Measuring sustainability: an elaboration and application of the system of environmental-economic accounting for Indonesia

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Chapter 4

Environmental Cost in Indonesia Spillover Effect between Consumption and Production

Abstract

Reducing environmental costs is a significant concern for Indonesia's future. This paper explores Indonesia's environmental costs from emissions and forest resources and identifies the priority sectors in terms of economic and environmental performance. We use environmentally extended input-output analysis for calculating the environmental costs and further extension with linkages analysis to identify the priority sectors. The study finds that the total environmental costs of emissions due to final demand is around 7 % of GDP. This environmental cost is significantly due to domestic products, with household consumption being the largest contributor. The top ten sectors in the Indonesian economy are responsible for about 70% of the total environmental costs of emissions. Based on pollutants source, SOx, NOx, CO_2, and CH4 contribute more than half of emissions' environmental costs. We also find that forest resources' environmental cost is only 7.5% of the total environmental cost. Lastly, this study finds that key sectors of economic and sustainability points of view are textile manufacturing; publishing, printing, and reproduction of recorded media; chemicals n.e.c; manufacture of other non-metallic mineral products; Construction; other land transport. Finally, this paper discusses the policy options for Indonesia to promote sustainable consumption and production in terms of reducing environmental costs while managing economic development.

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4.1 Introduction

Environmental issues, for the first time, began to garner global attention at the Stockholm United Nations Conference on the Environment in Sweden in 1972. The conference, known as the Stockholm Conference, is the first international conference to discuss the environment as a major issue in response to various cases of environmental damage that are increasingly widespread and threatening the life of the world. Furthermore, in 1987, the World Commission on Environment and Development submitted its report titled "Our Common Future," also known as the Brundtland report, which became a milestone for the concept of sustainable development (Borowy, 2014).

Since the publication, the concept of sustainable development has become a popular discourse. Attention at the world level toward sustainable development continues to increase, most recently with the UN Sustainable Development Summit in September 2015 in New York in the United States. At that conference, all the countries jointly adopted the new development agenda "Transforming Our World: the 2030 Agenda for Sustainable Development," better known as sustainable development goals (SDGs), which include 17 goals with a total of 241 achievement indicators. Of the 17 goals, one of the SDGs is the 12th goal, namely, responsible consumption and production. Goal 12 implies that all parties should endeavor, for example, not to use hazardous materials in consumption and production activities. Goal 12 can provide an example of how the interests of all countries are represented in the SDGs. The existence of international regulations and bilateral agreements that prohibit using specific materials in export and import activities is one concrete example. Therefore, many development goals in the SDGs should be interpreted as a shared global vision that represents the interests of all parties, including Indonesia (Alisjahbana et al., 2018).

Wackernagel and Beyers (2019) group Indonesia into countries experiencing bio-deficit conditions, i.e., having an ecological footprint1 exceeding its bio-capacity. As shown in Figure 4.1, Indonesia's bio-capacity decreases over time, and the ecological footprint tends to increase. Based on data for 2016 from the Global Footprint Network, the percentage of ecological footprint exceeding bio-capacity deficit reaches 32% or around 0.4 gha per capita. Today, Indonesia is one of the top 10 countries with the highest ecological footprint in the world along with China, India, the United States, Russia, Brazil, Japan, Germany, Mexico, and the United Kingdom (Pata et al., 2021).

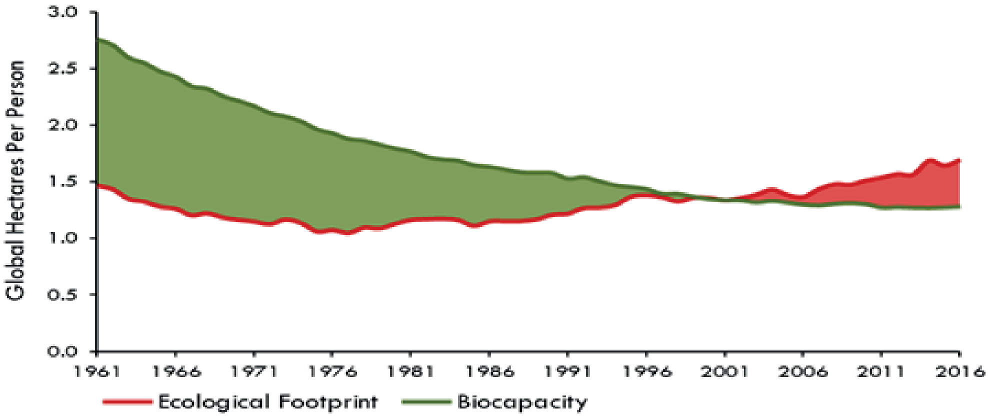

Figure 4.1. Ecological footprint and Bio Capacity Trend in Indonesia
Source: Global Footprint Network, 2019, https://www.footprintnetwork.org/licenses/public-data-package-free/

Numerous studies analyze factors affecting environmental deterioration due to increasing human activities. Danish et al. (2020) indicate that trends in economic progress accelerate the consumption and extraction of natural resources while increasing the ecological footprint. Hassan et al. (2018) underline that economic growth increases the need for natural resource use, which leads to environmental degradation in Pakistan. Other studies (e.g., Galli et al., 2012; Bello et al., 2018; Zall'e, 2018; Hanif et al., 2019; Pata, 2020) indicate similar results that environmental degradation might increase due to economic expansion. However, if sustainable development management practices are applied, the rate of resource depletion decreases, and resources are allowed to regenerate (Pata et al., 2021).

One option to reduce pressure related to environmental degradation and resource use is adjusting consumption patterns and shifting production toward more environmentally friendly sectors and technologies. According to Wiedmann et al. (2007), Watson et al. (2013), Peters et al. (2016), Tukker and Vivanco (2018), and Wiedmann and Lenzen (2018), environmental impacts from the economic system can be viewed from two complementary perspectives: production and consumption. The production perspective considers the direct environmental pressures caused by economic activities in a country. The consumption perspective focuses on the indirect environmental pressures driven along value chains by a country's final demand.

In the past decades, various studies discuss the environmental impact of both perspectives of production and consumption; see for instance Haas et al. (2005), Tukker et al. (2006), Tukker and Jansen (2006), Weisz and Schandl (2008), United Nations Environment Programme (2010, 2015), Jungbluth et al. (2011), Kitzes et al. (2007), Akenji and Bengtsson (2014), Ivanova et al. (2016), and Castellani et al. (2019).

