Master Thesis

Where do FiTs fit in?

Determining Factors of Exports in Products Used for Renewable Energy Generation

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A Panel Data Analysis

MSc Spatial, Transport and Environmental Economics

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Statement of Originality

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Abstract

This research has aimed to determine driving forces behind international trade in components needed for renewable energy generation in three specific technologies: small hydro power, solar PV power and wind power. By means of an adapted gravity model, commonly used in the international trade literature, a balanced panel data analysis has been conducted on a sample of 49 countries for the period 2000-2017 to discuss the effects of specific variables on bilateral trade, with a specific interest in policy and policy design, with a sole focus on Feed-in Tariffs (FiTs). The results indicate that the policy instrument presence or design are not driving forces promoting exports, with an initial significant negative effect of instrument presence that reduces over time. Contrary, importing country FiT presence is considered a driving force of imports of solar PV products, with tariff levels playing a significant role in this, whereas tariff length decreases imports significantly. The trade results indicate that FiTs might work particularly well in generating domestic demand, but that this does not reflect improved exports. The gravity variables have the expected signs in most estimations, but size and significance differences indicate the need for separate technology estimations. Furthermore, market size is found to be a driving force of exports of small hydro and wind power components, but the effect diminishes over time. Technology specific knowledge stock significantly deters imports of small hydro and wind power components, however, does not drive exports of these components. Finally, import tariffs remain a barrier to trade in solar PV and wind power components. In general, no significant evidence in favour of a narrow Porter hypothesis nor lead market hypothesis is found. Two additional estimations show: the negative effects of active fossil fuel support on renewable energy technologies, as well as difference in effects between develop and developing countries.

Keywords: Renewable Energy Technologies, Feed-in Tariffs, Gravity Model, International Trade, Panel Data Analysis

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Acronyms

BRICS	:	Acronym of *Brazil, Russia, India, China* and *South Africa*
CEPII	:	Centre d'Études Prospectives et d'Informations Internationales
FiT	:	Feed-in Tariff
G20	:	Group of 20
HSS	:	Heckman Sample Selection
IEA	:	International Energy Agency
IRENA	:	International Renewable Energy Agency
IPCC	:	Intergovernmental Panel on Climate Change
OECD	:	Organisation for Economic Co-operation and Development
OLS	:	Ordinary Least Squares
PPML	:	Poisson Pseudo Maximum Likelihood
PV	:	Photovoltaic
RES-E	:	Renewable Energy Sources of Electricity
RET	:	Renewable Energy Technologies
Solar PV	:	Solar Photovoltaic
UN	:	United Nations
WITS	:	World Integrated Trade Solutions
ZIP	:	Zero Inflated Poisson

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Introduction

The recently published sixth assessment report by the UN's Intergovernmental Panel on Climate Change (IPCC) report has not put it mildly: human influence has warmed our globe (IPCC, 2021). This might not sound as news to some. However, where this report differs from the preceding reports, is that it is not stating that this will have enormous consequences, but the consequences have become reality. In other words, climate change is not happing, but it has already happened. We are experiencing the consequences of this at present, with extreme weather being more regularly reported on the news, often with deadly consequences.

In their report, the new estimates show that the previously stated maximum increase in global warming of 2 degrees Celsius is now the new minimum estimate, with a mean expected increase of 3 degrees and a maximum of 5 degrees. These new estimates should not come as a surprise. In 2019, the Inger Anderson, the program director of the UN's environmental program, mentioned in an interview that the goals set in the 2015 Paris agreement will lead to an increase in global warming of more than 3 degrees (UN, 2019). The director stated that the only way to achieve the previously set maximum of 2 degrees would be if emission levels decreased with 7% annually until 2030. In line with the words of Ms. Andersen, the Dutch Environmental Assessment Agency has stated that to achieve the goals set for 2030, the Netherlands would have to double its efforts to reduce emissions until 2030, compared to what has been achieved in the period 2010-2019 (PBL, 2020). Even though the Paris agreement and its predecessor the Kyoto protocol showed (increased) global willingness to combat climate change, the lack of enforcement has led to not achieving the agreed upon targets.

The current COVID pandemic proves to be an opportunity to break with the old, as increased sounds for a green and sustainable post-pandemic economy are heard and as renewables thrived in some countries during the pandemic. At the same time, new investments in fossil fuel electricity generation are still made, and COVID relief stimulus packages in the energy production/consumption being vast, with airlines receiving a substantial part (IEA, 2020b). In addition, the IEA has stated that the COVID recovery has led to an increase in electricity demand, to an extent that outpaces growth in renewable energy capacity, with demand fulfilled through increased fossil fuel usage (IEA, 2021a).

