarching set of policies, standards and guidelines which describe the way in which organizations have agreed, or should agree, to do business with each other' under the heading of eGovernment.

Admittedly, some of the companies which make up the ECIS rely on peripheral services associated with open source software as a lucrative revenue stream.[791] However, many do not.[792] What incentives do these companies have to contribute technology to RF standards?

Before this question can be properly answered, it is important to distinguish between categories of potential participants in standard-setting, each of whom have different incentives.

A. Participants in Standard-Setting

This chapter follows Damien Geradin's identification of three main participants in standard-setting.[793] These are pure IP companies, vertically-integrated companies and pure downstream companies (standard implementers). Pure IP companies do not engage in production (of either hardware or software), but merely produce IP which is licensed to produce revenues. Vertically-integrated companies engage in R&D yielding IP as well as producing downstream products making use of IP. Pure downstream companies only produce the final product, which may implement the IP produced by both pure IP companies and vertically-integrated companies.

In a standards context, a vertically-integrated company has incentives to get its IP to read onto standards for two reasons. First, in order to tap into the potentially lucrative revenue streams of IP licensing from other companies making use of its IP. Second, by getting its IP to read onto a standard, a vertically-integrated company can raise the relative costs of implementation for its competitors in the downstream market for implementation. Even in the case where a vertically-integrated company fails to get its IP included in the eventual standard, it can still lower its implementation costs vis-à-vis pure downstream companies by concluding cross-licenses with other vertically-integrated companies which were successful in getting their IP included.[794]

Pure IP companies on the other hand would seem to only have incentives to get their IP included in a standard in so far as they can monetise that IP directly into licensing fees, although there may also be some weaker incentives to benefit indirectly through complementary assets not essential to the standard.[795] Unlike vertically-integrated companies, a pure IP company

791. For instance IBM receives around USD 2 billion annually from open source related revenue. See Benkler, *The Wealth of Networks,* 47-48

792. For example, *Nokia* and *Oracle.*

793. See generally Geradin, 'What's Wrong with Royalties in High-Technology Industries?' the same distinctions are also used in Lim, 'Standard Essential Patents'.

794. Ibid, 472.

795. See, *inter alia*, Teece, 'Profiting From Technological Innovation'.

would not be interested in cross-licensing.[796] The special threat that these companies present to RF interoperability standards will be assessed in Part IV, Section A.

Pure downstream companies which do not have any IP clearly have incentives to lower their standard implementation costs as much as possible in order to maximise their final product margins (such as by pushing standards towards areas without IP rights) in so far as this drive does not affect the technological quality to the extent consumers are put off.[797]

In the following assessment of the incentives for participation in royalty-free standard-setting, it is important to keep these categories of participants in mind.

B. Fast Adoption Rates and Network Effects

One obvious advantage of RF standards from the point of view of a technology contributor is fast adoption rates.[798] All things being equal, zero licensing fees over a standard encourage that standard's adoption by pure downstream companies, and thus increases its foothold in a market vis-a-vis competing standards. If the vertically-integrated company owning the IP already has a downstream product on the market, then it can expect its market share to increase due to first-mover advantages and the natural monopoly characteristics and network effects often associated with standards.[799] As Andy Updegrove has argued, these network effects[800]:

> are so enormous that having even a slight advantage or head start, such as having your technology rather than a competitor's included in a new standard, can greatly outweigh any royalties that might have been obtained under the old regime. Companies are therefore quite happy to compete to get their technology included for free.

Clearly this model of indirect appropriation of the value from essential IPR requires that the company contributing the technology is also a manufacturer of downstream products. This argument would not apply to pure IP companies.

796. See Geradin, 'Royalties in High-Technology Industries', 469.
797. Clearly there is a compromise between quality and price such that consumers still demand leading-edge technology, but are not always willing to pay top dollar. The concept is that pure downstream companies wish to pay as little for implementation as they can get away with in the *market conditions*.
798. Fast adoption rates can help companies and technologies entrench their technologies as successful standards, see Arthur, 'Competing Technologies'; Arthur, 'Increasing Returns and the New World of Business'; Farrell and Klemperer, 'Coordination and Lock-In'.
799. A 'first mover' in the literature analysing the 'increasing returns to scale' is William Brian Arthur, *Increasing Returns and Path Dependence in the Economy* (University of Michigan Press 1994).
800. See Updegrove, 'Do Royalty-Free Standards Stifle Innovation?'

C. Strategic Considerations

Probabilistically it is clear that vertically-integrated companies with larger patent portfolios[801] in the relevant field of standardization may have relatively less incentive to participate in RF licensing since they have a higher chance of getting essential IPR reading onto the eventual standard and benefitting from the resulting licensing revenue stream or cross-licensing agreements (and vice-versa for companies with smaller patent portfolios). However, even large vertically-integrated companies may place a significant weight on using an unencumbered standard, particularly if the standard relevant area of technology has a high concentration of pure IP companies, who are uninterested in cross-licensing, and thus raise implementation costs for all implementers (whether vertically-integrated or pure implementers). If the weight placed by companies participating in an SSO on having an unencumbered standard is significant, then the tendency would be to drive standards towards non-proprietary technology in the technical committee phase of standard-setting.[802] In an SSO with open participation, the 'collective will' is most likely to lead to this outcome where, all things equal[803], among IP contributors: pure IP companies are outnumbered by vertically-integrated companies; and among, implementers: pure implementers outnumber vertically-integrated companies; and where the sum of all implementers is greater than the sum of all IP contributors. Whether the software sector conforms to this structure is an empirical question, but at least one study[804] points to the high potential, if not yet reality, of SMEs- which are usually pure implementers- to attain significant concentrations in this sector. According to Trond Undheim, a past director of Standards Strategy and Policy at the Oracle Corporation, participants in FRAND-based SSOs in the ICT sector largely push for, and adopt, unencumbered or royalty-free technologies as the final standard: [805]

801. Overwhelmingly, the size of a company's patent portfolio is proportional to its size, see Blind *et al*, 'Interaction Between Standards'.
802. See also the dynamics captured in the game theoretical treatment of the 'assurance game ' covered in Part III, Section C of this thesis.
803. '*Ceteris paribus'* here may be an unreasonable assumption since different technologies are more or less appropriate for standards. Indeed, some SSO allow exceptional technology to be adopted as part of a standard even without any licensing commitments at all, *e.g.,* ETSI and IETF.
804. Ghosh, 'Open Standards and Interoperability Report', 9.
805.See Trond Undheim, 'Portugal's New Interoperability Law' (*Oracle Blog*, 13 April 2011), <http://blogs.oracle.com/trond/entry/portugals_new_interoperability> accessed 14 October 2016.

> The interesting thing is that, notwithstanding the fact that the overwhelming number of ICT standards are still created in standards development organizations that allow royalties to be charged, very few standards are ever released that do, in fact, require the payment of royalties – even though those that have developed them often do own patents that would be "necessarily infringed" by a product built to their standards.

If Undheim is accurate in his assessment, this demonstrates that there are forces at work – even if this chapter has incorrectly identified them – which drive IP holders to contribute to royalty-free standardisation even where their IP could potentially yield licensing fees. In other words, innovators (excluding, of course, pure IP companies) voluntarily choose to compete on implementation as opposed to attempting to capture the standard. In fact, examples of RF standards and 'open platforms' are already fairly wide spread, and the list is steadily growing. In addition to the examples of Bluetooth and the OPUS audio codec, mentioned in chapter 1 and the Preface to this thesis, chapter 3 also mentioned Twitter[806], Google[807], Tesla[808] and Toyota[809] as companies who have agreed to license their patents on an RF basis to all comers.[810]

This state of affairs would seem to suggest that direct IPR compensation in the form of FRAND licensing fees may well be assessed by rational companies as less lucrative than harnessing the network effects of wide RF standard implementation and technology use in the downstream market. The existence of these incentives may go some way to ensure that the quality of technology contributed to the standard is of the same value as that contributed to a traditional FRAND licensing regime.

D. Mandatory RF Licensing in Practice

Few formal European and international SSOs contain mandatory RF IPR licensing provisions, though many explicitly provide for the possibility of RF licensing.[811] The greatest concentration of those that do mandate RF IPR licensing is found in the software sector.

806. Adam Messinger, 'Introducing the Innovator's Patent Agreement' (*Twitter*, 17 April 2012) <https://blog.twitter.com/2012/introducing-the-innovator-s-patent-agreement> accessed 14 October 2016.
807. Google , 'Open Patent Non-Assertion Pledge' <https://www.google.com/patents/opnpledge/pledge/>.
808.Elon Musk, 'All Our Patent Are Belong To You' (*TESLA*, 12 June 2014) ("Musk, 'All Our Patent Are Belong To You'")<https://www.tesla.com/blog/all-our-patent-are-belong-you> accessed 14 October 2016.
809. Charlie Osborne, 'Toyota Pushes Hydrogen Fuel Cell Cars With Open Patent Portfoli' (*ZDNet*, 6 January 2015) <http://www.zdnet.com/article/toyota-pushes-hydrogen-fuel-cell-cars-with-open-patent-portfolio/> accessed 14 October 2016.
810. Generally, the RF licensing commitment is made contingent on a reciprocal RF licensing obligation.
811. See the GSC definition of 'open standards ' which explicitly provides for RF licensing. It is stated in *Resolution GSC- 13/24:* 'the standard is subject to RAND/FRAND Intellectual Property Right (IPR) policies which do not mandate, but may permit, at the option of the IPR holder, licensing essential intellectual property without compensation'

In particular, standards relating to the Web and the Internet are almost without exception licensed on an RF basis.[812] By and large, this is due to the historical and cultural forces between these communities[813], such as the W3C, which creates standards for the Web, and the Internet Engineering Task Force (IETF), which creates standards for the Internet back-bone. Outside of the context of the Web and the Internet, RF standards for stand-alone client-side software are less common, though still present. For example, the *Organization for the Advancement of Structured Information Standards* (OASIS) has an RF IPR policy 'track', under which the Open Document Format (ODF) was adopted (now an ISO standard[814]). Microsoft has also adopted an arguably[815] 'open' RF document format, Open Office XML (OOXML).

Given that this chapter aims to assess IPR policies in relation to the ICT sector as a whole, the question arises whether there is an important distinction to be made between Web standards and client-side software standards. It is submitted that the distinction between the two, though easy to support only a few years ago, is of less relevance today. The exponential growth of Web-enabled devices[816] and the advent of cloud computing which permits Web applications to take over most of the functionality of client-side stand-alone software[817], is making the notion of 'stand-alone' computing a thing of the past. This is particularly visible in relation to codecs[818], the software compression programs responsible for encoding and decoding digital audio-visual information. Traditionally, such standards have been licensed on royalty-bearing terms. The MPEG format for example, and which the software vendors' lobbying group, the *Business Software Alliance* (BSA), cites[819] as a successful FRAND standard, is ubiquitous in the ICT sector in both client-side applications and on the Web. However, this situation is changing. In 2011, Google announced development of a new royalty-free audio-visual compression codec, called *WebM* (V8), which Google and others[820] intended as an alternative to the MPEG-4 AVC (H264) codec.[821] In addition to demonstrating a shift towards

812. Some key and recognizable examples are: HTML, CSS, XML, TCP/IP etc.
813. See generally Contreras, 'A Tale of Two Layers'.
814. ISO, 'ISO/IEC 26300' (1 December 2006) < http://www.iso.org/iso/catalogue_detail?csnumber=43485> accessed 14 October 2016.
815. RedHat, and a number of other open source companies, argue that OOXML 'is not fully implementable by non-Microsoft vendors or partners', see RedHat, 'Red Hat's Position on OOXML and Open Standards'<http://www.redhat.com/f/pdf/RedHatOOXMLPosition.pdf> accessed 14 October 2016.
816. By 2050, Cisco projects that this number will reach 50 billion. Cisco, 'Internet of Things' <http://blogs.cisco.com/wp-content/uploads/internet_of_things_infographic_3final.jpg accessed 14 October 2016.
817. Niamh Christina Gleeson and Ian Walden, '"It's a Jungle Out There"?: Cloud Computing, Standards and the Law' (2014) 5(2) Eur J L & Tech 1. There are many examples of this phenomenon, including Google Docs (Word Processing), Spotify and Grooveshark (for music-playing applications).
818. See Wikipedia, 'Codec' <http://en.wikipedia.org/wiki/Codec> accessed 14 October 2016.
819. See Business Software Alliance letter, 2.
820. Supporters of *WebM* include Mozilla Firefox, ARM, ORACLE, AMD, etc.
821. In actual fact, MPGEG-LA and Google began a long drawn-out patent dispute over the royalty-free status of WebM, including a threatened patent lawsuit about anticompetitive use of a patent pool. In 2013, this dispute was eventually resolved. See discussion in Carl Mair, 'Is the Future Open for Web Video?' (*Leiden Law Blog*, 21 March 2013) <http://leidenlawblog.nl/articles/is-the-future-open-for-web-video> accessed 14 October 2016.

RF licensing with respect to codecs, this example also shows the effect Web standards are starting to have on the licensing practices on the client-side. In short, the interpenetration of the Web and client-side software may be leading to a shift in the traditional 'control' approach of the client-side towards the more 'open' culture'[822] and RF licensing models of the Web. But, as discussed below at sub-section A, this interpenetration of Web-based and client-side technologies might be leading to a 'culture clash' between the traditional royalty-bearing models of the client-side and the RF default of Web and Internet standards.

IV. RISKS FACED BY RF INTEROPERABILITY STANDARDS

In many cases even an RF IPR policy might not be enough to guarantee an unencumbered standard. SSOs such as the W3C also make use of provisions granting conditional reciprocal patent licenses, otherwise known as 'non-assertion clauses' (NACs). These provisions, which are prevalent in both technology pools such as the Open Invention Network[823] and wireless standards such as Bluetooth[824], work to solve a possible prisoner's dilemma besetting patents in standards: that essential IPR-holders (from either inside or outside the formal/informal SSO) over a standard may decide to enforce their patents in any case, as discussed in relation to cooperatively-set standards in chapter 1. NACs demand that essential IPR-holders over an RF standard or RF technology grant all other essential IPR-holders free use of their IP on condition of mutual non-assertion.[825] These provisions aim to nudge participants towards the cooperation/cooperation equilibrium of patent non-assertion as opposed to the defection/defection equilibrium of a potential all-out patent war.[826] Such provisions however are only effective if essential IPR-holders actually practice in the industry (i.e. are vertically-integrated). It does not protect against the threat of 'patent trolls'[827] (also known as Non-Practising Entities (NPE)), or legitimate pure IP companies. For example, the *Bluetooth Special Interest Group* (Bluetooth SIG) is a consortium which licenses essential IPR over Bluetooth

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822. As described by Andrew L Russell, 'The W3C and its Patent Policy Controversy: A Case Study of Authority and Legitimacy in Internet Governance' (31st Conference on Communication, Information, and Internet Policy, Alexandria, Virginia, 20 September 2013) 18-20, <http://www.arussell.org/papers/alr-tprc2003.pdf> accessed 14 October 2016.

823. See section 1.1 and 1.2 of the OIN license agreement, available at < https://www.openinventionnetwork.com/joining-oin/oin-license-agreement/> accessed 29 April 2017

824. See the Bluetooth Membership Agreement, available at < https://www.bluetooth.com/membership-working-groups/membership-types-levels/membership-agreements> accessed 29 April 2017

825. *i.e.,* NACs have arguably a function like a *de facto* patent pool.

826. Further discussion in chapter 3 of this thesis also presented an alternative game-theoretical model which presented this strategic interaction as an 'assurance game '.

827. Ewing and Feldman, 'The Giants Among Us'; Magliocca, 'Blackberries and Barnyards'; Rantanen, 'Slaying the Troll'. A possible difference between a pure IP company and a patent troll (if we care to make the distinction) is that pure IP companies actually invest in R&D, while patent trolls tend just to acquire patents in company buy-outs or bankruptcy proceedings.

technology to all members on an RF basis, provided the member grants a reciprocal license for any essential IPR it may have over the standard.[828] However, the enticement of a NAC has not prevented the *Washington Research Foundation*[829] and *Rembrandt IP*[830] – third parties to the consortium and pure IP companies- from asserting their patents across the industry. These cases serve as an important reminder that the 'openness' of standards is always under threat, regardless of the character of ex ante IPR policies, even if those policies mandate royalty-free licensing.

Indeed, RF standards may well be even more vulnerable to third party patent infringement claims than if they were adopted under FRAND licensing conditions, as discussed below.