This study aims to provide a comprehensive analysis of Indonesia's environmental costs. This study also tries to identify key sectors where economic and environmental performance are considered. Specifically, this study aims to answer the following questions: (i) How much are the environmental costs for each final demand component? (ii) How much is the ratio of environmental costs to value added by the economic sector? (iii) Which sectors and emissions are most responsible for pressures driven by final demand? (iv) How much is the value of environmental costs embodied in import due to final demand? (v) What are the economic sectors that perform best when both economic performance and environmental costs are considered simultaneously?

In answering these questions, we use the input–output (IO) analysis approach. This approach can link, in a comprehensive way, how consumption via value chains drives production and, in
turn, emissions, resource use, and related external environmental costs or so-called "external cost" (Miller and Blair, 2009; United Nations Environment Programme, 2010, 2015; Jungbluth et al., 2011; Akenji and Bengtsson, 2014).

This study is structured as follows—section 2 reviews (environmentally extended) IO studies for Indonesia and related environmental cost accounts. Section 3 describes in more detail the methodology used in this study to answer the research questions. Section 4 provides the results. Section 5 ends with the conclusion and policy considerations.

4.2 Input output tables and environmental cost accounting for Indonesia

Indonesia's Central Bureau of Statistics has published IO tables for various years between 1971 and 2010 (see Appendix Table 4.8). In this study, we use the latest published IO table, the Indonesian IO table 2010. We realize that this IO database seems to be outdated; we decided to use this database with the following considerations:

(i) In analyzing the economic and environmental impacts from the production and consumption perspectives in detail, theory and empirical studies suggest using life cycle analysis or IO models.

(ii) The IO can be expanded to EE IO. IO tables, to our knowledge, contain comprehensive and detailed data not found in other databases, such as economic structure, sectoral added value, distribution of goods and services, and sectoral export-import structure.

(iii) During the 2010–2020 period, the sectoral contribution to the economy in Indonesia remained unchanged, and it is still dominated by three sectors: manufacturing; agriculture, fishery, and forestry; and wholesale and retail trade, car and motorcycle repair.

Based on these considerations, we conclude that, even though the data is outdated, they are still relevant to current conditions in Indonesia and have practical significance for today's policymaking.

There are no publications from official sources in Indonesia that present detailed information on resource extraction, emissions, and related external cost data by economic sector. To our knowledge, Pirmana et al. (2021) provide the first detailed description of environmental costs for each economic sector. Information on extraction of non-renewable resources and forestry products, including their external cost, can be obtained from Indonesian sources. Emissions by sector are, however, not available from Indonesian sources. Pirmana et al. (2021), therefore, utilize emission estimates for each sector in Indonesia provided in the Global Multi-regional Environmentally Extended Input-Output (GMRIO) database EXIOBASE (Stadler et al., 2018). By creating a common classification of 86 sectors between the 163 sectors of EXIOBASE and the 185 sectors of the Indonesian IO table (IIOT) and some other conversions, emissions for 86 sectors in Indonesia can be estimated. Pirmana et al. (2021) also estimate the external costs of these emissions based on the concept of damage costs related to human health and the environment.

This approach resulted in an EE IOT for Indonesia including extensions (E) and external costs (P) by sector (Figure 4.2), which was placed on the n + 1 line of the aggregated 86-sector version of the IIOT as an extension (outside the system of the goods/services flow matrix, where n is the number of sectors).

Sector of production	Sector of (intermediate) consumption				Final Demand	Total Output
	1	2	…	N		
1	x_{11}		…	x_{1n}	f_{11}	X_1
2	x_{21}		…	x_{2n}	f_{21}	X_2
.	.		.	.	.	.
.	.		.	.	.	.
	x_{ni}			…	f_{ni}	X_n
Value-Added	v_1	v_2	…	v_n		
Import	m_1	m_2	…	m_n		
Total Input	X_1	X_2	…	X_n		
Environmental extensions: - **natural resource use** - **emissions**	E_1	E_2	…	E_n		
External costs	P_1	P_2	…	P_n		

Figure 4.2. Structure of the Indonesian Environmentally Extended Input-Output Table

4.3 Methodology

4.3.1 Leontief approach to calculate consumption based external costs

As indicated in the previous section, EEIO is used to calculate the environmental costs driven by various components of final demand in Indonesia. The components are household consumption, consumption of non-profit institutions, government consumption, gross fixed capital formation, and exports (see Appendix Table 4.9 for detail).

We decided to limit ourselves to the external costs from emissions and the forestry sector and not to include non-renewable resource extraction.

The basic IO relationship developed by Leontief gives the relationship between the total output x and final demand y (Miller and Blair, 2009; Brolinson et al., 2010) by the following formula:

$$x = (I - A)^{-1} y \qquad (4.1)$$

Where $(I - A)^{-1}$ is the inverse matrix or so-called Leontief matrix. By applying an environmental coefficient matrix F (environmental cost per unit of economic output) on equation (4.1), the total environmental cost can be calculated. This is show in equation (4.2), as follow:

$$E = F(I - A)^{-1}y \quad (4.2)$$

To assess the environmental costs embodied in imported products, various approaches can be followed. In the ideal case, one would use a GMRIO, such as EXIOBASE, GTAP, or EORA (Tukker and Dietzenbacher, 2013; Wood et al., 2019) to estimate the emissions and resource use embodied in Indonesian imports. However, none of the available GMRIOs include external cost estimates for these emissions and resource uses. Trying to develop such external costs for the many countries included in such GMRIOs falls outside the scope of this study. Therefore, we fall back on a simplifying assumption called the domestic technology assumption despite the fact that this can lead to less accurate results (e.g., Tukker et al., 2013). We estimate data on the import IO coefficient matrix (direct import requirements) from total IO transaction data minus domestic transaction IO data. Because, as we show later, the externalities in imports are relatively small compared with the externalities in domestic production, our approach still is a reasonable proxy of reality. Based on this approach, we can modify the input coefficient matrix A in Equations (4.1) and (4.2) by creating a direct import requirement matrix:

$$A^d + A^m = A^{tot} \quad (4.3)$$

Where A^d is the direct domestic requirement (domestic input-output coefficient matrix), A^m is the direct import requirement (import input-output coefficient matrix), and A^{tot} is direct total requirement (total input-output coefficient matrix). Likewise, to obtain the total final demand, we can add final demand for domestic products and imported product:

$$y^d + y^m = y^{tot} \quad (4.4)$$

To calculate environmental costs associated with final demand, equation (4.2) then can be rewritten:

$$E = f(I - A^{tot})^{-1}y^{tot} \quad (4.5)$$

To assess the embodied environmental cost from imported products, the above equation can be rewritten in such a way that domestic technology assumption is made explicit by replacing A^{tot} and y^{tot} by their domestic and import shares:

$$E = F(I - (A^d + A^m)^{-1}y^d + F(I - (A^d + A^m)^{-1}y^m \quad (4.6)$$

4.3.2 Prioritizing sectors based on economic and environmental performance

It is essential to identify priority sectors when the economic and environmental performance takes into account. This identification of priority sectors approached with a linkage analysis between sectors or what is commonly known as backward and forward linkages (Sonis et al., 2000; Dietzenbacher, 2002; Shmelev, 2010; Nguyen, 2018; Peng et al., 2020).

