**Master's Thesis of Flurim Aliu**

# The Effect of Energy Infrastructure Reliability on Foreign Direct Investment (FDI) Inflows

## 에너지 인프라 신뢰성이 외국인 직접 투자 (FDI) 유입에 미치는 영향

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# The Effect of Energy Infrastructure Reliability on Foreign Direct Investment (FDI) Inflows

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***Abstract (English):***

This study examines the relationship between energy infrastructure and FDI. It finds that, all else equal, a one percent increase in energy infrastructure reliability as measured by decreased electricity distribution losses contributes to an increase in FDI inflows by around 0.5%. Similarly, a decrease in the frequency and duration of electricity outages also contributes to increased FDI inflows. Furthermore, the study also shows some signs that while energy infrastructure availability on its own may not be an important FDI determinant, increased energy production from renewable sources can be an important FDI determinant. All else equal, an increase in a host country's reliance on renewable energy by one percent, can attract between 0.1% to 0.2% more FDI, depending on the income-level of the country. Hence, while investment in energy infrastructure offers many benefits such as improved productivity or improved health and education outcomes, it also provides positive externalities in the form of increased FDI inflows.

***Abstract (Korean):***

본 논문은 에너지 인프라와 FDI의 관계를 조사한다. 전력 분배 손실 감소에 의해 측정된 에너지 인프라 신뢰성이 1% 증가하면 FDI 유입량이 약 0.5% 증가하는 것으로 나타났다. 마찬가지로 정전 빈도와 지속시간 감소도 FDI 유입 증가에 기여한다. 또한, 에너지 인프라 가용성 (Energy Infrastructure Availability) 자체만으로는 결정적인 FDI 유입요인이 되기 어렵지만, 재생 에너지 (Renewable Energy)에 대한 의존도를 결합할 경우 중요한 FDI 결정요인이 될 수 있음을 보여준다. 연구 결과는 다른 모든 조건이 동일할 때 (Ceteris Paribus), FDI 주입국의 재생 에너지 의존도 1% 증가 시 국가 소득 수준에 따라 0.1%에서 0.2%의 FDI 추가 유치 가능성을 보여준다. 따라서 에너지 인프라 투자는 생산성 향상, 보건 및 교육 개선과 같은 다양한 내수적 이점 외에도 FDI 유입 증가의 형태로도 긍정적인 외부 효과를 제공한다.

*Key Words:* Foreign Direct Investment, Infrastructure, Reliability, Energy, Renewable Energy

*Student Number:* 2018-21241

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## Introduction

Foreign direct investment (FDI) has been an important companion of trade since the dawn of capitalism. The Dutch East India Company, one of the world's first multi-national corporations (MNCs), is one of the pioneers of direct investment abroad. As early as in the sixteen-hundreds, the Company established factories in Indonesia where it produced the spices it subsequently sold in Europe (Greenville 2017). Since then, FDI became a wide-spread phenomenon across the world. Just in the last fifty years, FDI activity (as a percentage of GDP) increased more than four-fold world-wide and the total amount of FDI flows in the world reached more than $1.3 trillion (USD) in 2019. In the period between 1970 and 1974 the median FDI-to-GDP ratio across the world was just above 0.6%. In the five-year period between 2015 and 2019, on the other hand, this ratio increased to more than 2.5% (World Bank 2020).[1] Moreover, while in the 1970s the median high-income country received more than twice the amount of FDI low-income countries received, currently low-income countries are at the forefront of FDI (World Bank 2020).

This increase of FDI flowing into developing countries can be partially attributed to factors such as the increase in trade openness or the relaxation of cross-border capital movement regulations across the world (Asiedu 2002). However, the proliferation of FDI-attracting policies across the developing world also plays an important role. Such policies differ country-by-country, but they often include elements such as lower trade tariffs and lower corporate tax rates for foreign investment (Wekesa et al. 2016). Given the large fiscal constraints that developing nations are

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[1] This section uses the median ratios of FDI to GDP, as opposed to the average of this ratio, in order to account for some of the variation across countries. Some countries, especially known tax havens, have extremely high FDI/GDP ratios which greatly skew the averages.

facing during the COVID-19 pandemic, countries ought to re-evaluate their FDI-attracting strategies and construct sustainable policies that do not erode their fiscal capacity. Investment in infrastructure can be one such policy. While many direct effects and positive externalities of infrastructure development are discussed in academic literature and political discourse, the effect of infrastructure availability and reliability on FDI inflows is an understudied topic.

This study aims to fill this gap and provide empirical evidence on the FDI-attracting nature of infrastructure reliability. It focuses primarily on energy infrastructure as the most understudied type of infrastructure in relation to FDI. The study finds that, all else equal, a one percent increase in energy infrastructure reliability as measured by decreased electricity distribution losses contributes to an increase in FDI inflows by around 0.5%. Similarly, a decrease in the frequency and duration of electricity outages by a percentage point contributes to an increase in FDI inflows by around 0.1%. The study also finds that the FDI-attracting effect of energy infrastructure reliability varies with the income-level of the host country. While energy infrastructure reliability has a 0.3% positive effect on inward FDI into lower-middle income countries, its effect on upper middle-income countries can be as high as 0.6% or higher. Furthermore, the study also shows some signs that while energy infrastructure availability on its own may not be an important FDI determinant, when combined with reliance on renewable energy it can be an important FDI determinant. All else equal, an increase in a host country's reliance on renewable energy by one percent, can attract between 0.1% to 0.2% more FDI, depending on the income-level of the country. Hence, while investment in energy infrastructure offers many benefits such as improved productivity or improved health and education outcomes, it also provides positive externalities in the form of increased FDI inflows. Improving the reliability of their energy infrastructure can help countries attract more FDI in the short-run, while investing in renewable energy generation may be important in the long-run.

The remainder of this paper is structured as follows: the first section gives background information on the purpose and motivation of this study, as well as presenting stylized facts about its current relevance; the second section summarizes the existing academic thought on the topic, both from a theoretical perspective and from an empirical perspective; the following section describes the methodology of this paper and the data it uses; the fourth section presents the empirical results of the study; and the fifth section describes the policy implications of this work and concludes.

# Background

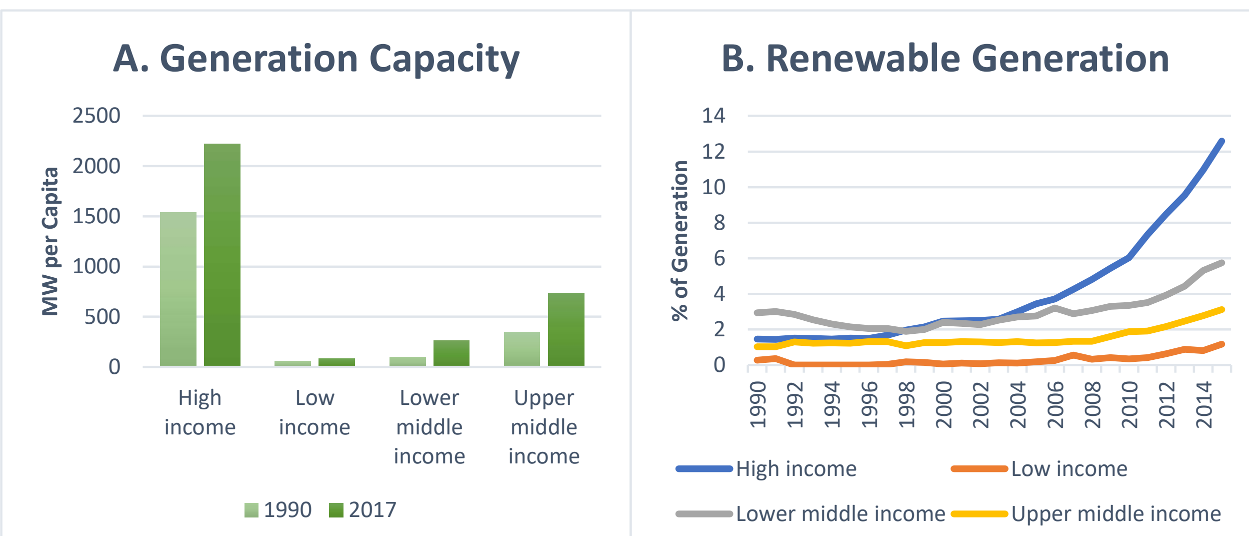
## Infrastructure: Improving Connectivity and Productivity

Physical infrastructure is the backbone of economic activity. Roads, railways, seaports, and airports ensure that people can get access to goods and services; fast and reliable internet and telecommunication services connect people to each other and make economic activity more efficient; a stable and reliable electricity supply guarantees that those goods and services can be produced in the first place. In Korea alone, in a given day, more than 13 million vehicles are on the road; over 3 million passengers board a plane; 800,000 tons of goods are loaded and unloaded in the port of Busan; around 8,000 tons of goods go through the Incheon Airport's cargo terminal; around 13 million people use the Seoul Metrorail System; and Koreans send over 11 billion messages on the Kakaotalk messenger. This is all powered through the consumption of over 385,000 tons of oil equivalent (TOE) units of energy and the generation of almost 200 GWh of electricity per day. Hence, a reliable infrastructure is needed for all this activity to occur smoothly.

Yet, worldwide, the availability and reliability of infrastructure is lagging. According to the World Bank, more than 840 million people live far away from all-weather roads, 1 billion people have little to no access to electricity, and 4 billion people have no access to the internet on a daily basis. Given this imperfect state of infrastructure quality in the world, it is imperative to carefully examine the benefits of increased infrastructure quality to help policy makers in developing countries design short-term and long-term strategies of infrastructure development. Focusing on energy infrastructure, this study attempts to do just that – it examines when countries should invest in improve their energy availability by increasing their generation capacity, for example, and when they should improve their reliability by lowering their distribution and transmission losses or ensuring there are fewer electric power outages.

## Recent Trends in Energy Infrastructure

*Figure 1. Energy Access and Generation Statistics (1990 – Present)*




*Source: World Bank, World Development Indicators (WDI) (2020)*

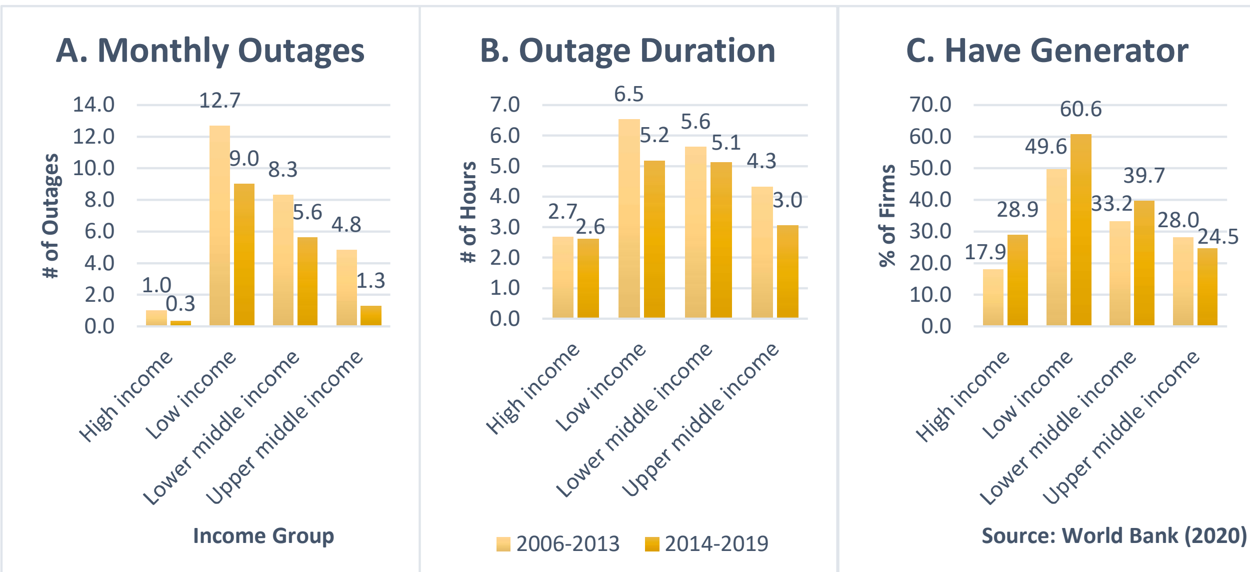
Access to electricity and energy infrastructure availability has increased dramatically over the past three decades. Whereas in 1990, only 16% of households in low-income countries had access to electricity, in 2017 almost 40% of those households are connected to the grid (almost a

2.5-fold increase). Similarly, in 1990, only 51% of households in the lower middle-income group had access to electricity, whereas in 2017, this number jumped to almost 77% (a 50% increase). The access to electricity rates improved even in upper middle-income and high-income countries, albeit more modestly, since there was less space for improvement (World Bank 2020).

Such an increase in access to electricity demanded an increase in electricity generation capacity. As shown in Figure 1A, generation capacity also increased across the world. In high-income countries, this number increased from around 1500 MW/capita to over 2200 MW/capita. In low-income countries this number went from 55 MW/capita to 81 MW/capita; in lower middle-income countries it increased more than 2.5-fold, going from 95MW/capita to over 260MW/capita; and in upper middle-income countries it more than doubled, going from around 345MW/capita to just over 730 MW/capita. Unfortunately, most of this increase came from non-renewable sources. Figure 1B shows that while the share of renewable energy (excluding hydropower) increased dramatically for high-income countries, renewable energy sources such as solar energy, wind energy, geothermal energy etc. still make up less than 13% of the energy production in those countries. These numbers are even lower for upper middle-income (~3%), lower middle-income (~6%), and low-income countries (~1%).

Nonetheless, while renewable sources currently only produce a miniscule fraction of the energy consumed around the world, the trend of increased reliance on renewable energy as shown in Figure 1B is expected to continue. For one, renewable energy generation prices have fallen substantially. In the last ten years alone, the price of onshore wind technology fell by 39%, while the price of solar Photovoltaics (PV) fell by 82% (IRENA 2020). In addition, 56% of the cases in which generation capacity was increased through renewable sources achieved lower electricity costs than the cheapest new coal plant (IRENA 2020). Along with falling prices, the signing of multilateral environmental agreements such as the Paris Agreement of 2015 signals that the preferences of the global community are shifting towards increased renewable energy generation as opposed to fossil fuel energy generation. International investors are taking note of these trends and favoring renewable energy projects over fossil fuel projects (Bumpus & Comello 2017). Hence, for long-term FDI projects, the host country's source of the energy may become just as important as the generation capacity or the overall availability of the energy infrastructure.

*Figure 2. Energy Reliability Statistics (2006 – Present)* [2]




*Source: World Bank, Enterprise Surveys (WBES) (2020)*

Furthermore, while Figure 3 showed that the availability of energy infrastructure increased around the world, its reliability improved only in high-income and upper middle-income countries. Figure 2A shows that firms in high income countries reported practically no monthly power

[2]The numbers reported for High Income countries in Figure 3 are likely lower than reported here. The reason for that is because these data come from the World Bank Enterprise Surveys which are typically only administered in countries that are still considered to be in the "development" phase (even if they are classified as high-income). Most Western Europe countries, the US, Canada, Australia, Japan, and other highly developed nations are not included there.

outages in recent years, whereas firms in upper-middle income countries only reported an average of just above 1 power outage a month in the period between 2014 to 2019. This is almost a four-fold decrease from the 4.8 power outages a month, reported in the period between 2006 and 2013. By contrast, firms in lower middle-income and low-income countries still experience, on average 6 or 9 outages a month, respectively. Though these numbers have dropped since 2006, they remain relatively high. Moreover, as shown in Figure 2B, the duration of the outages did not change much. An average power outage lasts over 5 hours in low-income and lower middle-income countries, whereas in high-income and upper middle-income countries that number is lower than 3 hours. Perhaps the clearest indication that energy infrastructure reliability remains an issue across the world is the fact that, as shown in Figure 2C, the percentage of firms owning or sharing electricity generators increased across the world, with an exception of upper middle-income countries. Over 60% of the firms in low-income countries own or share a generator, whereas almost 40% of firms in lower-middle income countries do the same. The numbers in upper middle-income and high-income countries also remain high, at 25% and 29%, respectively.

## Social Benefits of Improved Energy Infrastructure

Improving the availability and reliability of energy infrastructure can bring many benefits to a developing country. Access to electricity can increase the productivity of businesses since it allows the use of efficient electric equipment and tools. The review of an electrification project in rural Kenya found that connecting small and micro enterprises to the grid resulted in the improvement in productivity per worker by as much as 100 or 200%, depending on the task carried out (Kirubi et al. 2009). This increase in productivity resulted in a corresponding growth in income levels between 20% and 70%, depending on the industry in which the firms were engaged, and the products they made. The same study also found that electrification led to an improvement of the productivity in the agriculture sector as well, by allowing for more mechanization. Farmers from other regions (as far as 100km away) started renting their tractors to the newly electrified region because the electrification ensured that they can use wielding and other electric tools to fix the tractors in the case of a breakdown (Kirubi et al. 2009).

