DOKUZ EYLUL UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS (ENGLISH)
ECONOMICS PROGRAM
MASTER'S THESIS

THE EFFECTS OF POWER INFRASTRUCTURE QUALITY ON INDUSTRIAL PERFORMANCE: A PANEL DATA ANALYSIS ON MANUFACTURING SECTORS OF OECD COUNTRIES

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İZMİR-2019

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TEZ ONAY SAYFASI

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Öğrenci No : 2016800433
Tez Başlığı : The Effects of Power Infrastructure Quality on Industrial Performance: A Panel Data Analysis on Manufacturing Sectors of OECD Countries

Savunma Tarihi : 21/06/2019
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ABSTRACT

Master's Thesis

The Effects of Power Infrastructure Quality on Industrial Performance: A Panel Data Analysis on Manufacturing Sectors of OECD Countries

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This thesis investigates the impacts of power infrastructure quality on manufacturing performance in OECD countries over the period from 1995 to 2014. Panel Autoregressive Distributive Lag Approach (ARDL) is employed on annual data of the manufacturing production and value-added as proxy variables for manufacturing performance and electricity power transmission & distribution losses as a proxy for power infrastructure quality. Since the analysis denotes the existence of cross-sectional dependence and heterogeneity across panels, second-generation estimators, namely the Common Correlated Effects Mean Group (CCEMG) and the Augmented Mean Group (AMG), are used to estimate the causal relations. The results indicate that the transmission and distribution losses negatively affect both manufacturing production and value-added. According to the results, while the effect of transmission and distribution losses on manufacturing production is highly significant, that of on value-added is only slightly significant. The negative effect of power infrastructure quality on manufacturing performance remains consistent even when several control variables are included in the estimations.

Keywords: Power Infrastructure Quality, Manufacturing Performance, OECD Countries, Panel ARDL, Cross-Sectional Dependence.

JEL Codes: H54, L60, C33

ÖZET

Yüksek Lisans Tezi

Enerji Altyapı Kalitesinin Endüstriyel Performansa Etkileri: OECD Ülkelerinin İmalat Sanayi Sektörlerinde Bir Panel Veri Analizi

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İngilizce İktisat Programı

Bu tez, OECD ülkelerinde 1995'ten 2014'e kadar olan dönemdeki enerji altyapısı kalitesinin imalat sanayi performansı üzerindeki etkilerini incelemektedir. İmalat sanayi performansı gösterge değişkenleri olarak alınan üretimi ve katma değeri ile elektrik altyapı kalitesi göstergesi olarak elektrik iletim ve dağıtım kayıpları yıllık verileri üzerinde Panel Gecikmesi Dağıtılmış Otoregresif Model (ARDL) kullanılmıştır. Paneller arasında yatay kesit bağımlılığı ve heterojenliğin varlığı tespit ediliği için ikinci nesil tahminciler olan Ortak İlişkili Etkiler Ortalama Grup (CCEMG) ve Genişletilmiş Ortalama Grup (AMG) tahmincileri nedensel ilişkileri tahmin etmede kullanılmıştır. Ampirik bulgular, iletim ve dağıtım kayıplarının hem imalat sanayi üretimini hem de imalat sanayi katma değerini olumsuz yönde etkilediğini göstermektedir. Sonuçlara göre elektrik iletim ve dağıtım kayıplarının imalat sanayi üretimi üzerindeki etkisi istatistiksel olarak yüksek anlamlılık düzeyinde iken katma değer üzerindeki etkisi düşük anlamlılık düzeyindedir. Enerji altyapı kalitesi ile imalat sanayi performansı arasındaki negatif ilişki, regresyona dahil edilen farklı kontrol değişkenler ile tahmin edildiğinde dahi değişmemiştir.

Anahtar Kelimeler: Enerji Altyapı Kalitesi, İmalat Sanayi Perfomansı, OECD Ülkeleri, Panel ARDL, Yatay Kesit Bağımlılığı.

JEL Kodlar: H54, L60, C33

THE EFFECTS OF POWER INFRASTRUCTURE QUALITY ON INDUSTRIAL PERFORMANCE: EVIDENCE FROM MANUFACTURING SECTOR IN OECD COUNTRIES

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ABBREVIATIONS

2SLS	Two-Stage Least Squares Estimation
ADF	Adjusted Dickey-Fuller
AIC	Akaike Information Criteria
AMG	The Augmented Mean Group
ARDL	Panel Autoregressive Distributive Lag Approach
CADF	Augmented ADF
CCEMG / CCE	The Common Correlated Effects Mean Group
CD	Cross-Sectional Dependence
CIPS	Augmented IPS
COE	Carbon Dioxide Emission Per GDP
ECM	Error Correction Based Cointegration Test
ECT	Error-Correcting Term
EEA	European Environment Agency
EEL	Energy Efficiency Law
EI	Energy (Electricity) Intensity
ELECTRICITY	Electricity Transmission and Distribution Losses
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Production
GNP	Gross National Production
HTX	The Share of High Technology Exports İn Total Manufacturing Exports
IAEA	International Atomic Energy Agency
ICM	Integrated Conditional Moment

IEA	International Energy Agency
IPS	Im-Pesaran-Shin
LLC	Levin-Lin-Chu
LM	The Lagrange Multiplier
MG	The Mean-Group Estimator
NEEAP	National Energy Efficiency Action Plan
OLS	Ordinary Least Squares
PMG	The Pooled Mean-Group Estimator
R&D	Research and Development Expenditure
SIC	Schwarz Information Criteria
STO	State Planning Organization
SUR	Seemingly Unrelated Regression
TAX	Tax Revenue Percentage Of GDP
TEAS	Turkish Electricity Generation and Transmission Corporation
TEDAS	Electricity Distribution
TEIAS	Electricity Transmission
TETAS	Electricity Trade
TEUAS	Electricity Generation
TMMOB	Union of Chambers of Turkish Engineers and Architects
TUIK	Turkstat
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNIDO	United Nations Industrial Development Organization
VECM	Vector Error Correction Model
WLSM	Weighted Least Squares Method

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INTRODUCTION

Since the Industrial Revolution, energy has become one of the main inputs for the industry. There is no doubt that energy has an important place not only for industry but also for social and economic development yet, the industry is the foremost engine for sustainable development in the 21st century. In fact, in 2015, the United Nations (UN) published 17 goals to achieve sustainable development, 7th and 9th of which are associated with energy and industry within the scope of sustainable development, respectively. The goal 7, for instance, is identified as "Ensure access to affordable, reliable, sustainable and modern energy for all". Moreover, the goal number 9 is assigned as "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" (UN, 2015).

In addition to UN sustainable development goals, 30 energy indicators are identified and separated by social, economic, and environmental in the report of Energy Indicators for Sustainable Development, which is published by International Atomic Energy Agency (IAEA) with the cooperation of the United Nations Department of Economic and Social Affairs (UNDESA), the International Energy Agency (IEA), Eurostat and the European Environment Agency (EEA). Moreover, one of these 30 indicators is defined as the energy infrastructure quality (IAEA, 2005).

Industrial production must also be increased continuously to ensure sustainable economic development. On the other hand, increasing industrial production leads to increasing energy demand. Therefore, energy supply must also be sustainable for maintaining the sustainable industry. Consequently, if one country aims at sustainable development, it should place special emphasis on energy supply efficiency. With no doubt, sustainable, accessible, affordable, and reliable energy supply can only be maintained by better-qualified energy infrastructure.

Despite advancing technologies, electricity power transmission and distribution losses still, occur in both developed and in developing countries. Also, energy supply deficiencies have harmful effects on countries' economy, particularly on their industrial output since the industry is the main final consumer of electricity power. When the quality of the power infrastructure is poor, it does not provide uninterrupted energy supply, and there may be many power shortages. In the event of inefficient power infrastructure quality, continuous production in the industry cannot be achieved. Hence the manufacturing industry that uses energy as a crucial input may be affected negatively. Therefore, sustainable energy supply security can be provided by qualified infrastructure. In an attempt to overcome this situation and to provide better energy supply, countries need to invest in better and higher quality power infrastructure.

In light of the information above, the primary aim of this thesis is to quantitatively analyze the effects of power infrastructure quality on the performance of the manufacturing industry. In order to do that the electricity power transmission & distribution losses as a proxy for power infrastructure quality and annual data of the manufacturing production and value-added as proxy variables for manufacturing performance are used in empirical analyses. There are two data sets based on annual data of manufacturing production and value-added, as there are two different dependent variables. The time dimension of both datasets is 20 years. One of the data set consists of 27 countries, and the other one consists of 28 countries. Panel Autoregressive Distributive Lag Approach (ARDL) is utilized to analyze the impact of power infrastructure quality on industrial performance.[1]

Analyses are conducted with two main dependent variables, which are manufacturing production and value added. Firstly, the relation between energy infrastructure quality and manufacturing production is investigated for 28 OECD countries from the period 1994 to 2014. Secondly, the relation between energy infrastructure quality and manufacturing value-added is analyzed for 27 OECD countries from the period 1994 to 2014.

This thesis comprises two chapters. In Chapter 1, the importance of energy supply for sustainable development, the energy market in Turkey and the literature review have been explained. In the light of official reports, first sub-section of Chapter 1 gives insight into why energy access should be uninterrupted and continuous to ensure sustainable development. The rates of electricity power transmission and distribution losses for both Western European countries and some selected developing countries are shown. The second sub-section of Chapter 1

[1] For additional information about data and methodology see Chapter 4.

provides detailed information about electricity market of Turkey, one of the members of OECD.

The literature review is provided in the third sub-section of Chapter 1. Literature consists of two different perspectives on the relationship between energy and industrial performance. The first perspective is the relation between energy consumption and industrial productivity. The second one is the effect of energy infrastructure as a constituent of public investment on private capital productivity. Besides, studies concerning the impacts of electricity shortages on firms' costs also have been included in the literature review.

The methodology is described in Chapter 2, which consists of four sub-sections, which are a research question, data, method, and empirical results. In the first sub-section of Chapter 2, the research question, the main hypothesis, and variables that are used in regressions are explained. The second sub-section of Chapter 2 provides information about the data set, such as source, descriptive statistics of data and the mathematical transformations employed. In the third sub-section of Chapter 2, the methods that are used in the analyzes are explained. Error correction based cointegration test, cross-sectional dependence tests, and first- & second- generations unit root tests, panel autoregressive distributive lag approach (ARDL) with estimators are explained in this subsection. The fourth sub-section of Chapter 2 is empirical results. Results of regression which are utilized by second generation tests are demonstrated in this section.[2]

Finally, the conclusion includes the evaluation of the results, policy implications, and discussions.

[2] Since data set comprises of cross-sectional dependence, results of the second-generation tests are shown in the Chapter 2. The first-generation tests results are also provided in Appendices.

CHAPTER ONE

BACKGROUND INFORMATION ON POWER QUALITY

1.1.THE IMPORTANCE OF POWER INFRASTRUCTURE QUALITY

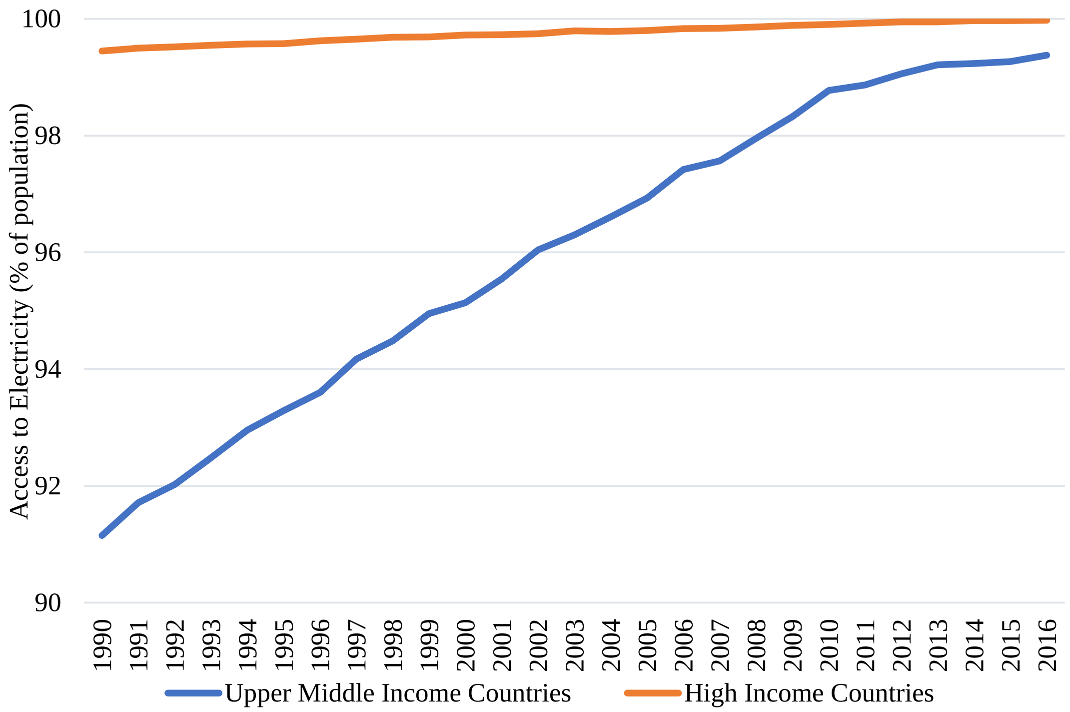
Energy has a remarkable role in terms of economy, industry, and well-being of people. In particular, energy is one of the core inputs for the manufacturing industry which is one of the main elements of the industry. Hence, interruptions in energy supply may directly affect production. In order to reduce this negative impact on production, the quality of power infrastructure is required to be strengthened or improved. Also, power infrastructures, in general, are categorized as production-generation of primary and secondary energy and transportation-distribution of produced energy sources to final consumers. Especially, the power transmission and distribution have a considerable role in power infrastructure since all developed countries and the great majority of developing countries have not many difficulties in the generation of electricity. Therefore, the power transmission and distribution are important for all developing and developed countries in terms of their industry as well as their economy. Besides, power transmission & distribution is still a hot topic all around the world. The importance given to power infrastructure and transmission-distribution can be clearly observed in the reports and publications written by many institutions and organizations, such as The European Union's (EU) 2011 Infrastructure Package, EU’s 2020 Energy Strategy, Energy Infrastructure and Industrial Development by United Nations Industrial Development Organization (UNIDO), World Energy Investment 2017 by International Energy Agency (IEA) and Lisbon Treaty (2007)[3].

