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Green Goods in Finland's Manufacturing

Natalia Kuosmanen
ETLA Economic Research, Finland
natalia.kuosmanen@etla.fi

Mika Pajarinen
ETLA Economic Research, Finland
mika.pajarinen@etla.fi

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Abstract

This report examines the production of green goods in Finland's manufacturing sector. Our findings reveal a notable concentration of green products to high-tech industries. While most firms maintain their green product portfolios stable over time, multi-product firms tend to expand their green product portfolios more actively. Large firms stand out with active management of their green goods portfolios, discontinuing some green products while introducing new ones. Additionally, we examine firm characteristics that associate with firms' engagement in the production of green goods. We find a positive correlation between production of green products and factors such as labor productivity, product diversity, and multi-industry operations.

Tiivistelmä

Vihreät tuotteet Suomen teollisuudessa

Tämä raportti tarkastelee ns. vihreiden tuotteiden valmistusta Suomen teollisuustoimialoilla. Tulostemme mukaan vihreiden tuotteiden valmistus keskittyy pääasiassa korkean teknologian aloille. Vaikka useimmat yritykset säilyttävät vihreän tuotevalikoimansa melko muuttumattomana yli ajan, monituoteyritykset laajentavat vihreitä tuotevalikoimiaan aktiivisemmin. Suuret yritykset pystyvät tekemään aktiivisesti muutoksia vihreään tuotevalikoimaan lopettamalla joidenkin tuotteiden valmistuksen ja lisäämällä uusia tuotteita valikoimaan. Lisäksi tarkastelemme yrityskohtaisia taustatekijöitä, jotka ovat yhteydessä vihreiden tuotteiden valmistuspäätöksiin. Havaitsemme, että vihreiden tuotteiden valmistus korreloi positiivisesti työn tuottavuuden sekä tuotevalikoiman monimuotoisuuden ja monialaisuuden kanssa.

Ph.D. **Natalia Kuosmanen** is a Chief Research Scientist at Etla Economic Research.

M.Sc. (Econ.) **Mika Pajarinen** is a Researcher at Etla Economic Research.

MMT **Natalia Kuosmanen** on Elinkeinoelämän tutkimuslaitoksen tutkimuspäällikkö.

KTM **Mika Pajarinen** on Elinkeinoelämän tutkimuslaitoksen tutkija.

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Keywords: Environmental goods, Green products, Firm renewal, Manufacturing industries

Avainsanat: Teollisuustoimialat, Vihreät tuotteet, Ympäristötuotteet, Yritysten uudistuminen

JEL: C23, L60, O44, Q54, Q55, Q56

Contents

1 Introduction: Green goods

Environmental goods, often referred to as green goods, still lack a universally agreed-upon definition. The Organisation for Economic Co-operation and Development (OECD) offers one of the most comprehensive definitions to date. According to the OECD (1996), environmental goods include products and services that "*measure, prevent, limit, minimize, or correct environmental damage to water, air, and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products, and services that reduce environmental risk and minimize pollution and resource use*".

Another perspective emerges from the European Union (2016), which defines environmental goods as "*products that directly contribute to environmental protection and climate mitigation by helping clean the air and water, helping manage waste, contributing to energy efficiency, controlling air pollution, and generating renewable energy*".

While consensus on a widely accepted conceptual definition of green goods remains elusive, operationalizing the concept of these goods using available data poses an even greater challenge. This is because standard statistical classifications are not designed to specifically identify green products. To address this issue, many international organizations have created numerous lists of green goods, each tailored to distinct objectives and subject to different compilation methodologies, making direct comparisons between these lists challenging.

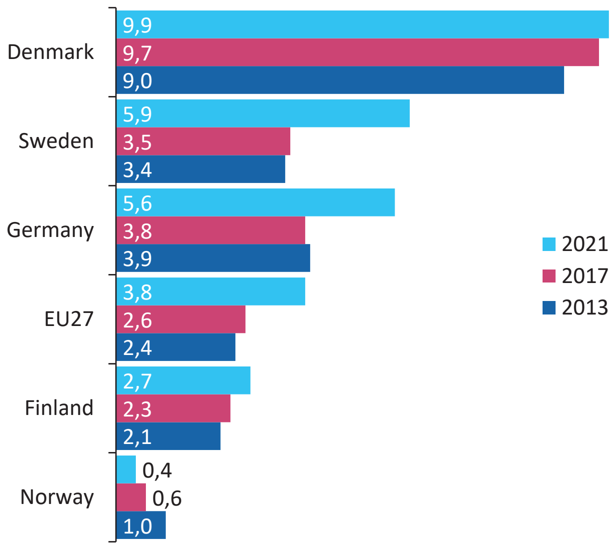
For instance, the OECD's list primarily highlights national environmental industries (Andrew and Thompson, 2001), while the Asia-Pacific Economic Cooperation (APEC) forum' list, originating from nominated goods and an agreed-upon classification system, lays the foundation for international trade in green goods through its 2012 agreement.[1]