However, increased access to electricity does not only affect the productivity of businesses. It also has broader societal impacts. A randomized controlled trial in Tanzania confirms some of the findings above and adds that improved access to electricity may also increase the labor supply, particularly among women. Aevarsdottir et al. (2017) find that access to electricity allows women in Tanzania to perform some household duties at night, freeing their daytime hours for employment and leading to an increase in the labor supply by 5% or more. Furthermore, the availability of electricity is essential for delivering health services. Health care providers without electricity connections or with unreliable electricity supply can face problems with the storage of vaccines and medicines requiring refrigeration; with the sterilization of medical tools due to the lack of proper sterilization equipment; have no illumination for performing any medical procedure; cannot offer health services after sunset; and be unable to power laboratory equipment to adequately diagnose patients (World Bank 2017).

Improving the availability and reliability of energy infrastructure also allows households to use clean energy for cooking (instead of using open fires) and offers them long-term health benefits by reducing indoor air pollution and the risk of respiratory illnesses (such as asthma and tuberculosis). For example, a study in Guatemala, found that, on average, infants born to mothers who used clean energy for cooking weighed 89 g more than those born to households using open fires (Thompson et al. 2011). Cooking with wood and fossil fuels leads to over 4 million premature deaths per year across the world due to the ensuing household air pollution (WHO 2016). Illnesses such as lung cancer, ischemic heart disease, and acute lower respiratory infections, all related to household air pollution, cause more than half a million premature yearly deaths in Sub-Saharan Africa alone (World Bank 2014). This makes household pollution the second largest health risk factor associated with death and disability in the region. Yet, because of inadequate local energy infrastructure, more than 3 billion people globally continue cooking with solid fuels and kerosene, despite the established evidence describing the negative health, environmental, and economic impacts of such practices. Improving these households' electricity access could lead to substantially better health and wellness outcomes.

Nonetheless, the benefits of increased energy infrastructure availability described above would be noticeably lower if that infrastructure was unreliable. Using survey data from Pakistan, Samad & Zhang (2018), for example, find that the lack of connectivity and especially the low reliability of the electricity supply in Pakistan may be costing the country around $4.5 billion (USD) per year. This translates to a loss of more than 1.7 percentage points of GDP, yearly. Yet, the reliability of the electricity supply is not an issue specific to developing countries. Developed countries experience reliability problems as well. For example, even though the US, one of the most developed nations in the world, seldom experiences large power outages or disruptions in its electricity supply, the economic impact of the rare and mostly small electricity supply disturbances that do occur is estimated to be $80 billion (USD), yearly (LaCommare & Eto 2004). In another example in 2003, a single tree falling into an important power line in Switzerland caused an estimated loss of $1.3 billion (USD) as 56 Million people in Switzerland and Italy were left without power for several hours (Böttcher 2016). Hence, when assessing the impact of energy infrastructure on other economic indicators it is important to look not only at energy infrastructure availability, but also at energy infrastructure reliability.

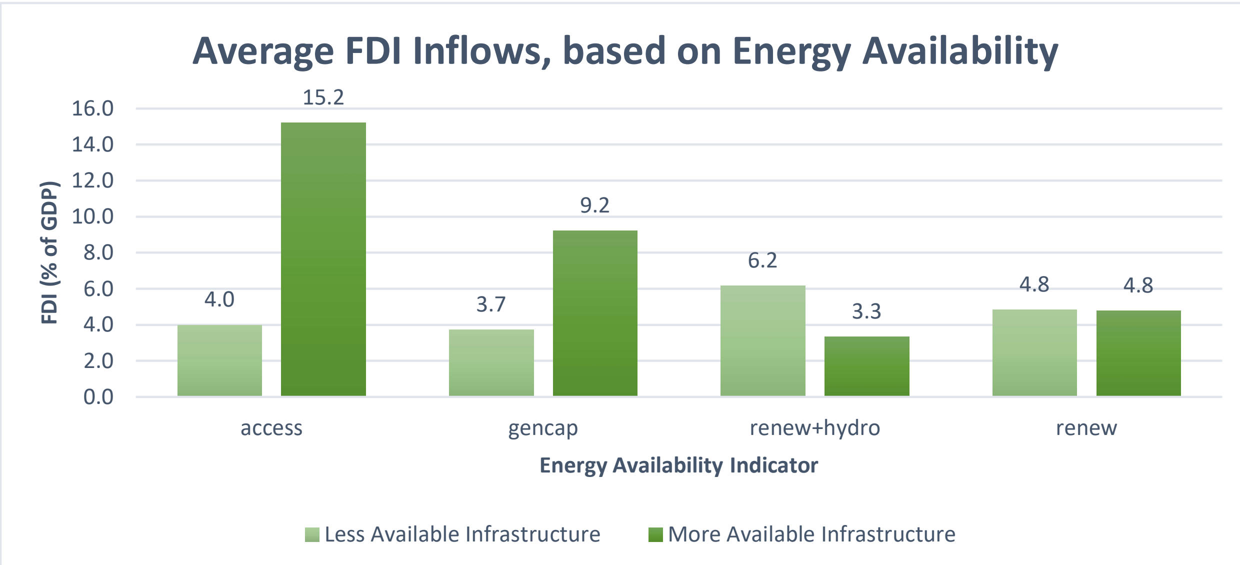
## Energy Infrastructure and FDI: Some Stylized Facts

As detailed above, many channels through which the improvement of energy infrastructure availability and reliability can improve the economic well-being of people have already been established. However, an interestingly understudied topic is the effect of energy infrastructure on FDI. Particularly, the potential of energy infrastructure as an FDI determinant in developing countries has not been studied extensively. Yet, as Figure 3 and Figure 4 show, there may be a link between the two variables.

Using data from the World Bank World Development Indicators (WDI) and the World Bank Enterprise surveys (WBES), we can examine whether countries with more available and reliable electricity supply, on average, receive more FDI (as a percentage of GDP). Figure 3 visualizes the relationship between FDI inflows as a percentage of GDP and four different energy infrastructure availability indicators: 1. The percentage of households with access to electricity, 2. The per-capita generation capacity of the country's electricity sector, 3. The share of electricity generation from renewable sources (including hydropower sources), and 4. The share of electricity generation from renewable sources, excluding hydropower sources (all from the WDI database).

As seen in the figure, there seems to be a strong positive correlation between energy infrastructure availability and FDI inflows. Countries with relatively higher access to electricity receive almost 4 times as much FDI as those with less access to electricity. Similarly, countries with higher per-capita generation capacities receive almost 3 times as much FDI as those with lower per-capita generation capacity. The relationship between reliance on renewable generation and FDI inflows is unclear. Using the renewable energy (including hydro) as a percentage of total generation indicator we find that countries more reliant on renewable energy receive less FDI, while using the same indicator and excluding hydropower we find that the generation source has no effect on the level of incoming FDI. However, since most of these indicators are highly affected by the income level of a country, a regression analysis which isolates the energy availability component from the income component is necessary to isolate the effect of the variable of interest.

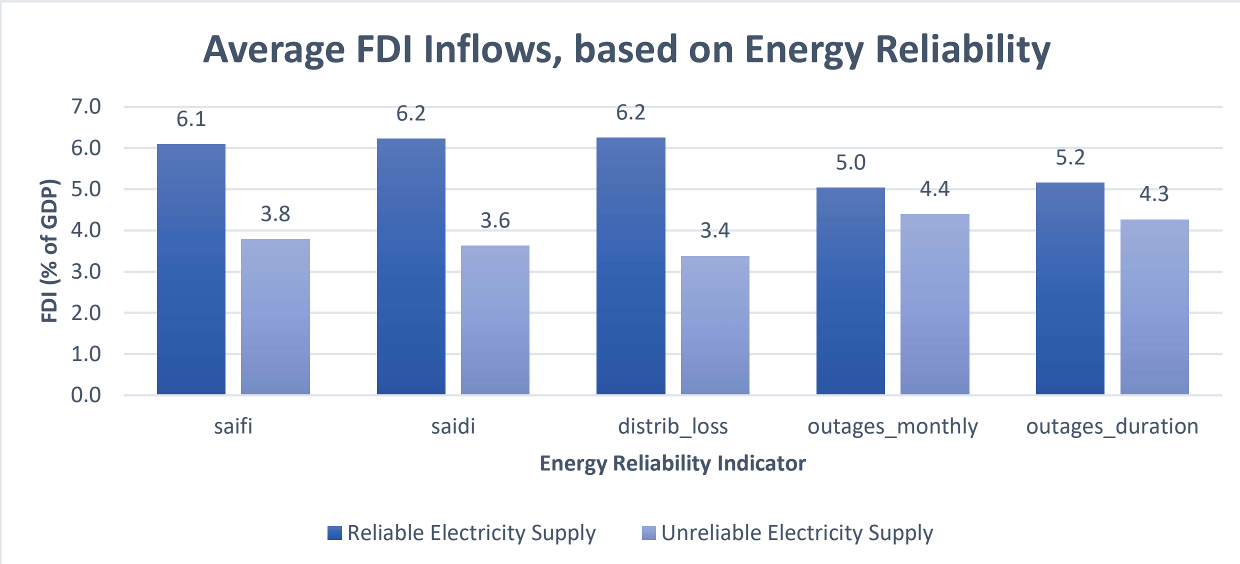
*Figure 3. FDI Inflows (% of GDP) by Energy Availability*




*Source: World Bank, WDI and WBES (2020)*

Similarly, Figure 4 visualizes the relationship between FDI inflows as a percentage of GDP and five different energy infrastructure reliability indicators: 1. The System Average Interruption Frequency Index (SAIFI), 2. The System Average Interruption Duration Index (SAIDI), 3. Distribution and Transmission Losses as a percentage of total output (all from the WDI database), 4. The average number of power outages in a month (from the WBES database), and 5. The average duration of power outages (also from the WBES database). However, in this case, the figures account for country income differences through normalizing the reliability indicators using the per capita GDP of the FDI receiving country – for example, the number of outages is reported as the number of outages/GDP per capita (in thousands).

*Figure 4. FDI Inflows (% of GDP) by Energy Reliability (normalized using GDP per capita)*




*Source: World Bank, WDI and WBES (2020)*

The results show that regardless of the reliability indicator used and even after accounting for country income levels, countries with more reliable energy infrastructure, receive, on average more FDI. If we use distribution and transmission losses as a reliability indicator, then countries with distribution and transmission losses/GDP per capita values below the world median receive only about half as much FDI (as a % of GDP) as countries with values equal to or above the median. The scale is similar when using SAIFI/GDP per capita or SAIDI/GDP per capita as a reliability indicator. Using the number and duration of outages/GDP per capita, on the other hand, shows that countries with values below the median receive less FDI by a magnitude between 0.6% to 0.9% of their GDP. These results are not as strong as the first three, but they are nonetheless substantial. However, what all these results show together is that energy infrastructure reliability may be an important determinant of FDI.

# Literature Review

## Summary of Academic Thought on FDI Determinants and Energy Infrastructure

Empirical literature mentioning infrastructure as an FDI determinant has existed since at least the 1970s. Agodo (1978) and Root & Ahmed (1979), for example, both mention physical infrastructure as one of the determinants of incoming FDI in the context of developing countries. However, like subsequent studies on FDI determinants from the next few decades, infrastructure indicators are seldom the primary focus of the study and if mentioned, these indicators focus on the availability of the infrastructure, rather than its reliability. Agodo (1978), for example, uses a calculated infrastructure score based on interviews with industry representatives as an indicator of infrastructure, while Root & Ahmed (1979) use "Energy production (equivalent tons of coal per 1,000 population)" as an indicator of the availability of electricity in a country (though, not necessarily as an energy infrastructure indicator).

Similarly, Wheeler & Moody (1992), one of the earliest studies directly investigating the role of infrastructure as an FDI determinant and one of the most commonly cited articles in this field of research, uses a zero-to-ten rating scale to determine the (loosely defined) quality of infrastructure. Many other subsequent studies (Ancharaz 2003; Asiedu 2002; Jordaan 2010; and Moosa 2012, among others) use the number of telephones per 1,000 inhabitants as a proxy for the availability of infrastructure. These studies not only solely focus on infrastructure availability as an FDI determinant, but also often completely ignore the role of energy infrastructure. Most studies either focus on transport infrastructure, or they focus on the digital infrastructure of a country. The reliability of infrastructure, in general, and the reliability of energy infrastructure, more specifically, are widely ignored in the FDI determinants literature.

From a theoretical perspective, the literature linking energy infrastructure reliability and FDI flows is even more scarce. The most developed theoretical body of literature on FDI determinants is at the firm-level and concerns the factors that influence Multinational Corporations (MNCs) to make the decision to engage in direct investment abroad. Given that this body of literature mostly concerns the endogenous factors determining a firm's decision to engage in foreign direct investment activity, it does not focus on the effect of infrastructure, in general, or energy infrastructure, specifically. Studies such as Helpman et al. (2004), Yeapple (2009), Antras & Helpman (2004), Kohler & Smolka (2014), and others fall within this category.

At the country-level, the theoretical literature establishing the connection between energy infrastructure (or physical infrastructure, in general) and FDI inflows is also scarce. The theoretical part of Wheeler & Mody (1992), while focusing on agglomeration economies, argues that infrastructure acts as an input-augmenting production factor. Meaning, while infrastructure is not in itself a production factor, well-developed infrastructure enhances the efficiency of other production factors. Seetanah & Khadaroo (2008) is one of the few studies attempting to directly establish the relationship between physical infrastructure and FDI inflows from a theoretical perspective. Like Wheeler & Mody (1992), this study characterizes infrastructure as an important intermediate input and argues that infrastructure availability lowers the production costs for the firms engaging in FDI and increases their profitability and productivity. However, this latter study only focuses on transport infrastructure and, like most studies concerning the effect of infrastructure on FDI inflows, largely ignores the effect of energy infrastructure. Hence, more research is needed to establish a concrete theoretical link between energy infrastructure and FDI inflows. Nonetheless, most theoretical literature agrees that infrastructure is particularly relevant for developing countries and not so relevant for already developed countries.

The remainder of the literature review section of this study is structured as follows. First, it offers a more detailed account of the theoretical literature regarding infrastructure as an FDI determinant. Next, presents the empirical support for the effect of infrastructure, in general, on inward FDI and the empirical support for energy infrastructure, in particular. It concludes by summarizing the gaps in the research and describing how this research project addresses these research gaps and how it contributes to the literature.

## The Theoretical Link between Energy Infrastructure and FDI

The theoretical literature concerning the positive effects of energy infrastructure on human capital, economic growth, and productivity is abundant. However, an increased inflow of FDI is seldom mentioned as one of the positive externalities of better energy infrastructure. This literature review exercise was not able to find any standalone theoretical papers specifically modeling the effect of energy infrastructure in the context of FDI. However, most empirical studies testing the effect of host country physical infrastructure on FDI inflows offer important theoretical insights on the relationship between the two variables. Hence, the theoretical literature section of this literature review will be split in two sections: the relationship between quality physical infrastructure and FDI and the positive externalities of energy infrastructure reliability. Combining these two bodies of research, this literature review section will be able to establish theoretical support for a relationship between energy infrastructure availability and reliability on FDI inflows.

One of the earliest studies including infrastructure variables in FDI inflow models is Agodo (1978). This study attempts to explain the determinants of the direct investment of US manufacturing firms in Africa. Agodo (1978) defines primary infrastructure as "facilities that are indispensable for the smooth and efficient discharge of the functions of economic agents." Based on this study, the primary role of physical infrastructure in FDI decisions of firms is related to the perceived operational efficiency and the resulting profitability of the investment. Particularly, in the context of developing countries, this study claims that infrastructure is as an important of an exogenous factor on an investing firms' profitability as endogenous factors such the organizational structure of the company, its management, or the technology it uses. However, the study fails to develop a concrete theoretical link between the two variables.

Similarly, Loree & Guisinger (1995) and Root & Ahmed (1979) also do not focus on energy infrastructure, but only on transport and communication infrastructure. Both argue that infrastructure is an imperative FDI determinant, but its importance varies by the objectives of the firm. Firms focused on exporting the majority of the output from the facility in which they invested do not place much importance on infrastructure availability, while firms focused on the domestic market may place more importance on infrastructure availability. However, such an argument is mainly applicable to transport or digital infrastructure and has limited applicability for energy infrastructure. Reliable energy infrastructure is important regardless of the destination of the outputs since without it, the outputs cannot even be produced.