A. The Challenge of IP Companies and Patent Trolls to RF Standards

One unfortunate side-effect of interoperability standards adopted according to a RF IPR licensing policy is that it may exclude pure IP companies from participating in standardisation as well as some large vertically-integrated companies. This risk is enhanced given recent developments in the IP marketplace where vertically-integrated companies transfer or exclusively license their IP to third party pure IP vehicles for enforcement and licensing.[831]

As already explained, pure IP companies follow a business model where licensing fees are the only revenue source. Situations can be imagined where such companies may nevertheless choose to contribute IP to an RF standard- as in where they expect to appropriate value indirectly from licensing complementary assets- but these incentives would be comparatively weak.[832] The majority of pure IP companies would have little incentives to engage in RF standard-setting. By not participating in SSOs, pure IP companies would not be bound by the IPR policies which usually mandate, inter alia, the ex ante disclosure of essential IPR over a standard. In comparison, pure IP companies would have incentives[833] to join SSOs with a FRAND IPR licensing policy and so would be bound by both the duty of disclosure as well

828. See the Bluetooth Membership Agreement, available at < https://www.bluetooth.com/membership-working-groups/membership-types-levels/membership-agreements> accessed 29 April 2017

829. See http://www.wrfseattle.org/about/ (last accessed 19 July 2011)

830. In 2015, Rembrant IP won damages against certain implementers of the Bluetooth standard (i.e Samsung) in an Eastern District of Texas Court Judgment, *Rembrandt IP Wireless Technologies v Samsung Electronics et al* Case No. 2:13-CV-213-JRG, available at < https://cdn.arstechnica.net/wp-content/uploads/2015/02/Rembrandt.Samsung.Verdict.pdf> accessed 29 April 2017

831. For example, Apple transferred many of its crucial SEPs to *Rockstar IP*, which has since been purchased (in 2015) by the patent aggregator, RPX Corporation. See < http://www.rpxcorp.com/rpx-news/rpx-news-releases/rpx-corporation-completes-purchase-of-rockstar-patents/> accessed 29 April 2017

832. The uncertainty of these benefits might not make the overall participation worthwhile

833. However some commentators have suggested that companies which get a significant proportion of their revenue from licensing tend to stay away from standardisation altogether. see generally Blind, Knut, *The Influence of Companies' Patenting Motives on their Standardization Strategies*," 2010, unpublished

as the duty not to charge excessive fees.[834] At the very least, the existence of RF SSOs may lead to the development of multiple competing standards.[835] More dangerously, though, third party IP companies (both pure and vertically-integrated) may choose to enforce their patents generally against implementers and users after the standard has been adopted.[836]

This risk is non-trivial since the SSO technical committee would not have had the opportunity to 'design around' the IP of IP companies in a royalty-free standard.[837] The risk is far from academic: in 2002, after the 'royalty-free' JPEG was already a well-established image-compression standard, a company called Forgent Networks started enforcing a claimed patent right over technology essential to the standard.[838] Before being declared invalid in 2006, the patent had already been asserted against more than thirty companies, raking in in excess of USD105 million in licensing fees.[839]

Admittedly, the RF standards which underwrite the Web and the Internet have so far escaped much patent litigation, perhaps due to certain historical and cultural features of the standards communities in these technology areas.[840] In addition, the technologies adopted as standards by the W3C and the IETF are highly specialised, pioneering, and relate mainly to the deep infrastructure of the Internet and Web. In contrast, interoperability standards such as, inter alia, document formats, structured data standards and compression codecs are the subject of independent R&D efforts by a number of private companies.[841] For this reason, companies implementing royalty-free standards covering these areas are at higher risk of ex post patent litigation. Furthermore, recent years have seen a marked proliferation of pure IP companies[842]

834. As determined by the so-called *United Brands* test under EU competition law. See *United Brands*.
835. See Anne Layne-Farrar *et al*, 'Payments and Participation: The Incentives to Join Cooperative Standard Setting Efforts' (2014) 23(1) J Econ & Management Strategy 25, 32 ("[a]lso importantly, firms might contribute technology to different SSOs that might create independent or competing standards").
836. Richard Tansey, Mark Neal and Ray Carroll, 'Patent Aggression: High Risk Intellectual Property Strategies in the Semiconductor Industries', (2004) 4 Businessperspectives.org 80 ("Tansey *et al.* "Patent Aggression"); Simcoe, 'Private and Public Approaches'.
837. Of course participants to an SSO adopting a royalty-free standard have incentives to search for any third-party patents in order to avoid the situation described. However, given the extremely large number of patents in existence, this task can never be exhaustive, and SSOs strongly depend on the duty of disclosure of their members. Importantly, even members to an SSO often only have a duty to perform a 'good faith' or 'reasonable' patent search in recognition of the heavy burden involved.
838. Priscilla Caplan, 'Patents and Open Standards' (2003) 14(4) Information Standards Quarterly 1, 2-3.
839. See Wikipedia, 'JPEG' <http://en.wikipedia.org/wiki/JPEG#Patent_issues> accessed 14 October 2016.
840. Contreras, 'A Tale of Two Layers' 865: ("In many respects, the differences in standardization practices between the Network world and the Internet arise from differences in the historical development of these two fields.")
841. A considerable number of companies such as Apple Inc, Panasonic, Sony, Hitachi all held essential patents to the H.264 codec standard for video compression. See Indiworks, 'H.264 List of Shame: All the Patent Holders' <http://indiworks.wordpress.com/2010/05/18/h-264-list-of-shame-all-the-patent-holders/> accessed 14 October 2016.
842. See Ewing and Feldman, 'The Giants Among Us' 1 ("The patent world is quietly undergoing a change of seismic proportions. In a few short years, a handful of entities have amassed vast treasuries of patents on an unprecedented scale…[T]he most massive of these has accumulated 30,000-60,000 patents worldwide, which would make it the 5th largest patent portfolio of any domestic US company and the 15th largest of any company in the world."); see also

as well as a general increase in patenting worldwide.[843] These factors suggest that the risk is growing.[844]The example of Google's WebM RF standard mentioned in Section III(D) is a case in point. Shortly after announcing its intention to release a new RF video codec that would be compatible with HTML5, the licensing administrator of traditionally royalty-bearing standards, MPEG-LA, responded to the threat of WebM by stating that the proposed standard infringed a number of patents in its pool.[845] Additionally, MPEG-LA launched a call for VP8-essential patents and attempted to form a patent pool around the codec to draw in royalties. As a result, support for Google's WebM swiftly disintegrated and active supporters (such as Mozilla FireFox) started implementing the H.264 codec into HTML 5.[846]

This example is just one of a growing trend of 'outsider' assertion of patents against SSO-developed standards. A recent empirical study[847] by Contreras et al, suggests that 'the assertion of SEPs by 'outsiders' constitutes a material segment of all SEP assertions'.

V. DEALING WITH THE CHALLENGE OF THIRD PARTY IP COMPANIES

Given that RF interoperability standards have a higher risk of exposure to third party IP litigation than FRAND standards, governments, implementers, and users must adopt a strategy to deal with this risk in order to maintain the openness of interoperability standards.

A. Defensive Patenting

One option would be to follow the lead of the open source community and adopt a strategy of 'defensive patenting'. In order to protect the openness of the Linux kernel, an IP company called the *Open Invention Network*[848] has a practice of acquiring patents relevant to the kernel and arranging royalty-free cross-licenses with third-party patent holders in order to guarantee

Simcoe, 'Open standards and Intellectual Property Rights',162-163.

843. Dietmar Harhoff et al., 'The Strategic Use of Patents and Its Implications for Enterprise and Competition Policies (European Commission Report 8 July 2007), 4: ("[a] surge in patent applications, "a patenting explosion", has been observed at the European Patent Office (E.P.O.) as well as at the patent office for the United States of America (U.S.P.T.O) and other patent offices world wide").

844. Although the risk is growing, competition authorities on both sides of the Atlantic are starting to pivot towards a tougher approach to such strategic use of patents, see Mair, 'Taking Technological Infrastructure Seriously'; Petrovcic, 'Patent Hold-Up'.

845. See this news article summarising the dispute and its resolution http://www.theregister.co.uk/2013/03/08/google_mpegla_webm_patent_license/> last accessed 29 April 2017

846. Eventually the US DOJ opened investigations into MPEG LA for anticompetitive practices, and the parties settled. See Carl Mair, 'Is the Future Open for Web Video?

847. Jorge L. Contreras 'When A Stranger Calls: Standards Outsiders and Unencumbered Patents' Journal of Competition Law & Economics, 1–33, 28

848. See OpenInventionNetwork, <http://www.openinventionnetwork.com/> accessed 14 October 2016.

mutual patent non-assertion. The company plays a crucial role in maintaining the continued openness of the Linux operating system by a combination of the carrot of a royalty-free license to essential Linux patents and the stick of patent litigation by outsiders.

If RF interoperability standards are to be defended in the same way as the Linux kernel, it would require SSO participants as well as downstream implementers and users to develop a culture of cooperation around IP management and filing patents similar to the open source community. This is perhaps not inconceivable given the potential for open source software companies to enter the market under a royalty-free licensing policy, and which may well have incentives as well as experience of dealing with such risks. However, as in the case of NAC's already discussed, pure IP companies and in particular, patent trolls, often have little to lose by the threat of a counter-suit. For this reason, defensive patenting would only be partially effective as a solution to maintaining the openness of interoperability standards.

B. Competition Law Remedies

Compared to the United States, the EU has taken a stronger stance[849] on using competition law to control the abuse of IP in the context of technological standards.[850] In the EU 'patent ambush' case of *Rambus*[851], the EU Commission imposed certain 'commitments'[852] designed to neutralise the deceptive conduct of the company, including granting 'royalty holidays' to licensees of the essential patents, as well as royalty caps on several others.[853]

In the earlier EU case of *Microsoft* the Court of First Instance (now the 'General Court') arguably applied the so-called 'essential facilities doctrine' to grant a compulsory license to certain 'interoperability information' under FRAND terms to competitors in a derivative market to which that information was essential to compete, in relation to the *de facto* technological standard of the Windows operating system.[854] Likewise, the 2014 case of *Huawei*[855] concerning cooperatively-set standards over mobile data communications led the European Courts to apply Art 102 TFEU and an effective compulsory licensing rule in relation to a willing licensee of SEPs.[856]

849. Not only a matter of will, however, but also a matter of law, since the US antitrust legal regime framework is less amenable to take on such cases. Petrovcic, 'Patent Hold-Up'.
850. See discussion in chapters 1 and 2 of this thesis.
851. See Commission, Press Release IP/09/1897.
852. Under Article 9 of Regulation 1/2003.
853. *Rambus*, para 49.
854. See the discussion of this case in chapter 2 of this thesis and also generally Case T-201/04 *Re Microsoft* .
855. See *Huawei v ZTE.* (see discussion generally in chapter 1 of this thesis)
856. See discussion in chapter 1 and Mair, 'Taking Technological Infrastructure Seriously'.

The European Courts' proactive stance on maintaining the openness of technological standards might seem to be encouraging for the situation of third party IP enforcement over an RF interoperability standard which we envisage. However, certain technical legal barriers make reliance on competition law for a remedy highly uncertain in practice.

First, unlike in the case of *Huawei,* an 'outsider' pure IP company would not have given any licensing commitment (RF, FRAND or otherwise), meaning that much of the analysis in this case would not apply.[857] Given this, the licensee would need to rely on an action under the essential facilities doctrine, as discussed in chapter 2. In order for this argument to go through, the pure IP company would need to have refused to license the IP. In the circumstances we envisage, it is much more likely a third party IP company would attempt some sort of 'patent holdup' against standard implementers: so the problem would be one of 'excessive pricing' rather than one of refusal to supply. Second, even if, as in *Microsoft*, the third party IP company is compelled to license its IP under the essential facilities doctrine, such a license would most likely be on mandatory FRAND terms, and would not be royalty-free. . In the case of *Rambus*, where certain 'royalty holidays' were granted, this was on facts where the company concerned deliberately misled the SSO by not disclosing its essential patent applications over the standard. In the situation we envisage, the third party company would never have participated in the SSO so could not be accused of deception nor misconduct of any kind. Furthermore, Art 31(h) of the *TRIPS Agreement* would likely prevent a competition authority from granting compulsory licensing without providing the patentee with 'adequate remuneration'.[858] This would rule out the possibility of compulsory licensing on royalty-free terms.

Given the above, once a royalty-free interoperability standard is successfully challenged by a third party as infringing its patent, EU competition law is unlikely to offer a remedy to reinstate its royalty-free status. The most it could do would be to grant a compulsory license on FRAND terms, as was the case in *Microsoft.* And as in *Microsoft,* this remedy offers little in the way of respite for open source software suppliers utilising the GPL-family of licenses, who would remain unable to implement the standard. [859]

857. Both *Huawei* and the English Court in *Unwired* (discussed in chapter 1) required an ex ante licensing commitment as a central part of the analysis.

858. Of course, it is still unclear to what extent *TRIPS* needs to be applied by the EU courts. In *Microsoft* for instance, the General Court stated that Community law prevails over international norms, but went on to argue that its judgment was nevertheless consistent with Article 31(k) of *TRIPS* – a provision that allows competition concerns to trump IP rights in some cases. In any case, the fact that the Court chose to make the IP licensed on FRAND rather than royalty-free terms is perhaps indicative of the kind of licensing terms to be expected in future cases involving anti-competitive behaviour absent misconduct. For further discussion of the relation between *TRIPS* and EU competition law , see Sujitha Subramanian, 'EU Obligation to the TRIPS Agreement: EU *Microsoft* Decision' (2010) 21(4) Eur J Intl L 997.

859. Krzysztof Siewicz, *Towards an Improved Regulatory Framework of Free Software* (EM Meijers Instituut, 2009).

C. Patent System Remedies

In terms of remedies supplied by the patent system itself, the choices are considerably narrower. If we assume that the third party IP company's patents over the royalty-free interoperability standard were not achieved by deception as in the case of *Rambus* or by misusing the patent system as in *Astrazeneca*[860], then very few options are available outside of outright patent invalidation.[861] Patent invalidation, however, would depend on the particular circumstances of each specific case.[862]

Nevertheless, as in the case of the JPEG standard, patent invalidation in the context of software-related patents is a promising choice of action. This is because the current European practice[863] of granting software-related patents is deficient in many important respects, such as prior-art searches which only involve patent databases and occasionally non-patent literature.[864] The cursory nature of these prior-art searches means that a great deal of software-related patents are probably granted which are technically invalid[865], including perhaps those which may be relevant to interoperability standards. The UK Intellectual Property Office's 6-month trial of a Peer-2-Patent programme (which ended in 2011)- and where patent validity examinations were outsourced to interested external experts, such as open source software programmers[866]- is just one policy which is being investigated to try to improve the quality of software-related patents, and which could help in the long-run to protect the openness of royalty-free interoperability standards.

Indeed, perhaps only real policy changes such as this will really have any effect on the risk exposure of royalty-free interoperability standards to third party IP infringement suits. This is because the risks of third party IP infringement which we envisage here are a result of

860. Judgement of the General Court Case T-321/05 Aztrazeneca.
861. The possibility of other remedies (as opposed to antitrust remedies), based on the equitable doctrine of patent misuse –such as the above cases represent- would not be a good course of action in the EU in any case. Firstly, EU patent laws are still jurisdiction-specific, meaning that pan-European remedies would not be available. Secondly, the doctrine is still under-developed for use in standards-related cases, particularly in the EU. For an assessment of the arguments for its use in such cases in the US context, see Daryl Lim, 'Misconduct in Standard-Setting: The Case For Patent Misuse' (2011) 51(4) IDEA: J L & Tech 557.
862. Mark A Lemley and Carl Shapiro, 'Probabilistic Patents' (2005) 19(2) J Econ Perspectives 75.
863. See generally Andreas Grosche 'Software Patents – Boon or Bane for Europe?' Int J Law Info Tech (2006) 14 (3).
864. See IPKAT Blog June 13, summarizing a presentation by Nigel Hanley from the UK IPO about software patents prior art searches, available at 'P2P: The Aftermath' (*The IPKat,* 13 June 2011) <http://ipkitten.blogspot.com/2011/06/p2p-aftermath.html> accessed 14 October 2016. ("Nigel Hanley from the UK IPO introduced the subject with an admission that the United Kingdom's Intellectual Property Office (IPO) primarily search patent databases and only search some of the available non-patent literature. They do some Internet searching but not much. P2P is about accessing that part of the prior art inaccessible to examiners.")
865. Not just in the EU system, however. The 2014 US Supreme Court case of *Alice Corp. v. CLS Bank International*, 573 U.S. __, (2014) No 13-298 arguably raised the bar for software patentability in the US, meaning that possibly dozens if not hundreds of currently in-force US software patents may now be deemed invalid. See Dan L Burk, 'The Inventive Concept in Alice Corp. v. CLS Bank Int'l' (2014) 45 Intl Rev IP & Comp L 865.
866. Ibid.

SSO participants and technical committee's collective inability to locate relevant third-party patents during patent searches; and this, in turn, was due to the search burden created by excess patent proliferation. If the search burden is reduced due to the systematic invalidation of unmeritorious software-related patents by crowdsourcing prior-art searches, then the patent system itself as well as royalty-free interoperability standards will be generally more robust.

VI. CONCLUSION

This chapter has applied pressure to the notion that RF interoperability standards are less innovative than standards adopted under a FRAND licensing policy. Companies do have incentives to contribute proprietary technology to RF standards. These incentives relate to the potential of network effects to increase the penetration of their end-products incorporating the technology which can then be indirectly monetised by selling more products. However these incentives do not apply to pure IP companies and some large vertically-integrated companies, which an RF IPR policy may well discourage from participating in standardisation. Since these companies are excluded from RF standard-setting, they could pose a threat to the integrity and openness of royalty-free interoperability standards in practice. This threat could be in the form of asserting patent claims against implementers of the RF standards or by creating standard fragmentation. While defensive patenting in the tradition of the open source community might offer a partial remedy to this problem, it would require a more cooperative effort between all stake-holders who have an interest in keeping RF interoperability standards royalty-free. Competition law remedies would be difficult to rely on since although they may be able to exert some price control on licensing fees and prevent outright refusals to license, they would be unable to maintain a standard's royalty-free status in the face of a valid patent, even if abused. To this end, patent invalidation remains the only sure solution against a third party claiming that an RF interoperability standard infringes its patent.

In the long-run, the openness of interoperability standards and technological infrastructure in general may only be maintained with improvements to the patent system itself and some cap on software-related patent proliferation. Possibilities of crowd-sourcing 'state of the art' information such as Peer-2-Patent initiatives might well be an answer to this problem on the policy level. In any case, if indeed royalty-free interoperability standards are what governments, users, and the open source software community want, they will have to be prepared to fight for them, as neither the competition law remedies covered in chapters 1-2 would be expansive enough to deal with the interests at stake in guaranteeing the continued openness of RF interoperability standards.

CHAPTER 5

INTEL, ARM AND PRIVATE ORDERING APPROACHES TO TECHNOLOGICAL INFRASTRUCTURE

I. INTRODUCTION

This chapter focuses on the role of business model innovation in ensuring the open access of technological infrastructure. Unlike previous chapters, which have focussed on the interaction between private ordering with an additional institution, such as competition law (chapters 1-2), public R&D subsidies (chapter 3), or the demand-side instrument of public procurement (chapter 4), this chapter argues that business model innovation and private ordering alone are sufficient to sustain the infrastructural approach of 'if infrastructure, then open access'. In particular, this chapter examines the CPU 'standards war' in the market for smartphones and embedded devices, including the evolving 'Internet of Things'. It looks in detail at the very different business models of ARM and Intel in this market, and analyses the extent to which ARM's infrastructural approach to IP licensing is helping it consolidate its position as the de facto CPU standard.

In June 2014, the General Court of the European Union ('EU') issued its decision in the *Intel* antitrust case.[867] The decision threw out in its entirety an action for dismissal brought by Intel Corporation ('Intel') against the European Commission's 2009 decision to fine Intel 1.06 billion Euros for anticompetitive practices. That decision was remarkable both for the magnitude of the fine (still the largest to date under Art 102 TFEU in the field of antitrust[868]) and for demonstrating the Commission's willingness to intervene in a market characterised by exponentially falling prices[869] and product performance increases. [870]

From the vantage point of 2017 (the time of writing), the decision is also remarkable for what it does not contain. Nowhere in its 517 pages does the original decision make even a passing reference to the company whose CPU designs have come to dominate the space for personal mobile devices ('PMD'), the ultra-portable form of personal computing which is eating up the market once dominated by the traditional PC. That company- ARM Holdings ('ARM')[871]- is now widely acknowledged to be the nimblest and most formidable challenger for Intel's

867. Case T-286/09 *Intel v Commission* (12 June 2014).
868. Damien Geradin, and Katarzyna Sadrak, 'The EU Competition Law Fining System: A Quantitative Review of the Commission Decisions between 2000 and 2017' (April 25, 2017). Available at SSRN: https://ssrn.com/abstract=2958317
869. Wouter P J Wils, 'The Judgment of the EU General Court in Intel and the So-Called "More Economic Approach" to Abuse of Dominance' (2014) 37(4) World Compet. Law Econ. Rev. 405.
870. Intel , 'Why the European Commission's Intel Decision is Wrong', <http://www.intel.com/pressroom/legal/docs/EC_response092109.pdf> accessed 14 October 2016, 2.
("[i]t is perhaps most remarkable that the Commission's decision essentially ignored the undisputable fact that microprocessor prices have declined significantly year over year, while innovation has proceeded at a stunning pace, and output has been expanding rapidly, more than tripling in recent years.")
871. In 5 September 2016, ARM Ltd was acquired by the Japanese company SoftBank Group < http://www.reuters.com/article/us-arm-holdings-m-a-softbank-group-idUSKCN0ZY03B>

respective home-turfs of personal computing and business servers, while currently powering 85% of all PMDs and upwards of 90% of 'wearables'.[872]

That the Commission decision failed to mention ARM as a potential competitor or dynamic constraint on Intel[873] is only remarkable from the vantage point of the time of writing. The process of dynamic competition in high technology is inherently disruptive.[874] At the time of the 2009 decision, the PMD sector was promising, but essentially restricted to smartphones[875]; in 2006- when the empirical surveys informing the decision were undertaken, the few PMDs which did exist were focused almost solely on commercial customers[876]; and in 2000, it didn't yet exist.