In this study, we rely on a list of green goods from Bontadini and Vona (2023), who matched and refined Eurostat's product-level dataset for the manufacturing sector, known as PRODCOM, to align with the most popular lists of green goods. Bontadini and Vona's list comprises of 221 green products, but when matched with PRODCOM data for Finland and addressing duplicates, we identify 89 unique green products. Based on our matched list, the Finnish manufacturing sector produced 57 green goods at the 8-digit level of PRODCOM classification in 2021, representing 2.7% of the sector's total production value (see Figure 1).

For specific green products, Appendix A lists the top ten green products in the Finnish manufacturing sector for 2021 at the 8-digit level of PRODCOM classification. These products accounted for 67% of the sector's total green goods production this year.

Furthermore, Figure 1 compares the shares of the production of green goods in total manufacturing production for several countries, including Denmark, Germany, Sweden, Finland, and Norway, and the EU27, for the years 2013, 2017, and 2021. Among these countries, Denmark leads in the production of green goods, accounting for approximately 10% of its total production, followed by Sweden (5.9%) and Germany (5.6%). Finland's production of green goods is slightly below the EU27 average, showing a slight increase from 2.1% in 2013 to 2.7% in 2021.

Figure 1 Green product share in manufacturing production by country, %



Source: Authors' calculations based on Eurostat's PRODCOM database and the list of green products by Bontadini and Vona (2023). The percentages in the figure represent the share of the production of green goods in the total manufacturing production for each respective country in the years 2013, 2017, and 2021.

The rest of the report is structured as follows: Section 2 explores the specific industries involved in the production of green goods within Finland's manufacturing sector. Section 3 analyzes product switching patterns among green product producers. Section 4 investigates the driving and hindering factors of the production of green goods. Section 5 presents our concluding remarks.

2 Locating green goods production

To gain insights into the distribution of the production of green goods across various manufacturing industries in Finland (industries C10-C33 of NACE classification), we rely on Eurostat's PRODCOM data for Finland, covering the period from 2013 to 2021. This dataset is complemented by the matched list of green goods discussed above.

PRODCOM codes are linked to the European industrial classification NACE Rev. 2. Each PRODCOM code consists of eight digits, with the initial four digits aligning with NACE industry codes. This allows us to characterize each product within a 2-digit industry, enabling the computation of industry-specific shares of green goods production.

More specifically, we assign each green product to a broader 2-digit industry j and calculate the industry's share of green goods production, denoted as s_{jt}. This share is derived by taking the ratio of the value of green goods production within that industry, y^g_{jt}, to the total production of green goods within the whole sector, $\sum_j Y^g_{jt}$:

$$s_{jt} = y^g_{jt} / \sum_j Y^g_{jt} \,. \qquad (1)$$

In Equation 1, 'g' stands for green goods production, and t represents the time period.

Table 1 presents the shares of green goods production among 2-digit industries within Finland's manufacturing sector for the years 2013, 2017, and 2021. Notably, the production of green goods is concentrated in specific industries, including *Manufacture of computer, electronic and optical products* (C26), *Manufacture of electrical equipment* (C27), *Manufacture of machinery and equipment n.e.c.* (C28), and *Manufacture of motor vehicles, trailers and semi-trailers* (C29). In 2021, these industries accounted for an 85% share of total green goods production. These industries are known for producing technologically advanced products that often require extensive research, development, and technical expertise.