Even in Wheeler & Mody (1992), the theoretical support for the inclusion of infrastructure variables in FDI flow models remains underdeveloped. Nonetheless, in their influential study, Wheeler & Mody (1992) argue that infrastructure is not as a production input in itself, but is an augmenting factor to other inputs. This is an important development because this theoretical reasoning is not only applicable to transport infrastructure, but also to digital infrastructure, and most importantly for the purpose of this study, energy infrastructure. Transport infrastructure could be considered an input-augmenting factor since its availability allows a firm to first receive its inputs (in cases of manufacturing firms, especially) and later distribute the finished products. However, similarly, energy infrastructure could also be considered an input-augmenting factor because its availability provides firms with a key production factor – electricity. Crucially, though, the reliability of energy infrastructure may be even more important than its availability. While unpaved roads (a potential measure of transport infrastructure reliability) still allow trucks to pass through, albeit slowly, unreliable electric supply may completely stop production and even destroy the production machinery. Hence, in this case, unreliable electricity supply not only does not augment the other inputs, but it also may harm them.

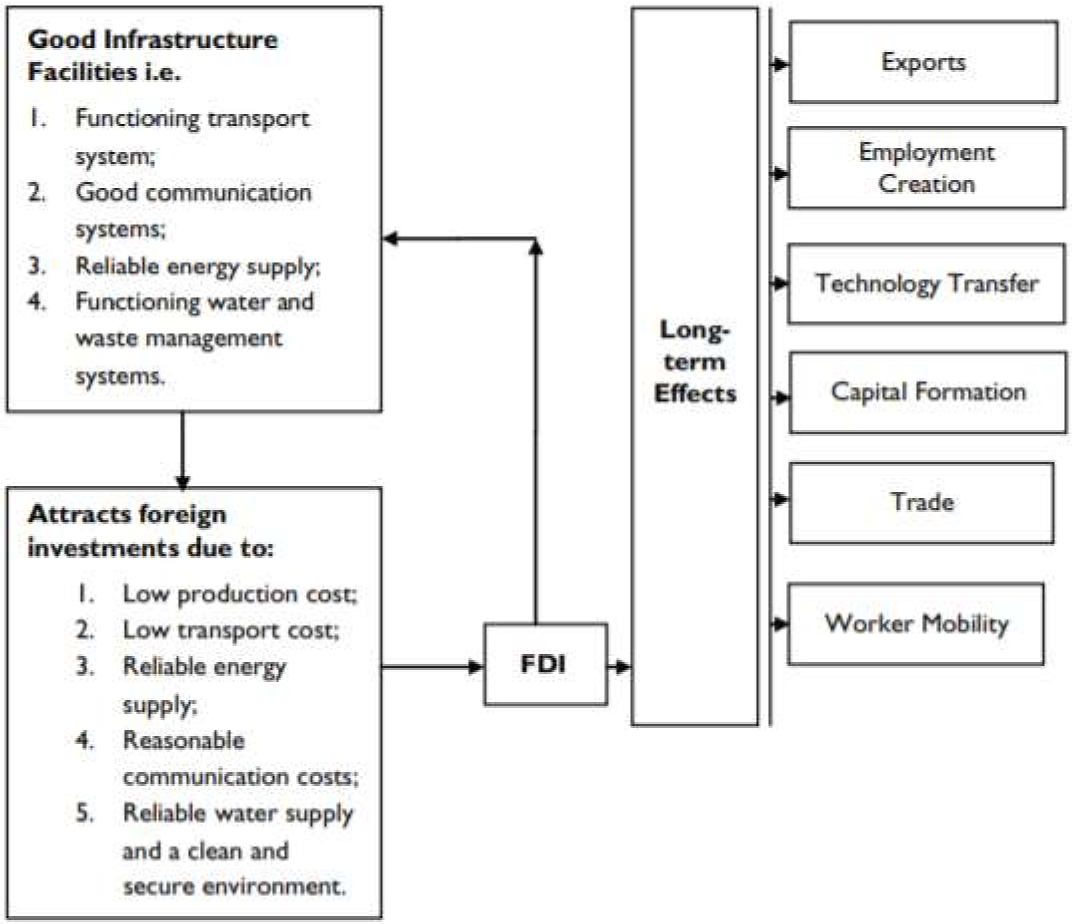
Unlike the previously mentioned studies in which the effect of improved infrastructure is not the main investigative focus, Richaud et al. (1999) is a rare case of a study that directly investigates the positive externalities of infrastructure. Even though the study focuses on growth spillovers of infrastructure, explaining the interaction between infrastructure and FDI is one of the main objectives of the study. However, Richaud et al. (1999) employs a different approach compared to the previously mentioned literature and focuses on the benefits of country-level versus regional-level infrastructure development policies. Its main argument is that infrastructure development has many positive externalities which are not constraint to national borders. An improvement of the infrastructure of one country, for example, leads to positive outcomes such as larger FDI inflows not only to that country, but also its close neighbors. Hence, the authors argue, that large infrastructure projects should be implemented at the regional level. However, while this may be true for transport infrastructure since its primary goal is improved connectivity, the same argument is weak in the case of energy infrastructure. It is hard to argue that the improvement of the electricity grid in one country will have spillover effects in terms of increased FDI inflows into neighboring countries since the firms and households of the neighboring country are only connected to their own country's grid (even if the two countries are engaged in electricity trade).

Therefore, similar to most of the studies mentioned above, its findings are mostly applicable to transport infrastructure and ignore energy infrastructure.

Similar to Richaud et al. (1999), Seetanah & Khadaroo (2008) is also directly concerned with the positive externalities of infrastructure development. However, unlike in the previous case which focuses on the infrastructure development benefits from a growth perspective, albeit through the FDI channel, Seetanah & Khadaroo (2008) is directly concerned with the FDI-inflow-enhancing properties of infrastructure. Though Seetanah & Khadaroo (2008) is also focused on transport infrastructure, some of its theoretical conclusions can be applied to energy infrastructure as well. For example, its argument that while infrastructure development can enhance both horizontal and vertical FDI, this relationship is stronger in the case of vertical FDI since the primary channel through which infrastructure affects FDI is cost reduction are applicable to all types of infrastructure.

Furthermore, similarly to Wheeler & Mody (1992), Seetanah & Khadaroo (2008) argue that infrastructure acts as an intermediate input in production. The authors argue that if infrastructure wasn't provided by the government, MNCs would inevitably have to try to develop it themselves if they wanted to operate successfully. This makes infrastructure an important intermediate input. The authors also argue that quality infrastructure also quality infrastructure also reduces the "wear and tear" costs of a company. While they were focused on the costs of transportation equipment, a similar argument could be made in the case of energy infrastructure. Frequent and unexpected electricity outages, inadequate lightening protection, and other similar problems with energy infrastructure may damage machinery (World Bank 2017). Thus, reliable infrastructure raises the return on investments and makes a country more attractive for FDI.

*Figure 5. The Relationship between Infrastructure and FDI*




*Source: Wekesa et al. (2016)*

Wekesa et al. (2016) also directly investigates the relationship between infrastructure and FDI inflows. However, unlike the previously mentioned studies (Seetanah & Khadaroo 2008, included), the authors investigate all different types of infrastructure and do not specifically focus on transport infrastructure. Just like Seetanah & Khadaroo 2008, Wekesa et al. (2016) argue that infrastructure is indeed a public good and as such has an important effect on the cost structure of the firm and with it, the firm's productivity and profitability. Similarly, they also focus on the counterfactual scenario of what MNCs would have to do if the government was not providing the needed infrastructure and conclude that public infrastructure reduces the cost of investment. The figure above is taken from this study and explains the relationship between infrastructure and FDI in detail, offering a glimpse of the long-term outcomes of this relationship as well.

As evident by the literature described above, the theoretical link between infrastructure and FDI inflows is mainly based on transport infrastructure. While some features of transport infrastructure are similar to the features of other infrastructure types, the development of each type of infrastructure delivers positive externalities through distinct channels. For example, increased connectivity (be it physically or digitally) is one of the benefits of developing transport and digital infrastructure, however this is less applicable in the case of energy infrastructure. Energy infrastructure has, arguably, a more fundamental role in the production of goods and services as it directly affects production processes. For that reason, in the case of energy infrastructure, reliability may be a more important factor than availability.

The importance of energy infrastructure reliability has been discussed by many (McCarthy et al., 2007; Straub, 2008; Schuler, 2010; Cohen et al., 2016; Millen, 2017; Brinkis et al., 2012; Hibbard et al., 2017; Blimpo & Cosgrove-Davies, 2019). Tierney et al. (2017), for example, argue that a reliable electricity supply is a necessary condition to ensure economic development, while also being an important factor for maintaining public health and safety. Furthermore, studies such as Millen (2017) and Cohen et al. (2016) also find energy infrastructure reliability to be an important factor for households considering whether to join the national grid. Households may elect not to join the national grid and use stand-alone generators if the electricity supply is unstable and unreliable. Nonetheless, the importance of energy infrastructure reliability in the context of FDI has seldom been discussed until now.

## Empirical Literature

The empirical literature confirming the effect of infrastructure on FDI inflows is more developed than its theoretical counterpart. However, even in empirical literature the effect of transport infrastructure is studied in detail while the effect of energy infrastructure is often ignored. This section of the literature review will present the evolution of the empirical support for the effect of infrastructure on FDI inflows. It starts by describing some earlier studies (the theoretical sections of some of which were mentioned above) which use interview methods to establish the link between the two variables. It continues by presenting the bulk of the empirical literature on the relationship between infrastructure and FDI which is focused either on overall physical infrastructure proxies or is based on transport infrastructure. Lastly, it finishes by presenting the empirical results of the few studies which include energy infrastructure variables and establishes the need for further research. As mentioned in the theoretical section of this literature review, most of these studies focus exclusively on developing countries since the FDI determinants of developed countries are different from those of developing countries.

Some of the earlier empirical studies on the effect of infrastructure on FDI inflows are based on survey responses. Agodo (1978) aims to explain the determinants of the direct investment of US manufacturing firms in Africa. The study uses the t-test method, as well simple and multiple OLS regression analyses. The statistical tests are based on hard data such as total GDP, GDP per capita, firm's investment amounts, etc. as well as codified data based on interviews with industry representatives. The infrastructure variable is based on the second kind of data. The respondents rated transport, digital, energy, and water infrastructure as "crucial" for their operations. In fact, in the regression analysis, infrastructure availability in the host country was the indicator with the second highest coefficient, only second to the population size of the host country. As mentioned in the theoretical part, operational efficiency stemming from infrastructure availability was described as the main reason for such a high degree of importance.

Similarly, Wheeler & Mody (1992) also use interview data to establish the link between FDI inflows and infrastructure. This study uses survey data on the capital expenditure of US MNCs published by the US Department of Commerce and country scores from Business Intelligence on a range of host-country factors, including infrastructure. The infrastructure is assessed on a scale from 0-10, where the score of zero was awarded to the countries with the worst transport, digital, and energy infrastructure conditions and *vice-versa*. Like in Agodo (1978), the infrastructure variable in Wheeler & Mody (1978) also includes all the different infrastructure types without differentiating between them and focuses on infrastructure availability rather than reliability. Nonetheless, the results of log-linear and interactive-linear regressions support the positive effect of infrastructure availability on FDI inflows. Like Agodo (1978), this study also shows that infrastructure has one of the highest coefficients in the model, particularly for the subset of developing countries analyzed in the study.

Building on this earlier literature, the next group of empirical studies use proxies for infrastructure availability and/or reliability which are not based on interviews, but rather on hard data. A common trend in studies assessing the impact of infrastructure on FDI is to use the proxy of “telephones per 1000 inhabitants” as a measure of infrastructure availability. Studies such as Ahmad et al. (2015), Asiedu (2002), Benhame (2012), Campos & Kinoshita (2003), Morrisset (2000), Rehman et al. (2011), among others have all used this proxy. Rehman et al (2011) for example, tests the importance of infrastructure as an FDI determinant for Pakistan. The study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach on a time-series dataset of FDI inflows. The use of this testing approach is justified due to the limited number of observations (since their study covers only one country). Traditional methods, such as OLS, often fail to provide meaningful results in cases with limited numbers of observations. Using this approach, the authors can prove that the infrastructure proxy is positive and significant, suggesting that the quality of infrastructure in Pakistan played an important role in the country's increase in incoming FDI. Similarly, Ahmad et al. (2015), also uses the ARDL bounds testing method to investigate the role of infrastructure on FDI. However its focus is Malaysia, and the study uses a time-series dataset consisting of FDI stocks, instead of flows, into Malaysia for the time period between 1980 and 2013. The authors argue that FDI stocks are more stable than FDI flows and, thus, offer a better view of the FDI coming into a country. In this study as well, the infrastructure proxy is positive and significant, suggesting that infrastructure availability played an important role in attracting FDI to Malaysia.

Benhame (2012), Campos & Kinoshita (2003) and Morrisset (2000), on the other hand, are not bound to specific countries but study the impact of infrastructure availability on inward FDI for larger groups of countries. Benhame (2012), for example, studies this relationship in the context of South Asian countries for the period between 1980 and 2009. The study uses bilateral FDI flows panel data and a random effect OLS regression. Its results are inconclusive, with the infrastructure proxy showing a positive and significant result in most equations, but that significance vanishing once the model controls for the human capital of the host country. The regions of interest in the Campos & Kinoshita (2003) study, on the other hand, are Eastern Europe and Central Asia and the period covered is 1990 to 1998. Like Ahmad et al (2015), but unlike Rehman et al. (2011) and Benhame (2012), the authors use bilateral FDI stocks as the main dependent variable in this study. The authors use a fixed-effect OLS model, as well as generalized method of moments (GMM) estimates to test the robustness of the results. The infrastructure proxy is not significant, or only significant at the 10% level when the regression estimates are calculated for the entire dataset. However, for the group of Commonwealth of Independent States (CIS) countries (which includes former Soviet Union countries, with the exclusion of Baltic states), the infrastructure proxy is positive and highly significant. The authors explain this difference by arguing that because CIS countries receive FDI mostly in the resource sector, good physical infrastructure is important.

In the case of Morrisset (2000) and Asiedu (2002), the region of interest is Sub-Saharan Africa. Similarly to Campos & Kinoshita (2003), Asiedu (2002) also attempts to explain the determinants of FDI into different groups of developing countries. Specifically, this study is interested in the FDI determinants for the Sub-Saharan region of Africa. The study uses OLS estimation methods on cross-sectional data from 71 developing countries. The dependent variable is the ratio of FDI inflows to GDP. The infrastructure proxy is tested both as an untransformed variable and as a quadratic variable (to test whether there is a threshold for its effect). However, while the untransformed proxy is positive and significant, the quadratic one is insignificant. The results remain the same even when robustness checks using panel data are performed. Interestingly, Asiedu (2002) is one of the first studies stressing the importance of infrastructure reliability, and not just availability, though is not able to test it due to the lack of data. Similarly, Morrisset (2000) is also interested in Sub-Saharan Africa and it uses fixed-effect panel and cross-sectional estimation methods to test the effect of the infrastructure proxy on FDI inflows. However, in this case, the infrastructure proxy is insignificant. The author points to the inadequacy of the proxy as one of the potential explanations as to why infrastructure does not have a significant impact on FDI inflows and suggests future studies use more specified indicators. The author's argument is valid, given the inconsistency of the results that we have seen coming from all the studies above that use the same indicator. Nonetheless, their results are promising and indicate that infrastructure may indeed be an important determinant of FDI inflows for developing countries.

Against this background, the next group of empirical studies discussed in this literature review uses more specific infrastructure indicators and tries to differentiate between the different types of infrastructure. Cheng& Kwan (2000), for example, use three different measures of infrastructure: road length per squared kilometers of land, high grade paved road length per squared kilometers of land, and railway length per squared kilometers of land. Their GMM estimations reveal that road density is important, while the quality of the roads and the availability of railways are less important as FDI attractors. Their findings, however, have limited applicability to the rest of the world since they only use Chinese data and they only cover the period between 1985 to 1995. Nonetheless, this is an interesting finding because it shows that in the case of transport infrastructure in China, infrastructure availability may be more important than infrastructure reliability. Nonetheless, given that the indicators used are strictly transport indicators, the findings of this studies cannot be applied to other types of infrastructure.

Similarly, Fung et al (2005) also use kilometers of rail and kilometers of paved roads as indicators of infrastructure. Just as Cheng& Kwan (2000), they also use Chinese FDI data, however, their period of study is between 1990 and 2002. Using panel regression techniques, the authors confirm that the roads indicator is consistently positive and statistically significant, while the rail indicator shows mixed results. Furthermore, they argue that "soft infrastructure" tested using indicators such as the number of Special Economic Zones per region and the proportion of output produced by State-Owned Enterprises (SOEs) is more important.