This study identifies the key sectors from an economic view by calculating an index of backward and forward linkages of economic sectors' value added. The formula to estimate these backward and forward linkages is as follows:

$$BL_j = \sum_{i=1}^{n} \alpha_{ij}^{d} \tag{4.7}$$

$$FL_j = \sum_{i=1}^{n} \beta_{ij}^{d} \tag{4.8}$$

Where $\sum_{i=1}^{n} \alpha_{ij}^{d}$ and $\sum_{i=1}^{n} \beta_{ij}^{d}$ are the i-th row and j-th column elements of the matrix $(I\text{-}A^d)^{-1}$ and $(I\text{-}B^d)^{-1}$, respectively. We can standardize the BL_j and FL_j to obtain the unified backward linkage (UBL) and forward linkage (UFL) into the following equations:

$$UBL_j = \frac{BL_j}{\frac{1}{n}\sum_{j=1}^{n} BL_j} \tag{4.9}$$

$$UFL_j = \frac{FL_j}{\frac{1}{n}\sum_{j=1}^{n} FL_j} \tag{4.10}$$

The key sectors in the economy are the sectors that have a backward and forward linkage index higher than one, which are sectors with high potential to drive value-added growth in the upstream and downstream sectors. From an economic view, policies aimed at influencing the amount of economic output are sufficiently focused on these key sectors so that the government can save the development costs. By adopting Equations (4.9) and (4.10), we can formulate an index of the backward and forward linkage of emissions and forest resources' environmental costs as follows (Peng et al., 2020):

$$BLE_j = \sum_{i=1}^{n} EI_i \alpha_{ij}^d \qquad (4.11)$$

$$FFE_j = \sum_{i=1}^{n} EI_i \beta_{ij}^d \qquad (4.12)$$

Where BLE is adjusted backward linkage of the environmental cost, FLE is the forward linkage of the environmental cost, and EI is environmental cost intensity. If this index is greater than 1, this implies that this sector has a greater influence than other sectors in increasing air pollution and related environmental costs in its upstream/downstream sectors. Based on the linkage indices for value-added and environmental costs, we can now identify four classes of sectors with different relevance for economic and sustainability policies as follows:

(i) Encouraged sectors: sectors with high linkages for value-added, and low linkages for external costs – sectors that should be stimulated by policy from a sustainability and economic point of view.
(ii) Slightly encouraged sectors: sectors with high value-added linkages, characterized mainly by low linkages in external costs.
(iii) Slightly constrained sectors: sectors with characterized mainly by low linkages for value-added, and high linkages in external costs.
(iv) Constrained sectors: sectors with low linkages for value-added and high linkages for external costs – sectors that are no priority for economic stimulation.

The detailed classification of the economic sectors in terms of potential for reducing environmental costs is summarized in appendix, table 4.9.

4.4 Results

4.4.1 Environmental costs driven by Indonesian final demand

This first result section analyses environmental cost induced by final demand in Indonesia. We discuss environmental costs of emissions (4.4.1.1), forestry resources (4.4.1.2), the total consumption based environmental costs and the ratio of environmental costs of value-added by consumption category (4.4.1.3).

4.4.1.1 Environmental cost from emissions driven by Indonesian final demand

Table 4.1 shows the total environmental costs of emissions resulting from Indonesia's final demand in 2010, which amounted to Rp. 449.41 trillion. Most of this environmental cost value comes from domestic production of final demand of Rp. 419.55 trillion (93.4%), while the environmental cost from import sources is only around Rp. 29.86 trillion (6.6%). According to the final demand component, both domestic and imported, household consumption is the largest contributor to the total environmental cost created in the economy, amounting to Rp. 196.26 trillion (43.67%), followed by environmental cost from the gross fixed capital formation of Rp 124.07 trillion (27.6%), and export of Rp. 101.81 (22.7%)

Table 4.1. Environmental cost from emission due to final demand in Indonesia (Trillion Rp)

Component	**Domestic**	**Import**	**Total**
Households Consumption	172.89 *(41.2)*	23.37 *(78.3)*	196.26 *(43.67)*
Consumption of Non-Profit Institutions	2.56 *(0.6)*	0.21 *(0.7)*	2.77 *(0.62)*
Government Consumption	13.81 *(3.3)*	0.08 *(0.3)*	13.89 *(3.09)*
Gross Fixed Capital Formation (GFCF)	119.09 *(28.4)*	4.98 *(16.7)*	124.07 *(27.61)*
Changes in Inventory	9.39 *(2.2)*	1.22 *(4.1)*	10.61 *(2.36)*
Export	101.81 *(24.3)*	- -	101.81 *(22.65)*
Total Final Demand	419.55 *(100)*	29.86 *(100)*	449.41 *(100)*

Source: Author's calculation
Notes: Number in parentheses shows the percent

Tables 4.2-4.3 show the product environmental costs from emission by final demand category. Driven by final demand, the top ten sectors are responsible for approximately 70.4% of the total environmental costs of emissions. Almost 50% of the total environmental cost of these emissions comes only from the top five sectors. Manufacture of basic iron and steel and of ferro-alloys and first products thereof is the sector with the highest environmental costs, amounting to Rp. 70.50 trillion (15.7%). Furthermore, in second place is the electricity sector with an environmental cost value of Rp. 53.95 trillion (12.%), followed by the sea and coastal water transport sector amounting to Rp. 31.62 trillion (7%); manufacture of rubber and plastic products of Rp. 30.98 trillion (6.9%); and the fifth position is coal mining, lignite, and extraction of peat amounting to Rp. 30 trillion (6.7%).