Broadly, access to electricity which is one of the indicators of the power infrastructure quality in developed and the most of developing countries, including Turkey, is ceased to be a problem as illustrated in Figure 1. According to the International Energy Agency (IEA), the number of people who cannot access to

[3]For additional information see Article 176 in the Lisbon Treaty.

electricity was 1.7 billion in 2000, this number declined to 1.1 billion in 2016. The number of people without access to electricity is clustered, mainly in developing countries in Asia and sub-Saharan Africa. As a matter of human rights, it is necessary to ensure that every individual has uninterrupted access to electricity. Moreover, the report states that there is a positive relationship between gender equality, which is the component of Human Right Index, health and access to electricity (IEA 2017b: 26-29, 39). Therefore, the uninterrupted access to electricity is an imperative necessity of sustainable development and welfare not only for industry but also rural area. Additionally, sustainable and continuous access to electricity is only possible with power infrastructures of high quality.

Figure 1: Access to Electricity for High and Upper-Middle Income Countries, 1990-2016



Source: Worldbank, World Development Indicators 2018

Apart from advancement in access to electricity, interruptions in energy supply cause still huge losses for the industry in some part of developing countries, even in some developed countries. Furthermore, IEA (2018) has identified that energy use in industrial activity increases as nearly 2% in 2017. According to the report, even manufacturing industries' energy intensity are fallen, their energy uses are still increased. (IEA 2018: 99-101) This means if there are any shortages or interruptions of energy supply, it can be a vital problem for production since energy is one of the life-blood inputs of industry. Owing to the fact that insufficient energy supply has a direct negative impact on production and increases costs, energy supply needs to be well-qualified and continuous. The only possible way to ensure well-qualified and continuous energy is to improve energy infrastructure.

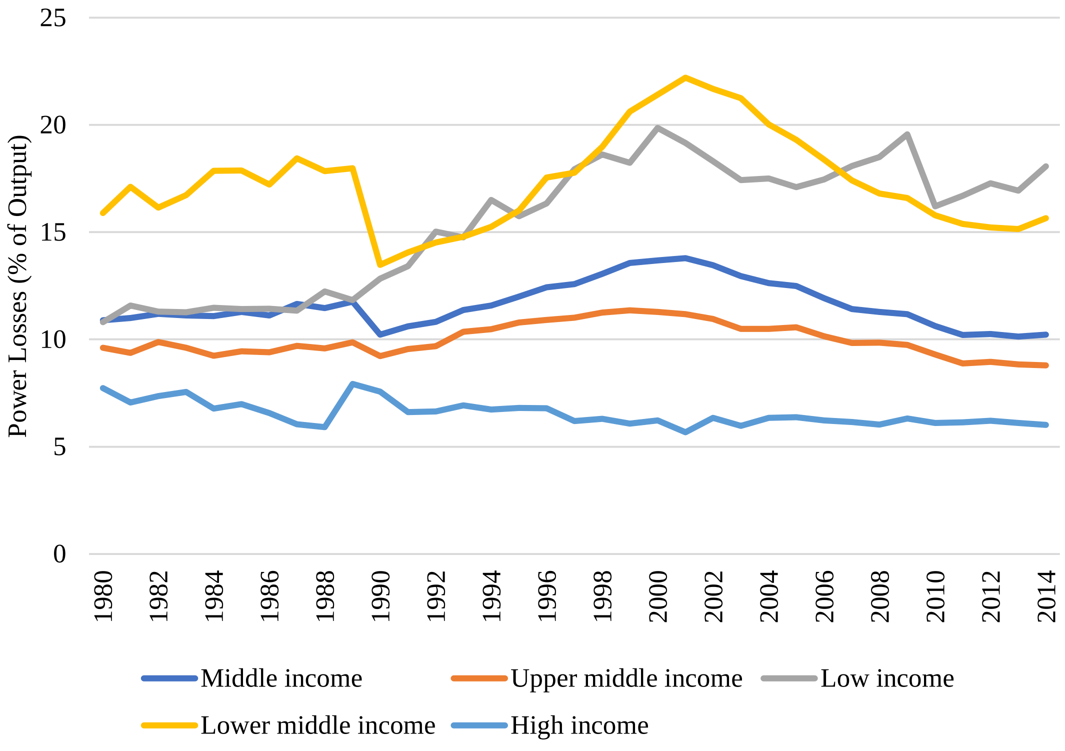
Moreover, IAEA (2005) has specified that energy conversion and distribution efficiency, which is one of the 30 indicators for sustainable development, has 4 different components. These are fossil fuel efficiency for electricity generation, electricity transmission and distribution efficiency, gas distribution efficiency, and oil refining efficiency (IAEA 2005: 46-47).

According to World Energy Investment Report 2017, published by International Energy Agency (IEA), investment in transmission and distribution infrastructure increased consistently from 2010 to 2016. The share of electricity transmission investment in total network investment is increased from 22% to 28% in 2015. Furthermore, 277 billion USD dollars were invested in electricity networks and storage spending in 2016. Despite increasing investment in transmission and distribution infrastructures, interruptions or shortages in electricity supply still bring about the extensive economic cost for developed countries. For instance, the United States' average cost of annual shortages is estimated to be 110 billion USD dollars (IEA 2017a: 50-51). All information from World Energy Investment dedicated that countries take cognizance of how the electricity transmission and distribution infrastructures are important for sustainable development and sustainable industry.

As can be seen in Figure 1, almost everybody in developed countries reaches to electricity, and most of the people in developing countries, almost all of them had access to electricity since 2012. The above information and Figure 1 show that access to electricity is no longer a problem; however, there are still losses in electricity transmission and distribution.

Figure 2 shows electricity transmission and distribution losses for high-income countries, upper-middle-income countries, middle-income countries, lower-middle income countries, and low-income countries. The averages of power losses from 1980 to 2014 are approximately equal to 7%, 10%, 12%, 15% and 17% for high-income countries, upper-middle income countries, middle-income countries, lower-middle income countries and low-income countries, respectively. As it is seen in Figure 2, electricity transmission and distribution losses were quite low for high-income countries.

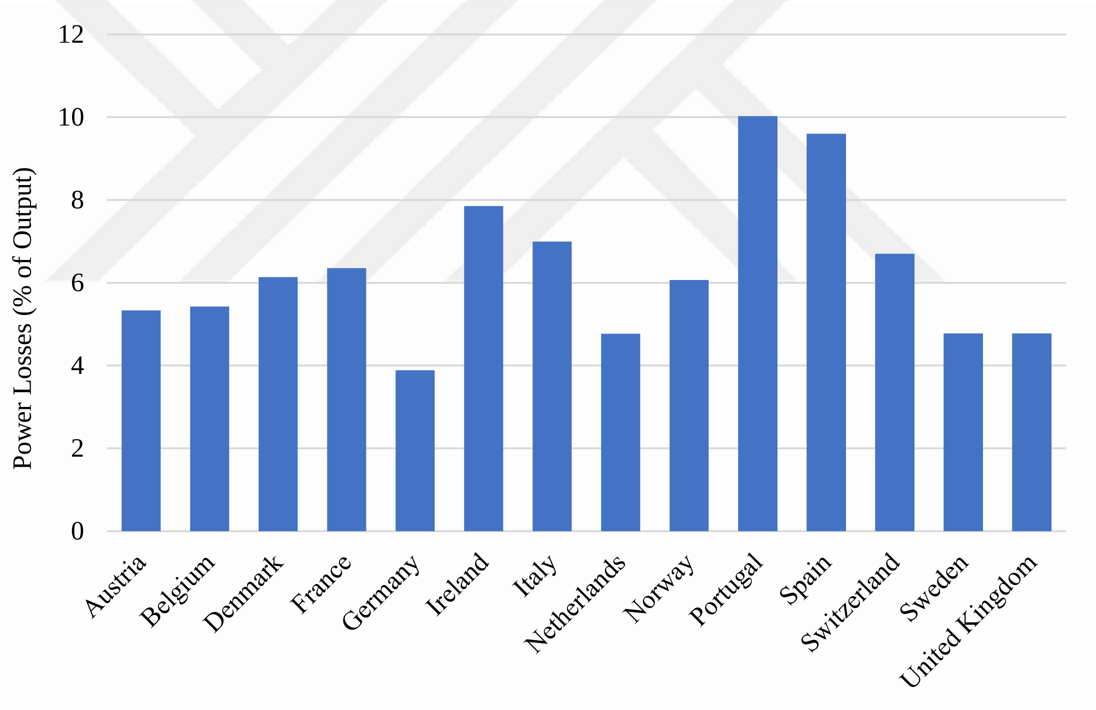
Figure 2: Electricity Transmission and Distribution Losses among Different Group of Countries, 1980-2014



Source: Worldbank, World Development Indicators 2018

When the average of power loss of countries and Figure 2 are considered, it can be suggested that there is a relationship between the income level of countries and power loss. This can be explained by increasing investments on power infrastructures. Especially in Western Europe, electric power transmission and distribution losses are very low in 2014, as shown in Figure 3. On average, measured in terms of percentage of output, power losses are approximately equal to 6% of total generated electricity in Western Europe countries.

Figure 3: Electricity Transmission and Distribution Losses, Western European Countries in 2014



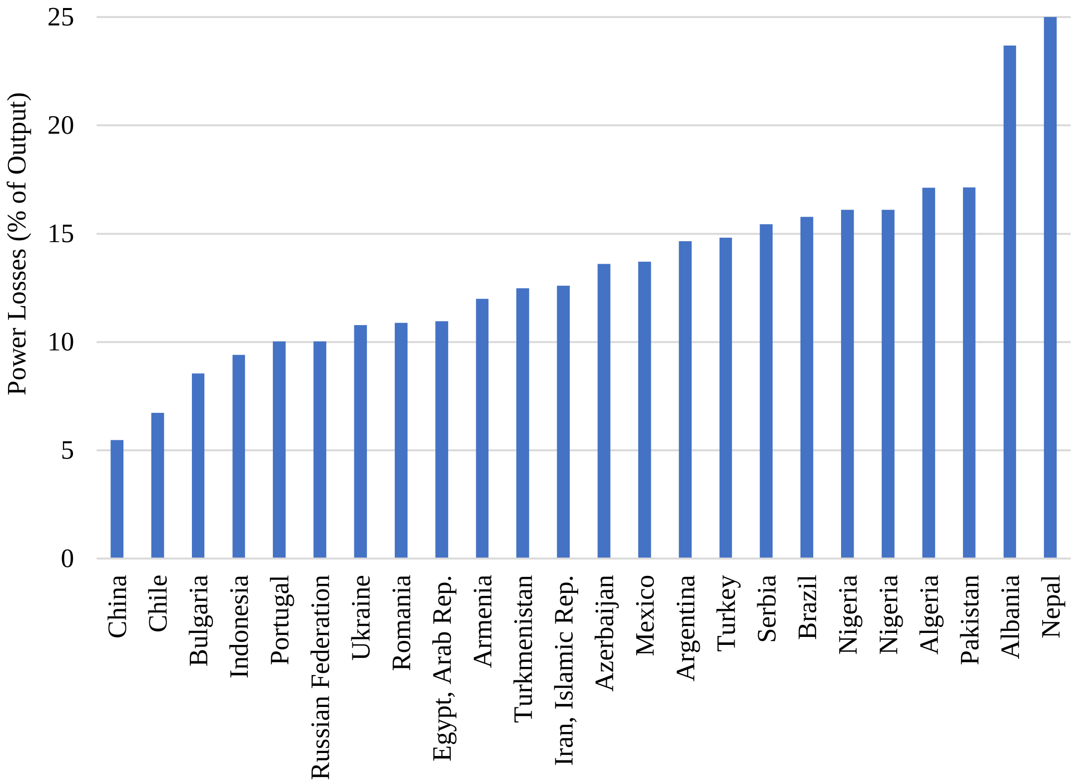
Source: Worldbank, World Development Indicators 2018

However, losses are very high in developing countries compared with developed and Western Europe countries. Figure 4 indicates electric power transmission and distribution losses in 2014 for some selected developing countries.[4]

[4] See Appendices for more data about developing countries.

The average of power losses is approximately equal to 15 for developing, upper-middle income, countries. The average of selected developing countries is two and a half times more than Western Europe's averages. Looking at the figures and the ratios, it is clear that the problem of electric power transmission and distribution losses is still an unresolved issue in developing countries.

Figure 4: Electricity Transmission and Distribution Losses in Selected Developing Countries in 2014



Source: Worldbank, World Development Indicators 2018

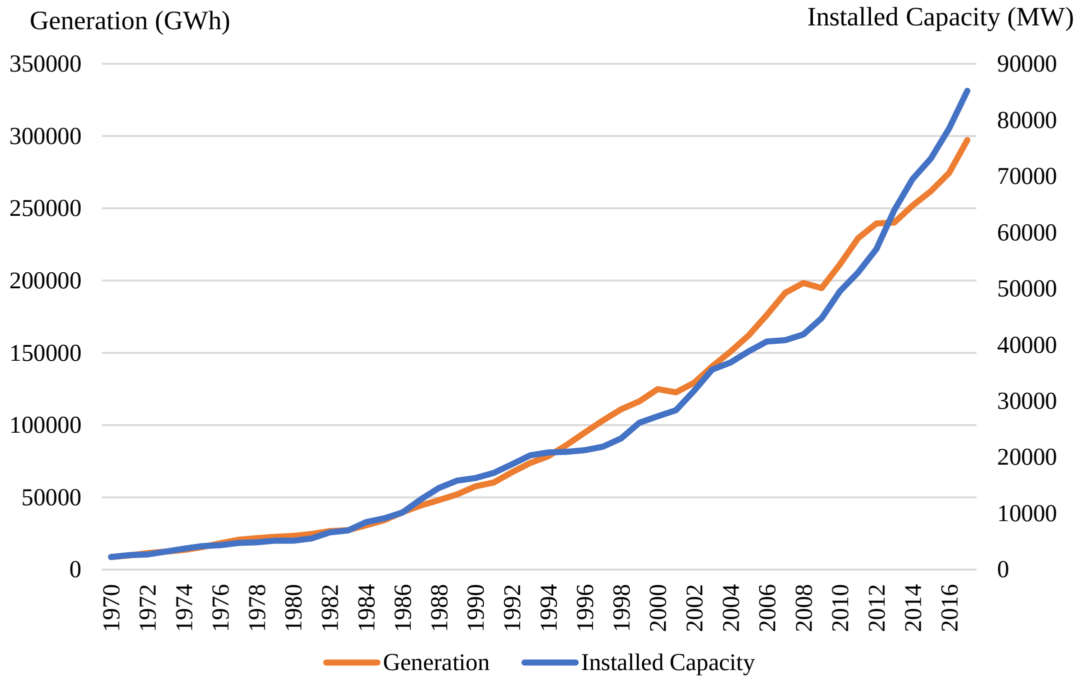
1.2.DEVELOPMENT OF TURKEY'S ELECTRICITY INFRASTRUCTURE

Energy efficiency, which is an aspect of sustainable development, has gained accelerating importance throughout the world. In line with the objectives of sustainable development goals and the Paris Agreements, Turkey should also increase the use of renewable energy sources and reduce CO2 emissions. While doing this, it should enhance energy efficiency simultaneously. Also, Turkey has taken the necessary steps with the law and action plan in order to ensure energy efficiency. In line with this target, firstly, Energy Efficiency Law (EEL) was enacted in 2007. The law suggests increasing energy efficiency implementations. Within the framework of the law, the practices have aimed at increasing energy efficiency in electricity generation facilities and transmission/distribution networks and increasing the use of renewable energy resources are taken as the basis (EEL 2007: Article 22). Afterward, National Energy Efficiency Action Plan (NEEAP) 2007-2023 has been published based on national strategic objectives such as mitigating the burden of energy costs in the economy, ensuring the security of energy supply, reducing risks arising from foreign dependency, the transition to a low-carbon economy and environmental protection. (NEEAP 2017: 1-2) The National Energy Efficiency Action Efficiency Plan consists of 12 actions for building and services, 6 for agriculture, 10 for energy, 7 for industry and technology, 9 for transportation, and 11 for horizontal issues. One of the 10 energy actions is Improvement of Efficiency in Electricity Transmission and Distribution Activities.