Nonetheless, even though these studies and others such as Barzelaghi et al. (2012) try to use multiple different infrastructure indicators, they only focus on transport infrastructure and ignore other infrastructure types. Loree & Guisinger (1995), is one of the earlier cases which goes beyond transport infrastructure indicators and uses multiple different digital infrastructure indicators as well. This study compiled an infrastructure dataset of 22 different indicators such as number of televisions, number of television stations, kilometers of paved highways, number of usable airports, passenger kilometers flown per capita, etc. to construct infrastructure indices. The results of the study show that both transport and digital infrastructure are an important determinant, however, they also completely ignore energy infrastructure indicators. In fact, with a few exceptions, only a handful of very recent studies include energy infrastructure indicators or focus entirely on energy infrastructure as an FDI determinant.

Root & Ahmed (1979) is one of the first and few empirical studies to include an energy infrastructure variable in its FDI determinants equation. The authors study a group of seventy developing countries which received different levels of FDI from the US in the manufacturing sector. Among other factors, they test the empirical significance of energy production, measured as tons of coal per 1000 inhabitants. The results of a multiple discriminant analysis revealed that energy production has a positive and highly significant correlation with the dependent variable as well as with the GDP growth rate. Unfortunately, given that energy infrastructure was not the primary focus of the study, the authors do not go into more detail about these results and their implications. Nonetheless, they characterize energy production as a "critical input to economic growth" (Root & Ahmed 1979).

Castro et al. (2007), Fitriandi et al. (2014), Chakrabarti et al. (2012), Jordaan (2008), Kumar (2006), and Wekesa et al. (2016), also test the significance of energy infrastructure as an FDI determinant. Chakrabarti et al. (2012), for example investigate the effect of different infrastructure types on FDI flows into 600 different Indian districts with data between 2001 and

2009. They use fixed-effect panel regressions, controlling for state level characteristics. Their findings differ somewhat from the rest of the literature as they can establish a non-linear relationship between infrastructure and FDI inflows. They find that up to a certain threshold, infrastructure availability has no effect on FDI, however once that threshold is crossed, the effect of infrastructure becomes strongly positive and highly significant. Nonetheless, just as most other studies described in this literature review section, they also only focus on energy infrastructure availability and not on reliability. Their indicator of choice is the percentage of households with electricity connections. Furthermore, they use all infrastructure indicators to create an overall infrastructure index and do not provide separate results for the different infrastructure modes.

Kumar (2006) also performs a similar exercise, however, in this case the data comes from 66 different countries for the period between 1982 and 1994. Using indicators such as road length per square kilometer of area, telephones per 100 inhabitants, and others for transport and digital infrastructure, as well as energy use per inhabitant for energy infrastructure, the author creates an infrastructure index and assesses its importance in the context of FDI. Kumar (2006) finds the infrastructure indicator to be important for the case of all firms as well as export-oriented firms specifically. This is different from Jordaan (2008) which gets mixed results on the significance of energy infrastructure in Mexico. Using random, between, and fixed effect generalized least squares (GLS) estimations of Mexican FDI data between 1998 and 2006, Jordaan (2008) establishes that infrastructure (including energy infrastructure) is not an important FDI determinant for export-oriented firms. His results, however, do support the significance of infrastructure as an FDI determinant for inward-oriented firms. The difference may lie on the subset of countries chosen. While Jordaan (2008) studies Mexican FDI exclusively, Kumar (2006) has a larger subset of countries in its data. Furthermore, the source country in the case of the former is the entire world, whereas in the case of the latter is just Japan or the US. Nonetheless, due to the studies' focus on the availability of energy infrastructure only (measured as the percentage of households with electrical connection in the Mexican case or energy intensity in the Kumar 2006 study), the studies fall short on exploring the total potential effect of energy infrastructure on FDI.

Unlike Chakrabati et al. (2012) and Kumar (2006) and just like Jordaan (2008), Wekesa et al. (2016) do not construct an overall infrastructure index but examine the effect of each mode of infrastructure separately. Wekesa et al. (2016) use Kenyan FDI data from the period between 1970 and 2013 and focus exclusively on the effect of infrastructure on FDI. They test the effect of multiple indicators for each infrastructure type. For energy infrastructure, they create an index based on per capita electricity consumption and oil consumption, energy generation-over-demand ratio, the share of renewable energy generation in the country's generation capacity, and the percentage of households connected to the electricity grid. Unfortunately, the empirical results of the multiple regression analysis are not significant for the energy indicator and are only robust for the transport indicator. The authors argue that this may be due to the exclusion of electricity prices from the indices. However, it could also be due to the study solely focusing on energy infrastructure availability and not its reliability. Castro et al (2007), run a similar test for the case of Argentina and obtain similar results. The use a spatially autoregressive (SAR) model to examine the determinants of FDI flowing into different Argentinian provinces. Similarly to Wekesa et al. (2016) they also only find transport infrastructure to be significant.

Fitriandi et al. (2014), on the other hand, use data from 30 Indonesian provinces for the period between 2000 and 2009 to test the significance of infrastructure as an FDI determinant. The infrastructure indicators this study uses are electricity distribution and road length over the country's total land mass and the per capita water distribution and water capacity. The results of

OLS, logit, Tobit, Poisson, and negative binomial models (NBMs) all show positive and significant results across the different modes of infrastructure examined. The energy infrastructure indicator is estimated to have a higher effect than the water infrastructure indicator, but a lower effect than the road and digital infrastructure indicators. However, just as in Wekesa et al (2016), Castro et al. (2007), and other similar studies, the indicator it uses is also solely based on energy infrastructure availability and not on reliability.

Armah & Fosu (2016) and Khan et al. (2020) focus exclusively on the effect of infrastructure on FDI inflows to focus on energy. The first study examines the effect of social infrastructure – defined as communal facilities such as schools, hospitals, cultural centers, and religious facilities, among others – and economic infrastructure (a synonym for physical infrastructure) on FDI inflows in Ghana (Armah & Fosu 2016). The authors use a Two Stage Least Squares (2SLS) estimation model and quarterly time series data from the period between 1975 and 2012. The energy indicator of choice is electricity production (kWh) with the argument that electricity generation is crucial component of all development projects. Their empirical results show that a percentage increase in the availability of energy infrastructure in Ghana can lead to an increase in FDI inflows up to 0.8%. This effect is over three times larger than that of social infrastructure. Nonetheless, as is common in this field of research, this study also only focuses on energy infrastructure availability and not on reliability.

Khan et al. (2020), on the other hand, investigates the relationship between energy infrastructure and foreign direct investment in China between 1988 and 2017 using ARDL model and the vector error correction model (VECM). Unlike all previously mentioned studies, Khan et al. (2020) also includes energy infrastructure reliability indicators. The study uses an energy infrastructure index constructed by Donbauer et al. (2016) which includes indicators on energy production and consumption (as availability indicators) and distribution and transmission losses (as reliability indicators). Using an ARDL bound test, the authors determine that the causality runs form energy infrastructure to FDI and not vice-versa. The energy infrastructure index is positive and significant even after including control variables such as trade openness, domestic investment, and institutional quality. An increase of energy infrastructure availability and reliability by one percent can increase FDI inflows between 0.3 and 0.5 percent, in the case of China. The authors check the robustness of these results using the Johansen multivariate cointegration test. Nonetheless, because of the nature of the index, they do not differentiate between the effect of energy infrastructure availability and reliability. Hence, further research needs to differentiate between those two factors to see whether one has a bigger impact than the other and to test this relationship for other countries besides China.

This master thesis research project attempts to fill in this gap in the energy infrastructure literature by providing cross-country results and testing the impact of energy infrastructure availability and reliability separately. This research will also contribute to the overall literature on the effect of infrastructure on FDI inflows given that this field of research: a) does not examine the effect of energy infrastructure, but only focuses on transport infrastructure and (in some cases) on digital infrastructure, b) does not focus on infrastructure reliability, but only in infrastructure availability, and c) mostly provides country-specific results and not cross-country results. Furthermore, it also provides preliminary empirical results about the growing importance of a host country's reliance on renewable energy generation and its impact on FDI attractiveness.

# Methodology

## The Model

In order to test the effect of energy infrastructure on FDI as accurately as possible, this research project will use a bilateral FDI model. Bilateral FDI models are popular in the FDI determinant literature because they allow us to control not only for host country characteristics, but also for source country characteristics (Asiedu, 2002; Seetanah & Khadaroo, 2008; Blonigen & Piger, 2014). After controlling for source country characteristics we can capture the main FDI determinants and have a higher degree of certainty that our results are meaningful. The most developed model of bilateral FDI flows is the Gravity Model. Like the Gravity Model on trade, the Gravity Model on FDI argues that size and proximity indicators are the most important ones in explaining the FDI flows between countries. The Gravity Model for trade was first developed by Walter Isard in 1954. In its most basic form, the model is written as follows:

$$F_{ij} = G * \frac{M_i * M_j}{D_{ij}}$$

On the left side of the equation, noted with *F*, are the trade/FDI flows between country "*i*" and country "*j*." On the right side of the equation, we have a constant, denoted with *G*, the market sizes of country "*i*" and country "*j*," denoted with *M*, and the distance between country "*i*" and country "*j*," denoted with *D*.

However, the exact specifications of the Gravity Model used to explain FDI flows differ by the income-level of countries being studied. On top of traditional indicators such as market size, proximity, purchasing power, openness, etc. which are common in the studies of FDI flows between developed countries and developing countries alike, factors like institutional quality, human capital, exchange rate regimes, and others are often mentioned. The infrastructure quality of the host country is sometimes also mentioned as an FDI determinant in the studies regarding FDI flows involving developing countries. However, as we saw from the literature review section, even the cases when physical infrastructure is mentioned as one of the FDI determinants, energy infrastructure is often neglected. Therefore, this research project uses the following models:

1) $lnFDIflow_{ij} = \beta_o + \beta_1 lngdp_j + \beta_2 lngdpcap_j + \beta_3 lndist_{ij} + \beta_4 lnarea_{i+j} + \beta_5 contig_{ij} + \beta_6 comcol_{ij} + \beta_7 fta_{ij} + \beta_8 lnopen_j + \beta_9 lnfxrate_j + \beta_{10} lnhumancap_j + \beta_{11} lngencap_j + \gamma_t + \delta_i + \varepsilon$

Let “i” be the FDI source (sending) country and “j” be the FDI host (receiving) country. In this model, the main independent variable is *lnFDIflow_ij*, which denotes the bilateral FDI flows from the source country to the host country. The main control variables are the following: *lngdp_*j, which measures the market size of host country; *lngdpcap_j*, which measures the purchasing power of the host country; *lndist_ij*, which measures the distance between the host and the source country; *lnarea_i+j*, which measures the physical size of the two markets, combined; *contig_ij*, which is a dummy variable confirming whether the two countries have a contiguous border with each other; *comcol_ij*, which is a dummy variable confirming the existence of a colonial relationship between the two countries; *fta_ij*, which is a dummy variable confirming the existence of a free trade agreement between the two countries; *lnopen_j*, which measures the openness of the host country’s economy; *lnfxrate_j*, which measures the exchange rate of the host country’s currency; and *lnhumancap_j*, which measures the human capital level of the host country.

The main independent variable, *lngencap_j*, is a measure of the energy infrastructure availability of the host country. To account for year-specific factors affecting the dependent variable, the model uses yearly fixed effects, denoted by gamma ($\gamma$). To account for differences in the source country, the model also uses source-country fixed effects, denoted by delta (δ). Lastly, the error term is captured using the epsilon symbol (ε).

2) $lnFDIflow_{ij} = \beta_o + \beta_1 lngdp_j + \beta_2 lngdpcap_j + \beta_3 lndist_{ij} + \beta_4 lnarea_{i+j} + \beta_5 contig_{ij} + \beta_6 comcol_{ij} + \beta_7 fta_{ij} + \beta_8 lnopen_j + \beta_9 lnfxrate_j + \beta_{10} lnhumancap_j + \beta_{11} lndistrbloss_j + \gamma_t + \delta_i + \varepsilon$

The second model uses the same dependent and control variables, but with a different main independent variable. Here, *lndistribloss_j* is the main independent variable and it measures the reliability of the energy infrastructure in the host country. The same model will also be tested using alternative measures of energy infrastructure reliability, such as the indices for the frequency and the duration of power outages (SAIFI and SAIDI). These models also use source-country and yearly fixed effects.

3) $lnFDIflow_{ij} = \beta_o + \beta_1 lngdp_j + \beta_2 lngdpcap_j + \beta_3 lndist_{ij} + \beta_4 lnarea_{i+j} + \beta_5 contig_{ij} + \beta_6 comcol_{ij} + \beta_7 fta_{ij} + \beta_8 lnopen_j + \beta_9 lnfxrate_j + \beta_{10} lnhumancap_j + \beta_{11} lngencap_j + \beta_{12} lndistrbloss_j + \beta_{13} genrenew_j + \gamma_t + \delta_i + \varepsilon$

The third model, on the other hand, combines models 1 and 2 and tries to see whether energy infrastructure availability or energy infrastructure reliability is more important as an FDI determinant. The third model, however, expands on the previous model and tests the importance of renewable energy reliance on FDI inflows. The variable *genrenew_j* captures the share of total electricity that is generated using renewable energy sources. In other words, the third model also tests whether increased reliance on renewable sources has an impact on incoming FDI. The rest of the model, including the fixed effects, remains the same as the second model. Summary statistics for the variables included in all three models, as well as other variables that were tested but were not included in the models can be found in Appendix I.

## The Indicators and the Data

### *FDI Flows*

The main dependent variable is the yearly flow of FDI from country "i" to country "j." The literature on FDI determinants is split on what the correct measure of inward FDI is – whether using FDI stocks or FDI flows is better. Bilateral FDI stocks measure the total level of direct investment from the source country to the host country at a given point in time, usually at the end of the year. Studies such as Ahmad et al. (2015), Campos & Kinoshita (2003), etc. use FDI stocks as the main dependent variable. They argue that FDI stocks are more stable than FDI flows and, thus, offer a better view of the FDI coming into a country. Because FDI stocks measure the total level of FDI at any given point in time, the magnitude of the difference year-by-year is not as large as with FDI flows. For example, FDI stocks from Germany to Turkey only changed from $379 million to $375 million (USD) (UNCTAD, 2020).

Bilateral FDI flows, on the other hand, measure the total value of direct investment from the source country to the host country during a given time period, usually a year. Unlike bilateral FDI stocks, they have a higher tendency to show high magnitude changes from one year to another. Nonetheless, authors, such as Rehman et al. (2011) and Benhame (2012), etc. for example, use FDI flows as the main dependent variable. They argue that FDI stocks are too rigid and do not adequately show the year-to-year changes in bilateral FDI between two countries. For example, while the FDI stocks from Germany to Turkey stayed at $375 million (USD) in 2005 and 2006 the FDI flows decreased from $391 million to $357 million (USD) (UNCTAD, 2020). This change in bilateral FDI tendencies between the two countries for these years is not captured at all. Furthermore, the magnitude of the year-to-year changes can be especially useful since it may highlight the response of investors to changing factors within the host country. For example, if a new, less democratic government is installed in a country, FDI flows could capture the nervousness of the investors better than FDI stocks.

While considering both sides of the argument, this study uses FDI flows as the main dependent variable, though the results will also be presented using the FDI stocks variable. The main reason for that is data availability. Bilateral FDI stocks covering most of the world are only available in the (UNCTAD) Investment Statistics and Trends Database. However, this database ends at 2012, not capturing the most recent years. FDI data from the IMF, on the other hand, are available for the period between 2009 and 2018. However, these data are only available as FDI flows. To create a bilateral FDI dataset that captures as many years as possible, this research project uses a combination of data from UNCTAD (for the 2001-2012 period) and from the IMF (for the 2013-2018 period). The final bilateral FDI dataset contains over 175,000 observations, with data for 190 host countries over a period of 18 years.[3] By using the year fixed effect in the regression analysis, the data variations between the two sources as well as concerns about the dynamism of the FDI flows variable (as opposed to the rigidity of FDI stocks) are mitigated.

*Market Size*

Market size is one of the main components of the Gravity Model and a key control variable. The size of the market is important because it captures some of the main economic conditions of the host country, but also because it dictates the potential local demand for goods and services produced by the investor in the host country. The latter is particularly important for horizontal

[3] Not all 190 countries have available data for all 18 years. Some only reported their FDI inflows for a limited number of years.