Although the prediction of technological trends can be a dangerous exercise[877], it is clear that the space of personal computing is rapidly changing – and in the direction of increased mobility. New constraints on CPU design (such as requirements of portability and power efficiency) have caused major disruption to the traditional PC research and development ('R&D') trajectory of ramping up raw processor power on the coat-tails of Moore's law.[878] ARM's mastery of these design constraints within the PMD space threatens to spill over into the whole (post-) personal computing market, as consumers and software developers place their bets on a single dominant microprocessor platform to harvest the positive network effects of the platform leader.[879] ARM's PMD market dominance also threatens to spill over into the evolving 'Internet of Things' ('IoT')- the networks of ultra low-power embedded devices, which seem to bestow sentience on an increasing array of everyday objects.[880] The battle for the microprocessor 'infrastructure' of the IoT, however, (unlike the PMD space) is

872. ARM Strategic Report 2015 <http://ir.arm.com/phoenix.zhtml%3Fc%3D197211%26p%3Dirol-reportsannual> accessed 14 October 2016.

873. For understanding of 'dynamic constraint', see Guidance on the Commission's Enforcement Priorities in Applying Article 82 of the EC Treaty [2009] OJ C45/02, para 16 ("[c]ompetition is a dynamic process and an assessment of the competitive constraints on an undertaking cannot be based solely on the existing market situation. The potential impact of expansion by actual competitors or entry by potential competitors, including the threat of such expansion or entry, is also relevant.").

874. Baker, 'Dynamic Competition'.

875. *i.e.,* the market for tablet devices was still underdeveloped

876. *i.e.,* mainly Blackberries and Nokia devices, as the iPhone of 2007 was not yet released. <https://www.canalys.com/newsroom/64-million-smart-phones-shipped-worldwide-2006> accessed 14 October 2016.

877. See Wu, 'Intellectual Property', 103 ("[i]n the 1980s, the Japanese government, consulting with experts, predicted where computer technology would be in ten years. The government then launched a huge national effort to build the predicted technologies, hoping to leapfrog other countries… The project was, unfortunately, centred on the mistaken belief that mainframe computers would remain dominant and that parallel supercomputing was the key to the future. It completely missed other less grandiose innovations, like the personal computer, the graphical user interface on the Apple Macintosh, and the computer networking now called the Internet. The project was an abject failure that damaged the Japanese computer industry.")

878. Daniel Nenni and Paul McLellan, *Fabless: The Transformation of the Semiconductor Industry* (SemiWiki 2013).

879. Lao, 'Terminal Railroad to Microsoft '.

880. David Rose, *Enchanted Objects: Innovation, Design, and the Future of Technology* (Scribner 2014) ("Rose, 'Enchanted Objects'").

still very much alive. Both Intel and ARM are heavily investing in attempting to become the *de facto* standard technological infrastructure, by scaling down their microprocessor designs to meet the extremely small power 'footprint' requirements of IoT devices, together with developing and supporting the tiny Operating Systems ('OS') needed to power them.[881]

This chapter argues that a large component of this 'standards war' will be determined by these two companies' very different approaches to innovation (including business model innovation), intellectual property, and industry partnerships. While ARM is essentially a pure IP company, engaging solely in R&D and liberally licensing its IP for (comparatively) razor-thin profit margins[882], Intel is a vertically integrated R&D and microprocessor fabrication company, which does not usually license its IP except by court order[883], and is used to raking in significant profits.[884]

The distinction between these two approaches to innovation and intellectual property licensing- one comparatively 'open', the other comparatively 'closed'- is argued to be a main determinant in the battle for the emerging post-PC marketplace. ARM's openness with respect to licensing its IP (often dubbed a 'partnership approach') has enabled it to become a key supplier of microprocessor designs across the semiconductor industry and have arguably helped it to become a *de facto* standard in both the 'embedded' and PMD spaces. ARM's approach can be viewed as a special case of the 'infrastructural approach' developed in this thesis, where ARM has used an open licensing business model to establish itself as the de facto CPU infrastructure of the PMD space; superficially, at least, reversing the logic of the infrastructural approach. [885]

This IP licensing strategy has permitted ARM to rapidly develop an 'installed base'[886] and leverage the power of 'indirect' network-effects[887] to ensure a vibrant downstream software

881. In many cases, these OS's are simply scaled-down versions of the open source embedded Linux operating systems, as discussed in Part IV

882. See Charlie Demerjian, 'How ARM Licenses its IP for Production' (*SemiAccurate* 8 August 2013) <http://semiaccurate.com/2013/08/08/how-arm-licenses-its-ip-for-production/>.

883. Such as toVIA and AMD, the only two companies who maintain a license to Intel's proprietary 'X-86' CPU architecture. See discussion in Greg Tang, 'Intel and the x86 Architecture: A Legal Perspective', (*Jolt Digest* 2011) http://jolt.law.harvard.edu/digest/patent/intel-and-the-x86-architecture-a-legal-perspective-2> accessed 14 October 2016. See also discussion of the X-86 architecture as an 'essentialy facility, W. Greg Papciak 'Intergraph Corp. v. Intel Corp.', 14 Berkeley Tech. L.J. 323 (1999).

884. Intel's Gross Margin Percentage for 2016 was 60.90%. See Intel Annual Report https://s21.q4cdn.com/600692695/files/doc_financials/interactive/2016/index.html

885. As will be developed further in this chaper, ARM's CPU designs have infrastructural characteristics (by being generic, non-rivalorous, and able to support downstream production); however, open access licensing are helping it establish the status of technological infrastructure *in fact*.

886. For importance of quickly establishing an installed base in network industries, see generally Annabelle Gawer, *Platform Leadership: How Intel , Microsoft and Cisco Drive Industry Innovation* (Harvard Business School Press 2005).

887. As mentioned in chapter 4, 'indirect network effects ' are simply the positive effects which the development of the downstream markets for complementary products (and services) have on the upstream technical platform. See

ecosystem making use of its CPU designs, such as its strong relationship with the open source Android software platform.[888] By contrast, Intel's historically closed approach to IP licensing has enabled it eat up the whole value chain from CPU design all the way to the final (CPU) product, and contract directly with device makers or Original Equipment Manufacturers ('OEMs'). However, by walling up the garden around its microprocessor architecture, Intel has prevented independent semiconductor design houses from using its designs as inputs to downstream products. This has so far (at least in the PMD market) arguably prevented Intel from being able to flood the market with compatible CPU architectures in the way ARM has, and thus has arguably prevented it from leveraging the indirect network effects in complementary software and hardware platforms to establish itself as the dominant technological infrastructure.

To briefly preview this chapter's conclusion: ARM's open approach to IP licensing enables its CPU designs to scaffold genuine 'bottom up' innovation, by permitting downstream semiconductor companies to easily and quickly configure and adapt ARM's designs to new use-cases and applications, as well as providing device makers with a genuinely competitive and diverse market of suppliers. It is argued that if scholars and observers of the rapid expansion of the PMD market have learnt anything from the dual PMD successes of ARM and the open source mobile OS, Android[889], it is that diversity, complexity and proliferation of successful solutions is scaffolded by an open and decentralised approach to technological infrastructure.

The chapter will be structured as follows. After this introduction, Part II will begin by a brief overview of the nature of the semiconductor industry (Section A) followed by a survey of IP licensing approaches in high-technology markets (Section B). Part III will then provide a historical and technical review of Intel (Section A) and ARM (Section B), linking their business models to their approach to IP licensing in both the PMD market and the nascent IoT space. Part IV will then provide an analysis of the complex relationship between microprocessor architecture, software OSs, and IP licensing strategies. This will include taking a close look at Google's open source Android platform (Section A), the feasibility of 'porting' an OS to a non-native microprocessor architecture (Section B), and an analysis of what the findings from these two sections mean for ARM and Intel's battle for the evolving IoT space (Section C). This last section will also draw some important distinctions between the PMD and emerging IoT markets, suggesting that ARM's model of 'bottom up' innovation is uniquely suited to the requirements of the IoT market. Part V will conclude.

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generally Economides, 'Competition Policy in Network Industries'. See also Lao, 'Terminal Railroad to Microsoft '; Mair, 'Taking Technological Infrastructure Seriously'.

888. However the actual openness of the Android OS in practice has been brought into question by a recent EU Commission antitrust investigation, see Commission, *Press Release MEMO-16-1484*.

889. Therefore also Linux OS, on which Android is based.

II. SEMICONDUCTOR INDUSTRY: OVERVIEW AND THEORY OF IP LICENSING

The semiconductor industry has long been a subject of study for both legal and economic scholars due to a number of unique characteristics. Over the last decades, the industry has been radically transformed by processes of deep vertical 'dis-integration'[890] and disaggregation, which has led to the creation of hyper-specialised niche companies focused on tightly specified tasks. The highly fragmented industry structure that has emerged has necessitated a unique approach to knowledge sharing, collaboration and intellectual property licensing, leading to a web of interdependence, referred to as the 'semiconductor ecosystem'.[891]

As will be shown in Section A below, much of the driving force behind this dis-integration has been due to the unforgiving economics of semiconductor R&D, which has required the mobilisation of enormous financial and human capital resources to keep up with the market demand for continuous innovation. The highly complex pattern of interdependence and knowledge sharing that has emerged as a result of these forces has also interested IP scholars, who focus their analysis on the unique types of intellectual property licensing in this knowledge-intensive industry.[892] In a seminal 2001 paper by Bronwyn Hall, the semiconductor industry was found to embody what was identified as a 'patent paradox': the wide-spread use and density of patenting behaviour despite strong empirical data that patents are peculiarly ineffective at driving innovation in the semiconductor domain.[893] This finding has led other scholars[894] to investigate the idiosyncratic ways patents and other semiconductor intellectual property are used in practice- called 'IP block licensing'- as will be discussed in Section B.

A. Semiconductor industry overview

In many ways, the semiconductor industry stands out as an anomaly in traditional theories of innovation and the innovative process. Innovation is often said to be stochastic and disruptive, yet semiconductor innovation seems to operate much like clockwork –with

890. Here this term is used to contrast with the more familiar term of 'vertical integration', meaning that large companies 'spinoff' components of the supply-chain which used to be subsumed under one company structure/
891. See Global Semiconductor Alliance, 'Collaborative Innovation in the Global Semiconductor Industry' <http://www.gsaglobal.org/gsa-resources/reports/collaborative-innovation-in-the-global-semiconductor-industry/>.
892. For a detailed discussion of IP licensing approaches in the semiconductor industry see Barnett, *supra* note. See also Grindley and Teece, 'Managing Intellectual Capital'; Deepak Somaya, David Teece and Simon Wakeman, 'Innovation in Multi-Invention Contexts: Mapping Solutions to Technological and Intellectual Property Complexity' (2011) 53(4) Cal Management Rev 47.
893. Hall and Ham, 'The Patent Paradox Revisited' (2001) RAND Journal of Economics Vol. 32, No.1
894. Tansey *et al.,* 'Patent Aggression'; Galasso, 'Cross-License Agreements in the Semiconductor Industry'; Ikka Tuomi, 'The Future of Semiconductor Intellectual Property Architectural Blocks in Europe' (JRC Scientifc and Tehnical Reports, Economic Commission 2009); Greenbaum, 'Open Source Semiconductor Core Licensing'.

not one, but two, empirical 'laws' describing its technological progress. There is "Moore's Law"- which states that 'computing power, as measured by the density of the silicon chips … doubl[es] about every eighteen months'[895], and the lesser known "Rock's Law" which observes that the cost of setting up a semiconductor manufacturing plant or 'foundry' doubles every four years.[896] This 'clockwork' analogy of semiconductor innovation has been taken a step further by Intel, which has built its development model on a two-stage innovation strategy called 'Tick-Tock'.[897] Each 'tick' corresponds to a microprocessor architectural innovation, and the 'tock' refers to an innovation in manufacture process.[898] As will be discussed in Part III, Section A, Intel is unique in the semiconductor industry by being able to innovate on both these fronts simultaneously, by maintaining vertical integration of semiconductor design and manufacture. Its status as an Integrated Device Manufacturer ('IDM') sets it apart from the majority of semiconductor companies, which tends to concentrate on highly specialised components of the semiconductor value ecosystem.

Broadly speaking, this ecosystem consists of individual companies providing electronic design automation tools ('EDA's) for designing integrated circuits ('IC') (*e.g., Cadence*[899]); pure-play IC design houses (also known as 'fabless'[900] design houses) who focus on the development of microprocessor architectures and other 'logic units' for specific purposes (*e.g., ARM* and *Qualcomm*); pure-play IC manufacturers or 'foundries' (also known as 'fabs') who manufacture the ICs (*e.g., TSMC*[901] Global Foundries[902]), as well as pure-play manufacturing tool suppliers who provide cutting-edge *e.g.,* photolithography technology to foundries (*e.g., ASML*[903]). The final product company that ends up integrating the microprocessors into a finished product is known as the Original Equipment Manufacturer ('OEM'), and here the company names become more familiar, as they are the consumer—facing Apple, HTC and Samsung.

The above-described fragmentation of the semiconductor value chain is generally ascribed to the extreme economics associated with semiconductor foundries, which are assessed as costing upwards of 10 billion USD to set-up[904]; are almost entirely fixed-cost assets with an

895. Ceruzzi, *A History of Modern Computing*, 297.
896. See IEEE http://spectrum.ieee.org/semiconductors/materials/5-commandments accessed 14 October 2016.
897. Actually, Intel 's "Tick-Tock "model has been replaced by a new model better characterised by "Tick-Tick-Tock", see Peter Bright, 'Intel Retires "Tick-Tock" Development Model, Extending The Life of Each Process" (*arsTechnica* 24 March 2016) <http://arstechnica.com/information-technology/2016/03/intel-retires-tick-tock-development-model-extending-the-life-of-each-process/> accessed 14 October 2016.
898. See Intel , 'The Tick-Tock Model' <http://www.intel.com/content/www/us/en/silicon-innovations/intel-tick-tock-model-general.html> accessed 14 October 2016
899. See Cadence <https://www.cadence.com/en/default.aspx> accessed 14 October 2016.
900. *i.e.,* no 'fabrication' plant or foundry
901. See TSMC, <http://www.tsmc.com/> accessed 14 October 2016.
902. See https://www.globalfoundries.com/ accessed 14 October 2016
903. See ASML, https://www.asml.com/ accessed 14 October 2016.
904. Nenni and McLellan, *Fabless*.

amortisation rate of approximately 50% of production costs; and which must be kept at full capacity at all times otherwise they will run at a loss.[905] This unforgiving economics has led the majority of semiconductor companies that were originally IDMs- such as *e.g.,* AMD - to 'spin off' their 'fabs' as independent manufacturers.[906] This trend, in turn, has opened up the possibility of 'fabless' IC design houses, and has triggered the subsequent hyper-specialisation and dis-integration of the other components in the supply chain, such as EDAs, design, and manufacturing tools development.

Of course, not all of the distinct semiconductor specialisations identified above are dis-integrated by every company, and there is still some degree of consolidation and integration of these tasks. For example, Samsung, is both a foundry and an OEM, and despite often being engaged in acrimonious patent lawsuits[907] with rival OEM and PMD company, Apple, is also Apple's chief supplier of manufactured microprocessors. Likewise, Apple is Samsung's largest foundry customer.[908] In addition, high value OEMs may try to get more control over their supply chains and essential technologies by either buying them up, or eliminating them from the supply chain and moving production in-house, such as recently happened in the case of Apple and Imagination Technologies.[909]

Furthermore, within the category 'pure-play IC design house' there is also a supply chain of some depth. For example, while Qualcomm is a pure-play IC design house designing microprocessors for the PMD space, core components of its designs are licensed directly from ARM.[910] ARM's CPU designs also provide the core logic units that power Apple's "A-series" CPU[911], as well as the other major PMD OEM CPUs such as those of HTC, Samsung, Huawei and LG, either directly, or via an intermediate fabless design house, like Qualcomm.[912]

As will also be discussed in Section B below, the complex web of partnerships and collaboration that sustains the semiconductor ecosystem is driven by a unique approach to intellectual property licensing, called 'IP block licensing'. Here, the term 'IP' differs from its normal use by lawyers and economists. An 'IP block' or 'IP core' refers to a 'functional module'

905. Ibid, 75. Also see Jim Turley, 'The Business of Making Semiconductors' (*InformIT*, 28 March 2003) <http://www.informit.com/articles/article.aspx?p=31338&seqNum=4> accessed 14 October 2016.
906. The 'fab' spun off is called Global Foundries, see <http://www.globalfoundries.com/> accessed 14 October 2016.
907. Such as during the so-called 'smartphone patent wars', see Thomas H Chia, 'Fighting The Smartphone Patent War With RAND-Encumbered Patents' (2012) 27(4) Berkeley Tech LJ 211; Lim, 'Misconduct in Standard-Setting'; Jones, 'Standard-Essential Patents'.
908. Nenni and McLellan, *Fabless*, 79.
909. See https://techcrunch.com/2017/05/04/imagination-technologies-starts-dispute-with-apple-over-graphics-chips/> accessed 7 May 2017
910. See ARM <http://www.arm.com/markets/mobile/qualcomm-snapdragon-chipset.php> accessed 14 October 2016.
911. See <http://www.anandtech.com/show/9686/the-apple-iphone-6s-and-iphone-6s-plus-review/4>
912. See ARM <http://www.arm.com/markets/mobile/qualcomm-snapdragon-chipset.php> accessed 14 October 2016.

which represents, in an abstract yet implementable form, the underlying logic of the IC, and integrates patented inventions, copyrights, as well as trade secrets.[913] Such IP cores may either be 'soft' or 'hard'. 'Soft' IP cores are delivered to customers in a form that looks like software source code- called hardware description language ('HDL')[914]- and which can be further configured and customised by the licensee. 'Hard' IP cores are delivered to customers already 'pre-compiled'[915] and cannot be further configured. When ARM licenses its microprocessor designs to downstream design houses or OEMs, its IP is provided in one of these two forms, depending on the requirements of the customer- and on the extent of the customer's in-house customisation capacities.

The reason why ARM is able to sustain such a diverse network of partners is due to the 'open' modularisation of semiconductor design- something widespread in the embedded and PMD spaces, but not yet fully embraced by Intel (see Part III, Section A). Open modularisation is a result of a push in the semiconductor industry towards the "System on a Chip" ('SoC') approach to PMD IC design. SoCs pack onto the same IC multiple hardware components, such as microprocessors, power management, memory, and external interfaces. [916] SoCs cut down on cost, increase the speed and efficiency of the logic units,[917] improve time to market,[918] and allow semiconductor design houses to leverage network partners' expertise in the creation of complex products- in the form of third party IP 'blocks'- in what is also a paradigm case of 'open innovation'[919] (see Section B below).