Turkey's electricity generation and installed capacity tend to increase, especially from the 1980s as it can be seen in Figure 5. This incremental trend can be explained by the liberalization after 1980 following goals of increasing energy generation in the 4th and 5th Five-Year Development Plan by the State Planning Organization (STO). Developments in the energy sector targeted in the previous development plans have not been achieved to the extent that development is required. In particular, the energy required by the manufacturing industry could not be ensured continuously and adequately and this problem was aimed to be solved in the 4th Five-Year Development Plan. In the 4th Five-Year Development Plan, the production of primary energy resources is projected to increase by an average of 11.6

percent annually. According to the development plan, energy demand is the main principle of energy policy and it will be met by domestic sources (STO 1979: 401-406). The 5th Five-Year Development Plan includes targets about increasing energy generation and quality, as in the 4th Five-Year Development Plan. In addition to 4th Five-Year Development Plans, the 5th Five-Year Development Plans aimed to prioritize using reliable and inexpensive energy sources to increase industrial production, furthermore, it concentrated on production and use of domestic resources. It has been emphasized in the 5th Five-Year Development Plan that the energy policy should be in a way to support and direct the intended economic growth and social developments (STO 1984: 104).

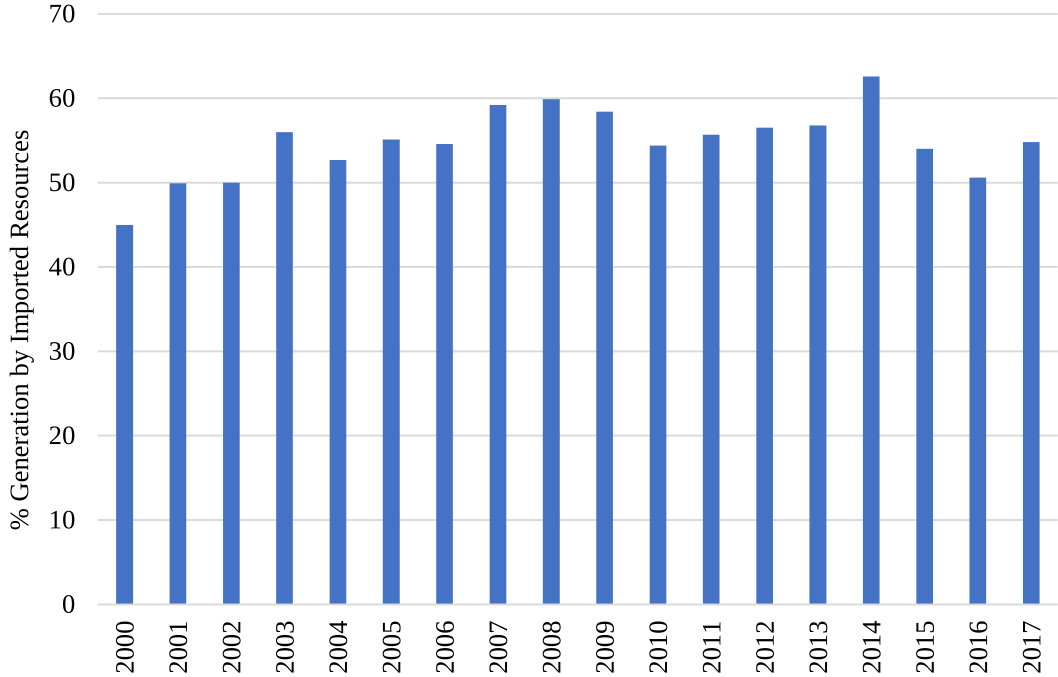
Figure 5: Annual Development of Electricity Generation and Installed Capacity in Turkey, 1970-2016



Source: TEIAS 2018

Despite the fact that Turkey has expanding electricity installed capacity and generations, it is an energy import-dependent country like many developing and developed countries. Besides, Turkey imports primary energy sources from foreign countries to produce electricity. Figure 6 indicates the share of imported resources-based electricity generation in total electricity generation in Turkey from 2000 to 2017. As illustrated in Figure 6, Turkey is heavily dependent on foreign resources to generate electricity. Still, more than 50% of electricity is generated in thermal power plants working on imported energy sources.

Figure 6: Share of Electricity Generated from Imported Primary Energy Resources in Turkey, 2000-2017



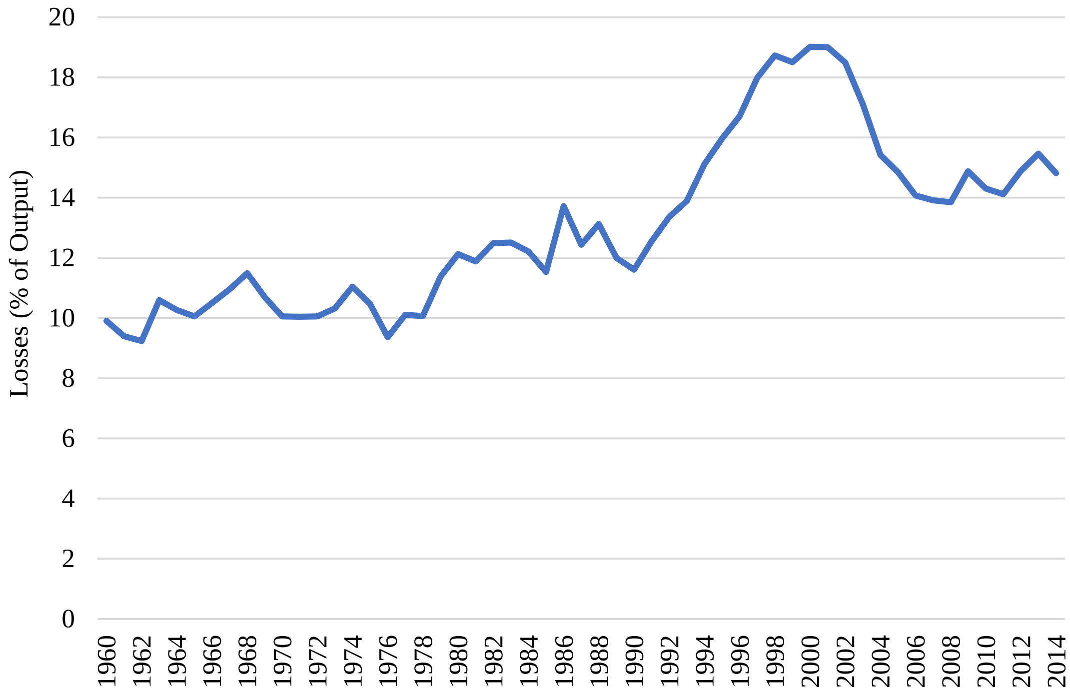
Source: TEIAS, 2018

As shown in Figures above, Turkey's electricity market has ever-growing electricity installed capacity/generations, and it imports energy from other countries highly. Although great developments in the electricity market have been achieved, transmission and distribution losses are a significant issue to achieve sustainable development goals.

To minimize the power losses and increase energy supply efficiency, Electricity Market Law no. 4628 was issued in 2001. Electricity Market Law no. 4628 emphasized that supplied energy should be an environmentally-friendly, cheap, continuous and high quality of electricity power (TMMOB, 2012: 13). Within this purpose, the liberalization movement in electricity markets was started with the privatization of the Turkish electric power distribution company, namely Turkish Electricity Generation and Transmission Corporation (TEAS). TEAS was separated into four companies; these are Electricity Generation (TEUAS), Electricity Transmission (TEIAS), Electricity Distribution (TEDAS), and Electricity Trade (TETAS) in 2001. As a result of separation, the electric power transmission has been in public administration as a national monopoly, while the electric power distribution has been split into 21 independent regional monopolies in order to be privatized (Karahan and Toptas 2013: 615).

Figure 7 denotes Turkey's electric power transmission and distribution losses from 1960 to 2014. As is seen from Figure 7, losses have a decreasing trend from 2001 as a consequence of the liberalization of Turkey power market. However, despite the separation and the privatization of electric power distribution, Turkey still suffers from electric power transmission and distribution losses. On average, Turkey's electric power transmission and distribution losses are approximately equal to 16 for 15 years for the period 2000-2014. The average of Turkey's electric power transmission and distribution losses is considerably above the averages of Western Europe.

Figure 7: Electricity Transmission and Distribution Losses in Turkey, 1960-2014



Source: Worldbank, World Development Indicators 2018

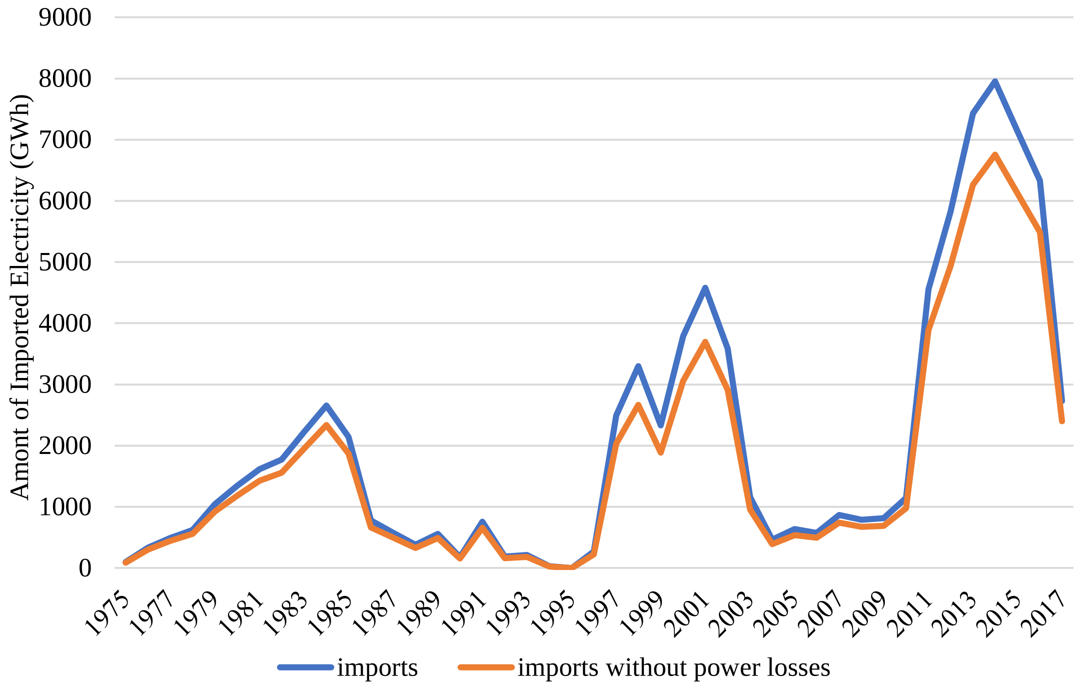
In addition to all these, Turkey's imports of electricity are also high. Additionally, Turkey imports electricity from foreign countries instead of primary energy resources. The amount paid for electricity imports for 2015, 2016, 2017 and 2018 is $ 325 171 296, $ 213 614 469, $ 85 501 108 and $ 57 030 872, respectively.[5]

Figure 8 demonstrates Turkey’s electricity imports with power transmission & distribution losses and without power transmission & distribution losses. The orange line in Figure 8 shows the import of electricity in case of the absence of Turkey’s power transmission and distribution losses. The blue line indicates the current electricity imports. If Turkey reduces power transmission and distribution losses rates, it may also fall in the amount of electricity to be imported.[6] The reduction of the amount of electricity imported by the country will also have positive

[5] Source: TUIK, 2019 (http://tuik.gov.tr/VeriTabanlari.do?vt_id=84&ust_id=104)
[6]The numerical table of the change in import rates in case of prevention of power transmission and distribution losses is in Appendices.

effects on the current account deficit and her economy. These positive effects on electricity imports can only be achieved by improving power infrastructure quality.

Figure 8: Turkey's Electricity Imports with and without Power Transmission and Distribution Losses, 1975-2017



Source: TEIAS 2018

In light of the information mentioned above, the effects of the power transmission and distribution losses on the economies of countries are seen obviously. Uninterrupted energy supply is not only an important factor for the sustainable development of countries but also for the industry since energy is a fundamental input for the industry. In particular, as the manufacturing industry is one of the most energy-consuming sectors, any disruptions in energy supply may adversely affect manufacturing industry production.

However, if power infrastructure quality is improved, power losses may be reduced, and thus, both the economy and the industry can benefit from these improvements. Therefore, it is necessary to obtain uninterrupted and sustainable energy supply for countries which desire to build and maintain a stronger economy.

1.3.LITERATURE

Since the pioneering study of Solow (1957), factors of production, which are affecting industrial productivity, have been extensively examined in the literature. There have been many studies investigating different factors that are affecting industrial efficiency in the ongoing studies after Solow. Jarmin (1999) examines the effect of the government-sponsored program on manufacturing firm. Leiponen (2000) investigates innovation and education as affecting factors on Finnish manufacturing firms. Dunne et al., (2004) also identify the effect of computer investment as an innovation on labor productivity in US manufacturing industry. Keller and Yeaple (2009) declare that foreign direct investment and import spillovers impact on US manufacturing firms. Similar to Keller and Yeaple (2009), Ozmen et al. (2012) also examine the effects of foreign trade on industry. Several empirical studies are trying to explain the factors affecting the industry, like studies described above. As one of the factors affecting the industry, energy has also been the subject of many studies.

Energy emerged as one of the essential inputs in industrial processes since the industrial revolution in the 18th Century. With ever-increasing demand, the industry has become the main final consumer of energy. In 2016, for instance, industry sectors were responsible for 37% of total global energy demand (IEA 2018: III.98-III.113) Therefore, energy supply deficiency may decrease industrial output and productivity. Also, sustainable energy supply, which can be provided by increasing the quality of energy infrastructure facilities, is one of the essential factors for continuous industrial production.