FDI. It is inevitable that countries like China, for example, with a population of almost 1.4 billion and a total GDP of more than 13.6 trillion (USD) will receive more FDI (in absolute terms) than countries like Montenegro, with a population of just over 600,000 and a total GDP of just 5.5 billion (USD) (World Bank, 2020).

The relevance of the market size as an FDI determinant is greatly supported by empirical literature (Wheeler and Mody, 1992; Loree and Guisinger, 1995; Asiedu, 2002, Seetanah & Khadaroo, 2008; Blonigen & Piger, 2014). The measure for market size used in this study is Nominal GDP in current USD. Though some studies use Real GDP as a measure of market size, the usage of Nominal GDP is more wide-spread (Asiedu, 2002). Furthermore, while some authors, like Scaperlanda and Mauer (1969) argued that market size only influences FDI inflows once a certain threshold of GDP is reached, the vast majority of literature considers this indicator linear and does not transforms it using a square root. Moreover, the total land area is an alternative market size indicator often used in bilateral FDI models (Coughlin et al. 1991, Benhame et al. 2012). The latter is measured as the total land area of the host country in square kilometers. The data for both of these variables come from the World Bank's World Development Indicators Database, which covers over 200 countries over a period of 60 years.

*Country Income and Purchasing Power*

The purchasing power of the host economy is also a standard FDI determinant. Based on the literature on FDI determinants, the purchasing power determinant used in this study is GDP per capita in current USD (Asiedu, 2002, Seetanah & Khadaroo, 2008; Blonigen & Piger, 2014). This indicator not only controls for the overall level of income and the purchasing power of host-country citizens, but it also reflects the overall level of development of the host country. This is particularly relevant for the infrastructure determinant since part of the variation in infrastructure can be explained by the overall development level of the country (Wheeler & Mody, 1992; Asiedu, 2002; Seetanah & Khadaroo, 2008).

Furthermore, some scholars consider GDP per capita as a measure of the investment climate in a country (Wei, 2000; Asiedu, 2002) or of the country's overall capital abundance (Edwards, 1990). The GDP per capita level of the host country could also be a proxy of its wage levels (Rehman et al. 2011). However, other authors like Wekesa et al. (2016) prefer indicators that are more directly linked to the wage level (i.e. average annual earnings in USD) as proxy for wages. Regardless of the exact number of factors for which GDP per capita affects, it is nonetheless an important control variable for the purpose of this study. Like for the previous determinant, the data for this variable also come from the World Bank's World Development Indicators Database.

*Distance and Borders*

Together with market size, distance is one of the key components of the Gravity model and a very important bilateral FDI determinant. Countries that are close to each other are more likely to trade with each other, but also to invest in each other. Conversely, the farther away from each other two countries are, the likelihood of FDI flows decreases (Wheeler and Mody, 1992; Loree and Guisinger, 1995; Asiedu, 2002, Seetanah & Khadaroo, 2008; Blonigen & Piger, 2014). The main reasons for this relationship are trade costs. With an increase in distance between two countries, transportation costs and other trade costs increase, and the investment becomes less profitable. It is no surprise that other neighboring countries are the biggest receivers of most countries' FDI. For example, proportional to market size, Austria, Denmark, Italy, Poland, the Netherlands, and France make up the top 6 German FDI destinations (OECD 2020). Unsurprisingly, all, but one of these countries (Italy) share borders with Germany.

The variable used to measure the distance between the two bilateral FDI partners is the distance between the two country's capitals, in kilometers. This variable comes from the Gravity Database published by the French Center for Research and Expertise on the World Economy (*Centre d'Etudes Prospectives et d'Informations Internationales* [CEPII]). CEPII's Gravity Database contains information about the main gravity indicators for every country-pair in the world, starting from the year 1948. However, because this distance variable only measures the distance between capitals, this research project also includes a dummy variable depicting the existence of a contiguous land border between the source country and the host country. The usage of this variable is also supported by empirical literature (Chakrabati, 2001; Blonigen & Piger, 2014). The data for this variable also come from the CEPII database.

*Colonial Relationship*

This study also includes dummy variables depicting whether the host country shares a former colonial relationship with the source country (was colonized by it or was the colonizer of it). It has been shown in literature that countries sharing a colonial past tend to trade and invest in each other in relatively high amounts (Asiedu, 2002; Seetanah & Khadaroo, 2008). The existence of cultural similarities between the countries – language similarities, customs similarities, shared history, etc. – can help explain this relationship. The existence of long-established trading partnerships and population migrations between the countries can also be one of the reasons why such a relationship exists (Wekesa et al. 2016). The data for this variable come from the CEPII database as well.

*Openness and Free Trade Agreements*

The openness of a country to trade and foreign investment is also an important FDI determinant. The exact effect of this indicator is hard to theorize. A more closed economy might attract horizontal FDI, but it will deter horizontal FDI. The reason for that can be explained by the "tariff jumping" hypothesis, which claims that faced with harsh tariffs, firms may choose set-up subsidiaries in the host country in order to serve the local market. However, firms which are focused on export-oriented investments may shy away from closed-off countries, given that they'll be faced with high tariffs and high transaction costs (Asiedu 2002). Hence, the openness of the country could be particularly important for those firms oriented in the export market, such as those that aim to participate in global value chains. Given the importance of global value chains in today's world, the argument for an overall positive effect of openness is stronger.

The most common indicator used to measure openness in the literature is the ratio of trade to GDP (Hufbauer et al., 1994; Blonigen & Piger, 2014; Wekesa et al. 2016). This indicator could also be used as a proxy of trade restrictions of a country. The more open a country is to the rest of the world, the more likely it is to have leaner tariffs and non-tariff restrictions. However, indicators such as the effective tariff rate are more appropriate as proxies for trade restrictions. Following the practices established by the literature, the openness indicator used in this research project is the ratio of trade to GDP, available at the World Development Indicators Database.

Similarly to the overall openness of a country, the relative openness of the host country to the source country – the existence of a free trade agreement between the host country and the source country – also helps facilitate FDI flows among them. However, the effect of an FTA on FDI flows between a country pair is much clearer. Given that free trade agreements often remove most tariffs and non-tariff barriers to trade and investment, they are especially beneficial for vertical FDI (Wekesa et al. 2006). Furthermore, because FTAs also often include dispute settlement mechanisms and investment protection clauses, they are likely to attract both kinds of

FDI (Seetanah & Khadaroo 2008). The indicator used to measure the existence of an FTA between the host and the source country is a dummy variable from the CEPII Gravity database.

*Exchange Rates*

The FDI determinant literature concerned with FDI inflows to developing countries also often includes exchange rate indicators. A weaker real exchange rate may attract vertical FDI because firms from the source country will seek to profit from the relatively low fixed and variable costs in the host country. It may also be beneficial for export-oriented firms as a weaker exchange rate will make their exports cheaper, and thus more attractive (Walsh & Yu 2010). Such a relationship has been empirically tested by Blonigen and Feenstra (1996), Blonigen (1995) and Froot & Stein (1991), Rehman et al. (2011), and others. Like Rehman et al. (2011), this study uses the official exchange rate from local currency units to USD indicator from the World Development Indicators Database.

*Human Capital*

The effect of human capital on FDI is also an extensively studied topic. Firms interested in investing in a foreign country are not only focused on the potential lower cost of labor in that country but are also concerned with the quality of that labor. The more educated and healthier a country's labor force, the faster they can learn and adopt new technology, resulting in higher levels of productivity. Higher levels of education also indicate the availability of skilled workers, which can further improve the attractiveness of the country to foreign investors (Seetanah & Khadaroo 2008). The effect of human capital is applicable to both horizontal and vertical FDI at the same magnitude, since both types of FDI seek to maximize productivity and profitability.

This relationship has been tested and confirmed empirically by many studied (Root and Ahmed, 1979; Chakrabati, 2001; Asiedu; 2002, Seetanah & Khadaroo, 2008; Blogigen & Piger, 2014, etc.). The indicator used in this research project is the human capital index from the latest version of the Penn World Tables which is based on years of schooling and returns to education. This indicator is more refined than the typical one used in literature – years of schooling – since it also indirectly measures the quality of the education by controlling for returns on education.

*Energy Infrastructure*

The main independent variables are those concerning the availability and the reliability of energy infrastructure. The empirical and theoretical support for the inclusion of energy infrastructure indictors has been discussed at length in the literature review section. Hence, this section will only describe which indicators will be used to measure energy infrastructure availability and reliability.

While some authors have used the percentage of households with access to electricity as an availability measure (Jordaan, 2008; Chakrabarti et al. 2012; Fitriandi et al. 2014), a more common measure of energy infrastructure availability is the generation capacity of a country (Armah & Fosu, 2016; Wekesa et al. 2016, Donbauer et al., 2016; Khan et al., 2020). Similarly to the literature, this study uses the per capita generation capacity as the main energy infrastructure availability indicator. These data come from the Energy Information Administration and are available for the period between 2001 and 2018. As the main indicator of energy infrastructure reliability, this study uses the distribution and transmission losses as a percentage of total output. This indicator has been used by Donbauer et al. (2016) and Khan et al. (2020). The data for this indicator come from the World Development Indicators Database and are also available for the period between 2001 and 2018. SAIFI and SAIDI, also from the World Development Indicators Database, are used as alternative energy infrastructure reliability indicators.

# Results

## Energy Infrastructure Availability

The first model tested here is that which only focuses on energy infrastructure availability. Similar exercises have been undertaken by Wheeler & Mody (1992), Loree & Guisinger (1995), Asiedu, (2002), Seetanah & Khadaroo (2008), etc. Table 1 shows the results of the regression analysis using per capita generation capacity as the main independent variable. The results are split for different subgroups of data, based on the income-levels of the countries, and are shown for both the FDI flows and the FDI stocks dependent variables. As is common practice in the literature (Chakrabati et al., 2001 ;Blonigen & Piger, 2014, etc.) most variables are transformed using the natural logarithm in order to normalize the distribution of their observations and make the interpretation of the results easier.

*Table 1. Fixed-effect Panel Regressions using Energy Infrastructure Availability*

| | ***Low Income*** | | ***Lower Middle Income*** | | ***Upper Middle Income*** | | ***High Income*** | |
|---|---|---|---|---|---|---|---|---|
| **Independent Variables** | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* |
| **Distance** | -0.461** | -0.739*** | -1.115*** | -0.898*** | -1.523*** | -0.979*** | -0.904*** | -0.776*** |
| **Market Size** | 1.107*** | 1.357*** | 0.373*** | 0.439*** | 0.590*** | 0.727*** | 0.380*** | 0.816*** |
| **Income** | -1.683*** | -1.392*** | 0.142** | 0.277*** | 0.164** | -0.253*** | 2.164*** | 0.458*** |
| **Colonial Relationship** | 0.083 | 0.483 | 1.170*** | 0.535*** | 0.900*** | 0.533** | 2.658*** | 2.708*** |
| **Contiguous Border** | 1.327*** | 1.074** | 1.131*** | 0.578*** | 0.510*** | 0.984*** | 1.035*** | 1.048*** |
| **Openness** | 0.620*** | 0.508** | 0.242*** | 0.032 | 0.361*** | 0.267*** | 0.620*** | 1.084*** |
| **Land Area** | -0.025 | -0.004 | 0.302*** | 0.147*** | 0.190*** | 0.114*** | 0.464*** | 0.394*** |
| **Human Capital** | -0.300* | -0.944*** | 0.395*** | 0.510*** | 0.297*** | 0.162* | 0.471*** | 0.353*** |
| **Exchange Rate** | -0.093** | -0.099*** | 0.002 | 0.083*** | -0.092*** | -0.067*** | 0.137*** | -0.008 |
| **FTA** | 0.148 | 0.377 | 0.437*** | 0.457*** | 0.415*** | 0.592*** | 0.023 | 0.215*** |
| ***Generation Capacity*** | ***-0.222**** | ***-0.482**** | ***0.059*** | ***0.132*** | ***0.043*** | ***0.001*** | ***-1.684**** | ***-0.566**** |
| **Constant** | -1.304 | -14.279*** | 3.685*** | -3.587*** | 2.893*** | -6.176*** | -9.150*** | -19.646*** |
| **Degrees of Freedom** | 1803 | 939 | 10165 | 5940 | 12397 | 7060 | 21811 | 15457 |
| **R-squared** | 0.937 | 0.494 | 0.911 | 0.542 | 0.923 | 0.627 | 0.927 | 0.708 |

Unsurprisingly, the main gravity model variables – market size and distance – as well as other typical variables such as purchasing power and human capital are significant and have high coefficients. However, the exact magnitude of each variable varies by the subset of countries used to perform the analysis. Distance is consistently among the variables with the highest coefficient and it consistently shows a negative sign. The effect of a 1% increase in distance between the two country's capitals lowers FDI by a margin between 0.5% – 1.5% It is interesting, however, that a contiguous border has a consistently high effect, even after controlling for distance. The existence of a contiguous border between two countries increases FDI between them by more than 1%.

The magnitude of the effect of market size, on the other hand, varies, while the relationship consistently shows a positive sign. For low income countries, a 1% increase in market size leads to an increase in FDI inflows between 1.1% and 1.4%. For middle-income and high-income countries, the effect of market size is lower – between 0.4% and 0.8%. This is unsurprising when considering that large developing countries such as China traditionally received high amounts of FDI. The effect of GDP per capita also depends on the sub-group of countries examined. For low income countries, this variable has a negative effect, while for middle and high-income countries it is positive. This indicates that in the case of low-income countries, all else equal, the GDP per capita is acting more as a proxy for wages. In that case, it is logical for investors to choose countries with lower wages to invest. For the case of middle and high-income countries, this indicator is acting more like a proxy of purchasing power. All else equal, middle and high-income countries with a higher purchasing power attract more FDI. Hence, for low income countries the market size indicator hints to the presence of horizontal FDI (since market size is especially important), while the income level hints to the presence of vertical FDI (since low wages are important).

The overall openness of the host country as well as the existence of an FTA between the host and source countries are also confirmed as significant factors. Though, interestingly, the latter does not seem to be an important factor for low-income countries. This is likely the case because many low-income countries frown upon free trade agreements as they are seen exploitative (Cagnin et al. 2012). For middle and high-income countries, on the other hand, the existence of an FTA increases inward FDI by around 0.4% (all else equal). The openness of the country is consistently a positive indicator and its magnitude is similar across the four income groups of countries. All else equal, a 1% increase in openness leads to an increase in FDI between 0.3% and 0.6% (though this effect is as high as 1% in the case of high-income countries).

The significance of human capital as an FDI determinant is also confirmed by these results. For middle and high-income countries, all else equal, a 1% increase in years of schooling can attract about 0.4% percent more FDI. Interestingly, the human capital variable, while significant, displays a negative sign for the subgroup of low-income countries. Given that these results are not supported by any valid economic theory, it is likely that they are due to a suboptimal number of observations for the low-income country group. The existence of a colonial relationship, on the other hand, displays a strong positive effect on incoming FDI. All else equal, the existence of a colonial relationship between the host and the source country positively affects FDI flows and stocks between them by a minimum of 0.6%, all the way to a possible 2.7%.

The exchange rate between the currency of the host country and USD seems to also be an important FDI determinant, though its effect is more volatile. For low income countries, unsurprisingly, this relationship is negative. All else equal, a 1% drop in the exchange rate can lead to an increase in FDI by 0.1%. This result also supports the vertical FDI argument which states that firms invest in low income countries in order to take advantage of cheaper labor, cheaper costs, and to re-export their products at cheaper rates. Surprisingly, though, this effect seems to hold for upper middle-income countries as well. This alludes that investors may try to take advantage of relatively cheaper factor prices and better export terms in upper middle-income countries, especially since human capital and openness have positive signs. Hence, all else equal, an ideal upper middle-income country for FDI attractiveness is a large and open country with high human capital, but low wages and low input costs. The results for the effect of exchange rates in the cases of lower middle-income and high-income countries are inconsistent – sometimes it is positive, sometimes it is insignificant.

Our main independent variable, generation capacity per capita, does not show the expected result. For the two ends of the spectrum of country incomes, generation capacity seems to be contributing negatively to FDI inflows. The results for low income countries could be explained by the low number of observations. Many low-income countries were dropped by the statistics software since they had incomplete data. For high income countries, it is likely that the infrastructure availability indicator is not specific enough. For example, it may be that investors do not prefer countries which have higher generation capacities if this generation is coming from non-renewable sources. This hypothesis will be tested in the next sections of this study. The results for middle income countries, on the hand, allude that infrastructure availability is insignificant as an FDI determinant. Only in the case of upper middle-income countries (when the dependent variable is FDI stocks) the generation capacity variable shows the expected sign and significance.

