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Firms Performance, Electricity Consumption and Carbon Dioxide Emission: An Estonian Firm Level Study

Master's thesis

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I have written this Research paper independently. Any ideas or data taken from other authors or other sources have been fully referenced.

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1. Introduction

Electricity consumption by firms is a crucial factor that positively impacts firms' productivity. The uninterrupted availability of affordable energy is essential for firms to operate efficiently and effectively. Productivity, a critical metric for measuring the efficiency of production processes, encompasses several factors, including labour productivity, technological advancements, and resource allocation. Researchers have conducted studies on the relationship between electricity consumption and firms' performance in various industries and regions to comprehend the intricate interplay between energy consumption and economic outcomes. Several studies have examined the causal relationship between electricity consumption and economic growth in different countries.

Conversely, a strong correlation exists between firm performance or productivity and economic growth. From a macroeconomic standpoint, firms' activity plays a pivotal role in driving economic growth. Specifically, the financial performance of firms can influence key macroeconomic indicators like GDP. Empirical evidence has consistently demonstrated a substantial impact of firms' financial performance on GDP. (Emara & El Said, 2021). The profit and turnover of firms can serve as critical factors for economic growth, mainly when development finance institutions contribute to increasing economic growth. (Massa, 2011). Understanding this relationship makes it possible to identify potential opportunities for improving energy efficiency and enhancing firms' performance. Consequently, this contributes to sustainable economic growth in Estonia.

Estonia predominantly relies on oil shale for electricity production, making it the largest producer of oil shale-based electricity globally. However, this reliance also poses a significant risk due to the substantial greenhouse gas emissions and environmental pollution it generates (Lehtveer et al., 2016). Furthermore, the country is currently transitioning towards making renewable energy its primary source of electricity. Estonia has set a target to exclusively produce electricity from renewable sources by 2030 (ERR, 2022). Regarding this matter, as of 2021, renewable sources account for 29.3% of Estonia's electricity production. However, it is worth noting that Estonia's primary renewable energy source is wood chips and waste, which, compared to other renewable sources like wind, hydro, and solar, poses environmental hazards. (*Energy | Statistikaamet*, n.d.). This also raises the question of how Estonian firms exhibit a high carbon intensity regarding their electricity consumption and productivity.

There are three primary rationales for studying the correlation between electricity consumption and the productivity of Estonian firms. Firstly, considering Estonia's ambitious energy transition and sustainability targets, it becomes essential to investigate how electricity consumption impacts firms' productivity, enabling businesses to align their practices with the country's environmental objectives. Secondly, due to Estonia's distinctive energy landscape, characterised by significant reliance on oil shale and renewable energy sources, examining the relationship between electricity consumption and firms' productivity can offer valuable insights for optimising energy usage and promoting economic competitiveness. Lastly, assessing the carbon dioxide intensity in electricity consumption holds significant importance for policy adjustments to achieve carbon neutrality by 2050.

Electricity consumption and firm production are closely interconnected in the field of macroeconomics. Research demonstrated that electricity consumption has a negative impact on manufacturing productivity in Ghana (Abokyi et al., 2018). Additionally, reducing the energy consumption of industrial facilities can create conditions for increasing the efficiency of using fuel, energy, and material resources during the production of heat and electricity, leading to increased productivity (Sinitsyn et al., 2020).

1.1 Current Energy Landscape of Estonia

Estonia, an EU and Eurozone member, is classified as a high-income country by the World Bank. The nation has made significant progress regarding general energy intensity, which refers to the overall electricity consumption. In 1991, Estonia's energy intensity stood at 4.87 kilowatt-hours (KWh) per US dollar, indicating that the country consumed 4.87 KWh in exchange for one US dollar. However, by 2018, this value had decreased by 55% to 2.19 kWh, highlighting the substantial improvement in the country's electricity efficiency. (*Energy Intensity*, n.d.). Furthermore, Estonia has experienced a decline in electricity demand in recent years. In 2022, the country's electricity demand reached 9.3 TWh. Notably, Estonia's average electricity generation in the same year (6.29 KWh) slightly exceeded the EU average (6.24 KWh). It significantly surpassed the figures observed in the other two Baltic countries, namely Latvia (2.73 KWh) and Lithuania (1.52 KWh). However, it is essential to note that Estonia's carbon intensity remains comparatively higher than that of the EU and other Baltic countries. In 2022, Estonia emitted 464 grams of CO2 equivalent per kWh of electricity, while the EU average stood at 278 grams. In contrast, neighbouring Lithuania and Latvia emitted 194 grams and 182 grams, respectively. (Ritchie et al., 2022). Based on the statistics, it can be inferred that for firms in Estonia, it holds relatively greater significance to reduce their electricity intensity[1].

Taking a broader perspective, it can be observed that Estonia's per capita energy generation exceeds the average of the European Union. In 2022, the European Union recorded an average per capita electricity generation of 6,249 kWh. Comparatively, upper-middle-income countries had a per capita generation of 4,919 kWh (2021), while lower-middle-income countries had a significantly lower figure of 1,130 kWh per capita. In contrast, Estonia's per capita electricity generation is 6,289 kWh per person (Ritchie et al., 2022).

This thesis aims to contribute to the existing knowledge base by investigating the correlation between electricity consumption by firms and their productivity in Estonia. Through rigorous empirical analysis and the use of relevant data sources, this research will provide insights into the factors that influence the relationship between electricity consumption and firms' productivity within the Estonian context. Additionally, the study will explore potential policy implications and offer recommendations to businesses and policymakers in Estonia, focusing on enhancing energy efficiency, improving productivity, and fostering sustainable economic growth. Furthermore, assessing CO2 emissions concerning electricity consumption will underscore the significance of electricity efficiency at the firm level.

To fulfil the objective of this dissertation, a comprehensive review of existing literature will be conducted, focusing on firm performance, energy consumption, and pollution. Additionally, an examination of the environmental regulations implemented by the Estonian government will be undertaken. The origins of energy production and distribution will be thoroughly explored. Moreover, a panel data model will be constructed to analyse the specific impacts on firms, and the empirical findings will be subjected to meticulous analysis.

CERCS: S180 Economics, econometrics, economic theory, economic systems, economic policy

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[1] Electricity intensity is defined as the amount of electricity consumed as per unit of economic output (Medlock III & Soligo, 2001)

2. Literature Review

The literature review examines both theoretical and empirical studies. The theoretical approach between electricity consumption, price, availability, and firm productivity can be explained through the interplay of these factors. The availability of electricity can affect the productivity of firms. Unreliable inputs to production, particularly those that are difficult to store, can significantly limit firms' productivity, leading them to react in several ways(Fisher-Vanden et al., 2015). Better-managed firms are significantly less energy-intensive, using less energy per unit of output and concerning other factor inputs (Bloom et al., 2010). Research has identified a vast potential for energy efficiency within the manufacturing sector, which is responsible for a substantial share of global energy consumption and greenhouse gas emissions (Solnørdal & Foss, 2018). Improvement in energy efficiency is one of the main options to reduce energy demand and greenhouse gas emissions (Hochman & Timilsina, 2017). There is a significant body of economic theory regarding energy and firms' productivity, with research focusing on the availability of electricity, the reliability of inputs to production, management practices, energy efficiency, and public infrastructure investment. Sijm et al. (2012) provide a theoretical approach to examining the impact of power market structure on the pass-through of CO2 costs to electricity prices under quantity competition. They argue that in a highly competitive market, firms may be unable to pass on the increased cost of electricity to consumers, leading to reduced profitability.

Researchers have conducted numerous studies from an empirical aspect to shed light on the impact of electricity consumption on productivity. Using cross-section and panel data, many studies have revealed that electricity consumption significantly impacts firms' productivity. Empirical studies linking electricity consumption and firms' performance are generally performed on three broad topics: electricity price, electricity availability or shortage, and electricity intensity.

Sahu & Narayanan (2010) used panel data to examine the relationship between electricity consumption and firms' productivity in the Indian manufacturing sector. The study found that electricity consumption had a positive and statistically significant effect on firms' productivity. The effect was more pronounced for firms operating in small-scale and large-scale industries, meaning they found a 'U' shaped relation with firm scales. Additionally, the study establishes that both capital and labour-intensive firms are more energy-intensive and that the firm's age is positively related to energy intensity.

Abeberese (2017) examined how electricity prices affected firms' industry choices, switching to less electricity-intensive production processes and productivity growth in India. The data used was from the Indian Annual Survey of Industries from 2001 to 2008, which covered manufacturing firms. The study discovered that when electricity prices increased due to external factors, firms would switch to less electricity-intensive production processes within specific industries. They would also decrease their capital intensity, and their output and productivity growth rates would decline. This outcome implies that high electricity prices restrict a country's productivity by making firms work in sectors with fewer opportunities for increasing productivity[2]. The study utilised an instrument for electricity prices in the form of the interaction between coal prices and the proportion of thermal generation in a state's total electricity generation capacity.