When examining the literature, the relationship between energy and industrial performance has been considered from two different perspectives. The first one is that the effects of energy consumption and energy intensity on industrial production have been investigated. The second and most common one is that; energy infrastructure has been taken a component of public investment and has affected private capital productivity. Within this knowledge, the first stream of literature in this thesis, the effects of energy consumption and energy intensity on productivity are considered. The second stream of literature in this thesis reviews the effects of public infrastructure investments on industrial productivity.

The paper of Kraft and Kraft (1978) is the fundamental study of the topic of the relationship between energy consumption and income. They reveal unidirectional Granger causality from Gross National Production (GNP) to energy consumption utilizing annual data on gross energy inputs and Gross National Production in the US from 1947 to 1974. They indicate that gross national production has causal effects on gross energy inputs and there is no causality from gross energy inputs to gross national production (Kraft and Kraft, 1978: 403). This means, economic activities affect energy consumption; however, energy consumption has not any impact upon Gross National Production. Therefore, energy conservation policies can be applied without harming economic activity. With this seminal paper, relations of energy consumption and industrial activity became prevalent in the energy economics literature.

Soytas and Sari (2007) identify the relevance of electricity consumption and value-added for the Turkish manufacturing industry from 1968 to 2002. They employ Granger causality test based on Vector Error Correction Model (VECM) with annual data of electricity consumption, manufacturing value added, employment in the manufacturing industry and investment in manufacturing. Results claim that energy is a significant input for the manufacturing industry. Furthermore, as opposed to the study of Kraft and Kraft (1978), electricity shortages and energy conservation policy may have negative effects on the manufacturing industry in Turkey (Soytas and Sari, 2007: 1163).

Jorgenson (1984) investigates the relationship between energy and productivity growth for 35 industries from 1958 to 1979 in the US. Contrary to Denison (1985), he claims that energy prices have an important role in US productivity slowdown in the 1970s. He finds that when energy intensity increases, productivity and labor growth increases. In particular, increasing of nonelectrical energy usage boots the productivity growth for selected industries in the US.

Haider and Ganaie (2017) explore the interaction between total factor productivity and energy efficiency by employing VECM in order to check the direction of causality in 1971-2013. They claim that there is a unidirectional causal relationship from energy efficiency to total factor productivity when energy intensity rises total productivity level also rises. Therefore, increasing total factor productivity requires more energy consumption (Haider and Ganaie, 2017: 161). Choi et al. (2017) examine causality between energy intensity and firm growth for 21 manufacturing industries for the six member countries of the International Energy Agency (IEA) from 1970 to 2005. Results state that declining in relative energy intensity, which is calculated with industries' energy consumption dived by value added (GDP), rises firm's profit, besides, impacts of declining in energy intensity has no significant effect (Choi et al., 2017: 409).

On the other hand, Miketa (2001) employs cross-country analysis with 39 countries by using Weighted Least Squares Method (WLSM). In consequence of findings, capital accumulation has an impact as increasing energy intensity, and these impacts are stronger in countries where sectoral output was high (Miketa, 2001: 775). Worrel et al. (2003) analyze the relationship of energy efficiency improvement and productivity for the iron and steel industry in the US. They employ an energy scenario analysis for over the 70 industrial case studies by using the Bottom-Up Energy Conservation Supply Curves and the Costs of Conserving Energy. They state that energy efficiency investment has significantly positive effects on whole industrial production (Worrel et al., 2003: 1096).

Studies for different countries declare that subsidies, promotion, and investments on energy efficiency technologies are beneficial to industrial productivity; Trianni (2013) examines Small and Medium-sized Enterprises manufacturing in Italy, Shah (1992) for Mexico, Greening et al., (1997) for manufacturing in 10 OECD countries the spanning period of 1970-1992.

As explained in the first stream of the literature, there are several investigations denote that the relations of energy consumption and energy intensity to industrial production and productivity. Within the second stream of the literature, studies about the contribution of public infrastructure investments, including energy infrastructure investments, on industrial activities are clarified below.

Since the seminal paper of Aschauer (1989), the topic of the relationship between infrastructure investment and industrial productivity became more widespread in the literature. Aschauer (1989) analyzes the public capital expenditures influence on productivity decline in the 1970s and 1980s. Output, public capital stocks, government spending, the capacity utilization rate and multifactor productivity are used in the estimation process to show how infrastructure investment affects productivity. Annual data are tested with Ordinary Least Squares (OLS) and Two-Stage Least Squares Estimation (2SLS) procedure from 1949 to 1985. He found that public capital has significantly positive effects on productivity (Aschauer, 1989: 185). Besides, his paper includes energy facilities as a component of core infrastructure. According to empirical results, the impacts of core infrastructure on productivity is 0.24. Even though the belief of increasing energy prices in the 1970s affects productivity negatively, Denison (1985) proves that increasing energy prices in 1970s is not a major factor in productivity slowdown. Consequently, Aschauer (1989) emphasizes that the decline in public investments have large effects on US' productivity deceleration in the 1970s and 1980s.

Munnell and Cook (1990) investigate the relationship between public capital stock and economic activity for the period of 1980-1988. They analyze the relationship with three steps. Firstly, the effects of productivity in the production process are explored; secondly, the role of public capital in private sector is examined; and thirdly, the role of public capital in employment growth is searched to demonstrate the effects of state's investment in public capital. Finally, they claim that increasing infrastructure affects output, private investment, and employment growth positively at the state and regional level (Mundell and Cook, 1990: 26). Esfahani and Ramírez (2003) find out similar outcomes about analyzing the relationship between infrastructure and output growth, especially the contribution of infrastructure on Gross Domestic Production (GDP) in the US for the period 1970-1986. Duggall et al. (1999) examine the effects of public infrastructure as part of technological constraint on productivity in the US for the period of 1960-1989 by employing Integrated Conditional Moment (ICM) test. Empirical results claim that the effects of public infrastructure are not constant, moreover these effects on capital and labor productivity increase with technological innovations (Duggall et al., 1999: 26).

Brox and Fader (1996) analyze the effects of public infrastructure on manufacturing cost for 1961-1992 time period, he compares the results of the

Canadian region and US. According to results, infrastructure has a strong positive effect on manufacturing cost, productivity, and public capital in each region. Albala-Bertrand and Mamatzakis (2004) evaluate the relationship between infrastructure capital and cost structure by diversifying two institutional periods, as developmentalist and neoliberal periods for the Chilean economy. Particularly in the neoliberal period, increasing public infrastructure reduced production costs and exchanged productivity in accordance with findings.

Numerous studies, which are a subject of public infrastructure and economic activities for other countries, indicate the positive relationship between infrastructure and economic activities; Wang (2002) for East Asian Economy, Paul (2003) for Australia, Wan and Zhang (2017) for Chinese manufacturing and Mamatzakis (1999) for Greece.

Additionally, recent studies in literature quantify that the impacts of electricity shortages on industrial firm productivities. Fisher-Vanden et al. (2015) analyze the relationship between electricity shortages and industrial firm productivity for China. Their study cover data of firm-level; production, electricity, self-generation of electricity, and out-sourcing of material inputs. They employ Seemingly Unrelated Regression (SUR) for 23000 Chinese's energy-intensive firms from 1999 to 2004. According to findings, firms' production costs have been risen due to the usage of substitute inputs to make compensate costs, which are arisen by electricity shortages (Fisher-Vanden et al. 2015: 184). Hence, firms' manufacturing costs increase due to using other factors as input for the elimination of electricity shortages.

Alcott et al. (2016) inspect the correlation between electricity shortages and productivity & revenue for Indian manufacturing from 1992-1993 through 2010-2011. They noticed that the effects of electricity shortages are more in revenue and less on productivity (Alcott et al. 2016: 184).

Grainger and Zhang (2017) investigate 4500 manufacturing firms in Pakistan for 2010-2011. They reveal that electricity shortages have negative impacts on manufacturing revenues and value-added in Pakistan.

Berk (2018) analyzes the effects of electricity shortages as a proxy for power infrastructure quality on manufacturing firms' performance. In order to show the effects, 131000 firms' data with 130 countries are used by gathered from World Bank Enterprise Surveys. According to empirical results, the inefficient power infrastructure affects firms' capacity usage negatively and cause to increase in labor efficiency (Berk 2018: 695).

These recent and similar studies have evaluated the impacts of electricity shortages on firms' production costs, revenue, and productivity. This thesis differs from existing studies since this thesis is based upon the subject of the impacts of power infrastructure quality, which is treated as a sustainable energy supply on manufacturing value added and production. Moreover, in this thesis, electricity power transmission and distribution losses are used as a proxy for the power infrastructure quality.

There are two main reasons for the use of electricity transmission and distribution losses as a proxy of the power infrastructure quality. The first reason is that some official reports show that power loss is a remarkable component of sustainable development and energy supply. Additionally, some official reports also declare countries' aims to reduce power losses. Nevertheless, there is no other study about the effects of power losses on the economy or industry. The second reason is that although electricity shortages are an indicator of the quality of the power infrastructure, electricity transmission losses provide more accessible data. Hence, data on electricity transmission and distribution losses allow creating panel data covering many countries and years.

CHAPTER TWO

METHODOLOGY

2.1. RESEARCH QUESTION

The main objective of this thesis is to demonstrate the relationship between power infrastructure quality and manufacturing industry performance in major OECD countries. As explained in Section 2.2, the data set covers major OECD countries over the period from 1995 to 2014. While manufacturing production and value-added are used to measure the performance, data on electricity transmission and distribution losses (electricity, hereafter) is employed as a proxy for power infrastructure quality.

Electricity transmission and distribution efficiency, which are stated as a component of the efficiency of energy conversion and distribution, are referred to one of the 30 energy indicators for sustainable development by IAEA (2005). Reducing losses during energy transmission and distribution can provide remarkable benefits for both industry and efficient use of energy.

The hypothesis of this thesis is as follows; electricity power transmission and distribution losses have negative effects on manufacturing production and value-added. As the data set, employed in this thesis, represents a panel structure, the hypothesis represented above will be tested by estimating β_i variable in the following equation:

$$y_{i,t} = \alpha + \beta x_{i,t} + \theta Z_{i,t} + u_{i,t} \tag{1}$$

where, i is the cross-sectional dimension, t is the time dimension, $y_{i,t}$, and $x_{i,t}$ represent the dependent (either production or value-added) and the independent (electricity) variables, respectively. Moreover $Z_{i,t}$ represents various control variables included in the regressions for robustness checks. The control variables have been selected by reviewing the relevant literature. Technology, openness, fiscal policy, energy, and climate-related variables are mainly used in consideration of the literature review.

In general, data of research and development (R&D) expenditure is used to check for technological level in a country. The share of high technology exports in total manufacturing exports (htx, hereafter) is utilized to proxy for technological development in the country's manufacturing industry because of the unavailability of research and development expenditure data. Effects of high technology exports on economic activities have been investigated in many studies, and positive effects of high technology exports on economic activities are denoted in several studies such as; Falk (2009), Yoo (2008), Hall and Mairesse (1995), Gokmen and Turen (2013).

Effects of foreign direct investment (fdi) are a much debated the subject in various studies. Positive effects of foreign direct investment (fdi) on R&D, productivity, and economic activity especially in manufacturing industry demonstrated for different countries with different methods; Blomström (1986) for Mexico, Liu et al (2000) for UK, Wei and Liu (2006) and Li et al, (2001) for China, Barrios and Strobl (2002) for Spain.

Taxes are notable factors for producers as tax has a remarkable impact on the industry's investments, employments and production. Negative impacts of taxes on the industry have been investigated by Plaut and Pluta (1983) for the US. Moreover, the effects of taxes on the shadow economy are founded negative by Davis and Henrekson (2004) for rich country and Thiessen (2003) for Ukraine. Therefore, in this thesis, the tax revenue percentage of GDP (tax) shows the effects of changing regulation in taxes on the shadow economy and manufacturing industry.

The topic of the relationship between energy consumption, energy intensity, carbon emissions and economic activities, especially in industrial performance is a widely debated issue. In general, studies have concluded that increasing energy intensity needs more energy consumption and increasing carbon emission. Also, they stated that energy-saving technology and decreasing carbon dioxide have positive impacts on industry and as well countries economy; Ang (2007), Soytaş and Sarı (2007), Feng et al. (2009), Arouri et al. (2012). In this respect, electricity power transmission and distribution losses affect the energy-intensive industry more. Therefore, Carbon dioxide emission per GDP (coe) and electricity intensity as a proxy for energy intensity (ei) used in regression as a control variable. Besides, estimating energy intensity has been done with two stages explained in sub-section 2 of Chapter 2.

2.2. DATA

Analyses are conducted with two main dependent variables, namely manufacturing production and value added. Firstly, the effect of energy infrastructure quality on manufacturing production is investigated for 28 OECD countries[7] from the period between 1994 and 2014. Secondly, the relationship between electricity infrastructure quality and manufacturing value added is evaluated for 27 OECD countries[8] spanning the period from 1995 to 2014.

Annual data on the manufacturing value-added, electric power transmission and distribution losses, high-technology exports, electric power consumption, CO2 emissions, GDP, and population were gathered by the World Bank's World Development Indicators. Data on manufacturing production, foreign direct investment and tax revenue were taken from OECD Statistics. The descriptive statistics about the variables of two different balanced panel data set are explained above is presented in Table 1 and Table 2.

Variables that include electricity transmission and distribution losses (hereinafter referred to as electricity), foreign direct investment (fdi), high technology exports (htx) and tax revenue (tax) are used as a percentage. Using the percentage of variables provides the opportunity for interpretation of coefficients as elasticities. Energy intensity, carbon dioxide emission per GDP, manufacturing production and value-added production has converted to its natural logarithm since estimations made by the natural logarithm of the variables also shows the coefficients as elasticity.

Manufacturing production is taken as 2010=100 index due to the unavailability of data for the percentage share. Manufacturing value-added (constant 2010 US$) is divided by GDP and multiplied by 100 to estimate shares of manufacturing value added in overall GDP.

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[7] The 28 OECD countries consists of Australia, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Israel, Italy, Japan, Korea, Latvia, Mexico, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States

[8] Data set for value added includes additionally data for Austria and Estonia. Canada, Israel and United States are not included in this data set as the absence of data for manufacturing value added.

Natural logarithm of manufacturing value-added and production are used as dependent variables in two different regression. The percentage of electricity power transmission and distribution losses (electricity) in total electricity generation is used as an independent variable.