## Energy Infrastructure Reliability

Given the inconclusive results for the main independent variable from the first model, we go on to test the importance of energy infrastructure through the reliability channel. Table 2 shows the results of the regression analysis using distribution and transmission losses as the main independent variable. Just as before, the results are split for different subgroups of data, based on the income-levels of the countries, and are shown for both the FDI flows and the FDI stocks dependent variables.

The results for the main gravity model variables remain similar in direction and magnitude to the previous model, though the distance variable loses its significance in the case of the low-income countries subset which uses FDI flows as the main dependent variable. However, even the distance variable remains significant for low income countries when FDI stocks are used as the main dependent variable. Just as before, the GDP per capita indicator is negative and significant for low-income countries, but positive for the remainder of the countries. The openness, human capital, and exchange rate variables lose their significance for low-income countries. As mentioned before, given the low number of observations for this subgroup of countries, it is likely that the results displayed for this model are misleading. The remainder of the results remain the same as in the previous model.

*Table 3. Fixed-effect Panel Regressions using Energy Infrastructure Reliability*

| | ***Low Income*** | | ***Lower Middle Income*** | | ***Upper Middle Income*** | | ***High Income*** | |
|---|---|---|---|---|---|---|---|---|
| **Independent Variables** | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* |
| **Distance** | -0.216 | -0.815* | -1.141*** | -0.916*** | -1.545*** | -1.071*** | -0.843*** | -0.755*** |
| **Market Size** | 1.143*** | 0.791** | 0.357*** | 0.413*** | 0.523*** | 0.628*** | 0.589*** | 0.918*** |
| **Income** | -1.416*** | -1.035** | 0.082 | 0.350*** | 0.272*** | -0.083 | 1.093*** | 0.068* |
| **Colonial Relationship** | 0.481 | 0.478 | 1.155*** | 0.489*** | 0.872*** | 0.702*** | 2.625*** | 2.628*** |
| **Contiguous Border** | 1.167*** | 0.542 | 1.148*** | 0.704*** | 0.471*** | 0.945*** | 1.093*** | 1.062*** |
| **Openness** | 0.297 | -0.06 | 0.287*** | 0.03 | 0.097 | -0.023 | 0.919*** | 1.186*** |
| **Land Area** | -0.312 | 0.116 | 0.354*** | 0.175*** | 0.179*** | 0.120*** | 0.287*** | 0.301*** |
| **Human Capital** | 0.415 | 0.068 | 0.403*** | 0.392*** | 0.299*** | 0.236** | 0.602*** | 0.431*** |
| **Exchange Rate** | -0.06 | -0.048 | -0.005 | 0.075*** | -0.108*** | -0.083*** | 0.142*** | -0.012 |
| **FTA** | 0.910* | 0.562 | 0.400*** | 0.446*** | 0.443*** | 0.528*** | 0.093 | 0.270*** |
| ***Distribution Losses*** | ***-0.029*** | ***-0.376*** | ***-0.261**** | ***-0.262**** | ***-0.504**** | ***-0.580**** | ***0.341**** | ***0.110*** |
| **Constant** | 0.477 | -1.599 | 4.961*** | -2.543** | 6.698*** | -1.474 | -16.074*** | -21.987*** |
| **Degrees of Freedom** | 1068 | 391 | 10075 | 5756 | 12387 | 7023 | 21571 | 15372 |
| **R-squared** | 0.941 | 0.553 | 0.911 | 0.548 | 0.924 | 0.636 | 0.924 | 0.705 |

The main difference, however, is in the results for the main independent variable. Here the energy infrastructure reliability variable is significant and mostly shows the expected sign. Though not significant at the 10% level, the energy infrastructure reliability indicator does show a negative relationship with FDI for low-income countries. For middle income countries is relationship is negative and highly significant. All else equal, a 1% decrease in distribution and transmission losses in the host country can lead to an increase in FDI between 0.3%, for lower middle-income host countries, to as high as 0.6% for upper-middle host countries. Unlike energy infrastructure availability, the reliability indicator is not only consistently significant, but it also has a much higher coefficient. For upper middle-income countries, the reliability indicator has a higher coefficient than more traditional indicators such as the presence of an FTA, the host country exchange rate, and even its human capital.

*Table 3. Coefficients of Variation (CV) for Host Country Indicators*

| Variable | Low Income | Lower Middle Income | Upper Middle Income | High Income |
|---|---|---|---|---|
| **openness_j** | 0.52 | 0.42 | 0.42 | 0.72 |
| **humancapital_j** | 0.31 | 0.25 | 0.15 | 0.11 |
| **education_j** | 1.37 | 0.63 | 0.42 | 0.25 |
| **lowskill_j** | 0.25 | 0.40 | 0.61 | 0.77 |
| **access** | 0.75 | 0.34 | 0.10 | 0.00 |
| **generation_capacity** | 1.89 | 1.20 | 0.53 | 0.57 |
| **saifi** | 1.03 | 1.37 | 1.72 | 1.01 |
| **saidi** | 0.91 | 1.37 | 2.19 | 1.25 |
| **outages_monthly** | 1.08 | 1.88 | 2.93 | 0.65 |
| **outages_duration** | 0.49 | 0.86 | 0.90 | 0.45 |
| **firmswithgenerators** | 0.38 | 0.64 | 1.00 | 0.71 |
| **distribution_losses** | 0.88 | 0.79 | 0.65 | 0.87 |

The results may seem surprising because they claim that energy infrastructure reliability is more important in the context upper middle-income countries than in the case of lower middle-income countries. Nonetheless, these results follow economic theory because they suggest that investors are particularly sensitive to infrastructure reliability for upper middle-income countries because the expectations for those countries to have more reliable energy infrastructure are higher. Besides dealing with investor expectations, these countries also have little variation in other indicators, which makes the reliability of their energy infrastructure a more important FDI determinant than for other country income groups. This is highlighted in Table 3, which shows the coefficient of variation (=standard deviation/mean) for the non-gravity control variables. Upper middle-income countries are very close to each other in terms of human capital (overall human capital, education, worker skill level), openness, and energy availability indicators, while they display more variation in energy reliability indicators than any other country income group. Upper middle-income countries show especially high variation in the number and the frequency of power outages (SAIFI, SAIDI, and number of outages indicator CVs, Table 3). Hence, for this group of countries improving and/or maintaining the reliability level of their energy infrastructure is crucial.

*Table 4. Fixed-effect Panel Regressions using Energy Infrastructure Reliability #2*

| **Independent Variables** | ***Low Income*** | ***Lower Middle Income*** | ***Upper Middle Income*** | ***High Income*** |
|---|---|---|---|---|
| **Distance** | -2.143** | -1.613*** | -1.898*** | -0.900*** |
| **Market Size** | -78.888 | 0.681*** | 0.623*** | 0.729*** |
| **Income** | 85.281 | 0.23 | 0.113 | 0.710*** |
| **Colonial Relationship** | 1.814* | 0.802*** | 0.938** | 3.499*** |
| **Contiguous Border** | -1.156 | 1.137*** | 0.454** | 1.051*** |
| **Openness** | -21.837 | 0.357 | 0.697*** | 1.264*** |
| **Land Area** | -2.034*** | 0.201*** | 0.353*** | 0.398*** |
| **Human Capital** | 91.318 | -0.038 | 0.796*** | 1.472*** |
| **Exchange Rate** | 78.145 | -0.024 | -0.207*** | 0.180*** |
| **FTA** | 0 | 0.544*** | 0.460*** | 0.241* |
| ***Outage Frequency and Duration*** | ***-0.279*** | ***0.105**** | ***-0.032**** | ***-0.003*** |
| **Constant** | 1056.713 | 5.935** | 9.935*** | -7.586*** |
| **Degrees of Freedom** | 242 | 2695 | 4621 | 8210 |
| **R-squared** | 0.76 | 0.622 | 0.732 | 0.676 |

This hypothesis is further tested through running econometric tests on other energy infrastructure reliability indicators. Table 4 shows the regression results using an alternative reliability indicator – the outage frequency and duration indicator. This variable is a composition of the System Average Interruption Frequency Index (SAIFI) and the System Average Interruption Duration Index (SAIDI) (outage frequency and duration=saifi*saidi) and is meant to test the severity of power outages in the host country, both from a frequency perspective and from a duration perspective. Due to data limitations, we are only able to test this effect for the FDI flows dependent variable. Nonetheless, we can confirm most of the results from the previous model. Most importantly, this model also confirms the importance of energy infrastructure reliability in the FDI attractiveness of upper middle-income host countries. It claims that, all else equal, middle income countries with 1% less severe power outages will receive 0.03% more FDI.

Despite the low coefficient, the significance of this indicator for upper middle-income countries shows that shows that energy infrastructure reliability – however proxied – is an important FDI determinant for this group of countries and should not be neglected in policy discussions. The power outage severity variable is also significant for the case of lower middle-income countries, though the direction of the effect is negative and different than expected. This could also be because of the low number of observations for this model. Furthermore, while insignificant, this alternative reliability indicator also shows a negative relationship to FDI flows for low-income and high-income countries.

### Renewable Energy

To further test the rigidity of our previous results regarding energy infrastructure reliability, this research projects test whether the reliability indicator remains significant when controlling for energy infrastructure availability. Furthermore, this study also tests whether reliance on renewable energy is important as an FDI determinant. The results of the fixed-effect OLS regression are presented in Table 5.

The energy infrastructure reliability indicator remains significant and negative, even after controlling for the infrastructure availability of the host country and its reliance on renewable energy. A 1% decrease of distribution and transmission losses in the host country can attract between 0.4% and 0.7% more FDI in middle-income countries. Like previously, the effect seems to be stronger for upper middle-income countries. Generation capacity, on the other hand, still does not show any consistent results across the different income groups of countries. However, for the case of lower middle-income countries, increased generation capacity does seem to matter.

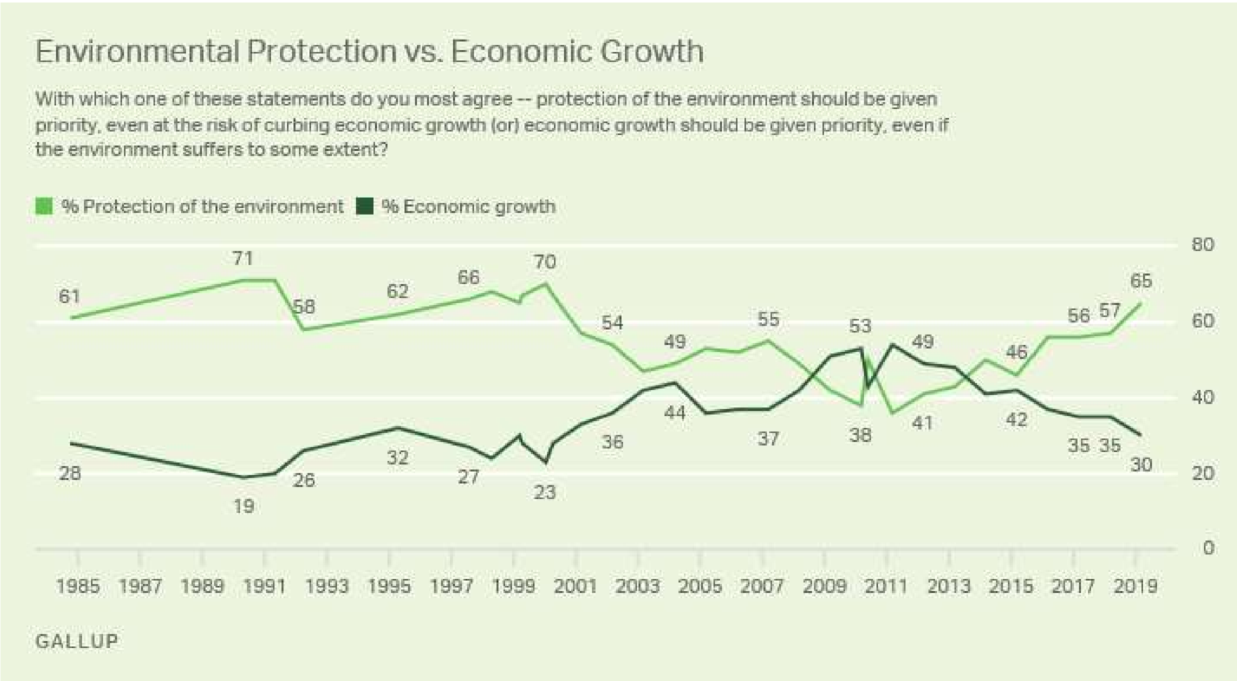
*Table 5. Fixed-effect Panel Regressions for Energy Infrastructure & Renewable Energy*

| | ***Low Income*** | | ***Lower Middle Income*** | | ***Upper Middle Income*** | | ***High Income*** | |
|---|---|---|---|---|---|---|---|---|
| **Independent Variables** | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* | *FDI flow* | *FDI stock* |
| **Distance** | 0.028 | -1.215** | -1.205*** | -1.052*** | -1.567*** | -1.105*** | -0.928*** | -0.840*** |
| **Market Size** | -0.349 | -0.914** | 0.341*** | 0.352*** | 0.536*** | 0.585*** | 0.295*** | 0.734*** |
| **Income** | 0.342 | 1.179 | 0.105 | 0.357*** | 0.347*** | 0.117 | 2.316*** | 0.668*** |
| **Colonial Relationship** | 1.654* | 0 | 1.161*** | 0.486*** | 0.958*** | 0.557** | 2.591*** | 2.671*** |
| **Contiguous Border** | 0.531 | -0.605 | 1.174*** | 0.568*** | 0.451*** | 0.866*** | 1.032*** | 1.055*** |
| **Openness** | 1.970*** | 0.435 | 0.282*** | 0.03 | 0.262*** | 0.01 | 0.310*** | 0.745*** |
| **Land Area** | -0.509* | 0.456 | 0.326*** | 0.194*** | 0.194*** | 0.148*** | 0.444*** | 0.392*** |
| **Human Capital** | 1.736** | 1.158 | 0.579*** | 0.580*** | 0.025 | 0.045 | 0.619*** | 0.483*** |
| **Exchange Rate** | -0.711*** | -0.052 | 0.035* | 0.122*** | -0.121*** | -0.077*** | 0.122*** | -0.004 |
| **FTA** | 1.354* | 2.026*** | 0.356*** | 0.368*** | 0.472*** | 0.540*** | -0.133* | 0.007 |
| ***Generation Capacity*** | ***-0.041*** | ***-0.551*** | ***0.124**** | ***0.188****** | ***-0.274****** | ***-0.343****** | ***-1.547****** | ***-0.519****** |
| ***Distribution Losses*** | ***0.054*** | ***-1.557*** | ***-0.361****** | ***-0.489****** | ***-0.648****** | ***-0.671****** | ***0.220****** | ***0.236****** |
| ***Renewable Generation*** | ***-0.610****** | ***0.451*** | ***0.102****** | ***0.191****** | ***0.128****** | ***-0.033*** | ***-0.140****** | ***-0.106****** |
| **Constant** | 48.391** | 20.68 | 5.422*** | -0.884 | 4.330*** | -0.414 | -7.701*** | -22.250*** |
| **Degrees of Freedom** | 709 | 229 | 9981 | 5711 | 12356 | 6916 | 20615 | 14402 |
| **R-squared** | 0.944 | 0.716 | 0.912 | 0.561 | 0.924 | 0.644 | 0.93 | 0.729 |

For lower middle-income countries, the indicators for generation capacity and renewable energy reliance are both positive and significant, while the results for distribution losses are negative and significant. This suggests that, for this country income group, investors are looking for countries with relatively more reliable and available energy infrastructure, but also for countries which focus more on renewable generation. For the upper middle-income country group, however, the results are different. For this group of countries, energy infrastructure reliability is even more important than before, while a focus on renewable energy is appreciated more than a pure increase in generation capacity. In fact, for upper middle-income countries, the indicator for generation capacity turns negative, once controlling for renewable energy generation. This suggests that the foreign investors in those countries pay attention to the source of any increased generation and perceive increased generation coming from non-renewable sources negatively. All else equal, the regression results suggest that an increase in the share of renewable energy generation in total generation can attract between 0.1% to 0.2% more FDI. The small magnitude of the effect is unsurprising, given that increased reliance on renewable energy is a recent trend (as shown in Figure 1B in the background section) and the data used in these regressions is historical. It is interesting that we can already see the first signs that renewable energy reliance may become an important FDI determinant.

