Taking technological infrastructure seriously

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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.

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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

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.

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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.