Dehning et al. (2017) conducted a study using a multiple linear regression model on the factors influencing the energy intensity of automotive manufacturing plants. The study reviewed the existing literature on energy efficiency in the automotive industry and identified the most significant factors affecting energy intensity. The authors found that the plant's size, the automation level, and the production process were the most significant factors affecting energy intensity. The study also found that using renewable energy sources and energy-efficient technologies could significantly reduce energy intensity in automotive manufacturing plants. The authors concluded that combining energy-efficient technologies and renewable energy sources could help automotive manufacturers reduce their energy consumption and carbon emissions.

Access to reliable electricity has been shown to impact firms' performance positively. Several studies have demonstrated that electricity outages have a negative effect on firms' productivity, especially in Africa and among small firms whose activities depend on the availability of electric power and reliable supply of electricity translates into the higher performance of SMEs; hence efforts should be geared towards the provision of reliable electricity (Forkuoh & Li, 2015).

Xu et al. (2022) explore the effect of energy shortages on businesses in developing countries, particularly Pakistan. The study uses a sample of 424 non-financial listed companies in Pakistan over the period 2001-2017 to analyse the impact of energy crises on

[2] Firms move to less electricity-intensive production processes and reduce their capital intensity, resulting lower output and productivity growth rates.

profitability and productivity. The study employs fixed effect and generalised methods of moments as regression techniques to examine the impact of seven measures on profitability and productivity. These measures include four measures of electricity shortfall (i.e., neutral period (NP), increasing shortfall (IS), worst shortfall (WS), decreasing shortfall (DS)), energy consumption (EC), energy price (EP), and access to electricity (ATE)). The study reveals that energy crises have a negative impact on business profitability, and IS, WS, and DS significantly reduce profitability by 39%, 36%, and 33%, respectively. However, NP has a significantly positive impact on profitability, where a 1% increase in NP increases profitability by 33%. The findings of this study suggest that energy supply is a critical factor for business profitability and productivity in developing countries. This study provides policymakers with critical policy implications that can help them overcome energy crises.

Yvette et al. (2022) found that the availability of electrical energy positively affects the productivity of industrial companies in Cameroon. The study used a two-step econometric approach and firm-level cross-sectional data from the World Bank Enterprise Survey (WBES) for 2016. The first step estimates total factor productivity through the Cobb-Douglas production function, and the second step uses the (IV-2SLS) estimation method to correct both sample selection and endogeneity issues.

Using firm-level data, Arnold et al. (2008) examined the relationship between services inputs and firm productivity in Sub-Saharan Africa based on the World Bank Enterprise survey of 1000 firms. The authors argue that services inputs, such as telecommunications, electricity, transport, and finance, are essential for the region's firm productivity and economic growth. The study finds that service inputs positively and significantly impact firm productivity in Sub-Saharan Africa. Precisely, firms that generate electricity are positively linked to firms' total factor productivity, and power shortage is negatively linked. The authors suggest that policymakers should focus on improving the quality and availability of services inputs to promote regional economic growth and development. On the contrary, (Iimi, 2011) identifies infrastructure quality on business costs in Eastern Europe and Central Asia using firm-level data and argues that infrastructure quality, such as transport, telecommunications, and energy (electricity, water, gas), is essential for reducing business costs and improving economic competitiveness in the region.

Collard et al. (2005) explore the relationship between electricity consumption and information and communication technology (ICT) in the French service sector. The authors argue that the increasing use of ICT in the service sector has led to a significant increase in electricity consumption. The study provides empirical evidence from a sample of French service sector firms, which shows that the use of ICT is positively correlated with electricity consumption. The authors suggest policymakers consider ICT's impact on energy consumption when designing energy policies. Overall, the article provides valuable insights into the relationship between ICT and electricity consumption in the service sector and highlights the need for policymakers to consider the impact of technological advancements on energy consumption. The study combined two dataset electricity consumption and the diffusion of ICT capital goods from 1986 to 1998[3]. The authors use a dynamic panel approach to thoroughly combine the data's cross-section and time series dimensions and estimate the five parameters plus six sectoral-specific constant terms, accounting for fixed effects.

On the contrary, a pertinent argument pertains to the relationship between CO2 emissions and firms' performance. Several studies contend that imposing restrictions on firms' greenhouse gas emissions and CO2 output could potentially exert a detrimental impact on firms' productivity. Conversely, an opposing viewpoint suggests that the limitation of emissions acts as a catalyst for advancing green technologies (Alvarez, 2012). Meanwhile, the Estonian Environmental Board set annual emission permits for a single year for emission sources according to Regulation No 67(*Air Pollution Permit and Annual Report | Keskkonnaamet*, 2016). While the EU has introduced the emission of Green House Gas (GHS) trading system, European Union Emissions Trading System (EU ETS), for the industry sector. Chan et al. (2013), using panel data analysis based on 5873 firms in 10 European countries during 2001-2009, explore that the EU ETS regime saw an increase in material cost by 5% to 8% in construction sectors. However, the revenue of that sector was not affected by the increase in material costs, suggesting the cost might be channelled to the customer side. However, there was a positive effect on the power sector's material costs and revenue.

On the other hand, policy stringency would promote cleaner innovation. It is evident that innovation for greener technology promotes firms' performance in the EU area. Data from 44,647 firms from 13 European countries shows that green innovation positively impacts firms' turnover and performance (Madaleno et al., 2020).

[3] The detailed sector-based electricity consumption data is collected from Centre for Economic Studies and Research on Energy (CEREN) and disaggregated level ICT data is collected from e French National Statistical Institute (INSEE)

Based on the existing literature, this study formulates the hypothesis that a relationship exists between electricity consumption and firms' productivity. This association can exhibit either a negative or positive correlation depending on the selected factor productivity and the electricity intensity of production within firms. However, considering the specific production scenario of Estonia, it is also suggested that the electricity consumption of Estonian firms is positively linked to CO2 emissions.

Table 1

Short description of key literature

Author	**Name**	**Small Description**	**Data & Method**
Bloom et al. (2010).	Modern Management: Good for the Environment or Just Hot Air?	Better-managed firms are significantly more productive and have less energy-intensive emissions.	Gross output, Management score, labour, capital, deflated expenditure on nonenergy intermediate inputs (materials) and deflated energy expenditure of
Hochman & Timilsina (2017)	Energy efficiency barriers in commercial and industrial firms in Ukraine: An empirical analysis	Energy efficiency will reduce greenhouse gas emissions. Results from 509 industrial and commercial firms from Ukraine show behavioural barriers resulted in obstacles to adopting energy-efficient technologies.	Generalised ordered logit model
Yvette et al. (2022)	Electric Power Availability and Productivity of Industrial Enterprises in Cameroon	The availability of electrical energy positively affects the productivity of industrial companies in Cameroon.	Two-step firm-level cross-section analysis
Ito et al. (2012)	The Choice of an Invoicing Currency by Globally Operating Firms: A Firm-Level Analysis	The availability of electricity can affect firms' productivity, and unreliable inputs to production can significantly limit firms' productivity	23 representative Japanese firms

	of Japanese Exporters		
Sahu & Narayanan (2010)	Determinants of Energy Intensity in Indian Manufacturing Industries: A Firm-Level Analysis	Electricity consumption had a positive and statistically significant effect on firms' productivity, and a firm's age is positively related to energy intensity.	Multiple regression model of 28,120 observations
Madaleno et al. (2020)	Eco-innovation and firm performance in European high energy consumers and polluting sectors	44,647 firm from 13 European countries shows that green innovation has a positive impact on firms' turnover as well as performance	Cross-section econometric techniques
Chan et al. (2013).	Firm competitiveness and the European Union emissions trading scheme	EU ETS regime saw an increase in material cost by 5% to 8% in the construction sector. Revenue is not affected in the construction sector.	Panel data analysis based on 5873 firms in 10 European countries during 2001-2009

Source: author's analysis

3. Data and Methodology

Based on the discussion of empirical studies and the introduction presented in this paper, it is evident that electricity consumption plays a vital role in positively influencing firms' productivity. The availability of uninterrupted and cost-effective energy is crucial for facilitating efficient and effective operations within firms. Additionally, electricity consumption serves as a significant input for numerous industries, suggesting the existence of a positive correlation between electricity consumption and firms' productivity. However, it is important to acknowledge that this relationship may not be applicable universally across all industries, as certain sectors may exhibit lower dependence on electricity or may encounter other constraints that impede their productivity. In order to provide further insights into the situation of Estonian firms, this dissertation endeavours to establish a relationship between productivity and electricity consumption within this specific context.