SO_x, NO_x and the greenhouse gases CO_2 and CH_4 contribute to over 50% of the external costs. Also, here we see that emissions within Indonesia are most important; only for CO_2 and the contribution of imports to external costs is slightly over 10% (see appendix table 4.12-4.14 for details). We see further that for most emissions there is no major difference in how the type of final demand drives contribution to external costs. For SO_x we see that Government consumption and exports has a somewhat higher than average external costs compared to total final demand, whereas for lead this is the case for Gross fixed capital formation (see appendix table 4.15).

Table 4.2. Top ten of total environmental cost from emissions by sector in Indonesia in 2010 (Trillion Rp)

No	Sector products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Man. of basic iron, steel, ferro-alloys, and first products thereof	6.22	0.10	0.78	47.92	11.93	3.55	70.50
2	Electricity	38.90	0.75	1.86	6.52	5.48	0.44	53.95
3	Sea and coastal water transport	20.63	0.14	0.30	2.61	7.69	0.25	31.62
4	Man. of rubber and plastic products	9.38	0.08	0.64	7.71	12.40	0.76	30.98
5	Mining of coal lignite; and extraction of peat	2.13	0.04	0.14	2.79	24.74	0.15	30.00
6	Cultivation of paddy rice	22.73	0.23	1.70	0.36	0.59	1.27	26.88
7	Fertilizer	12.14	0.20	0.61	2.41	5.19	0.45	21.00
8	Livestock and their results	14.98	0.09	0.32	2.48	0.52	1.07	19.46
9	Manu. of cement, lime and plaster	1.10	0.02	0.17	16.07	0.75	0.41	18.50
10	Paper & pulp	4.38	0.10	2.50	1.55	4.57	0.16	13.26
	Other sectors	63.69	1.03	4.85	33.63	27.95	2.10	133.25
	Total	196.26	2.77	13.89	124.07	101.81	10.61	449.41

Source: Author's calculation

Table 4.3. Top ten of total environmental cost from emissions by sector in Indonesia in 2010 (percent)

No	Sector Products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Man. of basic iron, steel, ferro-alloys, and first products thereof	3.17	3.50	5.64	38.63	11.72	33.48	15.69
2	Electricity	19.82	27.12	13.37	5.26	5.38	4.19	12.00
3	Sea and coastal water transport	10.51	4.93	2.17	2.10	7.55	2.40	7.04
4	Man. of rubber and plastic products	4.78	2.92	4.61	6.21	12.18	7.19	6.89
5	Mining of coal and lignite; extraction of peat	1.08	1.35	1.03	2.25	24.30	1.41	6.67
6	Cultivation of paddy rice	11.58	8.18	12.27	0.29	0.58	11.98	5.98
7	Fertilizer	6.19	7.33	4.38	1.95	5.10	4.22	4.67
8	Livestock and their results	7.63	3.35	2.33	2.00	0.51	10.06	4.33
9	Man. of cement, lime and plaster	0.56	0.57	1.24	12.95	0.73	3.82	4.12
10	Paper & pulp	2.23	3.57	18.01	1.25	4.49	1.50	2.95
	Other sectors	32.45	37.16	34.94	27.11	27.45	19.76	29.65
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Author's calculation

4.4.1.2 Environmental cost of forest resources driven by Indonesian final demand

Pirmana et al. (2021) estimate that the environmental costs derived from forest resources in 2010 in Indonesia are Rp. 61.45 trillion, caused by the depletion of forest resources (wood resources) of 33.09 trillion (including conversions and damages), from the loss of eco-services value from the tropical forest of Rp. 28.35 trillion, and those caused by domestic emissions of Rp. 22.94 billion, meanwhile from this study, including emissions from import activities, it becomes Rp. 25.4 billion.

This study attempts to trace the environmental costs of these forest resources from a consumption perspective. The estimation results may overestimate because it only accumulates in the forestry, logging, and related service activities sector. This situation occurs because the responsibility for conversion and damage to forest resources may also be caused by activities in other sectors such as sector groups in plantations and agriculture.

After the calculation and analysis of environmental costs originating from emissions in the previous section, which includes those from the forestry sector, table 4.4 below shows the results of the estimated calculation of environmental costs from timber resources from the consumption perspective. Total environmental costs of timber resources reach Rp. 36.66 trillion. Gross fixed capital formation and household consumption and export are final demand components with the highest environmental cost, each amounting to Rp. 18.02 trillion (49.2%) and Rp. 9.79 trillion (26.7%), and from export around Rp. 6.51 trillion (17.8%).

Table 4.4. The environmental cost of timber resources due to final demand in Indonesia in 2010 (Trillion Rp)

Components	**Environmental costs (trillion Rp)**	**Percentage of total environmental costs**
Household Consumption	9.79	26.71
Consumption of Non-Profit Institutions that serve Households	0.13	0.35
Government Consumption	0.99	2.69
Gross Fixed Capital formation	18.02	49.15
Total Export	6.51	17.75
Changes in Inventory	1.23	3.35
Total	36.66	100.00

Source: Author's calculation

4.4.1.3 Total environmental costs/value-added driven by Indonesian final demand and comparison with value-added creation

In this section we combine the external costs from emissions and the use of forestry resources driven by Indonesian final demand (table 4.5). The total environmental cost from a consumption perspective is 486.04 trillion, with details of environmental costs originating from emissions amounting to 449.39 (92.5%) and environmental costs derived from forest resources of 36.66 trillion (7.5%). The external costs related to forest resources are fully allocated to consumption of forestry products. This leads to a total environmental cost from a consumption perspective for forestry products of Rp. 36.66 trillion[3], of which the costs related to timber resources is Rp. 36.63 trillion (99.9%), and the costs related to emissions created in the value chain of forestry products is only Rp. 25.4 billion (0.07%).

Table 4.5. Total environmental costs due to final demand in Indonesia in 2010 (Trillion Rp)

Component	**Environmental Cost from emission (trillion Rp)**	**Environmental Cost from forest resources (trillion Rp)**	**Total Environmental Costs (trillion Rp)**
Households Consumption	196.26	9.79	206.05
Consumption of Non-Profit Institutions	2.77	0.13	2.9
Government Consumption	13.89	0.99	14.88
Gross Fixed Capital formation	124.07	18.02	142.09
Changes in Inventory	10.61	6.51	17.12
Export	101.81	1.23	103.04
Total Final Demand	449.41	36.66	486.04

Source: Author's calculation

We also calculated the ratio the total environmental costs, combination of environmental cost form emission and forest resources as a fraction of added value in Indonesia in 2010. This ratio appeared to be 0.07. Table 4.6 shows the top ten sectors with the highest ratio in Indonesia in 2010. The table shows that the environmental costs of emissions resulting from the consumption of

[3] Pirmana et al. (2021) include environmental costs from the loss of eco-services value from the tropical forest in calculating the forestry sector's environmental costs. In this study, we calculate environmental costs from a consumption perspective and not include the environmental costs due to loss of eco-services value from the tropical forest.

products in these ten sectors have a greater value than value-added (except electricity). The fact that total environmental costs exceed value-added implies that if the national accounts had included air pollution's external costs, these production outputs would create a negative value-added (Pirmana et al. 2021).