The IPCC report states until 2050, global warming will continue, unless we find a way to rapidly decrease emission levels and stating that the only way to limit future climate change is to reduce emissions of greenhouse gasses to zero. This shows the that fast and global utilization of renewable energy is the sole way out of the current situation and prevention of the devastating future scenarios described in the report. To achieve this, governments should take responsibility and undertake swift action. According to the International Energy Agency (IEA), faster innovation is needed to get to net zero emissions by 2050 (IEA, 2020a). Even though this is a part of the solution, the uptake of renewable energy technologies (RETs) is equally important. Ever since the ratification of the Kyoto protocol, the level of innovation in less mature technologies has been impressive, nonetheless, the actual switch to utilizing these technologies at a large scale has not been sufficient. This shows that in addition to efforts aimed at improving the existing technologies, policymakers should target increasing the installed capacity of renewable energy technologies.

One possible way in which this increase can be affected is trough trade, which is often viewed as one of the channels of international diffusion. This is where this research comes in, discussing which factors influence trade in RETs and especially what role environmental policies play in this, and adding to the existing and growing literature on the dynamics of trade in RETs. With numerous policy instruments being implemented by policymakers and studied in the literature on this subject, this research will focus on Feed-in tariffs and their effects on the export of RETs to see if the certain conclusions in terms of effectiveness can be drawn. In the literature discussion, additional policy instruments and their findings will also be discussed.

The remainder of this study looks as follows. In the upcoming chapter an overview of literature on and related to the subject will be discussed and a summary of what is studied in this research will be given at the end, indicating how it contributes to the existing literature. This is followed by a chapter discussing the estimation method and model tested as well as the data used in this research. Subsequently, the results will be displayed, discussed, explained as best as possible and put into context of findings of previous research. To conclude, the last chapter will give an overview of what has been conducted, followed by a summary of the findings and its implications and finally discussing limitations of the research and recommendations for future research. Note that as the author is colour-blind, all the figures throughout the research will be displayed in black and white, and are made by the author using the data gathered from the source mentioned in table A3.3.

Literature Review

This chapter will be devoted to an overview of existing literature on trade in RETs, as it will discuss what has been studied in terms of technologies, what has been studied in terms of policies and what the authors have concluded. The chapter will close with a summary, indicating what has not been discussed in the literature and what this research aims to study.

Previous Research

In terms of what has been studied, there has not been one definitive direction or research aim when it comes to renewable energy technologies, as there have been studies that have focused on innovation, investments, and trade in RETs. As this research focusses on trade in components needed for renewable energy generation, past literature on this specific subject will be the focus, but there are some aspects of the other two subjects that will be discussed first.

In general, it is believed that the large uptake of renewable energy is due to the positive effects of policies that promote either the use of renewable energy or that disincentives the use of fossil fuels. In broad terms, two different policy types can be found, and this research will follow the definitions discussed in Bahar, Egeland and Steenblik (2013), with both policy types aimed at generating more renewable energy, but via different paths. The first policy type is defined as *Technology Push* policies, which entail that the policy measure used are aimed at the invention and innovation stage of a product. Policies that fall within this group are government support for research and development (R&D) which could be given in the form of grants or subsidies, or tax incentives. The second policy type is defined as *Market Pull* policies, which are aimed at increase demand or the uptake of the product that is being promoted. Policies that fall within this group are Feed-in Tariffs (FiTs) or premiums, quotas (often referred to as Renewable Portfolio Standards), tradable energy certificates/permits, and taxes used to disincentives the use of fossil fuels such as a carbon emissions tax.

Most commonly, FiTs have been mentioned as the most implemented policy type, and policy instrument included in this research, for which arguments will be given. For this reason, a definition is in place to make the upcoming parts and chapters understandable. According to Bahar et al. (2013) FiTs can be defined as a technology specific tariff, which acts as a guaranteed price or premium over the electricity price that is paid for a pre-determined fixed period for each unit (often kWh) of renewable energy generated. The aim of this instrument is to reduce the risks associated with investments in renewable energy technologies and bridge the gap between the, often low, electricity price and higher costs of generation of renewable energy sources. This cost of generation is technology specific, with decreases over time being observed for most technologies, making some RETs' generation costs comparable to those of fossil fuels, with credit to this process often being given to the policies promoting renewable energy usage and technology maturity. FiTs can affect trade, as the policy is aimed at increasing a home market, which drives down domestic prices and allows firms to enter foreign markets due to cost advantages.

Jenner, Groba and Indvik (2013) who studied how FiTs have influenced capacity growth of wind power and solar PV development in Europe. The authors show that in the period studied, the development of these technologies was significantly positively influenced by FITs. The authors provided evidence that the policy has been functional for solar PV development as the return on investment of solar PV development significantly increased due to the FiT in place. For the growth of the wind sector, FiTs have found to not have significantly improved the profitability of investments. The authors measured both return on investment of the policy, including design aspects, as well as simple policy presence and found that the design aspects play a significant role, as the outcomes differed substantially from estimations that used only policy presence. The authors claim that the difference in technology maturity were the reason for the different outcomes, with solar being an immature and therefore relatively expensive renewable energy source in terms of generation cost. Wind power on the other hand is a technology that according to the authors can already compete with fossil fuel sources. An additional explanation is given that FiTs work better for RETs that do not require high upfront investment costs.