To further understand the role of green goods production within these industries, Table 2 reports the shares of green goods production relative to the total produc-

Table 1 Share of industry's green goods production in total green goods production of the Finnish manufacturing sector (2013, 2017, and 2021), %

NACE Rev. 2	Label	2013	2017	2021
26	Manufacture of computer, electronic and optical products	21.56	34.74	35.72
27	Manufacture of electrical equipment	26.33	21.20	21.06
29	Manufacture of motor vehicles, trailers and semi-trailers	10.31	11.73	16.53
28	Manufacture of machinery and equipment n.e.c.	26.22	15.46	11.27
33	Repair and installation of machinery and equipment	4.24	4.84	5.96
30	Manufacture of other transport equipment	4.43	5.75	5.89
23	Manufacture of other non-metallic mineral products	2.66	1.80	1.86
25	Manufacture of fabricated metal products, except machinery and equipment	4.07	4.39	1.71
24	Manufacture of basic metals	0.18	0.07	0.00

Source: Calculations are based on Eurostat's PRODCOM database for Finland and the green goods list from Bontadini and Vona (2023). The percentages, calculated using Equation 1, represent each industry's share of green goods production within the Finnish manufacturing sector for the years 2012, 2017, and 2021.

tion within each of these specific industries. The industry-specific share of green goods production, k_{jt}, is calculated as the ratio of industry *j*'s green goods production to the total production of this industry, including non-green goods production, denoted as 'ng':

$$(2) \quad k_{jt} = y_{jt}^{g} / \left(y_{jt}^{g} + y_{jt}^{ng} \right).$$

In Equation 2, y_{jt}^{g} represents the production value of green goods produced by industry *j* during period *t* and y_{jt}^{ng} is the total production value of this industry, which is the sum of green goods and non-green goods production.

Table 2 illustrates the integration of green goods production within various industries and highlights notable trends over time. Industries, such as the *Manufacture of computer, electronic and optical products* (C26) and *Manufacture of motor vehicles, trailers and semi-trailers* (C29), have seen an increase in their green goods production shares. For example, the *Manufacture of computer, electronic and optical products* industry increased its green goods production share from 22% in 2013 to 33% by 2021. Conversely, industries, such as *Manufacture of machinery and equipment n.e.c.* (C28), experienced a decline in green goods production share during the same period.

3 Product switching patterns

We next analyze green product switching patterns among Finnish manufacturing firms using Statistics Finland's PRODCOM data spanning from 2008 to 2021. Our dataset exclusively consists of firms that have engaged in the production of green goods at some point during this time span, resulting in a total of 550 firms for our analysis[2]. These firms introduced green products at different times within this period. To better understand their green product portfolio distribution after the initial introduction of such products, we categorize these firms into three distinct groups:

1. *No Change*: Firms that introduced at least one green product in a specific year (referred to as year *t*) and continued to produce it without alterations.

2. *Green product adding*: Firms that, after introducing a green product in year *t*, subsequently expanded their green product offerings by introducing new green products in subsequent years.

3. *Green product dropping*: Firms that introduced green products in year *t* but later discontinued certain green products, leading to a reduction in their green product portfolio.

Table 2 Share of industry's green goods production in industry's total production (2013, 2017, and 2021), %

NACE Rev. 2	Label	2013	2017	2021
26	Manufacture of computer, electronic and optical products	21.45	31.53	32.96
27	Manufacture of electrical equipment	10.04	9.60	11.85
29	Manufacture of motor vehicles, trailers and semi-trailers	14.25	6.52	22.61
28	Manufacture of machinery and equipment n.e.c.	4.63	3.07	2.78
33	Repair and installation of machinery and equipment	2.94	3.38	4.59
30	Manufacture of other transport equipment	6.98	6.27	6.58
23	Manufacture of other non-metallic mineral products	1.92	1.50	1.59
25	Manufacture of fabricated metal products, except machinery and equipment	1.23	1.55	0.73
24	Manufacture of basic metals	0.03	0.01	0.00

Source: Calculations are based on Eurostat's PRODCOM database for Finland and the green goods list from Bontadini and Vona (2023). The percentages, calculated using Equation 2, represent each industry's share of green goods production in its total production for the years 2013, 2017, and 2021.

To provide an overview of firms' green product-related activities using pooled data from 2008 to 2021, Table 3 displays the average shares of firms involved in these activities. We analyze these patterns across various firm types, including all firms, multi-product firms, firms of different sizes (small, medium, large), firm of different ages (young, mid-age, old), and whether they are exporting or domestic firms.