Waste management and recycling sector is sector with the highest ratio, with a ratio of 3.17, this means that the environmental cost contained in this sector is 3.17 times greater than its value-added. The second position was the fertilizer, with a ratio value of 2.70, followed by product from manufacture of basic iron, steel, ferro-alloys, and first products thereof (2.45); other livestock’s product (2.18); and product from manufacture of medical, precision, and optical instruments, watches, and clocks in with a ratio of 1.70. Meanwhile, the other five products in the top ten group’s has a ratio between 0.92 and 1.67.

Table 4.6. Top ten ratio of total environmental cost compared to value-added

No	Sector	Environmental Cost (EC) (Trillion Rp)	Value-Added (VA) (Trillion Rp)	EC/VA
1	Waste management and recycling	0.26	0.08	3.17
2	Fertilizer	21.00	7.77	2.70
3	Man. of basic iron, steel, ferro-alloys, and first products thereof	70.50	28.81	2.45
4	Other livestocks	3.52	1.62	2.18
5	Man. of medical, precision and optical instruments, watches and clocks	2.62	1.53	1.70
6	Sea and coastal water transport	31.62	18.93	1.67
7	Cultivation of sugar cane, sugar beet	8.57	5.86	1.46
8	Inland water transport	7.96	6.70	1.19
9	Man. of cement, lime and plaster	18.50	18.52	1.00
10	Electricity	53.95	58.87	0.92
	Other sectors	260.38	6,534.99	0.04
	Total	486.04	6,683.68	0.07

Source: Author’s calculation

4.4.2 Priority sector based on linkage analysis

Using the method discussed in section 3.2., table 4.7 shows a calculation of forward and backward linkages for both value-added as environmental costs. As mentioned in the previous section, sectors are classified into four groups: (i) encouraged sectors; (ii) slightly encouraged sectors; (iii) slightly discouraged sectors; and (iv) discouraged sectors. Of the 86 sectors, 6 sectors are classified as "encouraged sectors", 42 sectors as "slightly encouraged sectors", 34 sectors as "slightly constrained sectors", and 4 sectors are grouped as "constrained sectors". From a policy perspective the following categories are most relevant:

(i) Encouraged sectors. These include manufacture of textile; publishing, printing, and reproduction of recorded media; chemicals; manufacture of other non-metallic mineral products; Construction; other land transport. Stimulation of economic activity in these sectors hence will have a more than proportional positive impact on Indonesian economic development, with a less than proportional rise of external costs.

(ii) Constrained sectors. Apart from not having a significant pulling and pushing effect on the development of other sectors, these sectors' activities also have a significant negative impact on environmental damage. Sectors included in the "constrained sectors" are the cultivation of sugar cane, sugar beet; other livestock; raw milk; and inland water transport. These sectors hence seem less of a priority for stimulation, from an economic and environmental perspective.

Table 4.7. Classification of sectors in the Indonesian economy, 2010, in terms of the potential of environmental costs reduction

No	Sectors	UBLj	UFLj	UBLEj	UFLEj
Encouraged sectors					
1	Manufacture of Textile	1.118	1.075	0.318	0.138
2	Publishing, printing and reproduction of recorded media	1.065	1.196	0.252	0.003
3	Chemicals nec	1.007	1.78	0.345	0.606
4	Manufacture of other non-metallic mineral products n.e.c.	1.109	1.096	0.663	0.337
5	Construction	1.177	1.787	0.645	0.172
6	Other land transport	1.006	1.631	0.228	0.235
Constrained sectors					
1	Cultivation of sugar cane, sugar beet	0.903	0.814	6.676	7.285
2	Other livestocks (meat nec)	0.788	0.61	11.352	11.376
3	Raw milk	0.961	0.631	2.494	2.488
4	Inland water transport	0.98	0.649	3.473	3.547

Source: author's calculation
Notes:
- (UBL: unified backward linkage of production; UFL: unified forward linkage of production; UBLE: unified backward linkage of environmental costs; UFLE: unified forward linkage of environmental costs).
- See Appendix for complete results

4.5 Conclusion and recommendation

This study is an initial attempt to provide an overview of the environmental cost of emissions and the associated environmental cost of forest resources from a consumption perspective and Indonesia's priority sectors when economic and environmental performance are considered. This study results can be used as a guide for policymakers in formulating sustainable development policies, especially in sustainable consumption and production (SCP) policies.

We found that the total environmental cost from emissions due to the final demand is around 7.3% of GDP. The environmental cost of emissions mostly comes from domestically produced final consumption, with household consumption as the largest contributor to total emissions environmental cost.

This study also found that driven by final demand; the top five sectors account for nearly half of the environmental costs of emissions. These sectors are manufacturing basic iron and steel and iron alloys and their first products; electricity; the sea and coastal water transportation; manufacture of rubber and plastic products; coal mining, lignite, and peat extraction. Efforts to reduce Indonesia's emission environmental costs should focus on these sectors.

SOx, NOx, CO_2, and CH_4 are the main contributors to Indonesia's environmental costs based on pollutant sources. Strategies to reduce environmental costs from emissions can be focused on these four pollutant sources. The results further show that, for most emissions, there are no significant differences in how the types of final demand drive contribute to environmental costs.

Regarding the environmental costs to value-added ratio, nine sectors have a higher environmental cost value than their value-added, with waste management and recycling is the sectors with the highest environmental cost to value-added ratio. Meanwhile, the total environmental costs derived from forest resources are about 7.54% of the total environmental cost.

Finally, the results from linkage analysis pointed out that key sectors for Indonesia from a sustainability and economic point of view (encouraged sectors) are: manufacture of textile; publishing, printing, and reproduction of recorded media; chemicals n.e.c; manufacture of other non-metallic mineral products n.e.c; Construction; other land transport.