Besides, higher electricity consumption by the firms can lead to more environmental pollution. Electricity generation from fossil fuels is a major source of greenhouse gas emissions as well as CO2 emissions (Jiang et al., 2014). Moreover, firms that are more productive may also be more likely to emit higher levels of CO2. But the relation may not always be significant. The literature reviewed in the previous section suggests that productivity does not always increase CO2 emissions. So, after exploring the firms' productivity, annual electricity consumption and firms' productivity impact on CO2 emission will be explored.

Based on the literature and the data structure of this dissertation, panel data analysis is appropriate for this study. Several types of panel data analysis exist, including pooled OLS, fixed effect, random effect, between effect, and first difference (Allison, 1994; Balestra & Nerlove, 1966; Greene, 2004). Based on the test, this paper will identify the appropriate models from the Pooled OLS, Fixed Effect and Random Effect models and explain the result accordingly.

3.1 Data

To investigate the association between firms' annual electricity consumption and productivity, the annual electricity consumption data of Estonian firms were collected for the period from 2017 to 2021. The consumption data is measured in megawatts per hour (MWh). A total of around 5,000 company consumption data points were initially gathered, which were then compared with the firms' financial data obtained from the Estonian Business Registry.

After cleaning the dataset to handle missing data, outliers, and anomalies, the number of firms remaining for analysis amounted to 1,740. These firms have appeared in the sample for at least one year. Specifically, in the year 2021, the dataset includes data from 1,473 firms. It is important to note that the total number of enterprises in Estonia is estimated to be around 127,357, and these enterprises collectively generated a turnover of approximately 79.90 billion euros, with a profit of 7.94 billion euros in 2021. Moreover, the enterprises contributed 0.19 billion euros in taxes during the same year (*Financial Statistics of Enterprises | Statistikaamet*, n.d.).

In contrast, within the research dataset, the annual turnover in 2021 is observed to be 4.31 billion euros (adjusted to CPI), representing about 5.39% of the total turnover generated by all Estonian enterprises. This discrepancy can be attributed to two possible explanations. Firstly, some firms in Estonia may not have a direct contract with electricity providers and instead include electricity costs as part of their rental expenses. Secondly, it is plausible that many small and micro firms are categorized as household clients and have contracts tailored accordingly.

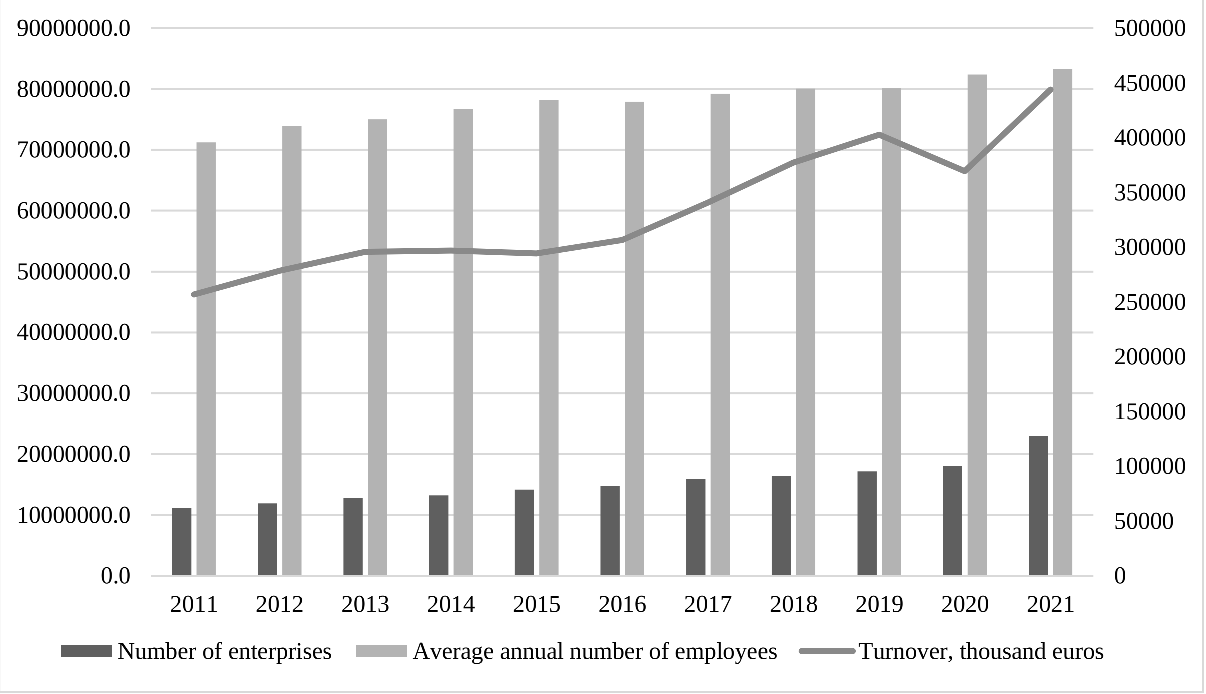

Figure 1. Estonian enterprises' key financial data over the period.

Source: (*Financial Statistics of Enterprises | Statistikaamet*, n.d.)

The average electricity price in 2021 was 91.01 euros per MWh. Including grid losses, the electricity consumption in 2020 was 8.44 TWh (*Electricity Consumption and Production | Elering*, 2021). On the other hand, the observed firms consumed 0.84 TWh in 2020, around 19.95% of total Estonian electricity consumption (including household and business).

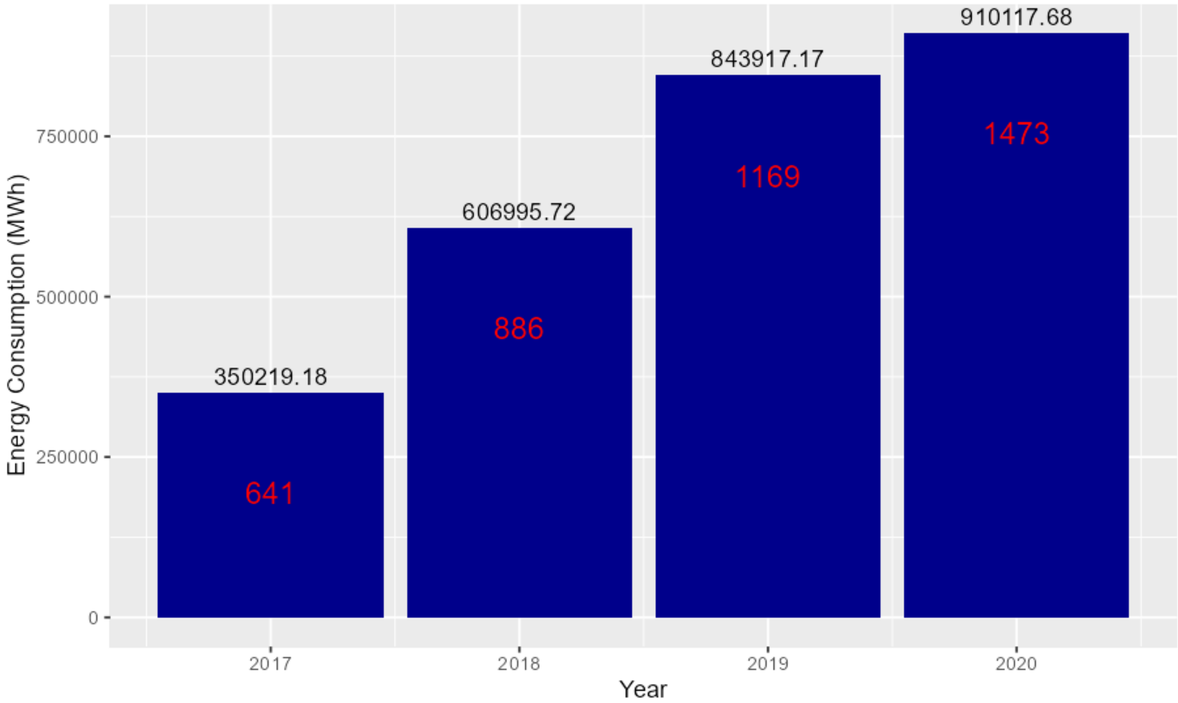

Figure 2. Annual electricity consumption and number of firms in the data set

The first model is built by constructing a relation between electricity and firms' productivity, where firms' productivity is taken as the dependent variable. Generally, firms' productivity means the ratio between output and input (OECD, 2023). This study calculates productivity mainly in three ways. Based on the study of (Xu et al., 2022), the first productivity variable is defined by taking the ratio of total sales and total assets (ATO).