Nonetheless, these results are expected, given the shift of public opinion towards heavier reliance on renewable energy, as discussed in the background section. To illustrate this point, we can draw a parallel to Nike's experience with the anti-sweatshop movement of the nineties. Reports that Nike was using child labor and paying workers as little as $1.25 per day, led to protests against Nike from students and activists across the United States throughout the nineties and the early 2000s (Wazir, 2001). Nike's reputation dropped so much so, that in 1998, Nike's then-CEO admitted his company had become the poster child for slave-level wages and overall worker abuse. He also argued that such an image was hurting the company's performance, especially in the United States (Nisen, 2013). This reputation proved costly for Nike, as the company suffered from a drop in sales and was forced to drastically alter its production strategy and invest in better labor conditions (Nisen, 2013).

*Figure 6. Public Opinion on the Importance of Environmental Protection*




*Source: Gallup (2020)*

Given the heavy shift of public opinion towards environmental protection (even in comparison to economic growth), as shown in Figure 6, firms looking to make long-term foreign direct investments may be cautious of such past experiences such as Nike's and try to get ahead of the curve. One way of doing that is by taking a proactive approach and investing in countries that are more environmentally friendly, without waiting for the public-opinion to force them to do so. With reliance on renewable energy still being relatively low in low and middle-income countries, policy makers should take note of this trend and invest in renewable energy generation as a strategy that would differentiate them from the rest of the countries in the global community. As the regression results from Table 5 show, such a strategy may already prove beneficial and its effect is only likely to grow in the future.

## Conclusions and Implications

This study investigated the relationship between energy infrastructure and FDI. To do that, it first reviewed the theoretical and empirical literature linking the two variables. This study found that the theoretical literature linking energy infrastructure to FDI is not very developed. However, important theoretical connections between energy infrastructure and FDI can be drawn by looking at the theoretical literature on the overall effects of infrastructure (without specifying the type) or on the effects of transport infrastructure specifically. This body of research showed that quality infrastructure provided by the government lowers the production costs of investing for private firms and makes host countries with more developed infrastructure, all else equal, more attractive locations for FDI. In the case of energy infrastructure, reliability is particularly important since an unreliable energy supply can directly increase the costs of investing firms by requiring them to invest in generators, fuel for those generators, and may also harm their production equipment.

The relationship between infrastructure, in general, and FDI inflows has been empirically tested before, though little attention has been given to energy infrastructure. Most earlier studies either ranked the quality of infrastructure in a country using interviews of experts or used very basic indicators such as the number of telephones per 1000 inhabitants as a proxy for all infrastructure. Even in the cases when energy infrastructure was mentioned, its effect was usually incorporated within an overall infrastructure measure and not tested by itself. Furthermore, most studies on the effect of infrastructure on FDI are based on single country cases and focus on the availability of the infrastructure, rather than its reliability. Hence, this study attempted to fill this research gap by: a) focusing on energy and examining the specific effect of energy infrastructure on FDI b) testing the impact of energy infrastructure availability and reliability separately, which allowed for more granular observations to be discussed below c) providing cross-country results and d) by providing preliminary results that the energy generation source is an important factor for policy makers to consider when designing FDI-attracting policies.

Using a fixed-effect panel regression on a bilateral FDI model, the study found that a one percent increase in energy infrastructure reliability as measured by decreased electricity distribution losses contributes to an increase in FDI inflows by around 0.5%. Similarly, a decrease in the frequency and duration of electricity outages also contributes to increased FDI inflows, albeit at a smaller magnitude (about 0.1% increase in FDI for a 1% decrease in outage frequency and duration, all else equal). Furthermore, the study also shows some signs that while energy infrastructure availability on its own may not be an important FDI determinant, when combined reliance on renewable energy it can be an important FDI determinant. All else equal, an increase in a host country's reliance on renewable energy by one percent, can attract between 0.1% to 0.2% more FDI, depending on the income-level of the country.

Interestingly, energy infrastructure reliability seems to be an important FDI determinant especially for upper middle-income countries. This is understandable given that many upper middle-income countries have quality infrastructure. Therefore, investors are especially sensitive to the state of infrastructure in those countries. Thus, upper middle-income countries that are lagging in this aspect may be doing themselves a disfavor and receiving less FDI than potentially possible. Nonetheless, this study also confirms the importance of energy infrastructure reliability for lower middle-income countries. Given that countries in this income group usually have less developed infrastructure, a lower middle-income host country's investment in energy infrastructure reliability may set the country apart from the group and improve its attractiveness for FDI (World Bank, 2017). Unfortunately, due to insufficient data, this study was not able to provide strong support about the importance of energy infrastructure as an FDI determinant for low-income countries.

Future research will need to address the importance of energy infrastructure, in general, and particularly the reliability of this infrastructure type as an FDI determinant for low-income countries. The importance of the reliability of transport and digital infrastructure as an FDI determinant also requires more research. Furthermore, reliance on renewable energy generation will also likely become an important FDI determinant, hence future research should examine this relationship more carefully as well. Nonetheless, the results of this research project allow us to draw some concrete policy recommendations for the governments of developing countries:

*In the short-term, developing countries should improve the reliability of their energy infrastructure to attract more FDI:* Investment in energy infrastructure reliability does not require the construction of new power generation facilities and would, thus, require less time (and likely less resources). In the short run, developing country governments may be able to attract some FDI if they improve the reliability of their existing infrastructure without necessarily increasing its availability. They can start by simply hiring more personnel in order to provide better upkeep for existing power generation, distribution, and transmission infrastructure. Consistent upkeep of power facilities ensures better technical conditions for those facilities and lowers the risk of outages (World Bank, 2017). Better upkeep also lengthens the life-span of such facilities and ensures that large infrastructure investments have to occur less often. Such actions can be undertaken in the short-run, while the country mobilizes resources for larger energy infrastructure investments (be it to improve availability or reliability).

Furthermore, small investments such as the replacement of wooden utility poles with concrete or steel utility poles can go to great lengths in lowering the risks of power outages, as well, since such structures are more rigid and less likely to break during bad weather. They may also be more environmentally friendly (Feltham, 2020). However, the movement of power lines underground is even more beneficial because it not only greatly reduces the risk of power lines breaking and causing outages during bad weather, but also lowers the electricity distribution and transmission losses (World Bank 2017). Hence, an investment on burying power lines would not only improve the reliability of a host country's electricity supply, but also indirectly improve the availability of electricity by ensuring that more of the electricity produced reaches the consumer. Furthermore, it also reduces the cost of production, since less fuel needs to be used to satisfy the electricity demand. Nonetheless, in the long-run, countries also need to invest in energy infrastructure availability in order to satisfy the growing demand for electricity. However, they should be careful in their choice of generation source since that may affect their FDI attractiveness.

*In the long-term, developing countries should increase the availability of energy infrastructure by investing in renewable energy generation:* The increase in FDI resulting from the short-term investment strategy in energy infrastructure may in itself increase the demand for energy and condition the improvement of energy infrastructure availability and generation capacity. However, when faced with the decision to increase their generation capacity, policymakers in developing countries should include the potential FDI-attractiveness of renewable energy in their cost/benefit calculations. Figure 1B in the background section showed that the overall trend of generation among high-income countries is moving towards renewable sources. Developing countries will soon be asked to follow suit. Furthermore, big international agreements such as the Paris agreement require all countries to greatly reduce their emissions. This will only be possible if the growing demand for electricity is met by renewable energy. As the results of this study show, reliance in renewable energy may already attract more FDI. Therefore, developing countries have another incentive to switch to renewable energy generation.

Countries around the world may be naturally forced to switch to renewable energy since fossil fuel reserves are already running out. While the official estimates from Saudi Arabia's Aramco state that the country has enough oil reserves to satisfy world demand for the next 70 years, some argue that it is more likely that such estimates overstate the availability of oil left. They argue that the country's oil reserves will last shorter than that, closer to 40 more years (Kemp 2016). Furthermore, increased efficiency and falling prices for renewable energy have made investment in renewable generation more economically viable. The price of solar has fallen so rapidly that within less than a decade, it may become economically justified to shut down existing coal plants and replace them with solar power plants (Niranjan 2020). In fact, renewable energy prices have fallen so low that some developing countries are already finding difficulties financing non-renewable energy generation projects. For example, up until recently, the construction of a new coal plant in Kosovo was the last remaining coal project in the World Bank's financing portfolio. The country has some of the highest coal reserves in the world and has little potential for hydroelectric power. However, a recent feasibility study from the World Bank found that despite the developing country's massive coal reserves, it is already more economically justified for Kosovo to invest in renewable energy such as solar and wind. Therefore, the World Bank receded its support for the construction of Kosovo's new coal plant (Mathiesen 2018). This example illustrates the international community's shift in attitude away from fossil fuels and towards renewable energy even for developing countries. Hence, policy makers in those countries should follow the trend and invest more in renewable generation, while ensuring that their current electricity system is reliable. By doing that, they may also attract more FDI to their countries.

# Bibliography

Aevarsdottir, A. M.; Barton, N. & Bold, T. (2017). The impacts of rural electrification on labor supply, income and health: experimental evidence with solar lamps in Tanzania. *International Growth Centre,* Working Paper E-89302-TZA-1.

Agodo, O. (1978). The Determinants of U.S Private Manufacturing Investments in Africa. *Journal of International Business Studies*, 9(3): 95-106.

Ahmad, N. A.; Ismail, N. W. & Nordin N.H. (2015). The Impact of Infrastructure on Foreign Direct Investment in Malaysia. *International Journal of Management Excellence*, 5(1): 584-590

Amaro, A. and Miles, W. (2006). Racing to the Bottom for FDI? The Changing Role of Labor Costs and Infrastructure. *The Journal of Developing Areas*, 40(1): 1-13.

Antras, P. & Helpman, E. (2004), Global Sourcing. *Journal of Political Economy*, 112(3): 552-580.

Anyanwu, J. C. (2012). Characteristics and macroeconomic determinants of youth employment in Africa. *African Development Review*, 25(2): 107–129.

Armah, M. K. & Fosu, P. (2016). Infrastructure and foreign direct investment inflows: Evidence from Ghana. *Journal of Emerging Trends in Economics and Management Sciences*, 7(1): 57-66

Asiedu, E. (2002). On the Determinants of Foreign Direct Investment to Developing Countries: Is Africa Different? *World Development*, 30(1): 107-119.

Bakar, N., Siti, H, C. M and Mukaramah, H. (2012). The Impact of Infrastructure on Foreign Direct Investment: The Case of Malaysia. *Procedia Social and Behavioral Sciences,* 65: 205–11.

Barry, F. (2002). Foreign Direct Investment, Infrastructure and the Welfare Effects of Labour Migration. *The Manchester School*, 70(3): 364-379.

Barteková, E. and Ziesemer, T. H. W. (2019). The impact of electricity prices on foreign direct investment: evidence from the European Union. *Applied Economics*, 51(11): 1183-1198.

Barzelaghi, M. T.; Dizaji, M. & Laleh M. M. (2012). The Effect of Transportation Infrastructure on Foreign Direct Investment Attraction in Iran. *International Journal of Economics and Finance Studies*, 4(2): 153-161.

Benhame, M. (2012). Foreign Direct Investment and Urban Infrastructure An Evidence from Southern Asia. *Advances in Management & Applied Economics*, 2(4): 253-259.

Blimpo, M. P. & Cosgrove-Davies, M. (2019). Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact. *World Bank Africa Development Forum Paper.*

Böttcher, C. (2016). The cost of blackouts in Europe. *The European Commission*. Accessed November 2, 2020. https://cordis.europa.eu/article/id/126674-the-cost-of-blackouts-in-europe

Brinkis, K.; Kreslinsh, V.; Mutule, A.; Olienikova, I.; Krishans, Z. & Kochukov, O. (2012). Fulfilment of Criteria of Electricity Supply Reliability in the Baltic Region. *Latvian Journal of Physics and Technical Sciences*, 48(6): 3-13.

Bumpus, A. and Comello, S. (2017). Emerging clean energy technology investment trends. *Nature Climate Change,* 7(1): 382-385.

Cagnin, C.; Amanatidou, E. and Keenan, M. (2012). Orienting European innovation systems towards grand challenges and the roles that FTA can play. *Science and Public Policy,* 39(2): 140-152.

Campos, N. F. and Kinoshita, Y. (2003). Why Does FDI Go Where it Goes? New Evidence from the Transition Economies. *IMF Working Papers.*

Castro, L. (2007). Infrastructure and the Location of Foreign Direct Investment A Regional Analysis. *Munich Personal RePec Archive*, Paper No. 6736

Chakrabarti, R.; Subramanian, K.; Sesha, M. and Sudershan, K. (2012). Infrastructure and FDI: Evidence from District-Level Data in India. *SSRN Electronic Journal.*

Cheng, L. K. & Kwan, Y. K. (2000). What are the determinants of the location of foreign direct investment? The Chinese experience. *Journal of International Economics*, 51(2): 379-400.

Cohen, J. J.; Moeltner, K.; Reichl, J. & Schmidthaler, M. (2016). Linking the value of energy reliability to the acceptance of energy infrastructure: Evidence from the EU. *Resource and Energy Economics,* 45(1): 124-143

Donaubauer, J.; Meyer, B. E. & Nunnenkamp, P. (2016). A New Global Index of Infrastructure: Construction, Rankings and Applications. *World Economy*, 39(2): 236–59.

Feltham, P. (2020). Utility Pole Showdown: Wood vs. Steel. *Electricity Today.* Link: https://www.electricity-today.com/overhead-td/the-utility-pole-showdown-wood-vs-steel

Fitriandi, P.; Kakinaka, M. & Kotani, K. (2014). Foreign direct investment and infrastructure development in Indonesia: Evidence from province level data. *Asian Journal of Empirical Research*, 4(1): 79-94.

Fung, K.C.; García-Herrero, A.; Iizaka, H.; & Siu, A. (2005). Hard or Soft? Institutional Reforms and Infrastructure Spending as Determinants of Foreign Direct Investment in China. *Japanese Economic Review,* 56(1): 408-416.

Gallup (2020). Polls about the Environment. *Gallup.* Accessed, January 10, 2021, https://news.gallup.com/poll/1615/environment.aspx

Globerman, S. & Shapiro, D. (2003). Governance infrastructure and US foreign direct investment. *Journal of International Business Studies*, 34(1): 19–39.

Grenville, S. (2017). The first global supply chain. *Lowy Institute*. Accessed October 24, 2020, https://www.lowyinstitute.org/the-interpreter/starting-point-first-global-supply-chain

Haughwout, A. F. (2001). Infrastructure and Social Welfare in Metropolitan America. *Economic Policy Review, The Federal Reserve Bank of New York*, T7(3): 1–16.

Helpman, E.; Melitz, M. & Yeaple, S. (2004). Export versus FDI with Heterogeneous Firms. *American Economic Review*, 94(1): 300-316.

Hibbard, P.; Tierney, S. & Franklin, K. (2017). Electricity Markets, Reliability and the Evolving U.S. Power System. *Analysis Group*.

IRENA (2020). How Falling Costs Make Renewables a Cost-effective Investment. *International Renewable Energy Agency*. Accessed October 24, 2020, https://www.irena.org/newsroom/articles/2020/Jun/How-Falling-Costs-Make-Renewables-a-Cost-effective-Investment

Jordaan, J. A. (2008). State Characteristics and the Locational Choice of Foreign Direct Investment: Evidence from Regional FDI in Mexico 1989–2006. *Growth and Change*, 39(3): 389-413.

Kang, S. J., & Lee, H. S. (2007). The determinants of location choice of South Korean FDI in China. *Japan and the World Economy*, 19(4): 441–460.

Keeley, A. R. & Matsumoto, K. (2018). Investors' perspective on determinants of foreign direct investment in wind and solar energy in developing economies – Review and expert opinions. *Journal of Cleaner Production,* 179(1): 132-142.

Kemp, J. (2016). Saudi Arabia oil reserves: How big are they really? *Reuters*. Link: https://www.reuters.com/article/us-saudi-oil-kemp-idUSKCN0ZL1X6

Khadaroo, J. & Seetanah, B. (2009). The Role of Transport Infrastructure in FDI: Evidence from Africa using GMM Estimates. *Journal of Transport Economics and Policy,* 43(3): 365-384.

Khan, H.; Shaheen, I.; Ahmad, M.; Bakhshaliev, E.; Khan, H. U. & Khabir, A. (2020). Energy Infrastructure and Foreign Direct Investment in China. *Entreperneurship and Sustainability Issues*, 8(1): 233-248.

Kirubi, C.; Jacobson, A.; Kammen, D. & Mills, A. (2009). Community-Based Electric Micro-Grids Can Contribute to Rural Development: Evidence from Kenya. *World Development*, 37(7): 1208-1221.