An essential factor of any SoC design is the means by which the different components of the SoC communicate, especially if those components are third party. The means by which SoCs coordinate the timing and interaction between SoC modules is by the use of 'interconnects' or 'buses'. In order for OEMs to be able to pick and choose among different modules for their customised SoCs, it is essential that the buses are standardised. The current industry standard for SoC buses is ARM's open protocol called the 'Advanced Microcontroller Bus Architecture' ('AMBA'). Intel's PMD SoCs currently utilise a proprietary 'chassis' known as the 'Intel On-Chip System Fabric' ('IOSF'). Since Intel's system of interconnects differs from the industry standard it means that Intel's customers are not able to pick and choose among different modules to the same extent as those of ARM. Furthermore, as will be discussed in

913. Such as implementation details which are not covered by IP.
914. Like *e.g.,* RTL or Verilog.
915. In the sense of already specifying particular electronic components, or by being specified into non-reversible 'netlists', see discussion and description of the latter in Greenbaum, 'Open Source Seminconductor Core Licensing'.
916. *e.g.,* like USB.
917. Due to closer proximity between components since on a single IC.
918. As can be 'printed' onto a single wafer.
919.Marcel Bogers, Rudi Bekkers and Ove Granstrand, 'Intellectual Property and Licensing Strategies in Open Collaborative Innovation' in C de Pablos Heredero and D López (eds), Open Innovation in Firms and Public Administrations: Technologies for Value Creation (Hershey, PA: IGI Global, 2012) 37-58.

Part III below, Intel's refusal to license its CPU architecture to downstream IC design houses means that OEMs generally receive a fully integrated SoC product from Intel. This means that Intel's PMD SoCs tend to be complete solutions, decided via a 'top down' 'exclusive property' approach, rather than by the 'bottom up' approach of 'open innovation', provided by ARM's more 'inclusive' property approach.

The relationship between the SoC design model and the various approaches to IP management and licensing will be discussed in Section B below, which will also engage a more general survey of approaches to IP management and licensing in high-tech industries.

B. Survey of IP licensing strategies in high technology

1. The closed 'exclusive' property approach to IP licensing

The two approaches to IP licensing identified in the introduction, and essentially summarised as 'open' and 'closed' also summarise the main approaches adopted by high technology companies to the problem of how to manage and stimulate innovation. Research and Development ('R&D')- the production of new knowledge assets, such as product and process innovations- is extremely costly. For example, in 2014, Intel's R&D budget exceeded 11 billion USD (over a net revenue of 55billion USD)[920], whereas ARM's 2015 R&D budget was 215 million USD (over a net revenue of 1.4 billion USD.[921]) Given the R&D intensity of high technology markets (15-20% of revenue in these two examples), companies must make decisions over protecting the investment, monetising it, and stimulating further innovation.

When companies like Intel adopt a closed approach, they have chosen to solve these problems by heavily patenting their innovations, guarding the exclusivity of their rights by refusing to license IP, and litigating against infringers, as well as often providing 'complete solutions' to their end-customers, with little use of third-party IP.

The economics behind this 'exclusive property' approach to managing innovations constitutes the prevailing 'orthodoxy' in IP theory. In brief, it recruits the idea that unprotected knowledge assets engender 'market failure' due to the extremely high ratio of sunk R&D costs to marginal costs of reproduction of R&D results: unless such assets are protected, they won't be produced. Empirical evidence shows that in markets where the protected asset is relatively 'simple', then this economic reasoning is fairly robust.[922] However, as the complexity[923] of

920. See Intel Annual Report, 2014 <http://www.intc.com/intel-annual-report/2014/index.html> accessed 14 October 2016.
921. ARM Strategic Report 2015.
922. Lemley, 'Ignoring Patents '.
923. von Graevenitz, Wagner and Harhoff 'Incidence and Growth of Patent Thickets'.

the product increases, the picture becomes murkier. A 2001 study of the use of patents in the semiconductor industry discovered that while patenting rates are unusually high in this industry, their perceived effectiveness at both incentivising and protecting innovations are rated relatively low.[924] This 'gap' is explained by the use of such patents 'strategically', either as 'defensive mechanisms' or to engage in cross licensing.[925] Furthermore, when the 'exclusive property' approach predominates in a particular high technology market with complex products, companies may find themselves in a so-called 'patent thicket',[926] 'an overlapping set of patent rights'[927] requiring extensive licensing, cross licensing and sometimes litigation in order to bring products to market, as discussed further from a game theoretical perspective in chapter 3 of this thesis.

According to some scholars- some of whom explicitly base their analysis on the semiconductor industry[928]- not only does the adoption of the exclusive property approach to knowledge assets actually not encourage innovation, it may retard it. There are at least two components to this criticism of the exclusive property approach. The first component appeals to the economics of 'transaction costs', and argues that in high technology markets the costs of monitoring, enforcement, secrecy (when relevant), and licensing negotiations (in case of patent thickets) are significant (and significantly higher) than an 'inclusive' property regime[929], such as a 'commons' or 'open access' (as will be discussed in Section B(2) below). In this case, innovation may proceed slower due to diversion of resources away from R&D and towards the transaction costs of infringement monitoring and litigation.[930] The second component is a broadly empirical argument and is strongly contingent on the character of the underlying knowledge assets. It argues that in many cases the adoption of an exclusive property regime

924. Hall and Ham 'The Patent Paradox Revisited' 102 ("the gap between the relative ineffectiveness of patents (as reported in surveys) and their widespread use is particularly striking.")

925. Ibid; Barnett, 'Property as Process'.

926. Clarkson and DeKorte, 'The Problem of Patent Thickets in Convergent Technologies'; Ralph Siebert and Georg Von Graevenitz, 'Does Licensing Resolve Hold Up in the Patent Thicket ?'; Shapiro, 'Navigating the Patent Thicket'; Adam Mossoff, 'The Rise and Fall of the First American Patent Thicket: The Sewing Machine War of the 1850s' (2009) 53 Arizona L Rev 165.

927. Shapiro, 'Navigating the Patent Thicket'.

928. Barnett, 'Property as Process'; Hall and Ham, 'The Patent Paradox Revisited';

929. Ibid.

930. Kapczynski, 'The Cost of Price', 990 ("[t]ransaction cost and externality concerns are important components of the recent debates about the potential for an anticommons in information goods. If information is subject to especially high transaction costs, then in this context, price is also particularly problematic"); Samuels Bowles and Jung-Kyoo Choi, 'Coevolution of Farming And Private Property During The Early Holocene', (2013) 110(22) Proceedings of the National Academy of Sciences 8830. (Though not directly concerned with intellectual property or information resource management, Bowles suggested that the model developed in this paper concerning the emergence of the institution of property may be applied to intangible resources, and specifically intellectual property.) This insight has also been developed by Bowles in a talk given to the Berkman Klein Centre For Internet & Society at Harvard university 'Kudunomics: Information and Property Rights in the Weightless Economy, where it was suggested that open access approaches to information resources would be more efficient than exclusive rights approaches in today's knowledge economy <https://cyber.law.harvard.edu/interactive/events/luncheons/2009/11/bowles> accessed 13 October 2016

is mismatched to the natural process of cumulative and sequential innovation that drives development in complex product industries, such as high technology.[931] This is because R&D outputs are often simultaneously 'inputs' for future industry-wide innovative activity, such that 'locking' them up in exclusive rights harms that process. As a corollary to this last point, in markets characterised by sequential and cumulative innovation (such as high technology) exclusive ownership of critical[932] R&D outputs, such as the 'technological infrastructure', may facilitate a kind of 'centralisation' of industry-wide R&D investment decision-making. As put by Tim Wu[933]:

> Even accepting that useful incentives can be created by intellectual property, the effects on decision-making suggest a reason to be cautious about the assignment of broad rights. The danger is that centralization of investment decision-making may block the best or most innovative ideas from coming to market.

In other words, under certain conditions, it is possible for the IP system in high technology markets to put pressure on the decentralised 'bottom up' character of the innovative process and transform it into something more centralised and 'top down'. Such a system may permit 'a single private company…[to]… make decisions for all participants…[and]…unconstrained by market forces, such a private company is no more likely to perform well than government regulators.'[934] This is maybe particularly the case in relation the nascent IoT market, which is characterised by numerous cooperatively-set and de facto standards, creating a number of choke-points for private companies to exert control. IoT devices are in many ways the product of a drive towards technological convergence, and so must interoperate with a diversity of host devices, servers, and network hubs[935], implicating a 'jungle of standards'[936]. As argued in chapters 1 and 2 of this thesis, such standards operate in markets of relatively inelastic demand, creating incentives for private right holders to leverage their market control in exploitative or exclusionary ways. In relation to cooperatively-set standards, chapter 1 has already explained the ex ante and ex post legal approaches to ensuring 'open access' licensing.

931. Bessen and Maskin, 'Sequential Innovation'.
932. Lee, 'The Evolution of Intellectual Infrastructure'.
933. Wu, 'Intellectual Property'.
934. Lemley, 'The Regulatory Turn'
935. Jason R. Bartlett and Jorge L. Contreras 'Rationalizing FRAND Royalties: Can Interpleader Save the Internet of Things' (October 4, 2016). Review of Litigation, Forthcoming; University of Utah College of Law Research Paper No. 185. Available at SSRN: https://ssrn.com/abstract=2847599 3 ("…standards that will link a bewildering array of devices in vehicles, buildings and the environment known as the "Internet of Things."")
936. Nicolo Zingales, 'Of Coffee Pods, Videogames, and Missed Interoperability: Reflections for EU Governance of the Internet of Things' (2015) TILEC Discussion Paper No 2015-026, 31 <http://papers.ssrn.com/abstract=2707570> accessed 14 October 2016 ("a 'jungle of standards', generating confusion for their proliferation and the lack of certainty as to which standards provide adequate levels of interoperability and security.")

Although chapter 2 developed in detail the ex post competition law approach to managing de facto standards, it left to one side the various ex ante private-ordering approaches available to companies to ensure that the 'if infrastructure, then open access' model is applied in relation to technological infrastructure. The following section will develop some of these in detail, before exploring how ARM and Intel are choosing to self-organise in the standards war for the IoT CPU infrastructure.

2. Open approaches to IP licensing

Within the broad category of 'inclusive property' are a number of heterogeneous approaches to achieving 'openness' in high technology markets.

The most well known 'inclusive' property or 'openness' regime in high technology is the use of open source licenses over software. As will be discussed in more detail in Part III in relation to the PMD space, the Android mobile Operating System ('OS') is a Linux-based open source OS that currently powers more than 85% of all PMDs. The 'core' or 'kernel' of this OS is based on a pared-down distribution of the Linux OS kernel, and is specifically designed for embedded microprocessors, such as which power PMDs. The parts of the OS that expressly derive from Linux are licensed under the General Public License ('GPL' v 2) copy-left[937] style open source license, while the Android specific parts developed by Google and its partners are licensed under the 'permissive'[938] Apache License 2.0.[939] Open source licensing- particularly under 'permissive' terms- can be conceptualised as creating a kind of 'virtual commons', since all companies or individuals are permitted access and modification rights to the software source code[940] once published, provided the contractual terms of the license agreement are adhered to. In the case of Android, the code is also available for view, including use for projects and commercial applications, on the open source software repository website, Github.[941] Although the economics of open source software is still in a state of some theoretical uncertainty[942], it is clear that the main drivers for open source licensing models include (for companies), inter alia, the indirect value appropriation[943] via sale of complementary assets, and the fostering of interoperability between different systems and devices.[944] Aside from the efficiencies that arise from an OS being open source, (which

937. 'Copyleft' refers to an open source license which requires all derivative works to also follow the same licensing terms as the 'in-coming' code

938. 'Permissive' means that the licensing terms of derivative works can diverge from that of the 'in-coming' code provided that certain minimal criteria are met.

939. See Android , https://source.android.com/> accessed 14 October 2016.

940. Provided it has been 'published' or distributed.

941. See Android , <https://github.com/android> accessed 14 October 2016.

942. Josh Lerner and Jean Tirole, 'The Economics of Technology Sharing: Open Source and Beyond' (2005)19(2) J Econ Perspectives 99, 100 ("[t]he open source process of production and innovation seems very unlike what most economists expect.")

943. Benkler, 'Coase's Penguin'; Benkler, 'Free as the Air to Common Use'.

944. Benkler, *The Wealth of Networks.*

are in some ways very unique to 'platform' economics[945]) companies may also choose to release open source software 'libraries'- tools or development frameworks that implement specific functionalities. Projects such as Facebook's *react*[946], which is a JavaScript framework for building sophisticated user interfaces, and Twitter's *bootstrap*[947] (a framework for speeding up web development) are just two examples of commercial companies leveraging open source development models to sharpen their software as well as the Web generally.[948] The 'force' such companies are trying to harness has been elsewhere dubbed 'Linus's law', and represents the idea that the bigger the user/developer group of a project, the faster new features are added and bugs eliminated due to powerful positive feedback loop and network effects.[949] Furthermore, since these two libraries are in many ways 'infrastructural' components of Websites, both Twitter and Facebook stand to gain from a faster, more efficient Web, under a principle called the 'Cooking Pot Model'[950], which can be summarised by the expression 'a rising tide lifts all boats'.

Another 'inclusive' property approach that is commonly used in high technology markets is often referred to by the buzzword of 'open innovation'[951], but can be more intuitively dubbed 'innovation partnership' or 'cooperative innovation'.[952] In essence, the approach enshrines the use of 'third party' IP as central to the innovation process, and by consequence, replaces the heroic model of a company which can do all its innovation in-house, by that of a 'network of innovators'.[953] Unlike the open source software model of inclusive property, cooperative innovation relies on a bedrock of exclusive intellectual property rights which support the development of pure-play IP licensing business models. As already discussed in Section A above, the dis-integrated character of the semiconductor ecosystem encourages strong partnerships and collaboration among semiconductor companies, and has resulted in the unique 'IP block'

945. Robin S Lee, 'Competing Platforms' (2014) 23(3) J Econ & Management Strategy 507.
946. See React, <http://facebook.github.io/react/> accessed 14 October 2016.
947. See Bootstrap, <http://getbootstrap.com/2.3.2/> accessed 14 October 2016.
948. These Web development tools actually help web apps to run faster. Another reason for Twitter and Facebook to release these open source tools is because they are the indirect beneficiaries of a faster Web. Indeed, everyone benefits from a faster Web, but Twitter and Facebook do not benefit any less just because others do too.
949. Eric S Raymond, *The Cathedral and the Bazaar*, 12 ("[g]iven a large enough beta-tester and co-developer base, almost every problem will be characterized quickly and the fix obvious to someone. Or, less formally, 'Given enough eyeballs, all bugs are shallow.' I dub this: 'Linus's Law' […]").
950. See Rishab Aiyer Ghosh 'Clustering and Dependencies in Free/Open Source Software Development: Methodology and Tools' (2002) Working Paper UNU MERIT available at http://www-siepr.stanford.edu/programs/OpenSoftware_David/Ghosh.pdf> accessed 7 May 2017, 2 ("The "cooking-pot" model hypothesises that participants contribute their products to a delineated commons, or "cooking-pot", in a sort of exchange with implicit one-to-many transactions of the one-time production cost with the value gained from individual access to a diversity of products contributed by others. There are other parallel motives for contribution, but this is one of the main economic ones, and also happens to be in some sense quantifiable.")
951. See generally Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Harvard Business School Press 2003).
952. Bogers, Bekkers and Granstrand, 'Intellectual Property and Licensing Strategies'.
953. Ikka Tuomi *Networks of Innovation: Change and Meaning in the Age of the Internet* (OUP, 2002).

licensing approach. ARM is an example of a company using this approach and business model, although primarily as a licensor rather than as a licensee of IP semiconductor cores, which are then usually incorporated into SoCs. Despite having important differences from the open source model, ARM's 'open innovation' approach does have some strong commonalities with that model, such as the availability and re-use of configurable and modifiable IP 'blocks' to its downstream partners, which in many ways, function analogously to software libraries.

The final 'inclusive' property model to be discussed derives from the legal regime which has been developed by standard-setting organisations ('SSO's) in conjunction with competition regulators and the EU Courts[954], as described in detail in chapter 1 of this thesis. When companies engage in cooperative standard-setting, they are usually required to offer a contractual commitment to license any standards-essential patents ('SEP') on Fair, Reasonable and Non-Discriminatory conditions ('FRAND').[955] Once this commitment has been given, such companies are then compelled to enter into FRAND licenses with licensees, and at the same time lose the right to deny access to the SEPs to willing licensees.[956] Given the ubiquitous requirements of interoperability of high technology devices, standards and SEPs abound in both the PMD and the nascent IoT markets.[957] The FRAND IP licensing model is therefore a dominant 'open access' approach to ensuring an 'inclusive' property regime, as will be discussed in Part IV.

It is submitted that the open approach to IP licensing as summarised above is particularly suited to complex high technology markets, where markets are at risk of tilting in the direction of over-propertisation resulting in patent thickets and patent wars, as discussed in chapter 3. Indeed, the success of both ARM and Android in the PMD space is argued to be no accident, but the result of open' approaches permitting the creation of multiple 'nodes' of innovative activity (in the form of independent companies innovating around a particular open microprocessor infrastructure or open software platform). When property rights are decentralised via an open approach, the potential for independent companies to 'explore' innovative possibilities is liberated while maintaining interoperability. As developed further in Part III and IV of this chapter, this is argued to create a system of 'bottom up' innovation, which can result in products of considerable diversity and complexity, as upstream inputs are available for downstream mixing-and-matching.[958]

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954. See *Huawei*. See also Commission, 'Guidelines on the Applicability of Article 101'.
955. See the European Telecommunications Standard Institute Rules of Procedure (19 November 2014).
956. See *Huawei*, para 51 ("[…] the patent at issue obtained SEP status only in return for the proprietor's irrevocable undertaking, given to the standardisation body in question, that it is prepared to grant licences on FRAND terms").
957. Nicolo Zingales, 'Of Coffee Pods, Videogames, and Missed Interoperability: Reflections for EU Governance of the Internet of Things' (2015) TILEC Discussion Paper No 2015-026, 31 <http://papers.ssrn.com/abstract=2707570> accessed 14 October 2016 ("a 'jungle of standards', generating confusion for their proliferation and the lack of certainty as to which standards provide adequate levels of interoperability and security.")
958. This position assumes that the exclusive property approach to IP only has a muted effect on incentivising pro-

A useful way of summarising the above approaches to IP management and licensing in the high technology sector is to imagine them on a spectrum from the 'pure commons' approach of open source software, to the 'exclusive property' approach, as shown in Fig. 1 below. As the approach to IP licensing becomes more open, the productive inputs get distributed among potentially more nodes of innovative activity (which nonetheless remain interoperable), leading to a scenario of 'bottom up' innovation. Conversely, as the approach becomes more exclusive, the number of potential nodes decreases, leading to 'top down' innovation. Although top down innovation may still produce products of considerable value, the 'combinatorial' effect of a multi-node approach is lost, leading to potentially less complexity and product diversity. [959]

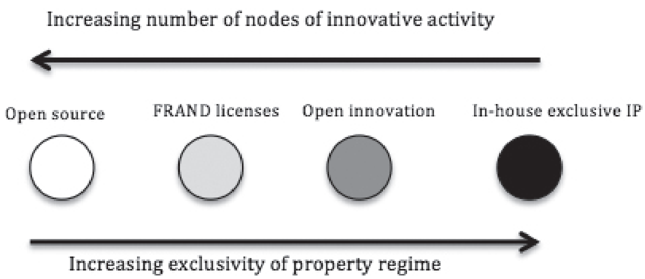

Figure 1. (adapted from Jonathan M Barnett)[960]

Another way to visually conceptualise the above is by means of nodes in a network. Under a decentralised approach, where the essential technological infrastructure is liberated by open licensing, the latter is free to scaffold multiple nodes of innovative activity without top-down control. Examples of the latter include the evolution of the Web (as discussed in chapter 4) and the Linux kernel, which is licensed under the GPL open source license, and has spawned a number of competing Linux 'distributions' (some of which have gone on to generate new innovations, which have then been fed back into the Linux 'ecosystem'[961]). Linux RedHat[962], Android, Ubuntu[963], and Tizen[964] are just four separate well-known nodes of innovative

duction. This seems empirically robust (see Hall and Ham, 'The Patent Paradox Revisited') although it bears repeating that even where the above does not hold true, it would only result in a single-node of innovative activity compared to the multi-node approach of open access regimes.