The other two productivity variables are defined as labour productivity – one is the ratio between total sales and the number of employees the other is labour productivity based on value-added per unit of input. That means subtracting total sales from the cost of intermediate inputs and dividing by the number of employees.

The study incorporates control variables from two aspects: inside firm data and year dummies. Year dummies are included as control variables to capture the business cycle and macroeconomic phenomena. Inside the firm, the study takes leverage, liquidity and firm size (proxied by total assets) (Xu et al., 2022). Furthermore, the industry of the firm is considered by utilizing the two-digit classification of The Estonian Classification of Economic Activities (EMTAK) code. This allows for examining how the relationship between electricity consumption and performance may vary across different industries. Additionally, location dummies are included to capture the geographical location of the firms.

Table 2

Description of the variables

Name	Description	Source	Sign
	Dependent Variable		
ATO	The ratio between annual sales to total assets	Estonian Business Registry	+
Labour Productivity	The ratio between annual sales to the number of employees		+
Value added productivity	The ratio between value added to the number of employees		-
	Independent Variable		
Annual Electricity Consumption	Natural logarithm of Total annual electricity consumption by each firm	Eesti Energia	+
	Control Variable (Inside firm)		
Leverage	The ratio of total liabilities to total asset	Estonian Business Registry	+
Firm Size	Natural logarithm of Total Assets		-
Liquidity	The ratio of current assets to current liabilities		-
Agriculture	Firms' sector		-
Manufacturing	dummy variables (Service as the base sector)		+
Construction			+/-
Location dummies	The south region is considered the base region		…
	Year dummies		
	Dummy variables (The year 2017 as the base year)	From sample	

Source: author's estimation

The study can account for potential regional differences by considering the firms' locations. The firms' locations are divided into four regions in Estonia:

1. Harju: This region includes Harju County and the capital of Estonia, Tallinn
2. North: This region includes Järva County, Lääne-Viru County, and Rapla County.
3. East: This region includes Ida-Viru County.
4. West: This region includes Hiiu County, Pärnu County, Lääne County, and Saare County.
5. South: This region includes Jõgeva County, Põlva County, Tartu County, Valga County, Viljandi County, and Võru County.

Some variables are converted to natural logarithms, and some are taken as the ratio of two variables. On the other hand, many values consist of zero, and it is theoretically impossible to apply natural logarithms to them. Moreover, the ratio will become inconsistent if either numerator or denominator is zero. In this regard, for the numerical variable, 1 is added to avoid having a variable with a value of zero. Moreover, all the financial data are in nominal terms converted to real terms using the yearly average consumer price index (CPI) from Statistics Estonia.

A generalized model was formed, taking productivity as the dependent variable.

Productivity model -

$$y = \alpha_i + \beta_1 \ln{(annual\ consumption)}_{i,t} + \beta_2\ leverage_{i,t} + \beta_3 \ln{(total\ assets)}_{i,t} + \beta_4\ liquidity_{i,t} + \beta_{5,6,7,8} \text{ location dummies}_{i,t} + \beta_9\ manufacturing_{i,t} + \beta_{10}\ agriculture_{i,t} + \beta_{11}\ construction_{i,t} + \varepsilon_{i,t}$$

Here,

y — productivity

α — unobserved constant heterogeneity for the fixed effect model, random for the random effect model and absent in the case of pooled OLS

β — coefficients

i — individual firms; 1, 2, ………, 1740

t — time period; 2017 - 202 1

Before applying the models, it is imperative to conduct an examination of the correlation among the independent variables. This analysis serves to assess the strength and direction of the relationships between the different predictor variables, allowing us to identify potential multicollinearity issues.

Table 3

Correlation between independent variables

	ln(consumption)	leverage	liquidity	ln(totassets)
ln(consumption)	1.0000000			
leverage	0.1298520	1.0000000		
liquidity	-0.0381390	-0.2567177	1.00000000	
ln(totassets)	0.4144453	0.1623860	-0.08429056	1.00000000

Source: author's estimation

The table presents the results of the correlation analysis conducted on the numerical independent variables. It reveals that the annual electricity consumption is not significantly correlated with any of the other independent variables, except for the natural logarithm of total assets. However, the correlation between electricity consumption and total assets is not strong enough to justify excluding the variable in the model.

Furthermore, the analysis shows that there is no significant correlation among the firms' variables themselves.

In the second model, CO2 emissions are considered as the dependent variable, with annual electricity consumption as the key independent variable. Additionally, firm size, total sales to CO2 emissions and value-added per unit of CO2 emission are taken as control variables. Based on the availability of the data, a total of 218 firms' CO2 emissions in kilotons from 2019 to 2021 are explored in the aspect of annual electricity consumption and productivity.

CO2 model -

$$\begin{aligned} \ln(y) = \alpha_i &+ \beta_1 \ln(annual\ consumption)_{i,t} + \beta_2\ sales\ to\ CO2\ emission_{i,t} \\ &+ \beta_3 \ln(total\ assets)_{i,t} + \beta_4\ value\ added\ per\ unit\ of\ CO2\ emission_{i,t} \\ &+ \beta_8\ manufacturing_{i,t} + \beta_9\ agriculture_{i,t} + \beta_{11}\ construction_{i,t} + \varepsilon_{i,t} \end{aligned}$$

Here,

y = natural logarithm of CO2 emission (kt)

i = individual firms; 1, 2, ………, 218

t = time period; 2019 – 2021

Table 6 presents the results of the correlation analysis among the independent variables. Based on these results, it is suggested that all desired independent variables can be retained in the analysis, as there are no significant correlations among them. This implies that the selected independent variables are not strongly interrelated, allowing for their inclusion in the model without concerns of multicollinearity.

Table 4

Correlation among the independent variables for the CO2 emission model

	sales to co2	value added per co2	ln(consumption)	ln(totassets)
sales to co2	1.00000000			
value added per co2	0.55104027	1.0000000		
ln(consumption)	-0.03406131	-0.1424551	1.00000000	
ln(totassets)	-0.08803292	-0.1349152	0.48573319	1.00000000

Source: author's estimation

3.2 Descriptive analysis

In this sub-section, the main focus lies in examining the kernel density plots of the key independent variable, which is annual electricity consumption, as well as three dependent variables related to productivity. Additionally, the analysis also includes a kernel density plot of CO2 emissions. By visually exploring the kernel density plots, this paper aims to understand the shape of the distributions, identify potential outliers or clusters, and gain insights into the variability of the variables. This information proves valuable in various scenarios, such as comparing different companies' performance or assessing businesses' financial health.

Furthermore, this study measures electricity efficiency by calculating the ratio of annual total sales to annual electricity consumption. Descriptive analysis is conducted to gain an understanding of the efficiency levels among the sampled firms

3.2.1 Kernel Density Plot

Kernel density estimation is a non-parametric method utilized to estimate the PDF of a random variable using a set of observations. In this analysis, the plots are constructed using the natural logarithms of the variables. Any identified outliers are removed, specifically the top 10% and bottom 10% of the data points.

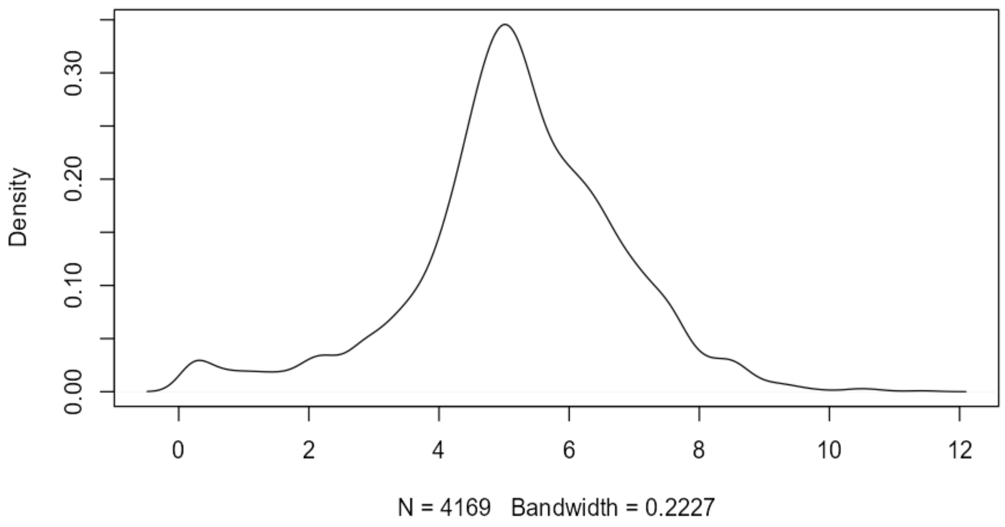

Figure 3. Kernal density plot of the natural logarithm of annual electricity consumption

Source: author's estimation

From Figure 3, we can see that the annual electricity consumption exhibits close to normal distribution behaviour. However, there are some small anomalies in the consumption pattern of sampled firms.