Across different firm types, a notable trend emerges regarding the maintenance of green product offerings. Approximately 90% of all firms made no changes to their green product mix. In contrast, multi-product firms tend to be more dynamic, expanding their green product portfolios, which account for approximately 7% of these firms.

Large firms exhibit the most notable changes, with 8% discontinuing certain green products from their green product portfolios, while an equal share of 8% introducing new green products to their existing green product lineup.

Firm age does not appear to play a significant role, as young, mid-age, and old firms all maintain fairly consistent patterns in terms of green product mix. Lastly, domestic firms show a higher tendency for no change, while exporting firms are slightly more inclined towards product adding than product dropping. This reflects potential strategic differences in green product strategies between domestic and exporting firms.

In summary, firms exhibit varying preferences in their green product-related activities, with large and multi-product firms displaying more dynamism by adapting their green product portfolios.

4 Drivers of green goods production

4.1 Methodology

To examine the factors associated with firms' engagement in the production of green goods, we employ binary logistic and Tobit regression models.

In the binary regression analysis, the dependent variable, denoted as Y_i, takes on the value of one if firm i is engaged

Table 3 Shares of firms in relation to green product-related activities among different firm types in Finnish manufacturing (2008–2021), %

	No change	Product adding	Product dropping
All firms	**90.39**	**4.92**	**4.69**
Product:			
– Multi-product	88.49	6.73	4.79
Size:			
– Small	92.77	3.59	3.64
– Middle	90.02	5.65	4.33
– Large	83.22	8.39	8.39
Age:			
– Young	88.60	5.70	5.70
– Mid-age	89.89	4.82	5.29
– Old	90.92	5.02	4.06
Market presence:			
– Exporting	88.79	5.92	5.29
– Domestic	94.16	2.68	3.16

Source: Authors calculations are based on Statistics Finland data pooled across years 2008–2021. The table displays the shares of firms engaged in one of the three green product-related activities across various firm types. A multi-product firm manufactures two or more products at the eight-digit level of the PRODCOM classification level during the same time period. Firm size categories are based on the number of employees: small (less than 50 employees), medium (50–249 employees), or large (at least 250 employees). Firm age categories include young firms (0–5 years), mid-age firms (6–20 years), and old firms (at least 21 years). Exporting firms engage in international trade, while domestic firms primarily serve domestic markets.

in green goods production in year t, and zero otherwise. To enhance the robustness and reliability of our results, we estimate both probit and logit models, accounting for diverse modeling approaches and assumptions.

To predict participation in the production of green goods, we utilize various observed firm-specific characteristics, including natural logarithms of labor productivity (the value-added-to-number of employees ratio), capital intensity (the capital-to-labor ratio), firm total sales, and firm age. Additionally, we include the product diversity index, which indicates the variety of goods produced by the firm, and two key financial indicators – equity ratio (representing the proportion of assets financed by equity) and EBIT ratio (representing the firm's profitability before interest and taxes).

Furthermore, we introduce dummy variables to account for firms' involvement in importing or exporting activities, as well as a multi-industry dummy variable. This latter variable indicates whether a firm operates across multiple industries at the two-digit level of the NACE classification. It takes on a value of one if the firm produces its products in more than one industry at this classification level, and zero if it operates solely within a single industry.

In our analysis, we control for industry-specific factors to capture potential industry-dependent variations within our dataset. Furthermore, to address time-specific effects, we include dummy variables for each year (time dummies). This allows us to capture any temporal variations that may impact firms' engagement in the production of green goods.

Formally, the probit model estimates the probability of firms' participation in green goods production as a function of observed firm-specific characteristics, industry-specific effects, and year-specific effects:

$$(3) \quad P(Y_{it} = 1) = \Phi(\beta X_{it} + \delta_j + \gamma_t + \varepsilon_{it}) .$$

In Equation (3), Y_{it} is the binary dependent variable, where $Y_{it} = 1$ if firm i participates in green goods production in year t, and $Y_{it} = 0$ otherwise. X_{it} represents the vector of observed firm-specific characteristics for firm i in year t. β is the vector of coefficients associated with the firm-specific characteristics. δ_j represents the industry-specific effect captured by dummy variables for each industry j. γ_t represents the year-specific effects captured by dummy variables for each year. ε_{it} is the error term, assumed to follow a standard normal distribution. In the probit model, Φ represents the cumulative distribution function of the standard normal distribution. In the logit model, Φ is replaced by the logistic distribution function.