959. See generally William Brian Arthur, *The Nature of Technology: What It Is and How It Evolves* (Penguin 2009).

960. Barnett, 'Property as Process' 401

961. Developed first by RedHat, the concept of containers is a way of creating virtualisations of separate instances of an OS within a single OS and has now become part of the overall Linux system. LinuxContainers <https://linuxcontainers.org/> accessed 14 October 2016.

962. RedHat <https://www.redhat.com/en> accessed 14 October 2016.

963. Ubuntu <http://www.ubuntu.com/> accessed 14 October 2016.

964. Tizen <https://www.tizen.org/> accessed 14 October 2016.

activity within the Linux ecosystem. In the diagram Figure 2 below, one can imagine each of these as forming one of the main nodes in the right hand side of the diagram ('decentralised'). The microprocessor designs of ARM are another example of a decentralised approach to innovation. ARM-based[965] chips now currently power all the major PMD devices, including Apple iPhone 7's A10 'Fusion' CPU, Qualcomm's 'Snapdragon'[966] and Kirin 950[967], all of which could be similarly imagined as forming the nodes on the right hand side of the diagram. The centralised approach to innovation, such as evidenced by both Intel and *e.g.,* Microsoft, can be imagined as forming the nodes (perhaps linear[968] or sometimes parallel versions[969]) as shown by the 'centralised' network on the left hand side of the diagram, which demonstrates strong top-down control by the central node.

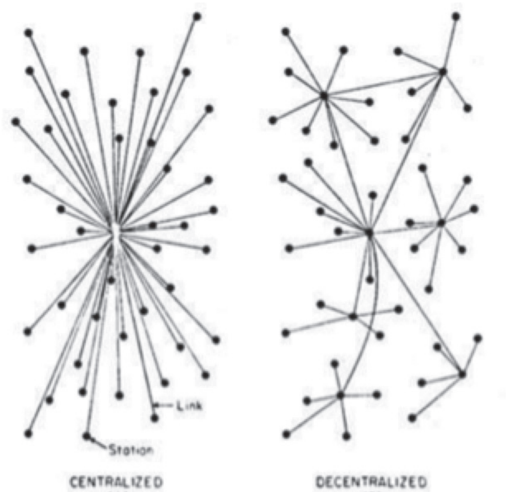

Figure 2. (adapted from Paul Baran[970])

The description of these different approaches to openness and control also links up with the analysis in chapter 3 of this thesis, which discussed the strategic dynamics in high technology as being characterised by an 'assurance game'. By adopting an open approach to their IP,

965. Specifically, the ARM instruction set architectures of ARMv7 and ARMv8.
966. Qualcomm, <https://www.qualcomm.com/products/snapdragon> accessed 14 October 2016.
967. Wikipedia, 'HiSilicon' <https://en.wikipedia.org/wiki/HiSilicon#Kirin_950> accessed 14 October 2016.
968. *i.e.,* gradual evolutions of a software platform, such as Windows 7, Windows 10 etc.
969. *i.e.,* slight divergences in *e.g.,* chip design depending on product market, so high-powered Intel chips versus those for low-powered uses. However, the divergences here are very limited compared to those available under a decentralised approach.
970. Paul Baran, 'On Distributed Communications', Memorandum RM-3420, RAND Corporation 1964, <http://www.rand.org/content/dam/rand/pubs/research_memoranda/2006/RM3420.pdf>

Linux (and to a lesser extent,[971] ARM) are also serving to create an open access equilibrium, which avoids the social costs of the 'strong IP' approach.

Having now outlined the unique character of the semiconductor industry (Section A) and surveyed the various approaches to IP management and licensing in high technology (Section B), Part III delves into more detail about the specific business and IP licensing approaches of Intel and ARM. This is intended to help set up the baselines for the more complex discussion of software and microprocessor platform interdependence and IP licensing contained in Part IV.

III. A CLOSER LOOK AT INTEL AND ARM

Below, Section A will briefly describe the history and business model of Intel. Particular emphasis will be given to the historically 'walled garden' approach to its microprocessor IP, and how this may play out (and has played out) in the PMD and IoT markets. Section B will then apply the same analysis to ARM, focusing instead on how its open approach to its microprocessor IP has helped to pave the way to its current dominance in the PMD space. A projection of how these approaches may play out in the nascent IoT space will also be included. Part IV will then discuss the intimate relationship between microprocessor architecture, IP licensing strategy and software platforms.

A. Intel's History, Business Model and IP Licensing Approach

Below, Intel's origin story (1), approach to IP licensing and the establishment of the 'walled garden' (2), and experience in the PMD and nascent IoT spaces (3) are briefly reviewed.

1. Intel's origin story

The relevant part of Intel's history begins in 1982 with the release of IBM's PC incorporating the Intel 8086 microprocessor, the ancestor to Intel's current 'x86' PC CPU *de facto* standard.[972] In order to speed up time to market and guarantee a reliable pool of component suppliers, IBM's approach to the PC was to have a modular 'open architecture', whereby suppliers got to keep control of their IP, and the hardware interfaces were open and standardised. At that time, IBM's policy was also to ensure at least two suppliers for every hardware component, and so 1982 was also the birth of AMD as a competing CPU supplier.[973] In

971. ARM, unlike Linux, of course still sues companies who infringe its patents without a license. It is position on the spectrum in Figure 1 as 'open innovation' means however that it generally always responds positively to license requests by practically every company, including competitors.
972. Ceruzzi, *A History of Modern Computing.*
973. Intel was forced by IBM to grant a license to the essential x86 patents to AMD, see ibid.

addition to IBM's open approach to hardware, the supplier of its OS (at that time, MS DOS) by the Microsoft Corporation was also able to retain control over its IP. As history has subsequently demonstrated, IBM's 'open architecture' approach had profound effects on the computer industry. As owner of neither the hardware nor software IP making up its PCs, IBM's hold over the PC market was weak.[974] Eventually, IBM's limited monopoly gave way to the proliferation of IBM-compatible PCs[975], tipping the market to the standard platforms owned by its suppliers who did retain IP rights: Intel's x86 microprocessor combined with Microsoft's MS-DOS (later, Windows). 'Wintel' is still the dominant combined software/ hardware 'platform' in the PC market today, with more than 80% of total PC OS market share.[976]

Despite being a virtual monopolist in the market for x86 microprocessors, Intel has continued to innovate at an astonishing rate. Due to a process called CMOS scaling[977] and innovations on the level of the microarchitecture, Intel has increased its microprocessor performance by a factor of 100 every decade in rough accordance with 'Moore's law', while consistently improving on the performance-cost ratio. Central to Intel's ability to ramp up processor speeds so consistently is due to an essential aspect of its business model which is rare in the semiconductor sector, and strongly differentiates it from ARM. In a world where most semiconductor companies have become 'fabless' or 'fab-lite' (see Part II, Section A), Intel both designs and manufactures its microprocessors. Intel's enduring status as an IDM has enabled it to innovate simultaneously on microprocessor design as well as manufacturing process, according to the development model dubbed "Tick-Tock", as discussed in Part II, Section A. This vertical integration of both microprocessor design and manufacture has allowed the two R&D trajectories to tightly co-evolve.[978] It has also allowed any IP in the form of trade secrets and confidential information over design and manufacture to remain entirely in-house, and not spill over into the industry.[979]

Indeed, Intel's exclusive property approach to its IP has meant that its patents and copyrights are generally only licensed in the context of cross-license agreements following legal proceedings. This approach to IP means that Intel's relationship with its customers is generally in the form of the sale of completed semiconductor products to OEMs, usually with very high profit

974. Gawer, *Platform Leadership*.
975. *e.g.,* DELL and HP, Compaq.
976. See NetMarketshare, 'Analytics Without the Bots' <https://www.netmarketshare.com/operating-system-market-share.aspx?qprid=10&qpcustomd=0> accessed 14 October 2016.
977. John Hennessy and David Patterson, *Computer Architecture* (Morgan Kaufmann 2012).
978. Of course, fabless companies have strong partnerships with foundries, but nothing comparable to Intel 's scale and integration.
979. Although, *e.g.,* via employee mobility it is impossible to contain spillovers completely, see Lemley and Frischmann, 'Spillovers'.

margins due the significant added value and the absence of vigorous competition. As will be discussed below, this approach has also meant that innovation around Intel's x86 CPU's has proceeded in a largely 'top-down' way, which, while resulting in a high-value product, has also resulted in a limitation in diversity, especially since the effective exit of Intel's main competitors from the market.

2. Approach to IP Licensing and Establishment of the 'Walled Garden'

Intel's dominance in the PC CPU microprocessor market has in many ways derived from its total commitment to the exclusivity of its x86 CPU 'instruction set architecture' ('ISA'). Put simply, an ISA is the set of machine-readable instructions which software source code must be compiled down to in order for the software to be able to tell the microprocessor what to do.[980] Because these instructions are shared by all microprocessors in a particular ISA 'family', software written for one microprocessor can (generally) also run on other microprocessors in the same family.

Due to the legacy of IBM requiring AMD as a second supplier of x86 CPUs, Intel and AMD entered a cross-licensing deal with respect to the x86 ISA in 1982. In the years while IBM was still the pre-eminent PC company, Intel continued to stick to the letter of the cross-license agreement by continuously updating the agreement to include subsequent extensions to the x86 design. During this time, Intel also maintained an effectively 'open architecture', meaning that the technical specifications relating to the way the CPU interacted with peripheral hardware (referred to as the 'bus') conformed to a standard used throughout the industry. This permitted OEMs who used the Intel chip to substitute the CPUs of other companies (such as AMD, VIA and NVIDIA) without the risk of "lock-in." However, with the virtual demise of IBM in the late 1980s due to the proliferation of 'PC clones', Intel sought to become the sole supplier of x86 chips in the burgeoning PC market by refusing to continue the technology exchange with AMD. In addition, Intel subsequently embarked on a legal crusade against all other, already marginalised, x86 manufacturers by suing for both patent and copyright infringement of the x86 ISA.[981] Intel's refusal to continue the cross license agreement with AMD eventually led to further litigation, concluding with a US Supreme Court Decision in 1994 granting AMD a time-limited license to new x86 extensions. An eventual settlement between the parties in 1995 secured AMD's continued viability in the x86 marketplace but ended the cross license agreement. With Intel's 1997 introduction of the x86 Pentium II microprocessor, Intel's hither-to comparatively open architecture, switched to one that

980. See *Intel* Commission Decision.

981. Greg Tang, 'Intel and the x86 Architecture: A Legal Perspective', (*Jolt Digest* 2011) http://jolt.law.harvard.edu/digest/patent/intel-and-the-x86-architecture-a-legal-perspective-2> accessed 14 October 2016.

was completely closed, and fenced around with Non Disclosure Agreements ('NDAs') and patents.[982]

What this meant in practical terms was that OEM's that utilised the Pentium family of CPUs would be unable to substitute CPUs designed by other companies. This decision kicked off a new era of litigation in the market for x86 CPUs, as rival x86 CPU makers found themselves cut out of the new generation x86 marketplace, which was rapidly adopting the Intel product as the *de facto* standard. Given Intel's steadily accumulating market share (90% of all x86 processors by late 1990s[983]), the legal arguments against Intel's exclusive IP licensing practices began to be couched in antitrust terms. In 1999, a US District Court even ruled that the proprietary information covering the closed Intel architecture constituted an 'essential facility' demanding compulsory licensing to competitors.[984] Although this decision was eventually quashed on appeal, a number of similar cases lodged by x86 CPU suppliers –also demanding access to the new x86 CPU architecture- followed in swift succession. In particular, lawsuits involving two x86 CPU markers, VIA technologies and NVIDIA- resulted in, respectively, a license to the x86 ISA but not to the proprietary architectural extensions (VIA),[985] and a monetary settlement of USD1.5 billion but no access to the x86 ISA (NVIDIA).[986] From Intel's now super dominant position in the market for x86 CPUs, its strategy against the main competitor who still retained an x86 ISA license- AMD- transformed from one of asserting IP rights to that of business tactics, involving, inter alia, extensive loyalty rebates in return for exclusive supply agreements with OEMs. These business tactics subsequently came under review, and sanction, in the 2009 EU competition case, whose decision to fine Intel 1.06 billion Euro was recently confirmed by the General Court in June 2014, although perhaps too late for AMD whose market share took a drastic tumble due to Intel's illegal practices, leading it to eventually switch focus from the PC CPU market to that of gaming consoles.[987]

The upshot of the above-abbreviated history of Intel's x86-related litigation is that Intel now holds the undisputed dominant position for the supply of x86 CPUs for PCs. Its main competitors have either been marginalised in the x86 PC market (VIA), sought greener pastures in gaming console CPU design (AMD)[988], or have been nudged out of the market

982. Ibid.
983. Richard Gray and David Banie, 'Intergraph Corporation v. Intel Corporation' (2000) 16(2) Santa Clara High Tech LJ 437.
984. Ibid.
985. See Agam Shah, 'Intel, Settle All Patent Cases' (*Computerworld,* 8 April 2003) <http://www.computerworld.com/article/2581013/technology-law-regulation/intel--via-settle-all-patent-cases.html> accessed 14 October 2016.
986. See Ryan Smith, 'Intel Settles With NVIDIA: More Money, Fewer Problems, No x86' (*Anandtech*, 10 January 2011) <http://www.anandtech.com/show/4122/intel-settles-with-nvidia-more-money-fewer-problems-no-x86> accessed 14 October 2016.
987. See <http://www.moorinsightsstrategy.com/the-real-reasons-microsoft-sony-chose-amd-for-the-xbox-one-and-ps4/> accessed 14 October 2016.
988. AMD has now moved into the PS4 and Xbox console CPU market, CrimsonRayne, 'Why PS4 and Xbox One

entirely (NVIDIA). Intel's x86 IP strategy has finally resulted in a 'walled garden' around its CPU architecture. Although Intel has never stopped innovating- and indeed is still at the forefront of semiconductor innovation (perhaps due to the phenomenon of 'self-competition' in durable goods monopolies[989] as well as its status as an IDM) its exclusivity over the x86 ISA means that its customers only benefit from a single 'node' of innovation, compared to the multi-node system resulting from ARM's open innovation approach, as discussed in Section B below. Since Intel is continuing to use its x86 architecture in both the PMD market (cf. Intel 'Atom') and IoT (cf. Intel 'Quark'), it is likely that this 'exclusive' property approach- and thus its 'top down' approach to CPU innovation- will continue as the status quo.

3. Intel's Experience in the PMD and Nascent IoT markets

Intel entered the market for PMDs substantially unopposed in the x86 CPU space, as one of only three[990] companies in the world still using the ISA. However, although the strategy of eliminating competition in the PC market bore fruits for Intel in the already mature PC market where x86 had already achieved status of *de facto* standard, Intel entered a very different market structure in the PMD space. As will be discussed below in relation to ARM's IP strategy, Intel entered a market replete with suppliers of ARM's competing CPU. Because ARM is an IP company and not a product company, ARM's CPU designs had rapidly achieved status of *de facto* standard on PMD SoCs, in part due to the sheer depth of the CPU's design supply base in the form of intermediate IP design houses supplying ARM-based microprocessors, as in the example of Qualcomm (see Part II, Section A).

Intel's entry into the PMD space began in 2012 with its release of the Intel 'Atom' SoC based upon the so-called 'Medfield' platform.[991] Like other companies in the PMD market, Intel's SoC also included some third party IP – already a milestone for a company that famously liked to develop all its IP in-house under its walled garden approach.[992] However, unlike ARM, Intel still refused to license its CPU architecture to downstream design houses, except perhaps for one example of the Chinese company *Spreadtrum*, although details are unclear[993]. In practice, this approach meant that Intel remained the sole supplier of x86-based SoCs, meaning that OEMs which adopted the SoC risked vendor "lock in", as well as a lack of diversity and depth

Moved to X86-64' (*RedgamingTech* 20 September 2013) <http://www.redgamingtech.com/why-ps4-and-xbox-one-moved-to-x86-64/> accessed 14 October 2016.

989. The concept that Intel must keep on innovating in order to entice consumers to keep upgrading their existing products based on Intel's previous generation. Ronald Goettler and Brett Gordon, 'Does AMD Spur Intel to Innovate More?' (2011) 119(6) J Pol Econ 1141.

990. Others include AMD and VIA, although the last two are on longer running ISA's compatible with Intel's.

991. See Intel <http://www.intel.com/content/www/us/en/processors/atom/atom-processor.html> accessed 14 October 2016.

992. Tassey, 'Standardization in Technology-Based Markets'.

993. See Usman Pirzada, 'Intel Looking to Grant x86 ISA License to a Third Company - Chinese CPU Maker Spreadtrum' (*WCCFTECH*, 2014) <http://wccftech.com/intel-x86-isa-license-spreadtrum/> accessed 14 October 2016.

in terms of power and efficiency options as well as SoC customisability. Unlike with ARM, where OEMs had a range of suppliers with a number of different ARM-based SoCs touting varying specifications, Intel's PMD customers were tied to the innovative capacity of a single company. This approach arguably invited potential customers into a new space of 'top down' innovation compared to the 'bottom up', multi-nodal R&D trajectories of a truly competitive market place (see Part II, Section B). Perhaps for this reason, Intel's entry into the PMD space has been assessed as more-or-less a failure, as currently only low-end smartphones- ASUS and Lenovo- are powered by Intel's x86-based SoCs, and it has failed to make any headway with the major OEMs[994]. However, as will be discussed in Part IV, some of this failure may be attributed to Intel's complicated relationship with software platforms, due to its late-starter status.