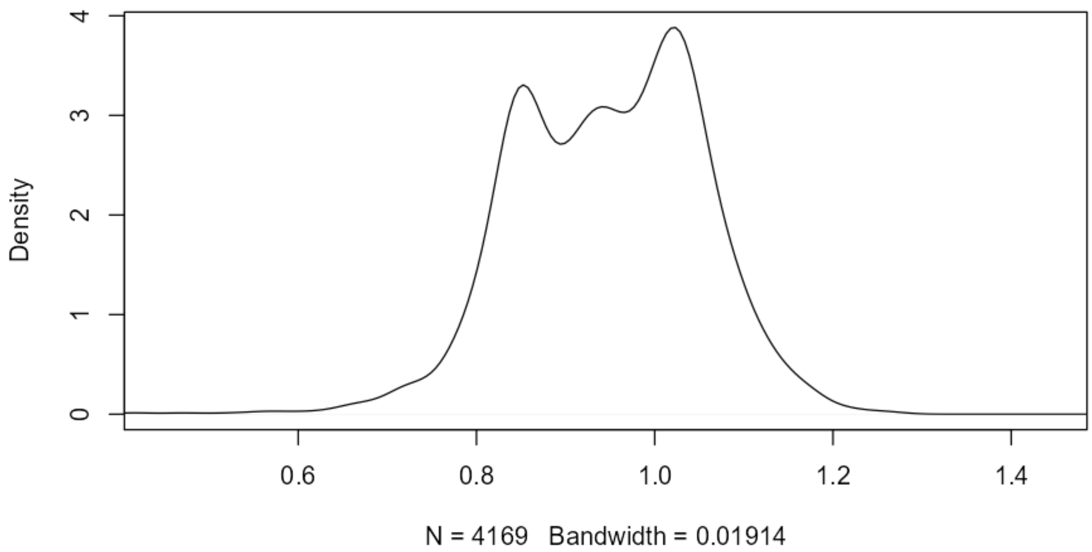

Figure 4. Kernal density plot of ATO

Figure 4 presents the kernel density plot of the sales to assets ratio. The presence of three waves in the kernel density plot of firm productivity over five years suggests that the productivity distribution is not unimodal but rather exhibits multiple distinct groups or patterns. The waves could potentially reflect different phases of the business cycle, sector-specific dynamics, firm heterogeneity, or policy/intervention effects. Domain-specific knowledge, such as economic indicators over the period, sector-specific trends, firm characteristics (firm size, market position, technological advancements, management practices) and policy changes, may present the observed patterns.

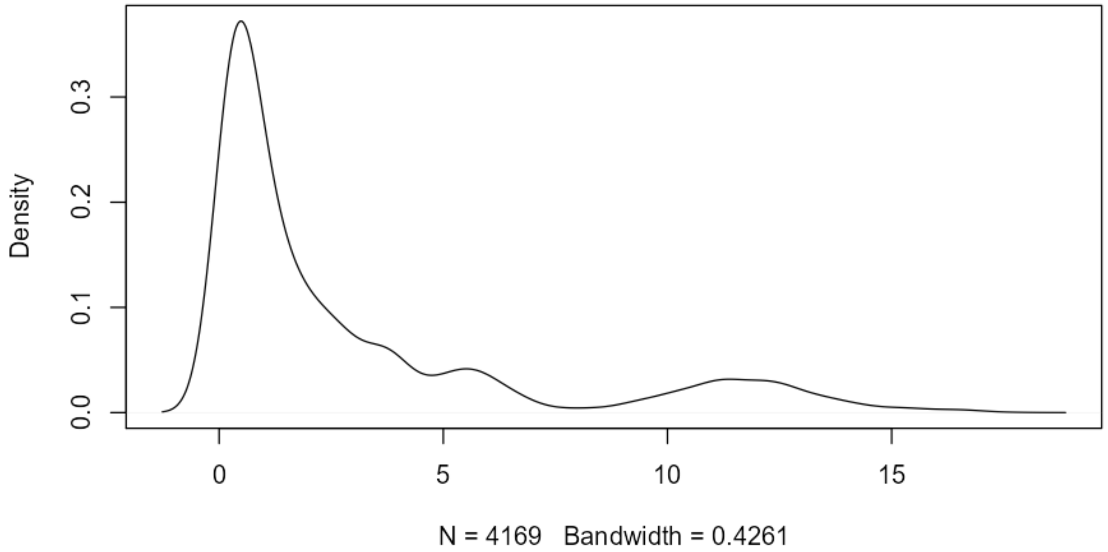

Figure 5. Kernal density plot of labour productivity

Figure 5 displays labour productivity, revealing that the median value is relatively low while the mean value is high. This disparity between the median and mean suggests the presence of skill differences across firms and the potential concentration of productivity among a subset of firms.

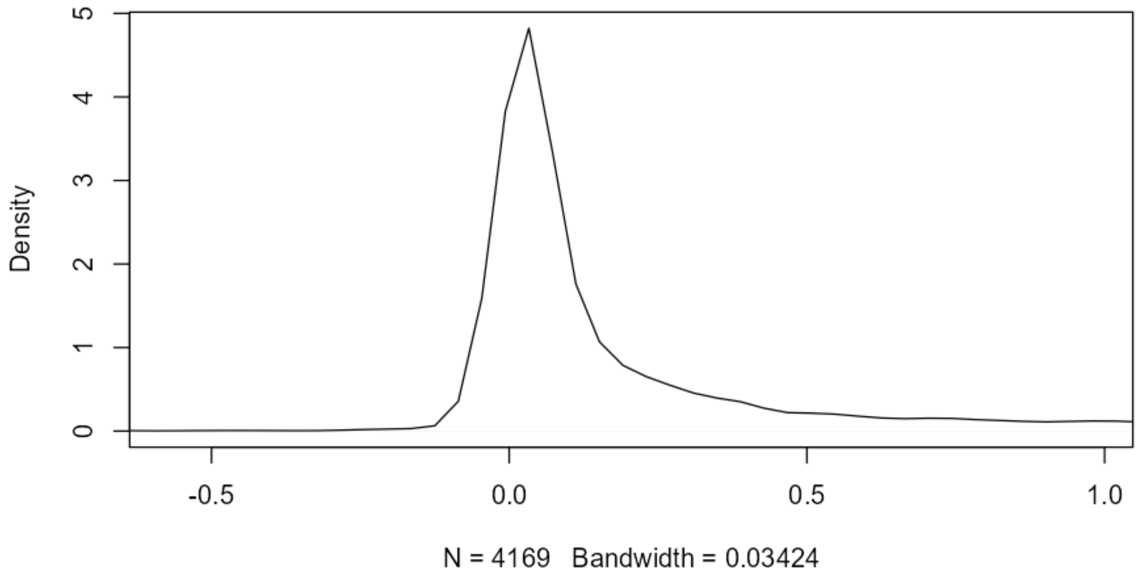

Figure 6. Kernal density plot of value-added productivity

The kernel density plot of value-added productivity exhibits a sharper spike, which suggests the presence of a specific mode or peak in the data. The spike could represent a group of highly productive firms or technological advancements.

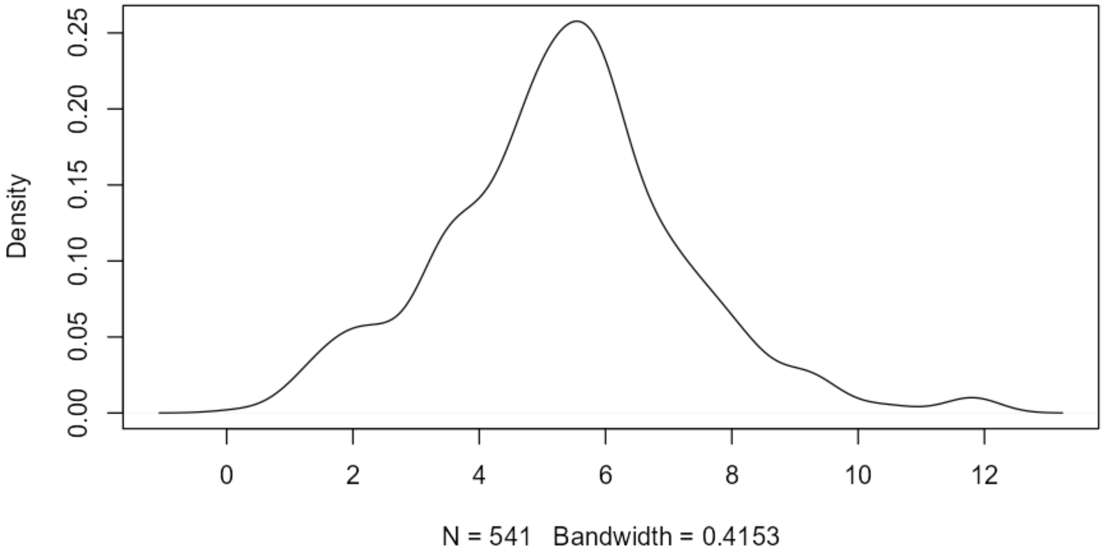

Figure 7. Kernal density plot of CO2 emission

In contrast, the kernel density plot of CO2 (figure 7) emissions demonstrates a distribution that is close to normal, albeit slightly left-skewed. This skewness may suggest ongoing efforts to reduce CO2 emissions, which could be attributed to factors such as regulatory measures, technological advancements, and the transition towards greener energy sources.