Based on the study findings, in order to reduce environmental costs and shift to more sustainable consumption and production, the following policy options and instruments can be considered by policymakers:

- Change consumer behavior. There are three different ways to influence consumer behavior. Firstly, raising consumer awareness via mandatory or voluntary labeling schemes, information campaigns, information websites, and eco-benchmarking tools. Secondly, making sustainable consumption easy by providing attractive offers to consumers and limit the range of non-sustainable products on the market. Thirdly, greening the market by improving products' environmental performance, prohibiting products with a harmful environmental performance, and increasing the market share of environmentally friendly products.
- Adopt a green public procurements system. The government with large public funds can regularly behave as a sustainable consumer to procure public goods and services. The application of green public procurement will benefit the government itself as a public organization, society, and the economy. On the other hand, government plays a vital role in reducing negative impacts on the environment.
- Stimulate the adoption of cleaner production. There is a wide range of economic and policy instruments that government may use to promote cleaner production. Tax, fees, and charges can be useful tools to promote cleaner production practices by raising the cost of harmful products or promote more efficient use of natural resources. Other instruments such as liability rules, financial subsidies, innovative financing for certain industries can be used as direct economic incentives to move away from polluting production technologies and unsafe products.

Lastly, from an economic point of view, sectors development to increase value-added growth, besides focusing on key sectors with strong linkages to the upstream and downstream sectors, can also be expanded to sectors with at least have a strong backward or forward linkage. The effective policy instruments to stimulate strong backward linkage sectors are demand-side policies. Otherwise, the supply-side is expected to be more effective in targeting strong forward linkage sectors. Some examples of policy instruments that can be applied to stimulate targeted sectors include:

- Demand-side policies. Changing fiscal policies (via government expenditure or taxes) concerning specific consumer commodities, improvement of the attractiveness of specific areas (which includes the provision or improvements of industrial sites and public utilities)
- Supply-side policies. Subsidies to certain sector activities, small business grants, wage subsidies, privatization, and lower-income tax rates.

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4.6 Appendix

This appendix contains the supporting information for this case study and includes details on the modelled processes, supporting calculations.

Table 4.8. Indonesia's Input-Output Tables

Year	Sector/Industry Classification	Description	Reference
1971	179		BPS (1977), "Tabel Input-Output Indonesia, 1971.
1975	179		BPS (1980), "Tabel Input-Output Indonesia, 1975.
1980	171		BPS (1985), "Tabel Input-Output Indonesia, 1980.
1983	66	IO updating*)	
1985	169		BPS (1990), "Tabel Input-Output Indonesia 1985.
1990	161		BPS (1994), "Tabel Input-Output Indonesia 1990.
1993	66	IO updating	
1995	172		BPS (1999), "Tabel Input-Output Indonesia 1995.
1998	66	IO updating	
2000	175		BPS (2002), "Tabel Input-Output Indonesia 2000
2003	66	IO updating	BPS (2004), "Tabel Input-Output Indonesia Updating 2003.
2005	175		BPS (2008), "Tabel Input-Output Indonesia 2005.
2008	66	IO updating	BPS (2009), "Tabel Input-Output Indonesia Updating 2008.
2010	185		BPS (2015), "Tabel Input-Output Indonesia 2010.

Source: Indonesia's Central Bureau of Statistics (BPS)
Notes: The IO updating is the IO table constructed using the non-survey method based on the previous IO table publication.

Table 4.9. Classification of sectors in term of the potential of environmental cost reduction

Group	Sector Group	Sector Indices				Relevant characteristics
		UBLj	**UFLj**	**UBLEj**	**UFLEj**	
I	Encouraged sector	High	High	Low	Low	Key sector. Low environmental cost
II	Slightly encouraged sector	High	High	High	Low	Key sector. Increase environmental cost by inputs
		High	High	Low	High	Key sector. Self-polluter and related environmental cost by demand
		High	Low	Low	Low	Backward linkage sector. Non-self-polluter and related environmental cost
		Low	High	Low	Low	Forward linkage sector. Non-Self-polluter and related environmental cost
		High	High	High	High	Key sector. Self-polluter by inputs and demand
III	Slightly constrained sector	Low	Low	High	Low	Self-polluter and related environmental cost by inputs
		Low	Low	Low	High	Self-polluter and related environmental cost by demand
		High	Low	High	High	Backward linkage sector. Self-polluter and related environmental cost by inputs and demand
		Low	High	High	High	Forward linkage sector. Self-polluter and related environmental cost by inputs and demand
		High	Low	Low	High	Backward linkage sector. Self-polluter and related environmental cost by demand
		Low	High	Low	High	Forward linkage sector. Self-polluter and related environmental cost by demand
		High	Low	High	Low	Backward linkage sector. Self-polluter and related environmental cost by inputs
		Low	High	High	Low	Forward linkage sector. Self-polluter and related environmental cost by inputs
		Low	Low	Low	Low	Non-polluter and related environmental cost
IV	Constrained sector	Low	Low	High	High	Self-polluter and related environmental cost by demand and inputs

Source: Adopted from Nguyen 2018, and Peng et al, 2020

Table 4.10. Top ten of domestic environmental cost from emission by sector in Indonesia (Trillion Rp)

No	Sector products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Man. of basic iron, steel and ferro-alloys, and first products thereof	5.37	0.09	0.78	46.41	11.93	3.02	67.60
2	Electricity	37.39	0.74	1.84	5.66	5.48	0.37	51.48
3	Sea and coastal water transport	19.80	0.13	0.30	2.49	7.69	0.24	30.65
4	Mining of coal and lignite; extraction of peat	1.99	0.04	0.14	2.69	24.74	0.14	29.74
5	Man. of rubber and plastic products	7.76	0.08	0.64	7.06	12.40	0.64	28.57
6	Cultivation of paddy rice	22.02	0.22	1.70	0.34	0.59	1.26	26.13
7	Fertilizer	10.79	0.19	0.61	2.34	5.19	0.41	19.52
8	Livestock and their results	14.17	0.09	0.32	2.47	0.52	1.06	18.63
9	Man. of cement, lime and plaster	1.01	0.01	0.17	15.99	0.75	0.39	18.33
10	Construction	0.53	0.01	0.12	11.70	0.31	0.16	12.83
	Other sectors	52.09	0.97	7.19	21.94	32.20	1.69	116.08
	Total	172.89	2.56	13.81	119.09	101.81	9.39	419.55