Given Intel's discouraging entry into the PMD space, its approach to the nascent IoT market has been somewhat more hands-on. Intel has continued in its reversal of its traditional R&D trajectory of ramping up raw power in its x86 architecture, by scaling back the power 'footprint' even further than its PMD-friendly 'Atom' SoC. For the IoT market, Intel has produced the 'Quark'-line of SoCs, designed to consume considerably less power and function as the logic 'chip' on miniaturised embedded devices.[995] Intel is even taking an active hand in developing and supporting a promising new OS for the IoT, Zephyr,[996] - an open source minimalist OS based on Linux- which will help it face the hurdles it encountered in the PMD space (see Part IV). As demonstrated by its Whitepaper, *The Intel IoT Platform*[997], Intel's approach to the IoT is an all-inclusive strategy to leverage first-mover advantages to try to get the Quark-line SoCs as a *de facto* standard technological infrastructure for the IoT.

However, so far all indications are that its IP licensing approach to its x86 architecture will remain an 'exclusive property' approach. This would mean that downstream IP design houses will not have access to the architecture in order to engage in 'bottom up' multi-nodal SoC innovation, thus arguably depriving OEMs of the diversity, complexity, and configurability which characterises the ARM-based approach, as discussed below. As further discussed in Part IV, this may have negative consequences for its ability to attract the depth of installed-

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994. See Micah Singleton, 'Lenovo's P90 is the First Smartphone with 64-bit Intel Atom Processor' (*The Verge*, 5 January 2015) <http://www.theverge.com/2015/1/5/7490143/lenovo-ces-2015-p90-vibe-x2-pro-vb10-intel-atom> accessed 14 October 2016. See also Intel, 'Smartphones For the Speed of Life' <http://www.intel.com/content/www/us/en/smartphones/smartphones.html> accessed 14 October 2016.
995. See Intel <http://www.intel.com/content/www/us/en/embedded/products/quark/overview.html> accessed 14 October 2016.
996. See 'The Linux Foundation Announces Project to Build Real-Time Operating System for Internet of Things Devices' (*Link Foundation,* 17 February 2016) <http://www.linuxfoundation.org/news-media/announcements/2016/02/linux-foundation-announces-project-build-real-time-operating-system> accessed 14 October 2016.
997. See Intel, 'Architecture Specification White Paper Internet of Things' http://www.intel.com/content/www/us/en/internet-of-things/white-papers/iot-platform-reference-architecture-paper.html accessed 14 October 2016.

based required for driving the achievement of *de facto* standard status as microprocessor infrastructure for the nascent IoT.

B. ARM's History, Business Model and IP Licensing Strategy

Below, ARM's origin story is briefly sketched (1) before taking a closer look at its IP licensing and business model (2), and finally its experience in the PMD and the nascent IoT spaces (3).

1. History of ARM

The relevant history of ARM Holdings begins in 1991, when it entered into a partnership with Apple Corporation ('Apple') to power the Apple Newton Personal Digital Assistant ('PDA').[998] Although this device was not a success, it formed a sufficient proof-of-concept of the technology to trigger its adoption as the microprocessor platform for Nokia's 2G mobile phones in the mid 1990s.[999] This 'design win' was quickly repeated by a number of other mobile phone OEMs, until by 2005, ARM-based microprocessors powered 90% of all mobile phones.[1000] In addition to mobile phones, ARM technology was chosen to power Apple's 2001 breakthrough product, the Apple iPod (and all subsequent versions) and now also powers all Apple iPhones and iPads and the majority of other leading smartphones, tablets and handheld devices. As of 2016, ARM-based microprocessors also power 90% of all hard drives, 40% of digital TV's and set-top boxes, and 15% of microcontrollers. [1001] ARM-based microprocessors currently outnumber Intel microprocessors by around four to one. This wide diversity of implementations and partnerships is what ARM calls its 'ecosystem approach' to computing and is only possible because of ARM's very different business model and approach to IP licensing, which will be discussed below.

2. ARM's open approach to IP licensing and business model

As a pure-play semiconductor IP company, ARM sits at the top of the semiconductor value chain, focusing the bulk of its R&D resources on microprocessor design. ARM's business model takes one of two main forms. Either ARM licenses out a microprocessor design (such as *e.g.,* the ARM-Cortex A9[1002] or Cortex A15[1003] which may then be implemented into SoCs as the CPU.) In such cases, both the microarchitecture and instruction set architecture are designed by ARM. The OEM or downstream semiconductor company (like *e.g.,* Texas Instruments) will then configure the CPU module into the SoC. Alternatively, ARM may just license out

998. Nenni and McLellan, *Fabless*.
999. Ibid.
1000. Ibid.
1001. ARM Strategic Report 2015.
1002. See ARM ,'Cortex-A9 Processor' <http://www.arm.com/cortex-a9.php> accessed 14 October 2016.
1003. See ARM ,'Cortex-A15 Processor' <https://www.arm.com/products/processors/cortex-a/cortex-a15.php> accessed 14 October 2016.

the ARM instruction set (usually the ARM v7 or v8[1004] ISA), and the OEM or downstream semiconductor company will be responsible for designing the microarchitecture of the microprocessor, such as is the case with Qualcomm and its 'Snapdragon' microarchitecture SoC.[1005] The downstream semiconductor companies or OEMs then usually make use of a third party foundry (which is often also in a partnership with ARM[1006]) to manufacture the completed SoC design.[1007] In consideration for its IP, ARM receives both an upfront licensing fee as well as a per-unit royalty over every chip sold.[1008] The licensing fees and royalties ARM reaps from licensing its IP cores are famously low[1009], although the precise royalty fee depends on the complexity of the microprocessor.[1010]

Given ARM's monolithic focus on microprocessor designs and the flexibility of its IP licensing arrangements- which permit high configurability of the end-product SoC- it has built up an ecosystem of unparalleled depth and range. This strategy has enabled its customers to simply 'slot in' the desired microprocessor according to use-case, or otherwise customise the microprocessor specifications according to need. Furthermore, given the fact that ARM's CPU designs tend to share an ISA, customers are able to choose between chip designs from either ARM or various intermediate suppliers without concern of compatibility problems with other hardware peripherals or downstream software platforms. This uniformity of ISA allows OEMs to benefit from competition between intermediate suppliers, including the continued innovation drive and improving cost-performance ratios across a number of different innovation nodes (see Part II, Section B).

The above 'open' approach to IP licensing can be contrasted with Intel's relatively closed 'walled garden' approach. The disaggregation of microprocessor design from the final product essentially allows PMD CPUs and peripheral hardware to evolve in a 'decentralised' manner, permitting the developmental trajectories to develop via a 'bottom up' process akin to some aspects of the open source software development mode, which, incidentally (or not[1011]), is also present in the approach of the dominant PMD software platform (see Part IV).[1012] It is

1004. ARMv8 is ARM 's 64-bit architecture, which the latest generation of PMD CPU's are migrating to, such as the iPhone 7's 'A10 Fusion' chip.
1005. Qualcomm, <https://www.qualcomm.com/products/snapdragon> accessed 14 October 2016.
1006. *e.g.,* ARM's foundry program ARM, <http://www.arm.com/products/buying-guide/licensing/processor-foundry-program.php> accessed 14 October 2016., since needs a license to ARM's IP in order to manufacture.
1007. In many cases, this will be TSMC.
1008. ARM Annual Report 2011.
1009. See Charlie Demerjian, 'How ARM Licenses it's IP for Production' (*SemiAccurate* 8 August 2013) <http://semiaccurate.com/2013/08/08/how-arm-licenses-its-ip-for-production/> accessed 14 October 2016.
1010. See <http://www.arm.com/products/buying-guide/licensing/> accessed 14 October 2016.
1011. In Part II, Section B it is argued that the dual dominance of both an open source software platform as well as an open innovation approach to CPU design is not an accident.
1012. In terms of permitting companies access to pre-designed modules which can be customised.

submitted that a decentralised approach, where the essential IP is available for customisation and integration by a variety of different parties- both intermediate and end product- permits the formation of multiple nodes of innovative activity, leading to products of a greater complexity and diversity than the 'single node' approach of fully integrated solutions.

3. ARM's experience in the PMD and nascent IoT spaces

In 2015, ARM reported that its network of partners had shipped a total of 15 billion ARM-based microprocessors, half of which went into PMDs.[1013] This brings the total number of shipped ARM-based chips to 75 billion since its inception. For the sake of comparison, Intel's number of shipped chips in 2013 for the PMD market was an order of magnitude less, at 10 million.[1014] Although comparison between these figures must take into account ARM's first mover advantage, which has allowed it to become the technological infrastructure and *de facto* standard in the PMD space, ARM's success is nevertheless astounding. One major reason for its success may be attributed to the fact that its IP licensing model is particularly suited to the nature of the PMD semiconductor market, whose extreme complexity and rapid pace of evolution arguably requires high flexibility and customisability of microprocessor and SoC designs, as discussed in Part II, Section B.

With respect to the nascent IoT market, ARM already has its foot in the door with its current dominance of the 'wearables' market.[1015] As with IoT, the wearables market requires heavily reduced power 'footprint' CPUs. ARM's microprocessor Cortex-M-series is already powering smart watches and intelligent parking meters.[1016] As with the PMD space, all of ARM's Cortex M-series architectures are individually licensable by design houses and integrated OEMs for the creation of fully customisable SoCs.[1017] Furthermore, as with Intel's support of the embedded Zephyr OS, ARM has its own open source IoT-specific minimalist OS, called mbed.[1018] Like Android, mbed is licensed under the permissive Apache 2.0 open source software license, and is available on the Github open source repository.[1019]

Given that the IoT market is still in in its infancy, one has to look to the example of the PMD space in order to try to discern some patterns as to how it may evolve. Since both Intel and ARM have either adopted or plan to adopt an open source OS for the software platform,

1013. ARM Annual report 2014, 16.

1014. Getting sales figures for more recent years was more difficult, perhaps due to the failure of Intel to thrive in these markets and hesitancy to publish. See Intel Annual Report 2013 <http://www.intc.com/intel-annual-report/2013/#> accessed 14 October 2016.

1015. See <https://www.arm.com/markets/wearables>

1016. See ARM , 'Internet of Things' <https://www.arm.com/markets/internet-of-things-iot.php> accessed 14 October 2016.

1017. See ARM , 'IoT System for Cortex-M' <http://www.arm.com/products/internet-of-things-solutions/iot-subsystem-for-cortex-m.php> accessed 14 October 2016.

1018. See ARMmbed, <www.mbed.com> accessed 14 October 2016.

1019.See ARMmbed, <https://github.com/ARMmbed/mbed-os> accessed 14 October 2016.

this shows that the astounding success of the open source Android platform in the PMD space may have been used as a model. As will be shown in Part IV below, once an application ecosystem grows up around a particular OS, this can drive demand for the underlying OS via the economics of two-sided markets.[1020] Such demand can also then feedback onto the underlying microprocessor infrastructure to create a situation of 'derived demand', whereby the demand for the user-facing apps 'reaches through' to drive demand for the CPU the OS is built on. In what follows, the example of software platforms in the PMD market will be examined in detail before distilling some take-home points for the importance of software platforms and open IP licensing in the battle for the future IoT microprocessor infrastructure.

IV. MICROPROCESSOR INFRASTRUCTURE AND SOFTWARE PLATFORMS

A crucial component in the success of a microprocessor platform is the depth and range of the software ecosystem associated with it.[1021] Software may be divided into two main categories[1022], operating systems and applications. By intermediating between the hardware and higher-level software, OS's provide the foundation upon which downstream applications ('apps') can be built. Like microprocessor families, OS families can also therefore be described as platforms. Software developers (often third parties) need to write apps according to specific rules unique to the OS, known collectively as 'Application Programming Interfaces' ('APIs'). Since these APIs are unique to the platform, apps written for a particular software platform cannot usually function on other software platforms. The software ecosystems of different platforms do not therefore overlap, and a user's choice between different platforms is generally mutually exclusive.

Just as apps are written to work on specific software platforms, software platforms are generally[1023] written to function on specific CPU architectures. In addition to working with peripheral hardware[1024], OS's must be organised to work with the instruction set of the underlying microprocessor. These one-way relationships (Apps→OS→CPU) might lead one to conclude that apps written for a particular software platform can only work on specific CPU architectures. Although this has often been the case in practice, it is possible for some applications to work across microprocessor platforms, provided the software platform remains constant, and various other technical conditions are met (see Section A below).

1020. Rochet and Tirole, 'Platform Competition in Two-sided Markets'.
1021. Barnett, The Host's Dilemma'.
1022. There also 'drivers' etc, but these are low-level software controlling the interaction between software and (peripheral) hardware.
1023. Two main caveats here. The web, and browser or internet based apps which work according to web and internet protocols independent of the hardware. And software which work via virtual machines, as will be discussed.
1024. *E.g.,* cameras, sensors, gyroscopes etc.

In what follows, we will examine the case of Intel attempting to enter the PMD space by reconfiguring key aspects of the ARM-based Android platform to work on Intel's x86 microprocessor (referred to as 'porting'). Given the fact that Android is open source (and thus freely available for such an endeavour)- as well as the fact that a port of Apple's iOS would have been impossible due to Apple's status as an integrated software and device company, such a port was Intel's best bet for success in the PMD market. This will be the subject of Section B below. Section A will be begin by an examination of the dominant PMD software platform- Android- in order to illustrate the crucial relationship between microprocessors and OSs. Section C will then aim to tie the various threads together, before Part V of this chapter will conclude.

A. The Dominant PMD Software Platform: Android

The Android mobile OS is the dominant software platform in the market for smartphones, with a market share currently exceeding 85% (compared to Apple's 13%).[1025] In the tablet market, Android's lead is less pronounced due to its reasonably late start, but is still 60% compared to Apple's 33%.[1026] Arguably, a significant component of the success of this platform is due to its 'openness', whereby any OEM may implement the platform into their devices without any significant intellectual property restrictions. As already mentioned in Part II, Section B, the IP licensing regime behind Android is governed by a variety of open source licenses, but mainly the GPL v2 (the kernel) and Google's (and partners') additional extension libraries under the Apache 2.0, both of which enable royalty-free use, modification and distribution of the software source code. Furthermore, the platform sponsors- Google and the Open Handset Alliance- provide OEMs with free compatibility guidelines, a test suite, and a verification suite, to ensure that particular implementations of the software platform retain cross-device interoperability. This policy has enabled Android to work across a diversity of different devices by different OEMs, ranging from Samsung, HTC, Motorola, Amazon, in both smartphone and tablet form. This approach contrasts sharply with, for example, Apple's tightly controlled iOS (permitted only to work on Apple hardware) and is arguably a major reason why Android was able to establish an installed base so quickly and accelerate its uptake.[1027]

The above cross-device compatibility has been driven significantly by the fact that all the above Android devices are running ARM-based CPUs with the same microprocessor

1025. See IDC, 'Smartphone OS Market Share, 2016 Q2' <http://www.idc.com/prodserv/smartphone-os-market-share.jsp> accessed 14 October 2016.
1026. See NetMarketshare, 'Analytics Without the Bots' <https://www.netmarketshare.com/operating-system-market-share.aspx?qprid=8&qpcustomd=1> accessed 14 October 2016.
1027. See Jack Wallen, 'Android is Winning the Platform Race' (*TechRepublic* 11 August 2014) <http://www.techrepublic.com/article/android-is-winning-the-platform-race/> accessed 14 October 2016.

instruction set architecture. This close coupling between the Android OS and ARM has arguably been both the cause and the result of a positive feedback loop (otherwise called 'network effects'[1028]) of the following (rather complicated) form: the open availability of Android led to high adoption rates by OEMs, which led to more Android devices, which in turn attracted third party app developers to the size of the user-base, which led to more apps, which attracted more users, which led to more Android devices etc. Clearly, a prime driver of this feedback loop was the openness of the Android OS, which permitted OEMs to easily adopt the OS. However, underwriting this entire feedback loop is ARM's open approach to its CPU architecture, which enabled Android to run on all the different devices in the first place.

The fast establishment of the Android installed base due to the open approach of both Android and the underlying ARM microprocessor infrastructure enabled it to create the vibrant application ecosystem embodied in its app store, 'Google Play', which has fuelled the further growth of the platform due to network- effects. As already mentioned, third party application developers are attracted by the platform's large installed base, and thus create more apps; meanwhile, the blossoming array of apps attract more users to the installed base, in a virtuous cycle. The growth of this two-sided market is also aided by the platform sponsors' relatively open attitude to granting developers access to the Google Play app store API, by only charging a one-time fee of USD25[1029], compared to Apple's USD99 fee.[1030] The current population of apps in the Google play store now exceeds 1.6 million, having recently overtaken Apple Appstore's 1.5 million.[1031]

Since apps unlock for users the real functionality of their PMDs or other embedded devices, a microprocessor platform which intends to break into the PMD market (or any dominant software platform which may arise in the nascent IoT space) will need to 'port' the dominant OS to its microprocessor infrastructure in order to participate in the network effects of the dominant app ecosystem. In the case of the IoT market, the two most likely software platforms to battle it out will likely be ARM's mbed and the Intel-supported Zephyr. Although both these software platforms are open source (see Part III, Sections A and B), they will still require significant reconfiguration to operate on a different microprocessor infrastructure, so as to unlock any eventual app ecosystem associated with them.

1028. Farrell and Klemperer, 'Coordination and Lock-in'.
1029. See Google , 'How to Use the Google Play Developer Console' <http://support.google.com/googleplay/android-developer/bin/answer.py?hl=en&answer=113468> accessed 14 October 2016.
1030. See Apple Developer, 'Choosing a Membership' <https://developer.apple.com/support/compare-memberships/> accessed 14 October 2016.
1031. See Statista, 'Number of Apps Available in Leading App Stores as of June 2016' <http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/> accessed 14 October 2016.

Below, Intel's experience with porting Android to its x86 microprocessor infrastructure will be discussed as a possible template for any such endeavour in the future evolution of the IoT. Section C will then aim to integrate the findings of Section A and B, before Part V concludes.

B. Intel x86 and Android: Possibility of 'Porting'

As has already been explained in Section A above, for software to function on microprocessors it must to be compiled down to the set of instructions understood by the ISA of the microprocessor. Although this is particularly crucial for the operating system, the great majority of application-level software must also meet a similar requirement via the APIs set by the OS. What this generally means is that applications do not work across software platform (due to different APIs) or across microprocessor platform (due to different ISAs). However, there are some important exceptions to this rule, such as in the case of cross-platform technologies like Java, Qt[1032] or HTML5.[1033] Fortunately for Intel, Android makes use of a Virtual Machine ('VM') called the Android Run-Time ('ART'), which can execute Java 'bytecode'. Applications built within the ART framework do not require apps to be compiled down to the microprocessor ISA in order to be executed, but instead compile down to an 'intermediate' 'bytecode' which runs on a 'simulated' ISA called a VM. ART (like the Java VM) acts to 'shield' the application source code from the microprocessor ISA via an intermediate translation step[1034], which can then be easily modified to match the ISA. This action enables all apps written to the ART API to work with any microprocessor, provided the VM is correctly configured for the particular microprocessor ISA. To achieve cross-microprocessor app compatibility, all that is required is a 'porting' of the VM to the new microprocessor infrastructure, rather than an individual porting of each individual app, which would otherwise be the case.