3.2.2 Electricity Efficiency

Table 5 reveals the descriptive statistics which are compared throughout the firms' sector.

Table 5

Electricity efficiency descriptive statistics

Sector	Mean	Median	SD
agriculture	4.22	2.49	7.70
construction	5.54	2.77	11.88
manufacturing	3.39	2.40	6.75
service	3.40	2.37	6.07
overall	3.56	2.4	6.67
Industry-Wide (Lyubich et al., 2018)	4.16		0.94

Source: author's estimation

The data presented in the table indicates that firms operating in the construction industry have lower energy intensity levels compared to those in the service and manufacturing sectors. Conversely, businesses in the service and manufacturing sectors demonstrate higher energy intensity levels. The overall mean energy efficiency across all sectors appears to be relatively low. This observation can be attributed to the broad categorization of sectors and the prevalence of numerous small-scale firms. Additionally, it is noteworthy that the construction sector may have larger annual sales values compared to the service industry, which likely contributes to the observed differences in energy intensity levels across sectors.

Furthermore, it is interesting to note that the agricultural sector, being less machine-intensive, tends to have higher electricity efficiency compared to other sectors.

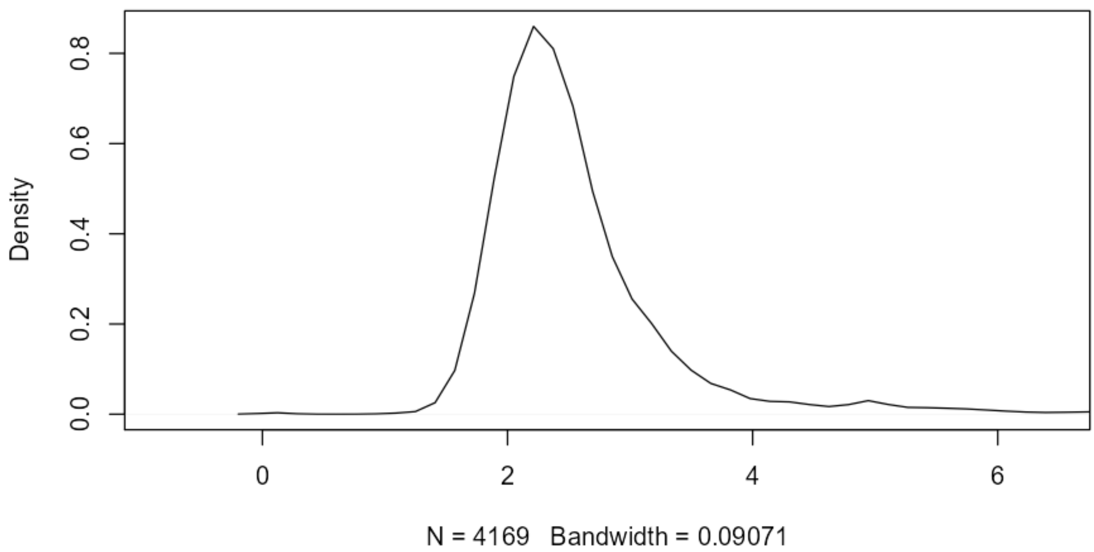

Figure 8. Kernal density plot of electricity efficiency

The figure depicts the electricity efficiency is left-skewed, suggesting the larger concentration of observations on the higher end of the electricity efficiency scale

4. Empirical Analysis

This study employs three regression models, namely, Pooled Ordinary Least Squares (OLS), Fixed Effect, and Random Effects, to investigate the relationship between productivity and various independent variables.

The current study runs three models for three productivity variables. The Hausman test result and the F statistics for the individual effect suggest that the fixed effect model is appropriate for all three dependent variables (Baltagi, 2021). (Details tables are in the APPENDIX A)

To check the robustness of the estimated model, a set of post-test diagnostic tests is conducted for all three estimated fixed effect models. As panel data analysis is utilized in this study, three primary diagnostic tests are employed, namely, Heteroscedasticity, Serial Correlation, and Cross-Section Dependence. The Breusch-Pagan test is used to detect heteroscedasticity, which tests whether the variance of residuals is constant across observations. The Breusch-Godfrey test is used to test for Serial Correlation of residuals, which tests whether the residuals are correlated with their lagged values. The Breusch-Pagan LM test is used to detect Cross-Section Dependence, which examines whether the residuals are correlated across different individuals or groups in the panel. If any of these tests result in significance, it suggests a violation of assumptions and may lead to biased and inconsistent estimates (Breusch & Pagan, 1980).

From the diagnostic test, all three models' residuals are not homoscedastic and serially correlated. Moreover, there is a presence of cross-section dependence. Overall, all three assumptions are violated for the fixed effect model (The details tables are in the appendix).

In this regard, N is larger than T in the panel data, so we can use heteroscedasticity-consistent standard errors. The most popular method under this is MacKinnon-White's method, where the cluster-robust variance estimator adjusts the standard errors of the coefficients to account for the clustering of the errors. Usually, one needs to group the observations into clusters based on some common characteristic. Then, the cluster-robust standard error estimation method, which accounts for the within-cluster correlation of the errors, can be applied. However, It is done in the present study directly through statistical software, and the model equation remains the same as the fixed effect model. Clustering occurs when observations within a group (or cluster) are more similar to each other than to observations in other groups. However, this can lead to an underestimation of the true standard errors. More importantly, the method corrects the cross-section dependence considering the presence of heteroscedasticity and autocorrelation among the residuals (Hoechle, 2007).

Table 6

Estimated coefficient with heteroscedasticity-consistent standard error

Coefficient (SD)	**ATO**	**Labor Productivity**	**Value added productivity**
ln(consumption)	0.06748180 ***	0.0339231**	-0.0073506
	(0.01970941)	(0. 0151267)	(0.0114628)
leverage	0.05093428*	-2.9087039***	0.6293800**
	(0.0256512)	(1.0061570)	(0.2920985)
liquidity	-0.00080987	0.0089185*	0.0199680
	(0.00114400)	(0.0270549)	(0.0183836)
ln(totassets)	-0.07521945**	0.1055238	0.1167232*
	(0.0012553)	(0.1444696)	(0.0583166)
harju	-0.00392687	-0.6191933	-0.0753703
	(0.01115388)	(0.7670998)	(0.0884744)
north	0.00036131	0.9689130	0.1064110
	(0.01224995)	(1.0172147)	(0.1128061)

Significant codes: *p<0.1; **p<0.05; ***p<0.01

Source: author's estimation

The results are discussed in the following section.

4.1 Results for Productivity Variable

Based on the regression analysis with clustered robust standard errors, it can be concluded that there is a positive association between annual electricity consumption and the ratio of total sales to total assets (ATO). At a significance level of 1%, it is observed that a 1% increase in average annual electricity consumption leads to a 0.0006 unit increase in the annual average ATO. Although the magnitude of the linkage appears to be small, it is important to note that the use of the dependent variable as the ratio of total sales to total assets. The control variables have both positive and negative associations with the dependent variable. Concerning the firm financial variable, if the average leverage increases by 1 unit, the average annual ATO increase by 0.35 unit. The firm size has a negative association with ATO, which means more the total assets less the ratio of total sales and total assets (ATO).

The model used in the analysis may not capture the differential effects of different sectors on the ratio of total sales to total assets (ATO). However, the pooled OLS model suggests that transitioning from the service sector to another sector is associated with an increase in ATO. Additionally, the firms' location does not appear to be significant. This lack of significance could be due to the fact that many firms have multiple branches located in different regions, leading to a dilution of the location effect in the analysis.