While binary analysis using dummy variables distinguishes firms engaged in the production of green goods from non-participating firms, it does not capture the nuances of green goods production intensity. it fails to account for varying degrees to which firms integrate green goods production into their overall output. To address this limitation and provide a robustness check, we use a firm's share of green products in its total sales as the dependent variable and employ a Tobit model.

The Tobit model is well-suited for our analysis, accommodating firms with zero engagement in green goods production. This is crucial because it enables us to explore the entire spectrum of green goods production adoption, spanning from firms with no green goods production activity to those where it constitutes a substantial portion of their overall output.

The Tobit model for predicting a firm's share of green goods production in total sales is represented as follows:

$$(4) \quad Y_{it} = max(0, \beta X_{it} + \eta_i + \gamma_t + \delta_j + \varepsilon_{it}) .$$

Here, Y_{it} is the dependent variable representing the share of green products sold in firm i's total sales in year t. X_{it} includes observed firm-specific characteristics for firm i in year t, similar to the those used in the probit and logit models. β represents the vector of coefficients associated with the firm-specific characteristics, assumed to be constant over time. η_i captures firm-specific random effects, accounting for unobserved firm-specific characteristics that remain constant over time. γ_t captures year-specific effects through dummy variables for each year t, while δ_j accounts for industry-specific effects using dummy variables for each industry j. Finally, ε_{it} represents the error term, assumed to follow a standard normal distribution.

The Tobit model is particularly suitable for situations where the dependent variable is censored, as is the case with the share of green goods production. This variable is bounded between 0 (indicating no green goods production) and potentially 1 (representing all production as green goods production). By accommodating this censoring, the Tobit model allows us to account for firms with zero green goods production and explore variations in the share of green goods production among firms.

4.2 Results

Table 4 presents the findings of the three regression models employed to examine the factors associated with firms' engagement in the production of green goods: probit pooled regression (Model 1), logit random effects regression (Model 2), and Tobit random effects regression

Table 4 Regression results for factors associated with firms' participation in green goods production

	(1) Probit (pooled) dy/dx/(S.E.)	(2) Logit (random-eff.) dy/dx/(S.E.)	(3) Tobit (random-eff.) Coef./(S.E.)
Labor productivity	0.009	0.004	0.061 ***
	(0.015)	(0.006)	(0.023)
Capital intensity	-0.018 ***	-0.006 ***	-0.018 ***
	(0.004)	(0.002)	(0.006)
Sales	0.002	0.002	-0.006
	(0.004)	(0.001)	(0.006)
Age	-0.006	-0.006 **	-0.013
	(0.006)	(0.003)	(0.013)
Product diversity	0.086 ***	0.063 ***	0.121 ***
	(0.010)	(0.004)	(0.014)
Foreign-owned firm	-0.003	-0.002	-0.031
	(0.015)	(0.006)	(0.027)
Equity ratio	-0.021	-0.014 ***	-0.092 ***
	(0.013)	(0.005)	(0.020)
Ebit ratio	-0.004	-0.016	-0.235 ***
	(0.054)	(0.022)	(0.085)
Multi-industry firm	0.040 ***	0.032 ***	0.057 ***
	(0.012)	(0.005)	(0.016)
Exporter	-0.023 **	-0.004	-0.006
	(0.010)	(0.004)	(0.013)
Importer	0.003	-0.003	-0.013
	(0.009)	(0.004)	(0.014)
Industry-indicators	Yes	Yes	Yes
Year-indicators	Yes	Yes	Yes
Observations	30119	30119	30119
Wald (Chi2)	578.352 ***	486.315 ***	638.827 ***
Log pseudolikelihood	-7552.631	-2394.984	
R^2(pseudo)	0.237		
LR test (panel)		10378.827 ***	13150.383 ***

Source: Authors' calculations based on Statistics Finland data. The table presents results for three models. Model 1 displays average partial effects and clustered standard errors from a 2008–2021 pooled probit regression. Model 2 reports average partial effects and standard errors from a logit random-effects regression. Model 3 presents coefficients and standard errors from a random-effects Tobit regression. Statistical significance is denoted as * p < 0.10, ** p < 0.05, and *** p < 0.01.

(Model 3). The table displays the estimated coefficients together with their standard errors.