In 2011, Intel successfully ported the ART VM to the x86 architecture.[1035] Android on Intel is apparently able to run around 95% of all Android apps.[1036] However, there is a minority of Android apps, which for performance reasons do not make use of the ART VM, and instead are written according to the Native Development Kit ('NDK'). Since these apps compile directly to the native Android architecture (ARM ISA), Intel's ART VM port does not assist with compatibility. Instead, Intel has had to create some extremely sophisticated translation

1032. See QT, <http://www.qt.io/> accessed 14 October 2016.

1033. *i.e.,* Web-based applications require only browsers which are compatible with the HTML5 standard in order to run the apps.

1034. *i.e.,* the compilation down to Java or ART bytecode.

1035. See Android , 'Android-x86 Open Source Project Announcement' <http://www.android-x86.org/> accessed 14 October 2016.

1036. See Lawrence Latif, 'Intel Claims Its Atom Chip Can Run 95 per cent of Android Applications'(*The Inquirer* 6 June 2012) <http://www.theinquirer.net/inquirer/news/2182314/intel-claims-atom-chip-run-cent-android-applications> accessed 14 October 2016.

software directly between the x86 and ARM binaries,[1037] which app developers have to make use of themselves if they want cross-platform interoperability of their Android apps.[1038] Whether NDK developers will find it worth their while, is another question, and depends on the number of design wins Intel can secure with its Atom SoC in the PMD space. What Intel has proven, however, is that mere technical barriers to interoperability are surmountable, and therefore have made their microprocessor a serious option to OEMs, at least on technical grounds.

Given the above template of OS 're-porting' to a different microprocessor architecture, it is conceivable that in the event that either ARM or Intel backed-OSs lose the IoT software platform standards battle, the open source nature of these OSs will enable the loser to play 'catch-up' in much the sane way Intel did in the PMD space. However, the technical viability of this approach will strongly depend on the way IoT apps interact with their native OS's (i.e whether they are *e.g.,* web-based HTML5 apps, or native apps) and cannot be predicted without further development on this front.[1039]

However, what it is clear from the nature of the feedback-loop discussed in Section A above, is that one of the prime drivers for Android's dominance in the PMD space was ARM's open approach to its microprocessor architecture. The openness of ARM's microprocessor architecture was what drove its adoption among device makers, which, when coupled with the openness of Android, drove the feedback loop between consumers and third party app developers. Of course, Intel's approach to its x86 infrastructure- even in the pared-down architectures powering its IoT-friendly 'Quark' SoC- still lacks this openness, so according the analysis in this chapter, Intel will still remain on the back-foot in an all-out standards war.

C. Integrating the software and microprocessor platform approaches with IP licensing strategies

Most software platforms are tightly coupled to the underlying microprocessor platform, and require significant adaptation ('porting') if they are to function on non-native platforms. Once a software platform has been ported to a new microprocessor, its value is only transferred if the app ecosystem associated with it is also transferred. Whether apps can also be transferred to a newly-ported software platform depends on the technology embodied in their APIs. If the APIs include cross-platform technology such as HTML5 or Java (or ART, in the case of Android), then it is possible for a non-native microprocessor platform to also inherit the ecosystem of apps, and thus inherit the true value of software platform. Since

1037. See Intel , 'NDK Android Application Porting Methodologies' (27 November 2013) <http://software.intel.com/en-us/articles/ndk-android-application-porting-methodologies/> accessed 14 October 2016.
1038. See Android , 'x86 Support' <http://developer.android.com/ndk/guides/x86.html> accessed 14 October 2016.
1039. The market is still too fragmented to see how this interaction will take place, as too many competing solutions

software platforms are user facing, it is easier for new entrant microprocessors that port dominant software platforms to gain market share (Android on Intel example) than for new entrant software platforms which port to dominant microprocessor platforms. This is due to the economics of two-sided markets and network-effects, which rewards first movers and interoperable products and punish late starters and incompatible products.[1040]

In the nascent IoT market, there is currently a huge amount of fragmentation along most axes of infrastructural components, including microprocessor infrastructure, OS's, radio communication protocols[1041], security measures, sensors, application-level APIs etc. While some of these components may not need standardisation due to the development of 'middleware' which are argued to ensure interoperability[1042], such middleware itself will still require standardisation, such as, for example, 'Alljoyn' (as is being currently developed by the AllSeen Alliance industry consortium[1043]) as well as 'open interconnects' (via the 'Open Interconnect Consortium'[1044]). Indeed, there are currently dozens of formal and informal SSOs promulgating hundreds of possible IoT standards.[1045] Perhaps the problem of fragmentation in the IoT market is due to having too many standards, not too few, creating a 'jungle of standards'.[1046]

However, given that, as with the PMD market- the main driver of demand will almost certainly be consumer applications- it will most likely be rich app ecosystems which will 'pick winners' among the lower-level infrastructures, via the forces of derived demand and network effects. If this is the case, then software platforms (and hence microprocessor infrastructures) will play a determinative role in the battle of the standards, due to the complex feedback loops and derived demands described in Section A above.

Given that the two likely contenders in the IoT software platform space- mbed and Zephyr- are both open source (and not therefore constrained anymore than Android was), to a particular microprocessor infrastructure, it is submitted that success in the microprocessor infrastructure 'battle of the standards' will be driven equally (if not more) by the diversity, range, and depth of the *hardware* ecosystem making up the IoT. In contrast to the PMD space, where, although SoC variety and diversity was argued to be central to ARM's success (see

1040.Farrell and Klemperer, 'Coordination And Lock-In'.
1041. For example, between Bluetooth Low Enery (otherwise known as 'Bluetooth Smart'), Zigbee, Z-Wave, or DECT.
1042. IEEE, 'IEEE Standards Association (IEEE-SA) Internet of Things (IoT) Ecosystem Study' (2015) <http://www.sensei-iot.org/PDF/IoT_Ecosystem_Study_2015.pdf> accessed 14 October 2016.
1043. See Allseen Alliance, <https://allseenalliance.org/framework> accessed 14 October 2016.
1044. See Wikipedia, 'Open Connectivity Foundation' <https://en.wikipedia.org/wiki/Open_Interconnect_Consortium> accessed 14 October 2016.
1045. Zingales, 'Of Coffee Pods, Videogames, and Missed Interoperability'.
1046. Ibid.

Part III, Section B), PMD diversity is still roughly limited by PMDs' status as a 'universal'[1047] device, rather than being task-specific. Not so with the IoT. Indeed, the IoT will arguably be completely defined by its diversity and specificity of its hardware. As stated by ARM in its analysis of the market potential of the IoT[1048]:

> If the mobile Internet is 10 billion units, the Internet of Things is 100 billion units…if mobile computing had tens of form factors, then IoT will have millions of form factors.

If the above is an accurate analysis of the way the IoT will evolve, then the truly crucial component of microprocessor infrastructure success will be the ability to combine a common software platform with a rich ecosystem of apps *and* a cornucopia of diverse task-specific devices with a variety of form factors.[1049]

In order to achieve this outcome, what is required is an approach to innovation and IP licensing which fosters diversity, complexity and configurability of end products. In short: an approach which favours innovative 'bottom up' exploration of the technological frontier, where key infrastructural inputs are distributed over multiple nodes of potential innovative activity. As argued in Part II, Section B, such an approach will most likely be encouraged by IP licensing models which favour openness over exclusivity, such open source, or the FRAND-based approach to technological standards, or the 'open innovation' regime of ARM's 'ecosystem' of downstream partners, each of which implements the infrastructural approach of 'if infrastructure, then open access'.

V. CONCLUSION

This chapter has attempted to outline in broad strokes some key considerations for the evolution of microprocessor infrastructure in the nascent IoT market. By examining the nature of the semiconductor industry and dominant IP licensing models, it developed the argument that Intel and ARM's respective fortunes in the PMD market were tightly interwoven with their approaches to IP. It further argued that these approaches can be projected- with some caveats- into the evolution of the IoT market in order to assess likely outcomes in the battle for microprocessor infrastructure.

1047. *i.e.* all PMDs such as smartphones and tablets are essentially personal computers, with sophisticated user interfaces and the ability to run millions of different apps.
1048. See ARM, 'Internet of Things' <https://www.arm.com/markets/internet-of-things-iot.php> accessed 14 October 2016.
1049. Ibid.

With respect to the PMD market, it concluded that the principal driver of ARM's success was its open approach to its IP, which scaffolded 'bottom up' innovation via the creation of multiple nodes of innovative activity around the core technological infrastructure of its microprocessor designs. This was contrasted to Intel's IP more closed, 'top down' approach, which although yielding extremely high-value products (due also to Intel's status as an IDM) can only provide a single node of innovative activity, thus limiting diversity, configurability and complexity.

While the PMD space- including its dominant software platforms- rewarded ARM and its partners' ability to produce highly diverse, configurable, and complex PMDs, it is argued that the IoT market may turn this reward into an economic bonanza. Unconstrained by requirements of 'universality' like PMDs, IoT devices are likely to be extremely diverse and highly task-specific. If ARM and Intel persist in their approaches to IP and business models in this new market of 'enchanted objects'[1050], then it is predicted that ARM's 'infrastructural approach' to its IP licensing will be a strong driver of its success.

1050. Rose, *Enchanted Objects*.

CONCLUSION

The five chapters in this volume have focussed on investigating access problems to technological infrastructure, and have attempted to demonstrate the power of the 'infrastructural approach' under different institutional conditions.

Chapters 1 and 2 constructed legal arguments using the institution of competition law, to explain how open access to such assets can be (and have been) imposed, as well as justified on economic and legal grounds. The main nerve of the competition law approach developed in these chapters was to show that the legal arguments for the two classes of technological infrastructure (cooperatively-set standards, chapter 1; and *de facto* standards, chapter 2) are unified by an 'infrastructural approach'. These chapters concluded that as real and virtual networks continue to proliferate in today's information economy, the standards which underwrite them can develop into 'choke points' for innovation if they are not managed in an open manner suggested by the infrastructural approach. Chapter 3 then took the economic reasoning developed in these chapters in another direction, by choosing to focus on another class of technological infrastructure, referred to as 'pioneering inventions' (or general purpose technologies). In particular, chapter 3 developed the argument that this class of technological infrastructure is likely to arise in cases of publicly subsidised R&D. By deploying tools from game theory, this chapter aimed to show that exclusive (IP) rights regimes can lead to sub-optimal access terms (such as 'property traps' and 'risk-dominant assurance' game equilibria[1051]), but that theses outcomes can be controlled if the structure of the subsidy grant is modified to 'dial up' subsidy intensity dependent upon the openness of the results.

The final chapters (chapters 4-5) then focussed largely on private strategic responses to institutions around technological infrastructure. Chapter 4 focussed specifically on the way private strategic behaviour can subvert the purpose of Government procurement policies, leading to the necessity for strategic responses on behalf of the public sector to help maintain the openness of procured 'open standards'. Chapter 5 switched focus to private ordering and business model innovation in innovation markets, and aimed to show that private incentives for openness do exist under certain conditions and by utilising certain business models. It also demonstrated that openness to intellectual property can, in some markets, actually be a driving force for diversity and complexity, by decentralising the control structure and permitting the bottom-up growth of new innovations.

One major unifying theme in the analysis of the chapters of this volume is that the access problems identified in relation to technological infrastructure are likely to grow rather than recede as modern economies continue to evolve away from industrial economies and towards those based on information and knowledge. Indeed, this thesis's focus on technological infrastructure in the form of interoperability standards is 'just one skirmish in a much larger

1051. See Part III, Section C in chapter 3.

war over openness and closure in technology networks.'[1052] The issues which underwrite this conflict are in many ways symptomatic of a broader change in the pattern of economic production in modern economies. As early as 1962, the Austrian-American economist, Fritz Machlup, heralded the transformation of industrial economies towards the knowledge-fuelled, innovation powerhouses he dubbed 'information societies'. The key property of the information society compared to its industrial predecessor, was considered to be its use of information assets as primary inputs to economic production. Then, as now, a central question of information economics was: who picks up the bill today for tomorrow's innovation, and in what currency is the bill payable?

Now that Machlup's vision of the future has more-or-less come to pass, it is interesting to see that the legal and economic scholarship on this central question is as divided as ever. Supporters of exclusive intellectual property rights maintain that strong IP drives the investment decisions which power the dynamism of the economy: society pays the bill for tomorrow's innovation in the currency of today's static efficiency losses. Supporters of the commons-based production model instead argue that the non-rivalrous nature of information can be leveraged to produce net gains and no social losses, by allowing for indirect value appropriation and truly dynamic competition with low barriers to entry.

One fascinating aspect of this debate that is often overlooked is that the question about the relationship between exclusive (or open) rights and innovation is fundamentally *empirical*, rather than theoretical. Despite being of an empirical form, the question seems to be intractable according to empirical methods. As Machlup observed in 1958, in a report on the US patent system: [1053]

> If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system… it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it.

Given the fact that we are immersed in a world where information is propertised it is difficult to see if the rapid pace of technological innovation is in fact driven by it, or if it occurs in spite of it. Since the causal connection is uncertain, one cannot suggest to abolish intellectual

1052. Contreras 'A Tale of Two Layers' 881
1053. Fritz Machlup, An Economic Review of the Patent System, Study No.15 of Committee on Judiciary, Subcommittee on Patents, Trademarks, and Copyrights, 85th Cong., 2d Sess. (Comm. Print 1958).

property; but neither can one argue that it is indispensable nor that the benefits outweigh the costs.[1054]

By focussing on one very special category of propertised information- what this thesis calls 'technological infrastructure'- the chapters in this volume have attempted to illuminate the complexities and trade-offs associated with the exclusions and access rights in today's version of Machlup's information society. This thesis has attempted to cash out the idea of technological infrastructure in two main ways, which run like two nerves through the chapters of this volume. First, that despite the neologism, the concept of technological infrastructure is a deep and old component of legal systems, finding expression in the boundary between protectable and non-protectable information resources, and in the interaction between competition law and intellectual property in a number of major EU and US cases. As the complexity of technologies increases, so do their interdependencies and requirements for common standards, whether these emerge from the market (de facto), are cooperatively-set, or involve pioneering inventions. The drive for continued innovation and the reliance on exclusive rights means that the clash between exclusivity and access, and the concomitant trade-off between private and social interests is sharpening, leading to increased pressure on legal systems to adjudicate disputes and set rules within which private interests can better track social ones. The second nerve that runs through the chapters in this thesis is that the innovation system is a system with many moving parts. All five chapters in this volume focus on the interaction of intellectual property rights with a second institution, which either operates to soften its hard edges or reorganises the strategic landscape of private interactions. In order to capture the richness of some of these private interactions, many of the chapters in this volume either use game-theoretical tools explicitly (chapters 1 and 3) or implicitly (chapter 4). Chapters 2 and 5, which do not structure arguments around private interactive models, nevertheless take the concept of incentives seriously, and deploy economic arguments that companies self-organise in the shadow of legal rules.

The upshot of all the above chapters is that when technological infrastructure is open the structure of innovation radically changes form: from one where essential information inputs are controlled under property rules via a top-down approach, to one where they are liberated under liability rules to operate via a bottom-up approach. The decentralisation of control and decision-making represented by the second approach dove-tails into Tim Wu's argument for polyarchal innovation structures[1055], where control over key resources is dispersed rather than concentrated, leading to multiple nodes of innovative activity (as discussed in chapter 5). Perhaps paradoxically, the key orientation of this approach is not pro-Government intervention at all, rather it is *pro*-market: it challenges economic theory which argues that

1054. ibid
1055. Wu, 'Intellectual Property'.

owners of technological infrastructure who exist in many ways outside of the disciplining effect of markets can make efficient decisions with regard to their resources. If the success of open source software and the study of socio-cultural production systems in general, have taught us anything, it is that we do not stand on the shoulders of giants but on the shoulders of countless individual agents who each make a contribution (no matter how minor) to the sum total of available knowledge.[1056]

According to the work of Sam Bowles on the historical emergence of property rights, the transformation of modern society's productive tools from *things* to *information assets*, brings with it a host of trade-offs which erodes the economic arguments for property rights. The logic Bowles applies is derived from his study of the *reverse* transition: from forager economies to agrarian economies, where property rights first developed. The nub of Bowles' argument is that enforcement costs, and the social costs of that enforcement, over assets of a 'weightless' information-based economy will likely outweigh the benefits.

Again, this is an empirical not a theoretical claim. But it may have some support. Between 2007 and the present, we have witnessed a number of startling pushes towards open access in the high technology sector, which have led to an interesting reconsideration of the merits of exclusive rights over information assets. In no particular order, we have witnessed both Court decisions and private ordering decisions which have led to: open access licensing over operating system interoperability information[1057]; the application of liability rules over cooperatively-set standards and patents in general[1058]; a flurry of cross-license agreements over smartphone-related standards-essential patents[1059]; patent non-aggression pacts and pledges by dominant software companies such as Twitter and Google; Tesla's opening up of its essential electric car patent portfolio. The list, does in fact, go on. But the point should be clear: exclusive rights over information in high technology has less cache than it used to.

Although it might be tempting to argue that the commons-production arguments have been right all along: that innovation is not a zero-sum game, and that the commons is a 'comedy'[1060] rather than a tragedy, the facts are more complicated. The key question: who pays, and in what currency? must still be asked, and the answer is surprising.

Future work in this area will have to take stock of the new form of information production incentivisation which is taking over the traditional product-for-a-fee model: product-for-

1056. Sterelny, *The Evolved Apprentice.*
1057. See chapter 2
1058. See chapter 3
1059. e.g the HTC-Apple 10 year cross license, see http://www.imore.com/applehtc-cross-licensing-deal-details-revealed-scads-redactions> accessed October 2016
1060. Carol Rose, 'The Comedy of the Commons: Commerce, Custom, and Inherently Public Property' (1986) 53(3) U Chicago L Rev 711.

data. Innovation in consumer-facing high technology products is currently being driven by data, based on the informal information-science principle that *more data* beats *better algorithms* every time.[1061] Of course, data drives advertising revenues as everyone knows, and the more technology companies know about their customers, the greater is their value on the multi-sided markets of advertising, app development, and consumers. However, more data also drives product innovation: search engines better calibrate their suggestions, maps sharpen their proposed trajectories, and dating apps accelerate lonely-hearts in the quest for their other half. Interestingly, most of the software that qualify as beneficiaries of more data also qualify as quasi technological infrastructure, since their successes in the market drive their status as *de facto* standards for the services they offer. Unfortunately, the analysis of this new form of currency is outside the scope of this thesis. However, future work could well focus on the extent to which this new model of 'payment' is supplanting and eroding the old models of direct value appropriation, while also raising a host of new issues, traversing the domains of innovation, economic relationships, and personal privacy.These new models may also place increasing pressure on the openness of standards: as data becomes more valuable, the standards which encode them may face increasing pressure to become proprietary and under the private control of data processors. For these new problems, as for the problems addressed in this thesis, solutions to these new legal and economic challenges will likely only be forthcoming, once lawyers, economists and policymakers begin by taking technological infrastructure seriously as infrastructure, and take stock of the fact that the real hubs of productive activity in the modern economy are privately owned resources with a growing public character.[1062]

1061. Pedo Domingos, 'A Few Useful Things to Know about Machine Learning' (2012) <http://homes.cs.washington.edu/~pedrod/papers/cacm12.pdf> accessed on 3 October 2016, 6 ('more data beats a cleverer algorithm').
1062. See generally Contreras 'Market Reliance' (where he discusses the public character of the various commitments made to ensure public licenses, such as patent pledges. The public character of these pledges is a necessary way of managing the essentially public character of the underlying assets that they regulate).