On the other hand, when examining labour productivity in terms of the ratio of total sales to the total number of employees, the results indicate a contrasting relationship. A 1% increase in average annual electricity consumption is associated with a 0.0003 unit increase in labour productivity. This suggests that higher energy consumption may lead to more energy-intensive production processes, resulting in increased labour productivity.

Furthermore, the analysis reveals a negative link between labour productivity and leverage. Excessive leverage can create financial constraints for companies, potentially leading to financial distress and a decline in labour productivity. This highlights the importance of managing leverage levels effectively to maintain optimal productivity levels within firms.

In contrast to the previous analysis, the current findings indicate no significant relationship between labour productivity, measured in terms of value added per unit, and average annual electricity consumption. While there is a negative linkage observed, it is important to consider that this negative association may be attributed to factors such as an increase in raw materials that require higher electricity consumption. Consequently, this could potentially lead to a decrease in labour productivity. It is crucial to interpret these results in the context of the specific industry or sector being examined, as the impact of electricity consumption on labour productivity can vary across different settings.

In addition, the pooled OLS model suggests that shifting from the service sector to any other sector is associated with a decline in labour productivity.

The negative association between electricity consumption and leverage or liquidity may be explained by the higher fixed costs associated with electricity consumption, which can limit a firm's flexibility in terms of managing its finances.

4.2 Empirical analysis for CO2 model

This study expands its analysis by introducing carbon dioxide (CO2) emissions as a dependent variable in the model, aiming to comprehensively investigate the impact of electricity consumption on environmental performance. The inclusion of CO2 emissions allows for an exploration of the relationship between electricity consumption and air pollution. Additionally, the study incorporates variables such as total sales to CO2 emissions and value-added per CO2 emissions.

CO2 emissions are utilized as a proxy for air pollution in this study due to their significant contribution to global warming and their status as a major air pollutant. By examining the relationship between CO2 emissions and productivity, the study aims to determine the extent to which productivity gains come at the expense of environmental degradation. Similar to previous models, panel models have been estimated to analyze the relationship between productivity, electricity consumption, and CO2 emissions.

Our analysis suggests that the random effect model is not appropriate for this study, and we have thus limited our estimations to the pooled OLS and fixed effect models. Based on the F-test results, the fixed effect model is deemed to be the most appropriate for our analysis. However, post-test diagnostics have indicated that the model requires the application of cluster-robust standard error methods, like the productivity model (Details in the APPENDIX B)

Table 7

Estimation of coefficient including pollution variable

	Coefficient	Standard Error	P Value
ln(consumption)	0.0292059*	0.0142143	0.05744
ln(totassets)	0.1306078	0.1046636	0.21517
sales to co2	-0.0731516***	0.0058229	0.00000
value added per co2	0.2700875**	0.1302015	0.04078

Significant codes: *p<0.1; **p<0.05; ***p<0.01

Source: author's estimation

The estimation results indicate that an increase in annual electricity consumption at the firm level is associated with a corresponding increase in CO2 emissions. Specifically, at a 10% significance level, a 1% increase in electricity consumption is estimated to result in approximately a 0.03% increase in CO2 emissions. This suggests that higher electricity consumption contributes to higher levels of CO2 emissions.

Furthermore, the analysis reveals that an increase in sales per CO2 emission is associated with a decrease in average firm-level CO2 emissions. This implies that firms with higher sales relative to their CO2 emissions tend to have lower overall CO2 emissions, indicating a more efficient use of resources and energy in their production processes.

However, it is noteworthy that the analysis finds a positive association between value added per unit of CO2 emission and average CO2 emissions. This suggests that reducing intermediary input costs, such as using lower-cost raw materials, may lead to an increase in CO2 emissions. This observation can be explained by the fact that low-cost raw materials may have a higher carbon footprint, resulting in higher emissions during the production process

Conclusion

The study explores the impact of annual electricity consumption on firms' performance based on Estonian firm-level data. Three types of firms' productivity, ATO, Labour productivity in terms of the number of employees and value-added per employee, are considered to indicate the firms' performance. For this purpose, the study uses 1,740 Estonian firms' data over the period from 2017 to 2021. Also, the current study wants to see the effect on the environment due to electricity consumption. For this purpose, the CO2 emission data for 218 firms over the 2019 to 2021 period is explored. The study combines firm-level data from Estonia with measures of productivity and CO2 emissions to examine the relationship between electricity consumption, firms' performance, and environmental impact. By conducting this analysis, the study contributes to our understanding of the effects of electricity consumption on both economic and environmental aspects of firms' operations.

The results of the analysis indicate that firms in Estonia tend to exhibit better performance, as measured by ATO, when they consume higher levels of annual electricity. This suggests a positive association between electricity consumption and firm performance in terms of efficiency and productivity. Similarly, the findings suggest a positive linkage between annual electricity consumption and labour productivity. This implies that higher electricity consumption is associated with higher levels of labour productivity, indicating a potential relationship between energy usage and workforce efficiency.

However, it is worth noting that when measuring productivity in terms of labour value added per unit of output (total sales), there is an insignificant negative association between electricity consumption and labour productivity. This may be explained by the fact that electricity cost is considered one of the input costs, and an increase in material costs, which may be associated with higher electricity consumption, could potentially lead to a decrease in labour productivity.

These results highlight the importance of considering different productivity measures and their relationship with electricity consumption. The findings suggest that while overall firm performance and labour productivity may benefit from higher electricity consumption, the specific impact on labour productivity can be influenced by factors such as input costs and resource utilization.

The analysis reveals a positive impact of electricity consumption on CO2 emissions, indicating that higher electricity consumption is associated with increased CO2 emissions in Estonia. This finding can be attributed to the country's heavy reliance on oil shale and fossil fuels for electricity production, which are known to be significant contributors to CO2 emissions.

On the other hand, the results indicate a negative relationship between sales of CO2 emission and CO2 emissions. This suggests that firms with higher sales relative to their CO2 emissions tend to have lower overall CO2 emissions. This finding highlights the potential for green technology advancements and more sustainable business practices to contribute to reducing environmental pollution, as firms that achieve higher sales while minimizing their CO2 emissions are operating in a more environmentally friendly manner.

These findings underscore the importance of transitioning towards greener and more sustainable energy sources and technologies to mitigate the impact of electricity consumption on CO2 emissions. By embracing and implementing green technology advancements, firms can reduce their environmental footprint and contribute to a more sustainable future.

Overall, our results suggest that policymakers and industry practitioners in Estonia should prioritize adopting green technologies and energy-efficient practices to promote sustainable economic growth while mitigating the negative environmental impacts of industrial activity. By reducing electricity consumption and promoting sustainable production practices, firms can significantly reduce their carbon footprints and contribute to global efforts to mitigate climate change. Moreover, the EU ETS may not affect the firms' productivity. Instead, it promotes green technology advancement.

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APPENDIX A

Tables and Results of Initial panel model estimation for the productivity variables

Table A8

Model Estimation for the Sales to Assets Ratio

	Pooled OLS	Fixed Effects	Random Effects
ln(consumption)	0.014***	0.007***	0.010***
	(0.001)	(0.001)	(0.001)
leverage	0.244***	0.051**	0.117***
	(0.018)	(0.025)	(0.019)
liquidity	-0.022***	-0.075***	-0.029***
	(0.001)	(0.003)	(0.001)
ln(totassets)	-0.022***	-0.075***	-0.029***
	(0.001)	(0.003)	(0.001)
manufacturing	-0.069***		0.077***
	(0.004)		(0.007)
agriculture	0.016***		0.025***
	(0.005)		(0.008)
construction	0.032***		0.033**
	(0.009)		(0.013)
harju	-0.007*	-0.001	
	(0.004)	(0.036)	
north	0.008	0.0004	
	(0.005)	(0.039)	
east	0.010		
	(0.009)		
west	-0.015***		
	(0.005)		
Constant	0.954***		1.163***
	(0.020)		(0.023)
yr18	0.001	0.002	
	(0.005)	(0.002)	
yr19	0.001		
	(0.005)		
yr20	-0.008*	-0.005*	
	(0.004)	(0.003)	
R2	0.191	0.190	0.659
Adjusted R2	0.189	0.183	0.658
Hausman Test			
Chi-square = 395.12	p-value < 0.0000	alternative hypothesis: one model is inconsistent	
F test for individual effects			
F = 12.163	p-value < 0.0000	alternative hypothesis: significant effects	

Note: *p<0.1; **p<0.05; ***p<0.01

Source: author's estimation

Table A9

Diagnostic Test for the Sales to Assets Ratio

Heteroscedasticity: Breusch-Pagan test		
BP = 949	p-value < 0.0000	H1 ensures that the residuals are heteroscedastic.
Serial Correlation: Breusch-Godfrey/Wooldridge test		
chisq = 178.09	p-value < 0.0000	H1 indicates the presence of serial correlation of residuals
Cross-sectional dependence: Pesaran CD test for		
z = 19.862	p-value < 0.0000	H1: There is presence of cross section dependence