Table 1: Descriptive Statistics for 27 Countries with 20 Years

Variable	Observation	Mean	Standard Deviation	Minimum Value	Maximum Value
value-added	540	14.959	4.076	6.863	28.943
electricity	540	7.894	4.382	1.820	46.577
fdi	540	4.583	7.312	-16.071	87.442
htx	540	15.244	9.063	1.205	47.839
coe	540	.325	.217	.0568	1.667
tax	540	33.215	8.069	10.977	49.583
ei	540	.244	.098	.098	.582

Table 2: Descriptive Statistics for 28 Countries with 20 Years

Variable	Observation	Mean	Standard Deviation	Minimum Value	Maximum Value
production	560	4.518	.257	3.476	4.957
electricity	560	7.205	3.065	1.820	19.016
fdi	560	4.239	7.017	-16.071	87.442
htx	560	15.804	9.237	1.205	47.839
coe	560	.326	.190	.056	1.363
tax	560	32.833	7.833	10.977	49.583
ei	560	.247	.0934	.098	.566

Energy intensity (ei)[9] for each country is calculated as follows:

$$ei_{i,t} = \frac{elec\_cons_{i,t}}{GDP_{i,t}} \tag{1}$$

where, $elec\_cons$ represents power consumption of country i at year t divided by GDP, which is taken as constant 2010 US$ in millions for all estimation purposes. Next section will demonstrate the empirical methods employed in this thesis.

[9] In general, energy intensity is calculated by Primary Energy Consumption (PEC) over Gross Domestic Product (GDP). However, electricity consumption is used as primary energy consumption of countries in the Equation (1) since the subject of this thesis is investments of electricity infrastructure.

2.3. METHODS

The examination of the relationship between electricity infrastructure quality and manufacturing activity is conducted in four steps. First, the data set is tested for the existence of cross-sectional dependence, which is a common issue in cross country analysis. Second, unit root tests are employed since there may be unit root problems when the large time dimension exists. Third, the panel cointegration test was used to control the long-run relationship between variables. Fourth, panel Autoregressive Distributive Lag Approach (ARDL) with second-generation estimators (i.e., CCEMG, AMG) is applied.

In order to estimate the short-run and the long-run relationship of variables, panel Autoregressive Distributive Lag Approach (ARDL) developed by Pesaran and Smith (1995) and Pesaran, Shin and Smith (1997) is utilized in this study. Before proceeding to panel ARDL method, panel unit root and cointegration tests are implemented. Panel ARDL approach requires large time dimension, moreover, the unit root is a common problem in large time dimension panels. Therefore, when the panel has a lager T dimension, there might be a stationarity problem, and hence, the unit root test should be utilized to control stationarity. To implement the unit root, cointegration, and panel ARDL tests; initially, a balanced panel data set was constructed for selected countries with 20 years as time periods.

To confirm the degree of integration of the variables which means the variables are I(0) or I(1), two different unit root tests: Levin-Li-Chu (hereafter LLC) proposed by Levin, Lin, Chu (2002) and Im-Pesaran-Shin (IPS) tests developed by Im, Pesaran, Shin (2003) are implemented.

The LLC unit root test does not allow for heterogeneity in the autoregressive coefficients and uses pooled t-statistic of the estimator to classify the null hypothesis against the alternative hypothesis (2).

$$H_o: \beta_{1=}\beta = 0$$
$$H_A: \beta_i \prec 0, \;\; for\ all\ i \qquad (2)$$

In other words, LLC assume that homogeneous autoregressive coefficients between individual and then, control the null hypothesis.

The basic panel unit-root test of LLC for N series and T time periods can be represented as (3):

$$\Delta y_{i,t} = \alpha_i + \rho y_{i,t-1} + \sum_{z=1}^{p_i} \beta_{i,z} \Delta y_{i,t-z} + \varepsilon_{i,t} \tag{3}$$

$$i = 1,2,\ldots,N$$
$$t = 1,2,\ldots,T$$

where $y_{i,t}$ denotes each independent, dependent and control variables, α_i is the individual effect ($\alpha_i = 0\ for\ all\ i\ under\ the\ null\ hypothesis, H_o$) which restricts the alternative hypothesis as it refers to the autoregressive parameters are assumed identical across the panel.

Since p_i is unknown, Levin et al. (2002) carried out three steps the LLC unit root test. Firstly, augmented Dickey-Fuller (ADF) regressions for each cross-section are distinguished and then two orthogonalized residuals are generated. Secondly, the ratio of the long-run to the short-run innovation standard deviation for each individual is estimated. Finally, the pooled t-statistics is calculated (Levin, Li, Chu 2002: 5).

Levin, Li, Chu (2002) does not allow for heterogeneity in the autoregressive coefficients, Im, Pesaran, Shin (2003, hereafter IPS) solved this problem with the help of assuming heterogeneity between units in a dynamic panel framework (Eggoh, Bangake, Rault 2011: 7412). Panel unit-root test of IPS for N series and T time periods can be represented basically as Equation (3); where $y_{i,t}$ represents each variable, e.i., independent, dependent and control variables, α_i is the individual fixed effects, ρ makes the residuals uncorrelated over time. The IPS statistics is based on the average of the adjusted Dickey-Fuller (ADF) test statistics, it can be written as equation (4), and computed for each member of the panel independently (Canning and Pedroni 2004: 9).

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{iT} \tag{4}$$

t_{iT} is the ADF t-statistics for the unit root test of each cross-section units. Under the H_0 assumptions, $\bar{t}$ is normally distributed and critical values for T and N are sustained. The null hypothesis is that all individual contains unit root (5);

$$H_0: \rho_i = 0 \ \forall_i \tag{5}$$

Against alternative hypothesis (6) is allows some of the individuals have unit root.

$$H_A: \quad \begin{array}{l} \rho_i < 0 \ for \ i = 1, 2, \ldots, N_1 \\ \rho_i < 0 \ for \ i = N_1 + 1, \ldots, N \end{array} \tag{6}$$

When the panel consists of cross-sectional dependence across the panel, LLC and IPS, which are first-generation unit root tests, are biased. Hence, the implementation of Pesaran (2007)'s unit root test is required as second-generation unit root tests. Although there are several unit root tests which allow cross-sectional dependence**,** augmented ADF (CADF) and augmented IPS (CIPS) unit root tests are used to check the stationarity of data in this thesis. Unit root test which is developed by Pesaran (2007) allows cross-section dependence and heterogeneity. This unit root test includes augmented Dickey-Fuller (ADF) regression with the cross-section averages. The CADF test statistics with the simple dynamic linear heterogeneous panel data model is denoted as (7);

$$y_{i,t} = (1 - \phi_i)\mu_i + \phi_i y_{i,t-1} + u_{i,t} \tag{7}$$

$$u_{i,t} = \gamma_{i,t} f_t + \varepsilon_{i,t} \tag{8}$$

$y_{i,t}$ denotes each variable, f_t is the unobserved common factor effects, $\varepsilon_{i,t}$ is the individual specific (idiosyncratic) error. As stated in Pesaran (2007) Equation (7) and Equation (8) can be rewritten as follows (9);

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i f_t + \varepsilon_{i,t} \qquad (9)$$

where
$\alpha_i = (1 - \phi_i)\mu_i$
$\beta_i = -(1 - \phi_i)$
$\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$

The null hypothesis of unit root for the whole panel, which is $\phi_i = 1$, is denoted as (10) against alternative hypothesis, series are stationary for some groups, (11);

$$H_o: \beta_i = 0 \; for \; all \; i \qquad (10)$$

$$H_A: \begin{matrix} \beta_i < 0, & i = 1,2,3, \dots, N_1 \\ \beta_i = 0, & i = N_1 + 1, N_1 + 2, \dots, N \end{matrix} \qquad (11)$$

Pesaran (2007) predicated test of unit root hypothesis, (10), on the t-ratio of the ordinary least squares (OLS) estimate of $b_i(\hat{b}_i)$ in the bellow CADF regression;

$$\Delta y_{i,t} = \alpha_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + \varepsilon_{i,t} \qquad (12)$$

The test statistics is developed by Pesaran (2007), is qualified by the simple average of the CADF statistics given by the OLS t-ratios. T-ratios is calculated with equation (13). The lag length for variables (i.e. $\bar{y}_{t-1}$, $\bar{y}_{t-2}$, $\bar{y}_{t-3}$) is based on information criteria such as Akaike (AIC) or Schwarz (SIC), and it is identified by the Berlett Kernel window width equals to $4(\frac{T}{100})^{2/9}$, where T is the number of observations (Persyn and Westerlund 2008: 238). Moreover, Pesaran (2007) provides critical values of individual CADF distribution of values with three standard cases in Tables 1a, 1b and 1c which dedicate no intercept and no trend, intercept only and intercept and trend respectively (Pesaran 2007: 284).

$$t_i(N,T) = \frac{\Delta y'_i \bar{M}_w y_{i,-1}}{\hat{\sigma}_i({y'}_{i,-1} \bar{M}_w y_{i,-1})^{1/2}} \tag{13}$$

Another second-generation unit root test is augmented IPS (CIPS) developed by Pesaran (2007) is based on equation (12). CIPS is the average of individual cross-sectional augmented ADF (CADF) statistics from estimating Equation (14). CADF test is utilizable for both N>T and T>N however, the truncated version of CIPS (CIPS*) that is demonstrated in equation (15) is recommended for small T or N>T (Pesaran 2007: 267).

$$CIPS\ (N,T) = t - bar = N^{-1} \sum_{i=1}^{N} t_i\ (N,T) \tag{14}$$

$t_i(N,T)$ is the cross-sectionally augmented ADF (CADF) statistics for t-ratio of the coefficient of $y_{i,t-1}$ in the Equation (14). Hence, the null hypothesis and the alternative hypothesis are the same with CADF test statistics as denoted by (10), (11).

$$CIPS^*(N,T) = N^{-1} \sum_{i=1}^{N} t_i^*\ (N,T) \tag{15}$$

The cross-country analysis may consist of cross-sectional dependence in the error terms ($\varepsilon_{i,t}$) due to the presence of common shocks and unobserved components, therefore, implementation of cross-sectional dependency test is important for the cross country analysis. The Lagrange Multiplier (LM) test developed by Breusch and Pagan (1980) is commonly known as cross-sectional dependence test. However, the LM test is valid when the time dimension is larger than the number of groups, $T > N$. When $N > T$, the number of groups is larger than the time dimension as in this thesis case, LM test is invalid. Hence, three statistical approaches, which are proper $N > T$ data set, are used in the estimating of cross-sectional dependence (Hoyos and Sarafidis 2006: 483-486). Three tests for cross-sectional dependence are cross-sectional dependence (CD) test developed by Pesaran (2004), Friedman's statistics (1937) and other test statistics of cross-sectional dependence proposed by Frees (1995). The basic panel data model denotes as;

$$y_{it} = \alpha_i + \beta' x_{i,t} + \varepsilon_{i,t} \tag{16}$$

where y_{it} represents the dependent variable, $x_{i,t}$ is independent and control variables, β is slope coefficient and α_i is individual intercept in Equation (16). The null hypothesis (17); $\varepsilon_{i,t}$ is independent and identically distributed across cross-sectional unit i and time dimension t. Under the alternative hypothesis $\varepsilon_{i,t}$ is correlated with cross-sections.

$$\begin{aligned} &H_o: cor(\varepsilon_{i,t}, \varepsilon_{j,t}) = 0 \ for \ all \ t, i \neq j \\ &H_A: cor(\varepsilon_{i,t}, \varepsilon_{j,t}) \neq 0 \ \ at \ least \ for \ one \ of \ i \neq j \end{aligned} \tag{17}$$

In other words, the null hypothesis assumes there is cross-sectional independence, on the contrary, the alternative hypothesis assumes there is cross-sectional dependence in the panel.

In order to estimate short-run and the long-run relationship of variables, panel Autoregressive Distributive Lag Approach (ARDL) developed by Pesaran and Smith (1995) and Pesaran, Shin and Smith (1997) is employed in this study. Before proceeding to the ARDL method; cointegration test is implemented in an effort to check variables of long-run integrations. Besides, employing unit root test is not necessary since the ARDL approach overcomes the problems resulting from non-stationary time series data; nevertheless, ARDL approach requires large time dimension, therefore panel might consist unit root problems. There are two tests that should be investigated prior to apply the panel ARDL. One of these tests is about unit root tests and the other one is cointegration test before the implementation of panel ARDL approach.

Initially, the presence of the long-run relationship between variables is examined. When the long-run relationship between variables exists, that means variables are cointegrated, and then the second step can be computed.[10] The second step is the investigation of the long-run coefficient based on the ARDL approach. To analyze the presence of the long-run relationship between variables, which is the first step of panel ARDL, error correction based cointegration test as generally known as ECM panel cointegration test developed by Westerlund (2007) is applied. The use of ECM panel cointegration test has more advantageous than the heterogeneous panel cointegration test proposed by Pedroni (1999, 2004). Pedroni (1999) cointegration tests consist of the null hypothesis of common factor restriction, in other words, cross-country dependence does not take into account. According to residual-based cointegration test, the long run parameters for the variables in their levels and the short-run parameters for the variables in their first differences are equal to each other; with these suggestions, cointegration test may cause a significant loss of power (Persyn and Westerlund 2008: 232). In response to this, the Westerlund (2007) proposed four new panel tests of the null hypothesis of no cointegration. They are based on structural rather than residual dynamics, and therefore, do not impose any common factor restriction (Westerlund 2007: 710). The basic equation for ECM cointegration test is equation (19) generating with equation (18);

[10] Unit root tests are also examined before ARDL approach. Inasmuch as unit root tests were explained in Chapter 2.3 before, unit root tests are not explained again.

$$\Delta y_{i,t} = \delta_i' d_t + \alpha_i\left(y_{i,t-1} - \beta_i' x_{i,t-1}\right) + \sum_{j=1}^{p_i} \alpha_{i,j}\, \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \gamma_{i,j}\, \Delta x_{i,t-j} + \varepsilon_{i,t} \qquad (18)$$

where d_t is the deterministic components, $d_t = 0$ means there is no deterministic term, $d_t = 1$ means $\Delta y_{i,t}$ generated with constant and $d_t = (1, t)$ means $\Delta y_{i,t}$ generated with both constant and trend. $y_{i,t}$ represents the dependent variable, in this study it denotes manufacturing value-added and production, and $x_{i,t}$ represents a set of independent and control variables. ECM cointegration test equation can be written by using equation (19);

$$\Delta y_{i,t} = \delta_i' d_t + \alpha_i y_{i,t-1} + \lambda_i' x_{i,t-1} + \sum_{j=1}^{p_i} \alpha_{i,j}\, \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \gamma_{i,j}\, \Delta x_{i,t-j} + \varepsilon_{i,t} \qquad (19)$$

Moreover, (19), $\lambda_i' = -\alpha_i \beta_i'$ with α_i demonstrate the speed of the system $y_{i,t-1} - \beta_i' x_{i,t-1}$ at which changes back to equilibrium after an unexpected shock. The number of lags and lead lengths for variables are determined by Akaike Information Criteria (AIC) and the Berlett Kernel window width equals to $4(\frac{T}{100})^{2/9}$, where T is the number of the time dimension. When $\alpha_i < 0$, the model is error correcting means that there is cointegration between the dependent variable $y_{i,t}$ and the independent variable $x_{i,t}$. In this case, the null hypothesis, which is denoted by (20), is tested. When $\alpha_i = 0$, the model is not error-correcting hence, there is no cointegration between variables. The alternative hypothesis differs as group mean test and panel test as proposed by Westerlund (2007) four different panel cointegration tests based on least square estimates of α_i and its t-ratio. For two of the four models namely as the group mean tests, G_τ and G_α tests, the null hypothesis versus the alternative hypothesis (21) indicates that at least one i in the panel is cointegrated. The other two tests namely as panel test denotes as P_τ and P_α uses the alternative hypothesis (22) which assumes α_i equals to all i, means that the panel is cointegrated.

$$H_o: \alpha_i = 0 \; for \; all \; i \tag{20}$$

$$H_A^G: \alpha_i < 0 \; at \; leats \; for \; one \; i \tag{21}$$

$$H_A^P: \alpha_i = \alpha \; < 0 \; for \; all \; i \tag{22}$$

After employing unit root and cointegration tests, panel autoregressive distributive lag approach (ARDL) proposed by Pesaran and Smith (1995) and Pesaran, Shin and Smith (1999) is employed. Panel ARDL approach has many advantages that concern lags of the dependent variable and the independent variables added to the model as a regressor. And also, series can be I(1) or I(0); the ARDL approach overcomes the problems resulting from non-stationary time series data (Laurenceson and Chai 2003: 28). After controlling cross-sectional dependence, unit root test and panel ARDL test's estimators should be reconsidered. If there is cross-sectional independence first-generation test can be implemented to the panel, yet, in the case of cross-sectional dependence first-generation tests are invalid and second-generation tests should be applied to the panel since they allow the cross-sectional dependence. Westerlund's (2007) cointegration test, which is clarified above, is utilized for both cross-sectionally dependent and independent panels.