Source: Author’s calculation

Table 4.11. Top ten of emission embodied in import by sector in Indonesia (Trillion Rp)

No	Sector products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Recycling of waste and scrap	6.48	0.06	0.00	0.03	-	0.00	6.57
2	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	0.85	0.00	0.01	1.52	-	0.53	2.91
3	Electricity	1.51	0.01	0.01	0.86	-	0.07	2.47
4	Manufacture of rubber and plastic products	1.63	0.00	0.00	0.65	-	0.12	2.41
5	Cultivation of sugar cane, sugar beet	1.49	0.00	0.00	0.06	-	0.05	1.60
6	Fertilizer	1.35	0.02	0.00	0.08	-	0.04	1.49
7	Sea and coastal water transport	0.83	0.01	0.00	0.12	-	0.01	0.97
8	Petroleum Refinery	0.84	0.01	0.00	0.10	-	0.02	0.97
9	Cultivation of vegetables, fruit, nuts	0.82	0.02	0.00	0.02	-	0.01	0.87
10	Livestock and their results	0.81	0.00	0.00	0.01	-	0.01	0.84
	Other sectors	6.75	0.06	0.04	1.54	-	0.36	8.77
	Total	23.37	0.21	0.08	4.98	-	1.22	29.86

Source: Author's calculation

Table 4.12. The top ten environmental cost from emission due to final demand by the substance in Indonesia (Trillion Rp)

No	Emissions	Domestic	Imported	Total
1	SOx	87.62	4.90	92.52
2	NOx	65.72	4.96	70.68
3	CO_2	54.90	6.58	61.48
4	CH4	38.85	1.45	40.30
5	NH3	33.34	2.64	35.98
6	Pb	33.07	1.45	34.52
7	TSP	28.49	1.26	29.75
8	PM10	20.84	0.98	21.82
9	PM2.5	18.35	0.93	19.28
10	Nitrogen	11.44	1.11	12.56
	Other emissions	26.94	3.60	30.54
	Total	419.55	29.86	449.41

Source: Author's calculation

Table 4.13. Total environmental cost of emission due to final demand by type of emission in Indonesia (Trillion Rp)

No	Pollutants	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Final Demand
1	SOx	38.63	0.63	4.06	22.91	24.75	1.53	92.52
2	NOx	33.86	0.43	2.05	18.59	14.51	1.23	70.68
3	CO_2	26.95	0.41	1.98	16.77	14.44	0.93	61.48
4	CH_4	21.48	0.22	1.45	3.03	12.88	1.24	40.30
5	NH_3	25.32	0.32	1.02	3.72	4.45	1.17	35.98
6	Pb	3.40	0.05	0.42	22.93	6.02	1.69	34.52
7	TSP	7.35	0.13	0.62	13.47	7.24	0.94	29.75
8	PM10	6.89	0.12	0.61	8.30	5.39	0.50	21.82
9	PM2.5	6.40	0.12	0.64	7.69	3.99	0.45	19.28
10	Nitrogen	8.72	0.13	0.41	1.20	1.78	0.31	12.56
	Other Emissions	17.27	0.21	0.63	5.45	6.37	0.61	30.54
	Total Emissions	196.26	2.77	13.89	124.07	101.81	10.61	449.41

Source: Author's calculation

Table 4.14. Environmental cost of emission due to final demand for domestic source by type of emission in Indonesia (Trillion Rp)

No	Pollutans	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	SOx	35.23	0.59	4.04	21.71	24.75	1.29	87.62
2	NOx	29.85	0.40	2.04	17.84	14.51	1.08	65.72
3	CO_2	21.40	0.36	1.97	15.95	14.44	0.79	54.90
4	CH_4	20.19	0.21	1.44	2.92	12.88	1.20	38.85
5	NH_3	22.83	0.30	1.01	3.64	4.45	1.12	33.34
6	Pb	2.95	0.05	0.42	22.19	6.02	1.44	33.07
7	TSP	6.72	0.12	0.62	12.98	7.24	0.80	28.49
8	PM10	6.28	0.12	0.61	8.01	5.39	0.43	20.84
9	PM2.5	5.78	0.11	0.63	7.44	3.99	0.39	18.35
10	Nitrogen	7.68	0.12	0.40	1.17	1.78	0.29	11.44
	Other	13.99	0.18	0.63	5.23	6.37	0.55	26.94
	Total	172.89	2.56	13.81	119.09	101.81	9.39	419.55

Source: Author’s calculation

Table 4.15. Top ten of emission embodied in import by substance in Indonesia (trillion Rp)

No	Pollutants	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	CO_2	5.55	0.05	0.01	0.82	-	0.15	6.58
2	NOx	4.01	0.03	0.01	0.76	-	0.15	4.96
3	SOx	3.41	0.03	0.03	1.20	-	0.24	4.90
4	NH_3	2.49	0.02	0.00	0.08	-	0.05	2.64
5	CH_4	1.28	0.01	0.00	0.12	-	0.04	1.45
6	Pb	0.45	0.00	0.00	0.74	-	0.25	1.45
7	TSP	0.63	0.00	0.00	0.49	-	0.14	1.26
8	Nitrogen	1.05	0.01	0.00	0.03	-	0.02	1.11
9	Phosphorus	0.95	0.01	0.00	0.03	-	0.02	1.01
10	PM10	0.61	0.01	0.00	0.29	-	0.07	0.98
	Other	2.94	0.03	0.01	0.44	-	0.11	3.52
	Total	23.37	0.21	0.08	4.98	-	1.22	29.86

Source: Author's calculation

Table 4.16. Classification of sectors in the Indonesian economy, 2010, in terms of the potential of environmental costs reduction