Source: author’s estimation

Table A10

Model Estimation for the Sales to Number of Employees Ratio

	Pooled OLS	**Fixed Effects**	**Random Effects**
ln(consumption)	0.223*** (0.039)	0.034*** (0.014)	0.103*** (0.035)
leverage	0.752 (0.637)	-2.909** (0.886)	-1.705*** (0.645)
liquidity	-0.008 (0.055)	-0.009 (0.040)	-0.003 (0.037)
ln(totassets)	-0.030 (0.038)	-0.106 (0.121)	-0.042 (0.049)
manufacturing	-2.160*** (0.161)		-2.47*** (0.233)
agriculture	-1.486*** (0.192)		-1.770*** (0.283)
construction	-0.966*** (0.319)		-1.109** (0.468)
harju	0.962*** (0.145)	-0.619 (1.294)	
north	-0.688*** (0.145)	0.969 (1.406)	
east	-1.081*** (0.194)		
west	-0.252 (0.192)		
Constant	4.051*** (0.726)		6.366*** (0.808)
yr18	-0.038*** (0.009)		
yr19	-0.010** (0.005)		
yr20	0.061*** (0.004)	0.003 (0.033)	
R2	0.104	0.091	0.057
Adjusted R2	0.101	0.078	0.056
Hausman Test			

Chi-square = 12.247	p-value < 0.0000	alternative hypothesis: significant effects
F test for individual effects		
F = 12.168	p-value < 0.0000	alternative hypothesis: significant effects

Note: *p<0.1; **p<0.05; ***p<0.01
Source: author's estimation

Table A11

Diagnostic Test for the Sales to Number of Employees Ratio

Heteroscedasticity: Breusch-Pagan test		
BP = 675.07	p-value < 0.0000	H1 ensures that the residuals are heteroscedastic.
Serial Correlation: Breusch-Godfrey/Wooldridge test		
chisq = 331.34	p-value < 0.0000	H1 indicates the presence of serial correlation of residuals
Cross-sectional dependence: Pesaran CD test for		
z = 177.68	p-value < 0.0000	H1: There is presence of cross section dependence

Source: author's estimation

Table A12

Model Estimation for the Value Added per Employee

	Pooled OLS	**Fixed Effects**	**Random Effects**
ln(consumption)	-0.044*** (0.011)	-0.007 (0.015)	-0.032*** (0.011)
leverage	-0.434** (0.172)	0.629** (0.308)	0.050 (0.199)
liquidity	-0.026* (0.015)	0.020 (0.014)	0.020 (0.013)
ln(totassets)	0.015 (0.010)	0.117*** (0.042)	0.022*** (0.014)
manufacturing	-0.374*** (0.044)		-0.447*** (0.062)
agriculture	-0.361*** (0.052)		-0.439*** (0.075)
construction	-0.287*** (0.086)		-0.331** (0.125)
harju	0.109*** (0.039)	-0.075 (0.450)	
north	-0.130** (0.052)	0.106 (0.489)	
east	-0.200 (0.088)		
west	-0.010 (0.052)		
Constant	0.841*** (0.196)		0.318 (0.236)
yr18	-0.024 (0.051)	-0.003 (0.030)	

yr19	-0.002	0.004	
	(0.049)	(0.030)	
yr20	-0.013***	-0.014	
	(0.047)	(0.032)	
R2	0.050	0.071	0.027
Adjusted R2	0.047	0.053	0.025
Hausman Test			
Chi-square = 12.247	p-value < 0.0000	alternative hypothesis: significant effects	
F test for individual effects			
F = 12.168	p-value < 0.0000	alternative hypothesis: significant effects	

Note: *p<0.1; **p<0.05; ***p<0.01
Source: author's estimation

Table A13

Diagnostic Test for the Value Added per Employee

Heteroscedasticity: Breusch-Pagan test		
BP = 675.07	p-value < 0.0000	H1 ensures that the residuals are heteroscedastic.
Serial Correlation: Breusch-Godfrey/Wooldridge test		
chisq = 331.34	p-value < 0.0000	H1 indicates the presence of serial correlation of residuals
Cross-sectional dependence: Pesaran CD test for		
z = 177.68	p-value < 0.0000	H1: There is presence of cross section dependence

Source: author's estimation

APPENDIX B

Tables and Results of Initial panel model estimation for CO2 Emission Model

Table B14

Model Estimation for the CO2 Emission Model

	Pooled OLS	**Fixed Effects**
ln(consumption)	0.0177***	0.029**
	(0.061)	(0.013)
salestoco2	-0.123***	-0.073***
	(0.021)	(0.017)
valueaddedperco2	-0.570	0.270
	(0.392)	(0.473)
ln(totassets)	0.348***	0.131**
	(0.063)	(0.218)
manufacturing	0.396***	
	(0.193)	
agriculture	-0.347***	
	(0.238)	
construction	0.687	
	(0.811)	
Constant	-0.522	

	(0.865	
yr20	-0.193	-0.086
	(0.166)	(0.057)
R2	0.386	0.452
Adjusted R2	0.369	0.335
F test for individual effects		
F = 17.669	p-value < 0.0000	alternative hypothesis: significant effects

Note: *p<0.1; **p<0.05; ***p<0.01

Source: author’s estimation

Table B15

Diagnostic Test for

Heteroscedasticity: Breusch-Pagan test		
BP = 675.07	p-value < 0.0000	H1 ensures that the residuals are heteroscedastic.
Serial Correlation: Breusch-Godfrey/Wooldridge test		
chisq = 331.34	p-value < 0.0000	H1 indicates the presence of serial correlation of residuals
Cross-sectional dependence: Pesaran CD test for		
z = -0.18274	p-value = 0.855	H1: There is presence of cross section dependence

Source: author’s estimation

Resümee

ETTEVÕTETE TEGEVUSEDUKUS, ELEKTRITARBIMINE JA SÜSINIKDIOKSIIDI EMISSIOON: EESTI ETTEVÕTTETASANDI UURING

Md Mursalin Hossain Rabbi

Käesolev magistritöö annab ülevaate elektritarbimise ja ettevõtete tulemuslikkuse vastastikusest mõjust, rõhutades energiasäästmise võimaluste olulisust ja süsinikdioksiidi heitmekoguste vähendamise potentsiaali Eesti elektrienergia turu kontekstis. Uurimuses tuvastatakse, et elektrienergia tarbimine mõjutab positiivselt ettevõtete tootlikkust. Katkematu ja taskukohase energia kättesaadavus mängib ettevõtete tõhusa ja tulemusliku toimimise tagamisel otsustavat rolli. Vaatamata Eesti elektritootmise tuginemisele valdavalt fossiilkütustel põhinevale elektritootmisele, vaadeldakse käesolevas uuringus ettevõtete tulemuslikkust, võttes arvesse kolme tootlikkuse näitajat, need on müügitulude ja koguvarade suhe, tööjõu tootlikkus müügitulude ja töötajate arvu suhtena ning tööjõu tootlikkus ettevõttes loodud keskmise lisandväärtusena töötaja kohta. Analüüsis kasutatud andmekogum hõlmab teavet 1,740 ettevõttelt aastatest 2017–2021. Ökonomeetrilises analüüsis kasutatakse staatilisi paneelandmete analüüsimeetodeid. Tulemused näitavad positiivset korrelatsiooni ettevõtte tootlikkuse ja elektritarbimise vahel. Need tulemused viitavad sellele, et suurem elektritarbimise tase on seotud suurenenud müügi ja tööviljakuse paranemisega. Elektritarbimise keskkonnamõju uurimiseks aastatel 2019–2021 hinnatakse töös eraldi regressioonmmudelit 218 ettevõtte andmetel, keskendudes CO2 emissioonile. Antud analüüs näitab positiivset seost elektritarbimise ja CO2 heitkoguste vahel, rõhutades ettevõtete energiakasutuse keskkonnamõjusid. Uuring toob välja julgustavaid signaale rohetehnoloogia kasutuselevõtu ja süsinikdioksiidi intensiivsuse vähendamise jõupingutuste kohta. Need tulemused viitavad sellele, et ettevõtted on üha teadlikumad oma tegevuse keskkonnamõjudest ja astuvad samme keskonda säästvamate tegevusviiside suunas. See nihe on ülioluline, arvestades tungivat vajadust leevendada kliimamuutusi ja minna üle vähese CO2-heitega majandusele.

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18/05/2023