When the panel does not exhibit cross-sectional dependence, there are two estimators of panel ARDL approaches to estimate long-run relationship; one of them is the pooled mean-group estimator (PMG) developed by Pesaran, Shin and Smith (1999) and the other one is the mean-group estimator (MG) developed by Pesaran and Smith (1995). The MG estimators based on N time-series regression and averaging the coefficients, though, PMG estimator based on pooling and averaging the coefficients (Blackburne and Flank, 2007: 198). When the model is homogeneous means that the long-run coefficients are equal to across all panel, PMG estimator is efficient. When the model is heterogeneous, the PMG estimator is inconsistent since the long run parameters are not the same for across panel, MG estimator is consistent (Berk and Yetkiner, 2014: 232). The test of differences between PMG and MG estimator is checked with Hausman test. The panel ARDL equation, where the optimal lag length is identified by using standard information criteria such as the Akaike Information or Schwartz Bayesian, can be express as follows;

$$y_{i,t} = \sum_{j=1}^{p} \lambda_{i,j} y_{i,t-j} + \sum_{j=1}^{q} \delta'_{i,j} x_{i,t-j} + \mu_i + \varepsilon_{i,t} \tag{23}$$

where $y_{i,t}$ is the dependent variable, x_i is the independent variable, the coefficients of the lagged dependent variables $\lambda_{i,j}$ is scalars and μ_i represents the group-specific effects. Pesaran, Shin and Smith (1999) applied re-parameterization of equation (23) with following error correction parameterization equation;

$$\Delta y_{i,t} = \phi_i (y_{i,t-1} - \theta'_i x_{i,t}) + \sum_{j=1}^{p-1} \lambda^*_{i,j} \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta'^*_{i,j} \Delta x_{i,t-j}\, \mu_i + \varepsilon_{i,t} \tag{24}$$

$$\begin{aligned} \Delta lnproduction_{i,t} &= \phi_i (lnproduction_{i,t-1} - \theta'_i electirictiy_{i,t}) \\ &+ \sum_{j=1}^{p-1} \lambda^*_{i,j} \Delta lnproduction_{i,t-1} + \sum_{j=0}^{q-1} \delta'^*_{i,j} \Delta electirictiy_{i,t-j}\, \mu_i \\ &+ \varepsilon_{i,t} \end{aligned} \tag{25}$$

$$\Delta lnvalue\_added_{i,t} = \phi_i(lnvalue\_added_{i,t-1} - \theta'_i electirictty_{i,t}) + \sum_{j=1}^{p-1} \lambda^*_{i,j} \Delta lnvalue\_added_{i,t-1} + \sum_{j=0}^{q-1} \delta'^*_{i,j} \Delta electirictty_{i,t-j}\, \mu_i + \varepsilon_{i,t} \tag{26}$$

where;

$$\phi_i = -(1 - \sum\nolimits_{j=1}^{p} \lambda_{i,j})$$

$$\theta_i = \sum\nolimits_{j=0}^{q} \delta_{i,j} \Big/ (1 - \sum\nolimits_k \lambda_{i,k})$$

$$\lambda^*{}_{i,j} = -\sum\nolimits_{m=j+1}^{p} \lambda_{i,m}$$

$$\delta^*{}_{i,j} = -\sum\nolimits_{m=j+1}^{p} \delta_{i,m}$$

ϕ_i is the error-correcting term (ECT) speed of adjustment, when $\theta_i = 0$ there is no cointegration. This parameter is expected to equal significantly negative values so that variables are adjusting back to equilibrium in the long-run. The long-run homogeneity restriction can be tested by Hausman test whose null hypothesis is homogeneity of the cross-section's long run coefficient. Under the null hypothesis of the long-run homogeneity, even the PMG and the MG estimators are consistent, the MG estimator is not efficient, the PMG estimator is efficient.

In the case of cross-sectional dependence across groups, second-generation estimators of ARDL are utilized to estimate the panel time series models with heterogeneous slopes. Pesaran and Smith (1995) indicated that when the panels are heterogeneous across cross-section, in other words, it includes cross-section dependence, pooling and averaging (PMG) estimator is biased. Mean Group (MG) estimator does not applicable since it does not consist of cross-section dependence (Pesaran and Smith, 1995: 80). MG assumes there is not an unobserved common factor, f_t, with heterogeneous factor loading, λ_i, which are obtaining heterogeneity and cross-section dependence. Therefore, the common correlated effects mean group (CCEMG or called as CCE) and the augmented mean group (AMG) estimators are used to estimate panel time series models with heterogeneous slopes. Both estimators made up with standard OLS and average of coefficient across groups (Eberhardt, 2012: 63). Before the explanation of CCEMG and AMG, the basic model which comprises the heterogeneous slope coefficients across group members as follows;

$$y_{i,t} = \alpha + \beta\, x_{i,t} + \theta_k Z_{k,i,t} + u_{i,t} \tag{27}$$

where, $u_{i,t} = \mu_i + \lambda_i f_t + \varepsilon_{i,t}$

In equation (27) $y_{i,t}$ represents two dependent variables chosen to proxy manufacturing performance, namely production and value-added. Moreover, $x_{i,t}$ represents independent variables and $Z_{k,i,t}$ represents several control variables. As shown in equation (27) $u_{i,t}$ consists of the unobservables, which are group fixed effects α_{1i} and unobserved common factor f_t with heterogeneous factor loading λ_i and the individual-specific (idiosyncratic) error terms $\varepsilon_{i,t}$.

For instance, when all control variables are included the equation for lnproduction and lnvalue_added take the following forms, respectively:

$$\begin{aligned} lndproduction_{i,t} \\ &= \beta_{1i} electricity_{i,t} + \beta_{2i} fdi_{i,t} + \beta_{3i} htx_{i,t} + \beta_{4i} lncoe_{i,t} \\ &+ \beta_{5i} tax_{i,t} + \beta_{6i} lne\_intensity_{i,t} + u_{i,t} \end{aligned} \tag{31}$$

$$
\begin{aligned}
&lnvalue\_added_{i,t} \\
&\qquad = \beta_{1i} electricity_{i,t} + \beta_{2i} fdi_{i,t} + \beta_{3i} htx_{i,t} + \beta_{4i} lncoe_{i,t} \\
&\qquad + \beta_{5i} tax_{i,t} + \beta_{6i} lne\_intensity_{i,t} + u_{i,t}
\end{aligned} \tag{33}
$$

The Common Correlated Effects Mean Group (CCEMG) developed by Pesaran (2006) and the Augmented Mean Group (AMG) proceed by Eberhardt and Teal (2010) estimators consist of cross-sectional dependence and heterogeneous slope coefficients. CCEMG is obtained by transforming of the MG estimator based on group-specific OLS regression. In addition, f_t, unobservable common factor, is treated as a nuisance, hence it is not particular interest for the analysis in the CCEMG estimator. However, in the AMG which is the alternative estimator of the CCMG estimator; includes a common dynamic process as unobserved common factors, f_t (Sadorsky, 2013: 55). AMG is implemented with three stages. Firstly, common dynamic process, cross-group average of the evolution of factors, is estimated by first difference OLS of pooled regression model augmented with year dummies. Secondly, the group-specific regression augmented with the estimated common dynamic process. Thirdly, the group-specific model parameters are averaged across the panel like in the MG and CCEMG estimator (Eberhardt, 2012: 64,65) In short, the AMG estimates the unobservable common factors in stage (1) while the CCEMG provides a proxy for the unobservable common factors with the cross-section averages of dependent and independent variables.

2.4. EMPIRICAL RESULTS

The cross-sectional dependence test results for dependent and independent variables from estimating Equations (25), (26) is demonstrated in Table 3.[11] According to all three test results for both regressions, panels exhibit the problem of cross-sectional dependence, they reject the null hypothesis of cross-sectional independence. In Table 3(a), P-value of Pesaran's CD test is less than alpha means that these test results reject the null hypothesis at 1% significance level. Also, Friedman's test rejects the null hypothesis at 1% significance level. In Free's Critical values are available for 1%, 5%, 10% significance level from Q distribution. Since the time dimension is less than 30[12], and also this test rejects the null hypothesis. As can be seen in Table 3(b), Pesaran's CD test and Friedman's test reject the null hypothesis due to P-value. Free's statistic is larger than critical values, thereby the null hypothesis of cross-sectional independence is rejected. According to Table 3 results, the panel consists of cross-sectional dependence for both regressions. Therefore, second-generation tests are implemented in this thesis in order to estimate consistent and unbiased results.[13]

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[11] The command "xtreg" is used in Stata (v.14) for the cross-sectional dependence estimations as explained in Hoyos and Sarafidis (2006). The results of the cross-sectional dependence test for dependent, independent variable and whole control variables are in Appendix.

[12] For additional information about Free's critical values for $T < 30$ and Q distribution please refer to Hoyos and Sarafidis (2006).

[13] First-generation tests results are available in Appendix.

Table 3: Cross-Sectional Dependence and Slope Heterogeneity Tests.

	Dependent Variable: PRODUCTION (a)		Dependent Variable: VALUE-ADDED (b)	
	Fixed-Effects (Within) Regression	Random-Effects (GLS) Regression	Fixed-Effects (Within) Regression	Random-Effects (GLS) Regression
Pesaran's CD[a]	16.288*** (0.0000)	23.165*** (0.0000)	6.292*** (0.0000)	6.294*** (0.0000)
Frees' test[b]	5.004*** (0.1294)* (0.1695)** (0.2468)***	7.128*** (0.1294)* (0.1695)** (0.2468)***	9.706*** (0.1294)* (0.1695)** (0.2468)***	9,664*** (0.1294)* (0.1695)** (0.2468)***
Friedman's test[c]	102.941*** (0.0000)	153.031*** (0.0000)	47.982*** (0.0054)	48.244*** (0.0051)

Notes 1: In the three tests the null hypothesis is that of cross-sectional independence
Notes 2: Optimal lag and lead lengths selected via AIC are both 1 and optimal Bartlett kernel window width is set to be 3.
P-values are reported in parenthesis for [a] Pesaran (2004) and [c] Friedman's statistics (1937)
Critical values are reported in parenthesis for [b] Frees (1995) ***, **, * represent significance at 1%, 5%, 10%

According to unit root test results shown in Table 4(a), electricity, fdi and coe reject the null hypothesis of non-stationarity, they are I(0) while production, htx, tax and ei do not reject the null hypothesis and they are stationary in first differences, I(1). In Table 4(b) electricity and fdi are stationary I(0) and value-added, htx tax, ei and coe's first differences are stationary, I(I).

In order to test the presence of unit root problem, all variables are estimated with Equations (15) which is the truncated version of CIPS proceed by Pesaran (2007) as mentioned in the previous section[14]. Since the truncated version of CIPS gives more significant outcomes for small T, CIPS* is utilized in estimation. Estimation results of the unit root test are denoted in Table 4[15].

[14] In Equation (15) is constructed for all variables. Also, Equation (15) is rearranged for control variables during the estimation process.
[15] The command "xtcips" is used in Stata (v.14) for the second-generation unit root estimations as explained in Sangiácomo (2016).

Table 4: Peseran (2007) Second-Generation Unit Root Tests

	Dependent Variable PRODUCTION (a)		Dependent Variable VALUE-ADDED (b)	
Variables	CIPS (levels)	CIPS I(1)	CIPS (levels)	CIPS I(1)
production	-1.291	-2.709***	-	-
value-added	-	-	-0.806	-3.308***
electricity	-2.490***	-	-2.708***	-
fdi	-3.381***	-	-3.393***	-
htx	-1.980	-3.957***	-1.729	-4.033***
coe	-2.388**	-4.298***	-2.079	-4.215***
tax	-1.750	-4.026***	-1.742	-4.024***
ei	-1.238	-3.766***	-1.218	-3.388***

Notes: In CIPS tests, the null hypothesis is non-stationarity of series.
*** represent significance at 1%

The long-run relationship between production and electricity is estimated by ECM panel cointegration test developed by Westerlund (2007) via Equation (19).[16] The four-cointegration tests results for production and electricity are presented in Table 5(a). All test statistics reject the null hypothesis of no cointegration between variables at 1% significance level.

The cointegration test results of value-added and electricity are demonstrated in Table 5(b).[8] According to four tests results, variables are cointegrated at 1% significance level for G_τ and G_a . Variables are cointegrated at 5% significance level P_a test, it rejects the null hypothesis at 5% significance level, whereas P_τ test does

[16] The command “xtwest” explained in Persyn and Westerlund (2008) is used in Stata (v.14) to estimate presence of panel cointegration between variables.

not reject the null hypothesis of no cointegration between variables at any significance level.

Table 5: Westerlund (2007) Panel Cointegration Tests.