Kohler, W. & Smolka, M. (2014). Global Sourcing and Firm Selection. *Economics Letters,* 124(1): 411-415

Kumar, N. (2006). Infrastructure Availability, Foreign Direct Investment Inflows and Their Export-Orientation: A Cross-Country Exploration. *The Indian Economic Journal,* 54(1): 125-144.

LaCommare, K.H. & Eto, J.H. (2004). Understanding the cost of power interruptions to US electricity consumers. *Ernest Orlando Lawrence Berkeley National Laboratory*

Loree D. W. & Guisinger S. (1995). Policy and Non-Policy Determinants of US Equity Foreign Direct Investment. *Journal of International Business Studies*, 26(2): 281–299.

Mathiesen, K. (2020). World Bank dumps Kosovo plant, ending support for coal worldwide. Climate Change News. Link: https://www.climatechangenews.com/2018/10/10/world-bank-dumps-support-last-coal-plant/

McCarthy, R. W.; Ogden, J. M. & Sperling, D. (2007). Assessing reliability in energy supply systems. *Energy Policy*, 35(4): 2152-2162.

Millen, A. (2017). Electricity supply reliability and households decision to connect to the grid. *HAL*.

Nguea, S. M. (2020). The Impact of Infrastructure development on Foreign Direct Investment in Cameroon. *HAL.*

Niranjan, A. (2020). Falling solar panel prices spell sunny future for clean energy. *Deutsche Welle*. Accessed, November 15, 2020, https://www.dw.com/en/cheap-solar-energy-prices-explained/a-53590607

Nisen, M. (2013). How Nike Solved Its Sweatshop Problem. *Business Insider*. Accessed, January 10, 2021, https://www.businessinsider.com/how-nike-solved-its-sweatshop-problem-2013-5

OECD (2020). FDI Flows by Partner country. Accessed, November 15, 2020, https://stats.oecd.org/Index.aspx?DataSetCode=FDI_FLOW_PARTNER

Omri, A. & Kahouli, B. (2014). Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models. *Energy Policy*, 67(10): 913-922.

Pradhan, R. P. (2008). Does Infrastructure Play a Role in Foreign Direct Investment?. *ICFAI Journal of Financial Economics*, 6(2): 48-60.

Rehman, A.; Ilyas, M.; Alam H. M. & Akram, M. (2011). The Impact of Infrastructure on Foreign Direct Investment: The Case of Pakistan. *International Journal of Business and Management,* 6(5): 268-276.

Richaud, C.; Sekkat, K. and Varoudakis, A. (1999). Infrastructure and Growth Spillovers: A Case for a Regional Infrastructure Policy in Africa, Mimeo. University of Brussels.

Root, F. D. and Ahmed A. A. (1979). Empirical Determinants of Manufacturing Direct Foreign Investment in Developing Countries. *Economic Development and Cultural Change,* 27(4): 751-767.

Samad, H. & Zhang, F. (2018). Electrification and Household Welfare: Evidence from Pakistan. *The World Bank,* Policy Research Working Paper 8582.

Sanchez-Robles, B. (2007). Infrastructure Investment and Growth: Some Empirical Evidence. *Contemporary Economic Policy*, 16(1): 98-108.

Schuler, R. E. (2010). Electricity Markets, Reliability and the Environment: Smartening-Up the Grid. *Hawaii International Conference on System Sciences.*

Seetanah, B. (2009). A Sector-Wise Panel Data Study on the Link between Transport Infrastructure and FDI in Mauritius. *Paper presented at 9th Global Conference on Business & Economics.*

Seetanah, B. & Khadaroo A. J. (2008). Transport infrastructure and foreign direct investment. *Journal of International Development,* 22(1): 103–123.

Straub, S. (2008). Infrastructure And Growth In Developing Countries: Recent Advances And Research Challenges. *World Bank Policy Research Working Papers*.

Tang, C. F. & Tan B. W. (2012). The linkages among energy consumption, economic growth, relative price, foreign direct investment, and financial development in Malaysia. *Quality & Quantity*, 48(1): 781–797.

Thompson, L. M.; Bruce, N.; Eskenazi, B.; Diaz, A.; Pope, D. & Smith, K. R. (2011). Impact of reduced maternal exposures to wood smoke from an introduced chimney stove on newborn birth weight in rural Guatemala. *Environmental Health Perspectives*, 119(10): 1489-1494

UNCTAD (2020). *World Investment Report.* New York. UNCTAD WIR/2020.

Walsh, J. P. & Yu, J. (2010). Determinants of Foreign Direct Investment: A Sectoral and Institutional Approach. *IMF Working Paper No. 10/187.*

Warfure, O. G. & Abu, N. (2010). Determinants of Foreign Direct Investment in Nigeria: An Empirical Analysis. *Global Journal of Human Social Science*, 10(1): 26-34.

Wazir, B. (2001). Nike accused of tolerating sweatshops. *The Guardian*. Accessed, January, 10, 2021, https://www.theguardian.com/world/2001/may/20/burhanwazir.theobserver

Wekesa, C.T.; Wawire N.H. & Kosimbei, G. (2016). Effects of Infrastructure Development on Foreign Direct Investment in Kenya. *Journal of Infrastructure Development*, 8(2): 93-110

Wheeler, D. (2001). Racing to the Bottom? Foreign Investment and Air Pollution in Developing Countries. *The Journal of Environment & Development*, 10(3): 225-245.

Wheeler, D & Mody, A. (1992). International Investment Location Decisions: The Case of U.S. Firms. *Journal of International Economics,* 33(1–2): 57–76.

World Bank (2014). Clean and Improved Cooking in Sub-Saharan Africa: Second Edition. Washington, DC: World Bank.

World Bank (2017). Getting Electricity Factors affecting the reliability of electricity supply. *World Bank Doing Business Survey.*

World Bank (2020). World Development Indicators. The World Bank Group. Accessed October 24, 2020, https://data.worldbank.org/

Yamin, M. & Sinkovics, R. R. (2009). Infrastructure or foreign direct investment?: An examination of the implications of MNE strategy for economic development. *Journal of World Business*, 44(2): 144-157.

Yeaple, S. (2009). Firm Heterogeneity and the Structure of U.S. Multinational Acitivity. *Journal of International Economics*, 78(2): 206-215.

# APPENDIX I: Indicator Summary Statistics

*Table 1. List of Indicators and Summary Statistics*

| Indicator | Description | Source | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|---|
| iso3_j | Host Country | | | | | | |
| iso3_i | Source Country | | | | | | |
| year | Year | | 149711 | 2011.82 | 5.097194 | 2001 | 2018 |
| FDIflow_i_to_j | FDI flows | UNCTAD, IMF | 124218 | 1.24E+09 | 1.84E+10 | -5980000 | 1.38E+12 |
| FDIstock_i_to_j | FDI stocks | UNCTAD, IMF | 47987 | 2520.043 | 15970.55 | -12851 | 592273 |
| contig | Contiguous border | CEPII | 149711 | 0.03478 | 0.183224 | 0 | 1 |
| comlang_jff | Same official language | CEPII | 149711 | 0.13655 | 0.343373 | 0 | 1 |
| comcol | Common colony | CEPII | 149711 | 0.054118 | 0.22625 | 0 | 1 |
| distw | Capital distance | CEPII | 149711 | 6897.711 | 4450.62 | 114.6373 | 19781.39 |
| pop_j | Population | World Bank WDI | 149702 | 66.47698 | 199.2668 | 0.009471 | 1392.73 |
| pop_i | Population | World Bank WDI | 143597 | 65.93833 | 207.2777 | 0.009788 | 1392.73 |
| gdp_j | Total GDP | World Bank WDI | 148799 | 8.34E+11 | 2.40E+12 | 1.32E+07 | 2.05E+13 |
| gdp_i | Total GDP | World Bank WDI | 139576 | 7.80E+11 | 2.20E+12 | 2.71E+07 | 2.05E+13 |
| gdpcap_j | GDP per capita | World Bank WDI | 148799 | 19452.4 | 22557.27 | 108.0145 | 116654.3 |
| gdpcap_i | GDP per capita | World Bank WDI | 139576 | 19467.9 | 21853.94 | 112.237 | 116654.3 |
| area_j | Land area | World Bank WDI | 149711 | 1129524 | 2726544 | 21 | 1.71E+07 |
| area_i | Land area | World Bank WDI | 149711 | 1053729 | 2602541 | 10 | 1.71E+07 |
| tdiff | Time zone difference | CEPII | 149711 | 4.070489 | 3.365214 | 0 | 12 |
| col_to | Colony to | CEPII | 149711 | 0.014942 | 0.121322 | 0 | 1 |
| col_fr | Colony from | CEPII | 149711 | 0.014234 | 0.118455 | 0 | 1 |
| colony | Colony relationship | CEPII | 149711 | 0.029176 | 0.168301 | 0 | 1 |
| sib_conflict | Conflict between | CEPII | 96824 | 0.07556 | 0.264294 | 0 | 1 |
| comcur | Common currency | CEPII | 149711 | 0.029296 | 0.168637 | 0 | 1 |
| fta_ij | FTA | CEPII | 149711 | 0.24212 | 0.428368 | 0 | 1 |
| eu_j | EU Member | CEPII | 149711 | 0.308013 | 0.461674 | 0 | 1 |
| eu_i | EU Member | CEPII | 149711 | 0.228634 | 0.419954 | 0 | 1 |
| lincome_j | Low income | World Bank | 149711 | 0.068532 | 0.252658 | 0 | 1 |

| *Indicator* | *Description* | *Source* | *Obs* | *Mean* | *Std. Dev.* | *Min* | *Max* |
|---|---|---|---|---|---|---|---|
| lmincome_j | High Income | World Bank | 149711 | 0.195437 | 0.396538 | 0 | 1 |
| umincome_j | Lower Middle Income | World Bank | 149711 | 0.26117 | 0.439274 | 0 | 1 |
| hincome_j | Upper Middle Income | World Bank | 149711 | 0.474862 | 0.499369 | 0 | 1 |
| taxhaven_j | Tax Haven | IMF | 149711 | 0 | 0 | 0 | 0 |
| taxhaven_i | Tax Haven | IMF | 149711 | 0 | 0 | 0 | 0 |
| openness_j | Trade/GDP | World Bank WDI | 147714 | 93.41139 | 65.26189 | 0.167418 | 442.62 |
| humancapital_j | Yrs. of Educ.+Return | PWT 9.1 | 124166 | 2.808984 | 0.654552 | 1.078746 | 3.974208 |
| education_j | Years of Education | World Bank WDI | 65751 | 59.87283 | 23.26052 | 0.4951 | 97.39979 |
| fxrate_j | FX Rate, LCU to USD | World Bank WDI | 133336 | 410.5741 | 1630.863 | 0.139 | 20828 |
| rgdp_j | Real GDP | PWT 9.1 | 133336 | 1103776 | 2742056 | 363.6839 | 1.90E+07 |
| lowskill_j | Employment in Agric. | World Bank WDI | 148968 | 19.26204 | 19.96877 | 0.059 | 92.303 |
| saifi | SAIFI | World Bank WDI | 62339 | 5.789335 | 17.87644 | 0 | 243.33 |
| saidi | SAIDI | World Bank WDI | 62537 | 10.01311 | 30.04984 | 0 | 365 |
| access | Access (% of pop.) | World Bank WDI | 132534 | 89.15958 | 22.70284 | 1.834531 | 100 |
| outages_monthly | # of Outages | World Bank ES | 11911 | 5.40568 | 13.28869 | 0.012328 | 100.711 |
| outages_duration | Duration of Outages | World Bank ES | 11911 | 3.776853 | 3.134211 | 1 | 57.0369 |
| avg_outagehours | # * duration outages | World Bank ES | 11911 | 31.42987 | 132.6897 | 0.012328 | 2335.46 |
| generation_carbonintensity | Carbon Intensity Gen. | World Bank WDI | 118600 | 55.99078 | 25.85152 | 0.040846 | 100 |
| distribution_losses | Distrib.+Transm. Loss | World Bank WDI | 127417 | 12.18869 | 11.15718 | 1.22449 | 200 |
| firmswithgenerators | Firms with Generators | World Bank ES | 11673 | 25.10021 | 21.89146 | 1.083693 | 94.67879 |
| generation_capacity | Per Capita Generation | World Bank WDI | 137133 | 1291.596 | 1236.044 | 0 | 8540.171 |
| elec_price | Price of Electricity | World Bank WDI | 59251 | 22.23877 | 76.59546 | 0.7 | 1038 |
| generation_coal | Gen. Share - Coal | World Bank WDI | 133883 | 22.82503 | 26.38159 | 0 | 100 |
| generation_totalemissions | Total Emissions, Gen. | World Bank WDI | 125867 | 35.05836 | 17.70217 | 0 | 80.12458 |
| generation_naturalgas | Gen. Share - Nat. Gas | World Bank WDI | 133883 | 24.29923 | 26.78264 | 0 | 100 |
| generation_nuclear | Gen. Share - Nuclear | World Bank WDI | 133883 | 9.748064 | 17.97996 | 0 | 86.01279 |
| generation_oil | Gen. Share - Oil | World Bank WDI | 133883 | 9.914938 | 20.58199 | 0 | 100 |
| generation_renewables | Gen. Share - Renew. | World Bank WDI | 133883 | 30.22503 | 29.44138 | 0 | 100 |
| timetoconnect | Time to connect to grid | World Bank ES | 11871 | 42.90478 | 44.0297 | 1 | 285.1861 |
| as_energy_gdp | Energy Budget, GDP | World Bank GHOST | 28513 | 0.611854 | 0.923846 | 0 | 5.847385 |

| *Indicator* | *Description* | *Source* | *Obs* | *Mean* | *Std. Dev.* | *Min* | *Max* |
|---|---|---|---|---|---|---|---|
| as_energy_totsp | Energy Budget, Tot. | World Bank GHOST | 30708 | 2.096558 | 3.144923 | 0 | 18.84257 |
| capex_energy_gdp | CAPEX Energy, GDP | World Bank GHOST | 28240 | 0.265164 | 0.538027 | 0 | 5.526594 |
| capex_energy_tot | CAPEX Energy, Tot. | World Bank GHOST | 29012 | 41.86309 | 34.81343 | 0 | 100 |
| ppp_commercialdebt | PPP Commercial Debt | World Bank GHOST | 14092 | 58.86408 | 29.34652 | 1.133009 | 100 |
| counterparty_risk | SOE Risk | World Bank GHOST | 74132 | 50.14783 | 24.37599 | 0 | 100 |
| ppp_domesticfinancing | PPP Domestic Finance | World Bank GHOST | 11631 | 60.30753 | 32.87564 | 0.299397 | 100 |
| enterprisespending_elec | Firm Spending, Energy | World Bank GHOST | 11911 | 10.97574 | 9.20345 | 0 | 63.97923 |
| exec_appr_ratio_energycapex | Executed/Approved Sp. | World Bank GHOST | 27503 | 0.988711 | 2.09731 | 0 | 21.46525 |
| exec_appr_energytot | Executed/Approved Sp. | World Bank GHOST | 29012 | 0.944403 | 1.209881 | 0 | 14.74914 |
| ppp_foreignfinancing | PPP Foreign Financing | World Bank GHOST | 18870 | 71.46598 | 35.07066 | 0.246414 | 100 |
| opex_energy_gdp | OPEX Energy, GDP | World Bank GHOST | 25617 | 0.004726 | 0.013927 | 0 | 0.251692 |
| opex_energy_tot | OPEX Energy, Tot. | World Bank GHOST | 28984 | 1.035213 | 4.650226 | 0 | 100 |
| ppi_invest_gdp | PPI, GDP | World Bank GHOST | 27126 | 0.727066 | 2.303479 | 0.001841 | 63.19228 |
| subsidies_energy_gdp | Subsidies, Energy, GDP | World Bank GHOST | 27937 | 0.101719 | 0.32781 | 0 | 4.090295 |
| subsidies_energy_tot | Subsidies, Energy, Tot. | World Bank GHOST | 29042 | 14.0628 | 27.93087 | 0 | 404.3127 |
| soe_transfers_energytot | SOE Transfr., Energy | World Bank GHOST | 27806 | 11.32052 | 24.60792 | 0 | 100 |
| elec_affordability | Electricity Affordable | World Bank GHOST | 12639 | 14.22967 | 103.1692 | 0.033201 | 1452.592 |
| elec_residentialtariffs | Residential Elec. Price | World Bank GHOST | 12695 | 0.297256 | 2.302529 | 0.000813 | 32.5868 |
| energy_intensity_economy | Energy Intensity | World Bank WDI | 126456 | 0.208395 | 0.176894 | 0 | 1.937 |
| generation_thermalefficiency | Thermal Efficiency | World Bank WDI | 109088 | 35.23251 | 8.398479 | 1.8 | 119.9226 |