The results consistently demonstrate a positive association between labor productivity and firms' engagement in the production of green goods, as well as a larger share of green products in their sales. This suggests that firms with higher labor productivity are more inclined to produce green goods. Conversely, firms with higher capital intensity exhibit a negative relationship with both green product participation and the share of green products in sales.

Notably, product diversity positively related to both the likelihood of firms engaging in the production of green goods and the share of green products in their sales. Thus, firms offering a more diverse range of products are more inclined to produce green goods.

The impact of financial ratios on participation in the production of green goods and the share of green products are less consistent across models. The Tobit model highlights a negative relationship between the equity ratio and the share of green products, suggesting that financial structures may affect the extent to which firms integrate the production of green products into their operations.

The analysis consistently reveals that multi-industry firms are more likely to engage in the production of green goods, emphasizing the importance of diversification across industries as a driver of producing environmentally conscious products.

The impact of exporter and importer status is less pronounced across models and does not emerge as a strong determinant of participation in the production of green goods.

In summary, the results highlight several key factors associated with firms' engagement in green goods production. Higher labor productivity, a diverse product portfolio, and multi-industry presence are positively associated with firms' engagement in green goods production. In contrast, capital-intensive firms may encounter obstacles when adopting green goods production. The role of financial structures and trade status in shaping strategies for green goods production requires further investigation.

5 Conclusions

This study examined the production of green goods within Finland's manufacturing sector, focusing on environmentally friendly goods designed to reduce environmental impacts and promote sustainability. Specifically, we utilized a list of green goods compiled by Bontadini and Vona (2023), which refined widely used lists of international organizations with Eurostat's manufacturing sector product-level dataset, called PRODCOM.

In 2021, Finland's production of green goods constituted only 2.7 percent of the sector's total industrial output, which is slightly below the EU27 average. Regarding the distribution of green goods production across various manufacturing industries, most of it are primarily produced by technology-driven industries, such as the *Manufacture of computer, electronic, and optical products* and *Manufacture of electrical equipment* industries.

Exploring the patterns of green product adoption among firms revealed that most firms maintained their original green product portfolios. In contrast, multi-product firms demonstrated greater dynamism, expanding their offerings of green products. Notably, large firms stood out for implementing substantial changes, discontinuing certain green products while introducing new ones.

Our results also shed light on the factors associated with firms' engagement in the production of green goods. Factors, such as labor productivity, a diverse product portfolio, and multi-industry presence were positively correlated with firms' participation in producing green goods. Conversely, capital-intensive firms faced potential obstacles in adopting green goods production. Further research is needed to explore the role of financial structures and trade status in shaping production strategies.

Endnotes

1. These lists are compiled using the Harmonized System (HS), which is the most widely adopted product classification system for international trade.

2. PRODCOM data include primarily firms that have at least 10 employees.

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Appendix A

Table A1 Top ten green products in Finnish manufacturing, 2021

PRODCOM code	PRODCOM label	Green product share, %
27123170	Other bases for electric control, distribution of electricity, voltage <= 1 000 V	12.6
26516690	Measuring or checking instruments, appliances and machines n.e.c.	10.3
29105200	Motor vehicles specially designed for travelling on snow, golf cars and similar vehicles	10.0
29102430	Motor vehicles, with both spark-ignition or compression-ignition internal combustion reciprocating piston engine and electric motor as motors for propulsion, capable of being charged by plugging to external source of electric power	6.6
33203900	Installation of other special-purpose machinery n.e.c.	5.9
28251130	Heat exchange units	5.5
26511200	Theodolites and tachymetres (tachometers); other surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances	5.2
26515395	Other non-electronic instruments and apparatus for physical or chemical analyses, n.e.c.	4.9
30202000	Self-propelled railway or tramway coaches, vans and trucks, except maintenance or service vehicles	3.1
26518200	Parts and accessories for the goods of 26.51.12, 26.51.32, 26.51.33, 26.51.4 and 26.51.5; microtomes; parts n.e.c.	3.0

Source: Authors' calculations based on Eurostat's PRODCOM database and the green goods list from Bontadini and Vona (2023). The PRODCOM codes in the table are based on the 2022 PRODCOM classification, https://www.stat.fi/en/luokitukset/prodcom/

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Kustantaja: Taloustieto Oy

Puh. 09-609 900
www.etla.fi
etunimi.sukunimi@etla.fi

Arkadiankatu 23 B
00100 Helsinki