	Dependent Variable PRODUCTION (a)		Dependent Variable VALUE-ADDED (b)	
	Value	P-value	Value	P-value
G_τ	-3.909***	0.000	-3,942***	0.000
G_α	-16.221***	0.000	-19,777***	0.000
P_τ	-13.319***	0.006	-11,083	0.452
P_α	-16.299***	0.000	-11,577**	0.011

*** and ** represent significance at 1%, 5%.

After establishing that manufacturing production and manufacturing value added are linked in the long run with electricity power transmission & distribution losses and control variables, panel ARDL second generation estimators can be tested with Equations (27). The results of the relation of manufacturing production (production) and electricity transmission & distribution losses (electricity) are shown in Tables 6 and 7; the results of the relationship between manufacturing value added (value-added) and electricity power transmission & distribution losses (electricity) are shown in Table 8 and 9.

Initially, dependent and independent variables are tested by CCEMG and AMG estimator proceed by Pesaran (2006) and Eberhardt and Teal (2010). Then each control variables added to regression in order to robust check and estimate specific effects of control variables, and also change in impacts of electricity power transmission & distribution losses on manufacturing production and manufacturing value added.

CCEMG estimator's results are denoted in Table 6 and AMG estimator's results are denoted in Table 7. According to the CCEMG estimator results in Table 6, when electricity power transmission and distribution losses increase by 1 percent, manufacturing production decreases by 0.028 percent in regression (1). In regression (2) whose fdi is included as a control variable, increase of the electricity power transmission and distribution losses by 1 percent brings along the decrease of manufacturing production by 0.026 percent. When htx implicated in the regression, the effects of electricity power transmission and distribution losses on manufacturing production remains the same percentage. In regression (4), which includes coe as a control variable, increase of the electricity power transmission and distribution losses by 1 percent leads to decrease in manufacturing production by 0.019 percent. When ei used as a control variable, this ratio has become 0.020. Once regression (5) involves tax as a control variable, the increment in electricity power transmission and distribution losses by 1 percent causes to decrement in manufacturing production by 0.020 percent. When all variables included in the regression (7), electricity still affects negatively, yet, it is not statistically significant for CCEMG estimator.

In CCEMG results, the effect is highly significant, except regression (7). Besides, electricity has negative and significant effects for all equation in AMG estimator's results, as seen in Table 7.

Table 6: Panel ARDL- CCEMG Estimator

Dependent Variable: PRODUCTION							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
electricity	-0.028***	-0.026***	-0.026***	-0.019***	-0.023**	-0.020***	-0.006
	(0.009)	(0.007)	(0.009)	(0.007)	(0.010)	(0.005)	(0.006)
fdi		-0.002					-0.000
		(0.002)					(0.001)
htx			-0.000				0.002
			(0.006)				(0.002)
coe				-0.180*			0.190**
				(0.107)			(0.082)
tax					0.009		0.005
					(0.007)		(0.004)
ei						-0.558***	-0.512***
						(0.171)	(0.188)

In Table (7), there were only two variables are tested, they are manufacturing production and electricity in regression (1). According to the result, if electricity power transmission and distribution losses increase by 1 percent, manufacturing production will decrease by 0.040 percent. In regression (2,) fdi is added as a control variable, negative effects of electricity power transmission and distribution losses have become 0.038. Htx and ei as control variables have used in regression (3) and regression (6), respectively, the effects of electricity power transmission and distribution losses are the same ratio for these regressions. When energy increases by 1 percent, production decreases by 0.034 percent for regressions (3) and (6). In regression (4) coe is included as a control variable. In this case, an increase in electricity power transmission and distribution losses by 1 percent generates 0.024 percent decline in manufacturing production. Regression (5) involves tax as a control variable. As stated in the results of regression (5) the rise of electricity power transmission & distribution losses by 1 percent leads to falling manufacturing production by 0.034 percent. In regression (7) all variables are put to regression and significant negative effect of electricity on production remains, and it is the amount of -0.014. In short, electricity affects production negatively in all regression and both CCEMG and AMG estimators.

Table 7: Panel ARDL- AMG Estimator

Dependent Variable: PRODUCTION							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
electricity	-0.040***	-0.038***	-0.034***	-0.024***	-0.031***	-0.034***	-0.014**
	(0.011)	(0.011)	(0.013)	(0.008)	(0.011)	(0.009)	(0.007)
fdi		0.001					-0.001
		(0.007)					(0.002)
htx			0.007*				0.004
			(0.004)				(0.003)
coe				-0.040			0.201*
				(0.151)			(0.116)
tax					0.009		0.006
					(0.006)		(0.004)
ei						-0.201	-0.454**
						(0.236)	(0.214)
c_d_p	0.860***	0.877***	0.914***	0.849***	0.741***	0.820***	0.940***
	(0.172)	(0.178)	(0.167)	(0.111)	(0.153)	(0.143)	(0.092)

Value-added means that the value of the net output of sector which is excluded from all outputs used in the production process and intermediate inputs. Therefore, manufacturing value added needs to be tested to demonstrate the pure effects of electricity power transmission & distribution losses on the industry.

The CCEMG estimator's results in Table 8 indicates that electricity has a negative effect on value-added, however, the effect is slightly significant. According to regression (1) in Table 8, an increase of the electricity power transmission & distribution losses by 1 percent leads to decrease in the manufacturing value-added by 0.009 percent. As is seen from regression (2), which maintains fdi as a control variable, the effects of the electricity power transmission & distribution losses increase as 0.01096 percent. In regression (4) the effect of electricity power transmission & distribution losses is -0.008. Once the electricity power transmission & distribution losses increase by 1 percent, manufacturing value added decreases by -0.008 percent. In regression (8), which is used ei as a control variable, the effects of the electricity power transmission & distribution losses are similar to 0.008 percent. In regression (3) and regression (5) which include htx and tax as control variables, respectively, the effects of the electricity power transmission & distribution losses still negative but not statistically significant. This situation remains the same for regression (7) that involves all control variables.

As is seen from Table 9 in AMG estimator's results, the effects of electricity are still negative, but the value of significance has decreased considerably. In Table 9, the negative effects of electricity on value-added are the same negative 0.005 for regressions (2), (3) and (5) that used fdi, htx and tax as control variables, respectively. This means that once increasing by 1 percent in electricity power transmission and distribution losses causes reduce to manufacturing value added by 0.005 percent. The results of estimating without control variables that is regression (1) show that if electricity power transmission and distribution losses increase by 1 percent, manufacturing value-added will decrease by 0.004 percent. When coe is added in the regression (4), the effect of electricity has become negative 0.009. In regression (6), ei was used as a control variable. According to results of regression (6) raising electricity power transmission and distribution losses by 1 percent leads diminishing manufacturing value-added by 0.016 percent. In addition, this effect is statistically significant at the 0.05 level. Once whole control variables are added into the regression (7), the effects of electricity power transmission and distribution losses have become -0.002.

The negative relation between electricity and value-added remains negative; even several control variables are included in the estimations for both CCEMG and AMG estimators.

Table 8: Panel ARDL- CCEMG Estimator

Dependent Variable: VALUE-ADDED							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
electricity	-0.009*	-0.010*	-0.008	-0.007*	-0.005	-0.008*	-0.002
	(0.005)	(0.006)	(0.006)	(0.004)	(0.005)	(0.004)	(0.006)
fdi		-0.000					-0.000
		(0.001)					(0.000)
htx			0.000				0.007***
			(0.002)				(0.002)
coe				-0.068			0.006
				(0.055)			(0.045)
tax					-0.00031		0.001
					(0.003884)		(0.002)
ei						-0.17138	-0.028
						(0.116266)	(0.106)

Table 9: Panel ARDL- AMG Estimator

Dependent Variable: VALUE-ADDED							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
electricity	-0.004	-0.005	-0.005	-0.009	0.005	-0.016**	-0.002
	(0.018)	(0.018)	(0.017)	(0.007)	(0.015)	(0.006)	(0.004)
fdi		0.000					-0.001
		(0.003)					(0.001)
htx			0.002				0.000
			(0.004)				(0.002)
coe				0.084			0.124**
				(0.102)			(0.060)
tax					-0.006		0.001
					(0.006)		(0.003)
ei						-0.114	-0.101
						(0.162)	(0.120)
c_d_p	0.838***	0.965***	0.888***	0.938***	0.880***	1.167***	1.005***
	(0.186)	(0.254)	(0.186)	(0.181)	(0.240)	(0.189)	(0.154)

In this thesis, AMG estimator is preferred to CCEMG since AMG maintains a common dynamic process as unobserved common factors. Also, the CCEMG includes the cross-section averages of dependent and independent variables as a proxy for the unobservable common factors. Moreover, the results of common dynamic process (c_d_p) which is estimated by the Augmented Mean Group (AMG) estimator in Table (7), (9) is positive and significant at 1% under all regression. This also denotes that necessity of using AMG estimator for the panel in this thesis. Furthermore, AMG is more advantages than CCEMG due to limited degrees of freedom.[17]

[17] More information about AMG and CCEMG is explained in methodology.

CONCLUSION

Uninterrupted and continuous energy supply has always been an important aspect of sustainable development. As an indication of this, the importance of sustainable energy supply and power infrastructure for countries and institutions is clearly seen in the published official reports. From this point of view, this thesis aimed at evincing the role of power infrastructure quality on industrial performance.

This thesis investigated the relationships between power infrastructure quality and manufacturing performance with empirical methods in major OECD countries over the period from 1995 to 2014. Accordingly, annual data of the manufacturing production, value added as proxies for manufacturing performance and electricity power transmission & distribution losses as a proxy for power infrastructure quality[18] are estimated by Panel Autoregressive Distributive Lag Approach (ARDL). Since the existence of cross-sectional dependence and heterogeneity across panels, second-generation estimators, such as the Common Correlated Effects Mean Group (CCEMG) and the Augmented Mean Group (AMG), are used to estimate the causal relations.

It was predicted that interrupted energy supply would affect the industry negatively within the knowledge of the literature review. Even though the electricity power transmission and distribution losses affect both series negatively, these effects were not at the expected level of significance for the second series in which the value-added is the dependent variable. This might have occurred due to the fact that the data cover OECD countries and do not cover undeveloped-developing countries because of the absence of data. Although developed countries have advanced technology in the storage of electricity, nevertheless, results show the evidence of electricity power transmission and distribution losses has still considerable effects on the industry. The results state that electricity power transmission and distribution losses have negative impacts on both for manufacturing production and for manufacturing value added. According to results, its impacts on manufacturing production are highly and on value-added are slightly significant.

[18] Also control variables included in both two regression for manufacturing production and value-added.

It is very difficult to prevent the energy import-dependent countries from being affected by the negative externalities which are arising from political and economic adverse events with their energy trade partners. Due to the fact that it is impossible to control externalities, the efficient use of existing resources has necessarily become more precious. Reduction of electricity power transmission and distribution losses is required to increase efficiency on behalf of the more efficient use of existing resources. Since OECD countries are also energy import-dependent countries, it would be beneficial for them to reduce electricity power transmission and distribution losses in order to use their resources efficiently.

The averages of electricity power transmission and distribution losses between 2009 and 2014 for OECD countries, which were used in analyses, are shown in Appendix 12. As can be seen in Appendix 12, some countries[19] are below the average of OECD. Especially, losses of Turkey and Mexico with 14% are more than twice of OECD losses. Electricity power transmission and distribution losses of Hungary, Latvia, Portugal, Spain and Canada along with Turkey and Mexico are also quite a lot compared to OECD averages.

Once countries whose electricity power transmission and distribution losses are above the OECD average reduce their losses to the OECD average or below it; and when countries whose electricity power transmission and distribution losses are below the OECD average reduce their losses to the minimum, they can reduce energy imports at the rate of losses they prevent.

Compare to OECD averages, some countries have a high rate of electricity power transmission and distribution losses like Turkey and Mexico. If these countries reduce the electricity transmission and distribution losses, they not only reduce energy imports, they can also allocate funds for other public or energy-related investments instead of investing in new power plants.

In summary, the main outcomes and conclusions of this study are that countries should promote sustainable and uninterrupted energy supply to make the industry better off. This can be ensured through the enhancement power infrastructure and the strengthening of existing ones.

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[19] These countries: France, Hungary, Ireland, Italy, Latvia, Portugal, Spain, Sweden, Switzerland, United Kingdom, Canada, Chile, Mexico, New Zealand, Turkey.

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APPENDICES

Appendix 1: Electric Power Transmission and Distribution Losses (% of Output) for Developing Countries in 2014

Country	Electric power transmission and distribution losses (% of output)	Country	Electric power transmission and distribution losses (% of output)
Algeria	17.1274244	Turkmenistan	12.4852941
Armenia	11.9870968	Turkey	14.8160643
Albania	23.6875529	Ukraine	10.7789532
Argentina	14.6573815	Venezuela, RB	36.0447183
Azerbaijan	13.5999676	Belarus	9.17518353
Brazil	15.7747976	Bosnia and Herzegovina	8.18069307
Bulgaria	8.55158011	Botswana	11.0246433
China	5.47126636	Colombia	10.6787808
Chile	6.73504178	Costa Rica	10.8250954
Egypt, Arab Rep.	10.9529664	Cuba	15.2896829
Ethiopia	18.6547556	Dominican Republic	12.1786887
Georgia	5.78536303	Ecuador	12.9222035
Indonesia	9.40116555	Gabon	27.7777778
Iraq	50.6315665	Guatemala	9.45945946
Iran, Islamic Rep.	12.6033743	Jamaica	26.7458778
Kazakhstan	6.7403967	Jordan	10.7464325
Kyrgyz Republic	23.7304419	Lebanon	10.4668004
Libya	69.6960059	Malaysia	5.79240383
Mexico	13.7056545	Mauritius	6.19679946
Nepal	32.2096392	Montenegro	17.554365
Nigeria	16.1072721	Namibia	36.2483311
Pakistan	17.1355666	North Macedonia	19.8920729
Portugal	10.0252122	Paraguay	6.57899497
Russian Federation	10.031412	Peru	10.969689
Romania	10.8846354	Suriname	8.71559633
Serbia	15.4368235	Thailand	6.11120126
South Africa	8.3937612		

Appendix 2: Turkey's Electricity Imports with Power Transmission and Distribution Losses and without Power Transmission and Distribution Losses, 1975-2017

Year	% of Imports	% Power Losses	%Imports with No Power Losses
1975	0.640	10.879	0.570
1976	1.903	9.808	1.716
1977	2.517	10.627	2.250
1978	3.029	10.670	2.706
1979	4.930	12.099	4.334
1980	6.129	12.908	5.338
1981	6.923	12.556	6.053
1982	7.057	13.201	6.125
1983	8.652	13.334	7.499
1984	9.237	13.023	8.034
1985	6.713	13.618	5.799
1986	2.106	14.769	1.795
1987	1.370	13.463	1.186
1988	0.835	13.820	0.720
1989	1.144	12.799	0.998
1990	0.324	12.318	0.284
1991	1.342	13.361	1.163
1992	0.299	14.254	0.257
1993	0.305	14.674	0.260
1994	0.043	16.051	0.036
1995	0.000	16.820	0.000
1996	0.300	17.600	0.247
1997	2.537	18.914	2.057
1998	3.127	19.711	2.510
1999	2.105	19.462	1.695
2000	3.194	20.014	2.555
2001	3.939	20.067	3.149
2002	2.900	19.343	2.339
2003	0.856	17.784	0.704
2004	0.320	16.022	0.268
2005	0.409	15.465	0.346
2006	0.338	14.031	0.291

Year	% of Imports	% Power Losses	%Imports with No Power Losses
2007	0.471	14.534	0.403
2008	0.416	14.482	0.356
2009	0.435	15.535	0.368
2010	0.563	14.884	0.479
2011	2.094	14.879	1.782
2012	2.559	15.659	2.158
2013	3.245	16.218	2.718
2014	3.322	15.590	2.804
2015	2.855	14.617	2.438
2016	2.417	13.596	2.088
2017	0.960	12.193	0.843

Appendix 3: The Results of the Cross-Sectional Dependence Test Includes Control Variables.