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SUMMARY

This dissertation investigates the problem of access to essential intellectual property ('IP') rights in high technology, or what this thesis calls 'technological infrastructure'.

It begins by defining and defending the unique status of such infrastructure and the costs involved in its exclusive ownership, such as choking off follow-on innovation and excess private control over R&D trajectories. It then develops the argument that these outcomes can be avoided or improved upon by recruiting other innovation institutions to operate together with the IP regime, either by softening its hard edges or by channelling behavioural incentives in such a way that they converge on what this thesis argues to be the optimal rule of 'open access'. These other institutions include competition law, government R&D subsidy programs, demand-side public instruments, and business model innovation. It is the interaction between the IP system and these additional institutions, which forms the nerve of the analysis for this dissertation's investigation into access rights to technological infrastructure.

Each of the chapters in this volume analyses the interplay between the IP regime and at least one other institution. The methodology involves first clarifying the economic conditions that underwrites the interaction between the different institutions, then trying to map the drive for open access to existing or new legal rules or mechanisms, using tools from game theory and the economic analysis of the law. The second part of the methodology assesses how these legal rules or mechanisms may be implemented under the particular institutional conditions, while striking a balance between incentives to create the infrastructure and its downstream accessibility. To this end, an underlying – sometimes implicit, sometimes explicit – framework for the chapters in this volume is Neil Komesar's comparative institutional analysis, which recognises 'institutional failure' as a key component of legal analysis. Sometimes markets fail to deliver desirable outcomes. Sometimes Governments fail. Sometimes intellectual property and competition law fail too. The important issue is to identify what the objective baseline is that enables us to assess success and failure and to unpack why and under what conditions institutions fail. For the purpose of this dissertation, the normative baseline is the optimal management of technological infrastructure under an open access rule, and the various chapters then focus on how additional innovation institutions (outside of IP) can be effectively recruited to sustain this outcome.

Chapter 1, entitled 'Taking Technological Infrastructure Seriously', focuses on how the institution of competition law can modify the strategic landscape and distribution of incentives to help private companies converge on open access licensing with respect to both *de facto* and *de jure* standards. This chapter introduces an 'infrastructural approach' to the problems of *de facto* and cooperative standard-setting in high technology. It reviews recent case law in the area, and attempts to provide robust economic arguments for the maintenance of 'open access' rules over such standards. First, it begins by qualifying such resources as 'technological infrastructure' according to the work of Brett Frischmann and Peter Lee. Subsequently, game theoretical tools are applied to the problem of cooperative standard-setting to demonstrate how the 'quasi-open access' FRAND commitment can constrain strategic behaviour. A legal analysis—including an examination of recent case law about the availability of injunctions—then follows to demonstrate the optimal 'negotiation framework' for the latter commitment to become credible. Finally, the infrastructural approach is expanded to demonstrate how it can elucidate a number of current controversies in high technology markets, where the tension between private ownership and public use of technological infrastructure is at its sharpest.

Chapter 2, 'Technological Infrastructure and the EU Essential Facilities Doctrine', develops in greater detail the application of the EU competition law rule of the essential facilities doctrine to *de facto* standards. As the most controversial aspect of the 'infrastructural approach' developed in chapter 1, this chapter focuses on fleshing out the legal and economic analysis with respect to technological infrastructure emerging from the market without the voluntary cooperation between companies or the granting of a FRAND commitment. The analysis digs into the details of the EU 2007 *Microsoft* case as the only EU case to date dealing explicitly with applying ex post open access rules over a privately-owned de facto technological infrastructure. The chapter also briefly considers the current EU Commission investigation into Google's open source Android Operating System, and the interesting wrinkles this adds to the analysis.

Chapter 3, 'Visible and Invisible Hands', zooms out from the competition law approach developed in the previous chapters and considers the interaction of the IP system with the institution of public (EU) R&D subsidy grants. This chapter constitutes a companion chapter to 'Taking Technological Infrastructure Seriously'; while that chapter developed the point that certain privately-provisioned knowledge assets may qualify as infrastructural assets, this chapter identifies infrastructural information assets arising in the intersection between public R&D programs and private IP rights. The nub of the argument is that information assets arising like this are unique in ways that have not been given sufficient attention in the literature: they are of sufficient social value to attract a subsidy and yet give rise to protectable inventions or creative works. Somehow each of these institutions must have failed to produce the asset, perhaps for reasons of risk or limited private appropriability. This chapter argues that the class of asset that most closely maps to these attributes is likely to be 'infrastructural'. Due to their status as infrastructure, it is argued that these R&D assets would be most effectively managed under an open access regime, and that European subsidy programs can have a have central role in ensuring this outcome by the tweaking of subsidy grant criteria.

Chapter 4, 'Open Standards and Their Enemies', continues in the vein of the previous chapters by considering the ways legal rules may induce technological infrastructure owners to operate under an open access rule. However, this chapter considers the *demand-side* institution of Government public procurement policies. It argues that public procurement policies that demand zero-fee or royalty-free patent licensing over standards may backfire by insufficiently considering the strategic landscape of the standard-setting process. The chapter suggests that the rise of the pure-play IP licensing company in the information technology market place may be incompatible with a royalty-free standards policy, as it drastically lowers their incentives to engage in formal standard-setting and the attendant licensing obligations. By limiting such companies' ability to derive revenue from participating in SSOs, open standards policies may (with the best intentions) result in standards being less open, as pure-play IP companies assert their patents after the adoption of the standard- thus shutting down access and jeopardising the standard ex post.

Chapter 5, entitled 'Intel, ARM and Private Ordering Approaches to Technological Infrastructure' considers the institutions of IP management and business model innovation as ways of managing technological infrastructure. It reviews how and why private companies often have incentives to engage in open access licensing even without the threat of competition law enforcement. Its focus is the fascinating market of CPUs that power the swathe of 'embedded devices' from smartphones to the nascent Internet of Things ('IoT'), and in particular, the approach to intellectual property licensing of the two main contenders there, ARM and Intel. These two companies are both deploying significant resources to become the *de facto* CPU standard and technological infrastructure for both the smartphone market and IoT devices. The companies have very different approaches to managing their IP, which this chapter argues may be a determinative feature in their battle to develop the emerging technological infrastructure. While ARM licenses its IP freely to downstream chip makers, Intel is extremely restrictive of who it licenses its IP to and generally attempts to be the only downstream supplier of its CPU architectures. These differences in IP licensing strategies are also replicated in the software space, where the openness or closedness of selected operating systems may serve to reinforce or undercut the drive towards de facto standardisation of the CPU. This chapter analyses the salient differences in these two broad strategies to IP licensing, and attempts to distil some predictions about how these different approaches will drive the process of technological infrastructure standardisation- in both hardware and software- for the emerging post-PC marketplace. The conclusions shed light on the use of business model innovation as a method for both managing and leveraging the success of technological infrastructure

The five chapters illustrate the many complexities and nuances in the debate over private rights over information technology infrastructure in its various guises, taking into account market conditions, legal rules, and private ordering. All these many guises serve to demonstrate that there is no silver bullet, that there are no one-size-fits-all solutions to openness in information technology markets, but that taking technological infrastructure seriously is a good place to start.

SAMENVATTING

TECHNOLOGISCHE INFRASTRUCTUUR SERIEUS NEMEN

Deze dissertatie onderzoekt het probleem van het recht van toegang tot vitale intellectuele eigendomsrechten (IE) binnen de *high tech* sector, hetgeen in deze dissertatie 'technologische infrastructuur' wordt genoemd. Eerst wordt de unieke status van die infrastructuur vastgesteld, alsmede de kosten die gemoeid zijn met haar exclusieve eigendom. Deze kosten omvatten onder andere de verstikking van verdere innovatie en overmatige particuliere controle op Onderzoeks- en Ontwikkelingstrajecten. Vervolgens wordt het argument uitgewerkt, dat deze uitkomsten voorkomen of verbeterd kunnen worden door innovatie-instellingen samen te laten werken met het intellectuele eigendomsregime. Dit wordt mogelijk door de harde kanten te verzachten en een gedragsstimulans op dusdanige manier te reguleren dat het juridisch regime en de gedragsstimulans samenkomen op het punt van de volgens deze dissertatie optimale regeling van *open access*. Enkele van de bovengenoemde innovatie-instituten, betreffen het mededingingsrecht, overheidsonderzoeksprogramma's, aanbestedingsinstrumenten en het innoveren van businessmodellen. Het is de interactie tussen het systeem van intellectuele eigendomsrechten en deze andere instituten die de zenuw van de analyse in deze dissertatie vormen met betrekking tot toegangsrechten in hoogtechnologische infrastructuren.

Elk hoofdstuk in dit deel analyseert het samenspel tussen het juridisch regime en ten minste één ander instituut. De methodiek omvat eerst de verduidelijking van wat de economische voorwaarden zijn, die de interactie tussen verschillende instituten waarborgen, waarna de onderliggende drijfveer voor *open access* binnen bestaande of nieuwe regels of mechanismen bloot worden gelegd. Deze analyse vindt plaats aan de hand van speltheorie en de economische analyse van de wet. Het tweede deel van de methodiek gaat na hoe deze regels of mechanismen geïmplementeerd kunnen worden onder de desbetreffende institutionele voorwaarden. Hierbij wordt naar een balans gezocht tussen prikkels om de infrastructuur te creëren en de beschikbaarheid daarvan breed te houden. Hiervoor wordt Neil Komesar's vergelijkende institutionele analyse - soms impliciet en soms expliciet - als basis gebruikt. Binnen deze theorie wordt het 'institutioneel falen' als een kernelement beschouwd voor de juridische analyse. Soms lukt het de markt niet om tot gewenste resultaten te komen. Soms faalt de overheid. De wetgeving omtrent intellectuele eigendomsrechten en mededingingsrecht kan eveneens falen. Het belangrijkste is, dat vastgesteld wordt wat de objectieve basis is die ons in staat stelt het succes en falen vast te stellen en na te gaan waarom en onder welke omstandigheden instituties falen. In deze dissertatie wordt de normatieve basis gedefinieerd als het optimale management van technologische infrastructuur op basis van open toegang. De verschillende hoofdstukken behandelen vervolgens hoe andere instituten (buiten IE) effectief ingeschakeld kunnen worden om die uitkomst te bestendigen.

Hoofdstuk 1, getiteld 'Technologische Infrastructuur Serieus Nemen', gaat na hoe het instituut mededingingsrecht het strategische landschap kan wijzigen en hoe de verdeling van prikkels particuliere ondernemingen kan helpen om de beslissing te maken over te stappen op *open access* licenties met eerbiediging van *de facto* en *de jure* standaarden. Dit hoofdstuk toont een 'infrastructurele benadering' van de feitelijke problemen en coöperatieve standaardisering binnen de *high tech* sector. Het onderzoekt recente jurisprudentie op dat gebied en probeert goede economische argumenten te leveren om open toegangsregels toe te passen op dergelijke standaarden. Allereerst worden deze bronnen als 'technologische infrastructuur' gekwalificeerd volgens het werk van Brett Frischmann en Peter Lee. Vervolgens worden speltheoretische instrumenten toegepast op het probleem van coöperatieve standaardisering om aan te tonen dat het vasthouden aan de 'quasi' *open access* van een FRAND-verplichting strategisch gedrag kan remmen. Dan volgt een juridische analyse - inclusief een onderzoek van recente jurisprudentie over de beschikbaarheid van bevelschriften - om daarmee te bewijzen, dat het optimale onderhandelkader voor de bovengenoemde verplichting haalbaar is. Tot slot wordt de infrastructurele aanpak gebruikt om aan te tonen hoe het een aantal actuele controverses binnen hoogtechnologische markten kan verhelderen, waarbij de spanning tussen privé-eigendom en publiek gebruik van technologische infrastructuur op haar scherpst is.

Hoofdstuk 2, getiteld 'Technologische Infrastructuur en de Essentiële Faciliteiten-Doctrine', gaat op een dieper niveau na hoe de EU mededingingsregels met betrekking tot de essentiële faciliteiten-doctrine kan worden toegepast op *de facto* standaarden. Het meest controversiële aspect van de 'infrastructurele benadering' die zich heeft ontwikkeld in hoofdstuk 1, vereist een diepgaande juridische en economische analyse met betrekking tot technologische infrastructuren, zonder de vrijwillige samenwerking tussen bedrijven en zonder het toestaan van een FRAND-overeenkomst. De analyse concentreert zich op de *Microsoft*-casus uit 2007, nu het de enige EU casus is waarbij expliciet open toegangsregels over een technologische infrastructuur in particulier eigendom *ex post* worden toegepast. Het hoofdstuk behandelt tevens kort het huidige onderzoek van de EU naar Google's open source-besturingssysteem 'Android' en de interessante complexiteiten die dit aan de analyse toevoegt.

Hoofdstuk 3, 'Zichtbare en Onzichtbare Handen', gaat weg van de mededingingsrecht-aanpak uit de vorige hoofdstukken en onderzoekt de interactie tussen het intellectuele eigendomsrechtsysteem met het instituut van (EU) subsidies voor Onderzoek en Ontwikkeling. Dit hoofdstuk is een begeleidend hoofdstuk bij 'Technologische Infrastructuur Serieus Nemen'. Waar dat hoofdstuk het argument uitwerkte, dat bepaalde privé-beheerde intellectuele eigendomsrechten gekwalificeerd mogen worden als infrastructureel bezit, behandelt dit hoofdstuk infrastructureel informatiebezit dat is voortgekomen uit de interactie tussen gesubsidieerde Onderzoeks- en Ontwikkelingsinitiatieven en particuliere intellectuele eigendomsrechten. De kern van het argument is dat informatiebezit, dat op deze manier ontstaat, uniek is op manieren die nog niet voldoende zijn belicht in de literatuur.

Zij zijn namelijk van voldoende sociale waarde om een subsidie te verkrijgen, terwijl er toch uitvindingen of creatieve werken ontstaan waarop intellectuele eigendomsrechten worden gevestigd. Op een of andere manier zijn alle betrokken instituten er dus niet in geslaagd dat bezit zelf te creëren, wellicht vanwege risico's of beperkte terugverdienmogelijkheden. Dit hoofdstuk stelt, dat de categorie van bezit, waarop deze kenmerken toegepast kunnen worden, waarschijnlijk 'infrastructureel' van aard is. Vanwege haar infrastructurele status wordt gesteld, dat dit Onderzoeks- en Ontwikkelingsbezit het meest efficiënt beheerd zou kunnen worden onder een *open access* regeling. Daarnaast zouden Europese subsidieprogramma's een centrale rol kunnen spelen bij het bereiken van deze uitkomst, door het aanpassen van subsidieverleningsvoorwaarden.

Hoofdstuk 4, getiteld 'Open Standaarden en Hun Vijanden', heeft een vergelijkbare structuur als de vorige hoofdstukken en gaat na op welke wijze het wettelijk kader de bezitters van technologische infrastructuren kan overhalen om te gaan werken volgens *open access* regelgeving. Het hoofdstuk behandelt echter de *vraagzijde* van het aanbestedingsbeleid van de overheid. Het beargumenteerd dat een aanbestedingsbeleid zonder vergoedingsvereisten voor licenties met betrekking tot open standaarden niet tot het gewenste resultaat kan leiden, omdat deze niet voldoende rekening houdt met het strategisch landschap waarin standaarden worden ontwikkeld. Het hoofdstuk voert aan, dat de opkomst van alleen op licentieverlening gerichte bedrijven binnen de informatietechnologiemarkt, een royalty-vrij standaardisering beleid kan doen mislukken. De reden is dat het de prikkel drastisch verlaagt om aan officiële standaardbepalingen en de bijbehorende licentieverplichtingen deel te nemen. Door die bedrijven de mogelijkheid te ontnemen om inkomen te genereren uit hun deelname aan standaardiseringsorganisaties, kan het open standaard-beleid ertoe leiden dat standaarden *minder* open worden, aangezien IE gerichte bedrijven pas een beroep doenop hun octrooien nadat het standaard aanvaard is. Daarmee sluiten zij de toegang tot hun octrooien af en brengen daarmee de standaard in gevaar.

Hoofdstuk 5, getiteld 'Intel, ARM en Particuliere Regulering in de Technologische Infrastructuur' gaat over de twee instituten van IE-management en businessmodel-innovatie. Dit zijn instituten waarmee technologische infrastructuur beheerd zou kunnen worden. In het hoofdstuk wordt ingegaan op welke manier en om welke reden bedrijven deelnemen aan *open access* licenties, zelfs zonder bedreiging van handhavers uit het mededingingsrecht. Daarbij wordt met name de fascinerende markt van de CPU's bekeken, die in de meerderheid van 'embedded devices' zitten, van smartphones tot het opbloeiende *Internet of Things* ('IoT'). Onderzocht wordt hoe de twee hoofdspelers op de markt, ARM en Intel, omgaan met intellectuele eigendomsrechtlicenties. Deze twee bedrijven investeren aanzienlijk om de *de facto* CPU-standaard en de technologische infrastructuur te worden voor zowel de smartphonemarkt als IoT-apparaten. De bedrijven benaderen het IE-beheer op verschillende manieren, hetgeen volgens dit hoofdstuk bepalend kan zijn in hun gevecht om de opkomende technologische infrastructuur te ontwikkelen. Waar ARM haar IE onbeperkt beschikbaar stelt aan chipfabrikanten, is Intel zeer beperkend in wie haar IE-licenties krijgt en probeertde enige downstream-leverancier van haar CPU-architectuur te zijn. Deze verschillen in hun IE-licentiestrategie zijn ook terug te vinden op het gebied van software, waar de openheid of geslotenheid van bepaalde besturingssystemen de pogingen tot het verkrijgen van een feitelijke standaard kan versterken of laten mislukken. Dit hoofdstuk analyseert de opvallende verschillen in beide algemene strategieën voor IE-licenties. Enkele voorspellingen worden gedaan over de wijze waarop die verschillende benaderingswijzen het proces van standaardisering van technologische infrastructuur, zowel in hard- als in software, zullen bepalen voor de opkomende markt die na het PC-tijdperk is ontstaan. De conclusies zetten het gebruik van businessmodel-innovatie uiteen als methode waarmee het succes van technologische infrastructuur zowel beheerd als beïnvloed kan worden.

De vijf hoofdstukken illustreren de vele complexiteiten en nuances binnen het debat over particuliere rechten en informatietechnologische infrastructuur in haar verscheidene vormen, waarbij marktvoorwaarden, regelgeving en beleid van bedrijven worden meegenomen. Al deze verschillende hoedanigheden laten zien, dat er geen wondermiddel is en dat er geen panklare oplossingen zijn voor openheid in de informatietechnologiemarkt, maar dat het serieus nemen van technologische infrastructuur een goed beginpunt is.

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