Code	Sector	UBLj	UFLj	UBLEj	UFLEj	Criteria
1	Cultivation of paddy rice	0.726	1.262	1.219	1.903	III
2	Cultivation of cereal grains nec	0.742	0.783	0.804	0.681	III
3	Cultivation of vegetables, fruit, nuts	0.725	0.880	0.739	0.626	III
4	Cultivation of oil seeds	0.806	1.560	0.622	0.693	II
5	Cultivation of plant-based fibers & crop nec	0.756	0.975	0.334	0.051	III
6	Cultivation of sugar cane, sugar beet	0.903	0.814	6.676	7.285	IV
7	Livestock and their results	0.957	1.031	0.960	1.439	III
8	Other livestocks (meat nec)	0.788	0.610	11.352	11.376	IV
9	Animal products nec	1.202	0.949	0.502	0.109	II
10	Raw milk	0.961	0.631	2.494	2.488	IV
11	Forestry, logging and related service activities	0.741	1.088	5.164	9.398	III
12	Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing	0.742	1.144	0.177	0.001	II
13	Mining of coal and lignite; extraction of peat	0.832	0.999	1.080	1.660	III
14	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	0.842	1.603	0.283	0.771	II
15	Extraction of natural gas and services related to natural gas extraction, excluding surveying	0.787	1.781	0.164	0.391	II
16	Mining of iron ores	0.962	0.634	0.450	0.314	III
17	Mining of copper ores and concentrates	0.834	0.618	0.120	0.012	III
18	Mining of nickel ores and concentrates	0.887	0.643	0.160	0.042	III
19	Mining of aluminium ores and concentrates	0.655	0.618	0.034	0.014	III
20	Mining of precious metal ores and concentrates	0.821	1.046	0.064	0.000	II
21	Mining of lead, zinc and tin ores and concentrates	0.726	0.804	0.125	0.103	III
22	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	0.774	1.325	0.157	0.244	II
23	Production of meat products nec	1.395	0.650	0.310	0.034	II
24	Processing vegetable oils and fats	1.181	0.927	0.348	0.001	II
25	Processing of dairy products	1.393	0.716	0.421	0.000	II
26	Processed rice	1.189	0.747	0.886	0.003	II
27	Sugar refining	1.309	0.848	1.317	0.029	II
28	Processing of Food products nec	0.726	2.150	0.348	0.013	II
29	Manufacture of beverages	1.236	0.676	0.340	0.003	II
30	Manufacture of fish products	1.140	0.632	0.151	0.034	II
31	Manufacture of tobacco products	0.942	0.693	0.166	0.026	III
32	Manufacture of Textile	1.118	1.075	0.318	0.138	I
33	Manufacture of wearing apparel; dressing and dyeing of fur	1.051	0.628	0.204	0.020	II
34	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	1.021	0.665	0.294	0.023	II
35	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.099	1.061	1.221	0.010	II
36	Paper & pulp	1.154	1.445	0.955	1.160	II
37	Publishing, printing and reproduction of recorded media	1.065	1.196	0.252	0.003	I
38	Petroleum Refinery	0.974	2.320	0.257	0.587	II
39	Plastics, basic	0.994	1.059	0.280	0.148	II

40	Fertilizer	1.032	0.803	5.194	7.327	III
41	Chemicals nec	1.007	1.780	0.345	0.606	I
42	Manufacture of rubber and plastic products	1.174	1.104	1.058	1.620	II
43	Manufacture of glass and glass products	1.085	0.658	0.401	0.103	II
44	Manufacture of ceramic goods	1.151	0.675	0.538	0.095	II
45	Manufacture of cement, lime and plaster	1.173	0.699	2.659	2.649	III
46	Manufacture of other non-metallic mineral products n.e.c.	1.109	1.096	0.663	0.337	I
47	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	1.199	0.994	3.122	5.939	III
48	Precious metals production	1.184	0.607	0.426	0.007	II
49	Casting of metals	1.104	0.609	0.739	0.125	II
50	Manufacture of fabricated metal products, except machinery and equipment	1.122	0.910	0.758	0.009	II
51	Manufacture of machinery and equipment n.e.c.	0.892	0.988	0.184	0.015	III
52	Manufacture of office machinery and computers	0.873	0.778	0.175	0.007	III
53	Manufacture of electrical machinery and apparatus n.e.c.	1.053	0.898	0.253	0.004	II
54	Manufacture of radio, television and communication equipment and apparatus	0.991	0.833	0.229	0.029	III
55	Manufacture of medical, precision and optical instruments, watches and clocks	1.087	0.624	2.957	2.771	III
56	Manufacture of motor vehicles, trailers and semi-trailers	1.073	0.912	0.120	0.007	II
57	Manufacture of other transport equipment	0.970	0.939	0.173	0.005	III
58	Manufacture of furniture; manufacturing n.e.c.	1.157	0.875	0.615	0.275	II
59	Electricity	1.637	2.131	2.637	4.708	III
60	Manufacture of gas; distribution of gaseous fuels through mains	0.965	0.822	0.121	0.000	III
61	Collection, purification and distribution of water	0.774	0.816	0.093	0.000	III
62	Construction	1.177	1.787	0.645	0.172	I
63	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories	0.878	1.227	0.128	0.000	II
64	Retail sale of automotive fuel	0.921	3.354	0.152	0.073	II
65	Hotels and restaurants	1.149	0.965	0.263	0.002	II
66	Transport via railways	1.265	0.620	0.500	0.163	II
67	Other land transport	1.006	1.631	0.228	0.235	I
68	Sea and coastal water transport	1.159	0.712	3.669	4.159	III
69	Inland water transport	0.980	0.649	3.473	3.547	IV
70	Air transport	0.930	0.779	0.404	0.280	III
71	Supporting and auxiliary transport activities; activities of travel agencies	1.005	0.874	0.456	0.146	II
72	Post and telecommunications	0.906	1.391	0.120	0.043	II
73	Financial intermediation, except insurance and pension funding	0.848	1.422	0.097	0.011	II
74	Insurance and pension funding, except compulsory social security	0.830	0.926	0.087	0.038	III
75	Activities auxiliary to financial intermediation	0.890	0.976	0.071	0.006	III
76	Real estate activities	0.786	0.737	0.080	0.001	III
77	Renting of machinery and equipment without operator and of personal and household goods	0.942	1.220	0.157	0.003	II
78	Computer and related activities	0.995	0.900	0.142	0.013	II

79	Research and development	0.985	0.936	0.159	0.004	III
80	Other services activities	1.112	0.923	0.143	0.023	II
81	Public administration and defence; compulsory social security	0.972	0.896	0.153	0.001	III
82	Education	0.931	0.664	0.183	0.037	III
83	Health and social work	1.121	0.719	0.311	0.033	II
84	Waste Management and recycling	1.246	0.606	8.648	8.429	III
85	Recreational, cultural and sporting activities	1.050	0.617	0.325	0.082	II
86	Private households with employed persons	0.950	0.630	0.197	0.028	III

Source: Author's calculation

Notes: Notes:

Encouraged sectors :

Slightly encouraged sectors :

Slightly constrained sectors :

Constrained sectors :

(UBL: unified backward linkage of production; UFL: unified forward linkage of production; UBLE: unified backward linkage of environmental costs; UFLE: unified forward linkage of environmental costs).