Cross-Sectional Dependence and Slope Heterogeneity Tests.

	Dependent Variable: PRODUCTION (a)		Dependent Variable: VALUE-ADDED (b)	
	Fixed-Effects (Within) Regression	Random-Effects (GLS) Regression	Fixed-Effects (Within) Regression	Random-Effects (GLS) Regression
Pesaran's CD[a]	8.019*** (0.000)	10.006*** (0.000)	5.871*** (0.000)	5.719*** (0.000)
Frees' test[b]	4.385*** (0.1294)* (0.1695)** (0.2468)***	6.558*** (0.1294)* (0.1695)** (0.2468)***	7.677*** (0.1294)* (0.1695)** (0.2468)***	7,712 (0.1294)* (0.1695)** (0.2468)***
Friedman's test[c]	68.661*** (0.000)	78.600*** (0.000)	37.538* (0.066)	36.839* (0.077)

Notes 1: In the three tests the null hypothesis is that of cross-sectional independence
Notes 2: Optimal lag and lead lengths selected via AIC are both 1 and optimal Bartlett kernel window width is set to be 3.
P-values are reported in parenthesis for [a] Pesaran (2004) and [c] Friedman's statistics (1937)
Critical values are reported in parenthesis for [b] Frees (1995) ***, **, * represent significance at 1%, 5%, 10%

Appendix 4: The Results of First-Generation Unit Root Tests, Dependent Variable: Production

First-Generation Unit Root Tests

	LLC (adjusted t-stat)		IPS (z-stat)	
Variables	Level	First Difference	Level	First Difference
production	-5.440***	-	-2.759***	-
electricity	-3.465***	-	-5.874***	-
fdi	-6.891***	-	-8.553***	-
htx	-6.276***	-	-3.224***	-
coepergdp	-3.032***	-	-5.132***	-
taxpergdp	-2.959***	-	-1.691**	-9.999***
ei	-2.521***	-	-0.655***	-11.439***

***, ** represents significance at 1% and 5%level

Appendix 5: The Results of the Mean-Group Estimator, Dependent Variable: PRODUCTION

Mean-Group Estimator, Dependent Variable: PRODUCTION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ec							
electricity	0.001	0.004	0.032	-0.264	-0.007	-0.735	0.004
	(0.079)	(0.048)	(0.044)	(0.231)	(0.111)	(0.731)	(0.036)
fdi		0.023*					0.013*
		(0.012)					(0.007)
htx			0.009				-0.001
			(0.009)				(0.009)
coe				-434.706			-0.070
				-4.163			(0.516)
tax					0.005		-0.002
					(0.012)		(0.015)
ei						301.654	-1.444***
						-3.873	(0.542)
SR							
ec	-0.427***	-0.484***	-0.519***	-0.490***	-0.489***	-0.584***	-0.898***
	(0.042)	(0.053)	(0.044)	(0.051)	(0.045)	(0.063)	(0.070)
D.electricity	-0.004	-0.002	-0.008	-0.002	-0.002	-0.003	-0.008
	(0.007)	(0.006)	(0.008)	(0.007)	(0.008)	(0.006)	(0.011)
D.fdi		0.003					-0.010
		(0.004)					(0.008)
D.htx			-0.010***				0.002
			(0.003)				(0.004)
D.coe				0.056			0.036
				(0.091)			(0.189)
D.tax					0.005		0.001
					(0.004)		(0.006)
D.ei						-0.257*	0.344
						(0.144)	(0.244)

Appendix 6: The Results of the Pooled Mean-Group Estimator, Dependent Variable: PRODUCTION

Pooled Mean-Group Estimator, Dependent Variable: PRODUCTION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ec							
electricity	-0.013	-0.016	-0.004	-0.022	-0.125***	-0.021	-0.005
	(0.014)	(0.012)	(0.009)	(0.013)	(0.013)	(0.012)	(0.004)
fdi		0.006***					0.002***
		(0.001)					(0.000)
htx			0.006***				-0.000
			(0.001)				(0.000)
coe				-0.107			0.821***
				(0.150)			(0.141)
tax					0.013***		0.022***
					(0.004)		(0.003)
ei						0.404**	-0.902***
						(0.158)	(0.115)
SR							
ec	-0.165***	-0.170***	-0.209***	-0.169***	-0.145***	-0.160***	-0.149***
	(0.032)	(0.035)	(0.041)	(0.029)	(0.041)	(0.032)	(0.035)
D.electricity	-0.014**	-0.013**	-0.013*	-0.014**	-0.003	-0.016***	-0.011**
	(0.006)	(0.006)	(0.007)	(0.006)	(0.005)	(0.006)	(0.004)
D.fdi		0.009*					0.003**
		(0.004)					(0.001)
D.htx			-0.011***				-0.008***
			(0.003)				(0.002)
D.coe				0.015			0.184*
				(0.093)			(0.101)
D.tax					0.007**		0.002
					(0.002)		(0.004)
D.ei						-0.505***	-0.523***
						(0.142)	(0.178)

Appendix 7: The Results of Hausman Test, Dependent Variable: PRODUCTION

Hausman Test, Dependent Variable: PRODUCTION

	(b) mg	(B) pmg	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
electricity	.004	-.005	.010	.036
fdi	.013	.002	.011	.007
htx	-.001	-.000	-.001	.009
coepergdp	-.070	.821	-.891	.496
taxpergdp	-.002	.022	-.024	.014
ei	-1.444.587	-.902	-.541	.530
year	-.002	.000	-.003	.015

b = consistent under Ho and Ha; obtained from xtpmg

B = inconsistent under Ha, efficient under Ho; obtained from xtpmg

Test: Ho: difference in coefficients not systematic

chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 20.73

Prob>chi2 = 0.0042

Appendix 8: The Results of First-Generation Unit Root Tests, Dependent Variable: Value-Added

First-Generation Unit Root Tests, Dependent Variable: Value-Added

	LLC (adjusted t-stat)		IPS (z-stat)	
Variables	Level	First Difference	Level	First Difference
mnf	-4.119***	-	-4.042***	-
electricity	-6.087***	-	-6.025***	-
fdi	-6.627***	-	-8.581***	-
htx	-5.794***	-	-2.694***	-
coepergdp	-2.880***	-	-4.127***	-
taxpergdp	-2.125**	-7.430***	-1.477*	-10.050***
ei	-2.814***	-	-0.592	-10.761***

***, **, * represent significance at 1%, 5% and 10% level

Appendix 9: The Results of the Mean-Group Estimator, Dependent Variable: Value-Added

Mean-Group Estimator, Dependent Variable: Value-Added							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ec							
electricity	-0.031	-0.000	-0.020	-0.092	0.740	0.396	0.008
	(0.059)	(0.030)	(0.015)	(0.066)	(0.738)	(0.383)	(0.017)
fdi		0.001					0.004
		(0.005)					(0.004)
htx			0.002				-0.003
			(0.002)				(0.003)
coe				0.269			0.223
				(0.175)			(0.252)
tax					-0.052		0.006
					(0.051)		(0.006)
ei						-262.096	-0.481
						-2.735.629	(0.496)
SR							
ec	-0.530***	-0.599***	-0.602***	-0.512***	-0.614***	-0.624***	-0.998***
	(0.048)	(0.053)	(0.053)	(0.054)	(0.052)	(0.062)	(0.082)
D.e_tdl	-0.002	-0.004	-0.001	-0.001	-0.003	-0.005	-0.009
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.011)
D.fdi		0.002					-0.004
		(0.002)					(0.002)
D.htx			-0.004**				0.002
			(0.001)				(0.004)
D.coe				-0.042			-0.060
				(0.060)			(0.101)
D.tax					0.001		0.000
					(0.002)		(0.004)
D.ei						-0.344***	-0.247
						(0.087)	(0.234)

Appendix 10: The Results of the Pooled Mean-Group Estimator, Dependent Variable: Value-Added

Pooled Mean-Group Estimator, Dependent Variable: Value-Added

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ec							
electricity	-0.011***	-0.012***	-0.016***	-0.011***	-0.014***	-0.018***	-0.021***
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
year	0.004***	0.004***	0.00310***	0.003**	0.004***	0.004***	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
fdi		0.000					0.001***
		(0.000)					(0.000)
htx			0.007***				0.006***
			(0.000)				(0.000)
coe				-0.054			-0.288***
				(0.060)			(0.043)
tax					-0.016***		-0.004**
					(0.004)		(0.002)
ei						0.168*	0.347***
						(0.101)	(0.077)
SR							
ec	-0.232***	-0.229***	-0.254***	-0.234***	-0.225***	-0.212***	-0.248***
	(0.053)	(0.055)	(0.054)	(0.055)	(0.054)	(0.056)	(0.074)
D.electricty	-0.004	-0.004	-0.005	-0.005	-0.002	-0.006	-0.003
	(0.004)	(0.004)	(0.005)	(0.004)	(0.003)	(0.004)	(0.003)
D.fdi		0.005*					0.002**
		(0.002)					(0.001)
D.htx			-0.004***				-0.004***
			(0.001)				(0.001)
D.coe				0.019			0.124**
				(0.045)			(0.062)
D.tax					0.004**		0.002
					(0.002)		(0.003)
D.ei						-0.277***	-0.376**
						(0.090)	(0.148)

Appendix 11: The Results of Hausman Test, Dependent Variable: Value-Added

Hausman Test, Dependent Variable: Value-Added

	(b)	(B)	(b-B)	
	mg	pmg	Difference	S.E.
e_tdl	.008	-.021	.029	.0172
fdi	.004	.001	.003	.004
htx	-.003	.006	-.009	.003
coepergdp	.223	-.288	.511	.248
taxpergdp	.006	-.004	.010	.005
ei	-.481	.347	-.829	.489
year	-.002	-.001	-.000	.008

b = consistent under Ho and Ha; obtained from xtpmg

B = inconsistent under Ha, efficient under Ho; obtained from xtpmg

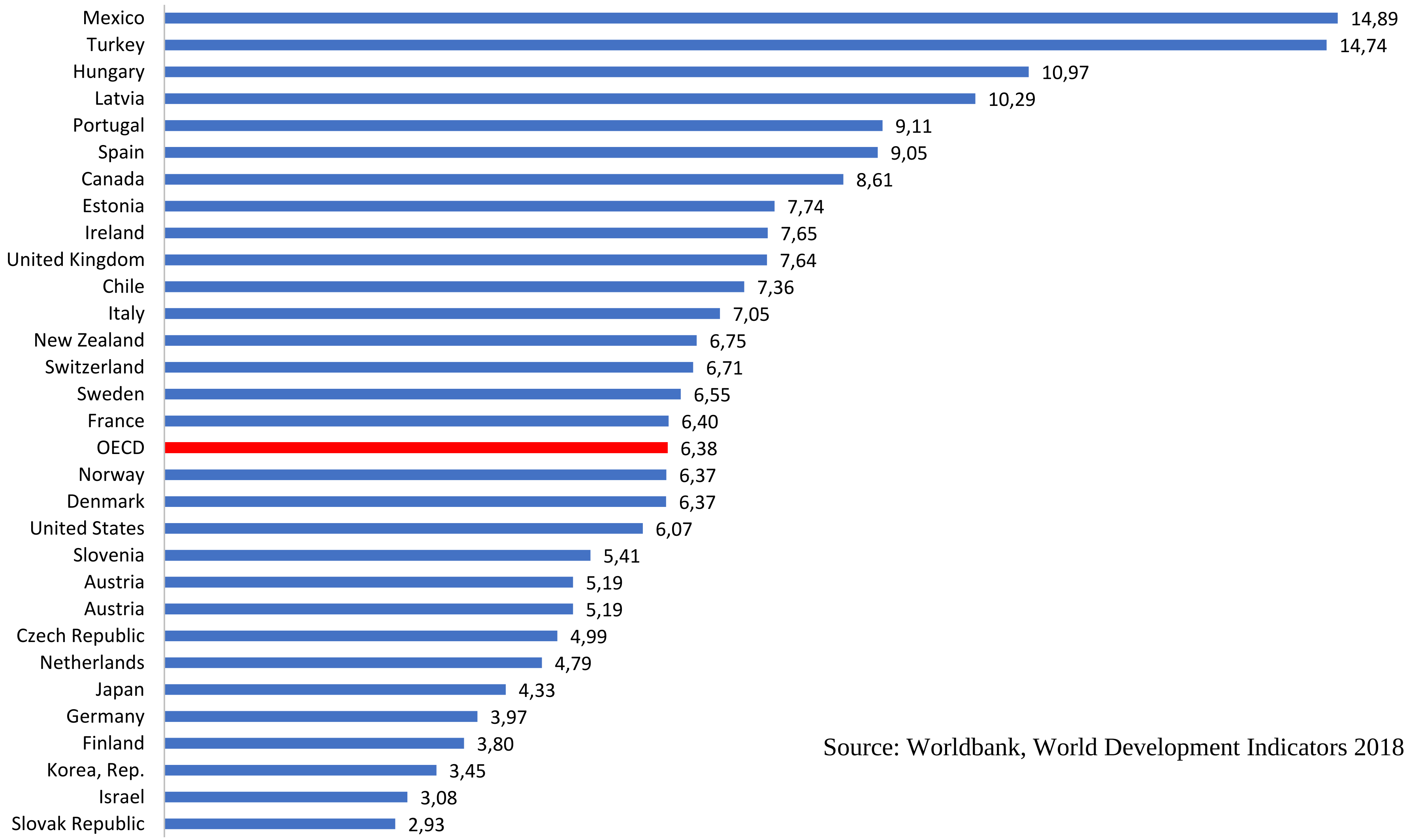
Test: Ho: difference in coefficients not systematic

chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 44.24

Prob>chi2 = 0.0000

Appendix 12: The Averages of Electricity Power Transmission and Distribution Losses for 2009-2014



Source: Worldbank, World Development Indicators 2018