Dijkgraaf, van Dorp and Maasland (2018) add to the research of Jenner et al. by discussing the effects of FiTs on the yearly added solar PV capacity in 30 OECD countries, with a focus on FiT design. The authors show that well designed FiTs can be much more effective than previously found results show, up to a factor 7. By using panel data spanning a twenty-year period, the authors show that when controlling for certain factors such as electricity price and generation costs, both fit presence as well as tariff levels and duration play an important role, with the consistency of the FiT also showing significant influence on effectiveness. In line with Jenner et al., the authors show that the effects of FiT design features are larger and more important than simple policy presence, and that for the solar PV development, FiTs have played a substantial role.

In addition to Jenner et al. and Dijkgraaf et al., Popp, Hascic and Medhi (2011) study the same subject for 26 OECD countries, and add that in addition to policies, knowledge stock as measured by cumulative patent count, increased added capacity significantly, when the technologies studied are pooled, and when individually discussed they find evidence for wind and biomass technologies. The authors argue that when countries need to lower carbon emissions, these technologies are chosen to be implemented first, primarily due to lower costs of generation, with FiTs being an insignificant driver of the uptake in these technologies specifically.

Johnstone, Hascic and Popp (2010) also discuss the influence of policies, however in contrast to the previously discussed studies, the authors discuss the effects of policies on innovation of RETs. In line with Jenner et al. (2013) and Popp et al. (2011) the authors find that more mature technologies are a more competitive alternative to conventional fossil fuel sources of energy due similar generation costs. For this reason, Johnstone et al. state that broad-based policies such as quotas are better suited to induce innovation in more mature technologies, as broader policies allow for the option to choose which technology to use to abide to the quota, which are often the most cost competitive ones. Innovation in less cost competitive RETs on the other hand, is found to be more driven by targeted policies such as FiTs, for the previously mentioned reason of decreasing investment risk through establishing a more even market for the higher-cost technologies.

The above-mentioned studies are just a few that find the mentioned outcomes in the spectrum of papers on non-trade related effects of policies and innovation of RETs. As the focus of this research is to determine factors affecting trade in renewable energy, to see if and how trade can increase general uptake of RETs, literature on this specific subject will be discussed next. The field of literature on trade in renewable energy technologies, and especially the effect of policies is not vast, with most papers having similar aims but using different methodologies and data (Sung & Song, 2014). In general, a broad number of different RETs have been studied, with solar PV and wind power being the most prevalent, and a geographical focus on OECD or EU countries studied from a mostly exporting country perspective, with only a select number of studies deviating from this. Where the studies differ is in terms of methods and variables included, which makes drawing a general conclusion a difficult task

One of the most widely researched topics has been the effect of policy measures on trade in terms of competitiveness and comparative advantage in terms of total export, as this is related to two different views on how environmental policies can affect trade, the Porter hypothesis, and the Pollution Haven Hypothesis. The Porter hypothesis in its general form states that ''well designed environmental regulation can lead to improved competitiveness'' (Porter & van der Linde, 1995), as this could push firms to innovate which could lead to an improved economy, and in turn increase competitiveness (Constanini and Crespi, 2013). This view was revolutionary as it was previously believed that the costs needed to abide to the new regulation were generally higher than the improved financial performance, which is in line with the Pollution Haven Hypothesis. This hypothesis stated that it was harmful for a country's competitiveness as production costs increased due to abiding to the country's stricter environmental policies, whereas production costs in countries without or with more lenient environmental regulation would be lower. This could lead to a relocation of polluting industries to countries with more lenient environmental policy to avoid incurring the costs of complying with the regulation. With findings generally not supporting evidence for the existence of a pollution haven effect, findings supporting the existence of a porter hypothesis are more common, however the studies finding these results mostly focus on specific industries (Constantini and Crespi, 2008). As this research does not study the effects of environmental regulation or policies on the economy as a whole but on the ''green side of the economy'', this study uses a on sub definition from Jaffe and Palmer (1997) who took the idea of Porter and divided the hypothesis into three different versions, with especially the narrow (both called strong and weak) version being of interest. This form states stringent environmental regulation might only positively affect the "green side" of the economy, as stricter regulation could result in the increased innovation of a newly developed environmental technology and allow this country to become a net exporter (Constanini and Crespi, 2013), indicating the creation of a strong domestic market through early adoption (Groba, 2014) which effectively means the existence of a lead-market hypothesis in the environmental sector.

It must be mentioned that even though countries can realise an export advantage in a certain technology, this does not necessarily mean that these countries don't also import products related to this technology, or that this export advantage implies a large home market. Algieri, Antonio and Succurro (2011) discuss how trade dynamics could help to diffuse cleaner technologies and find that several countries enjoy large scale comparative advantages when it comes to exports in solar PV components. For this specific technology they find that countries that had early established production bases, such as some European countries and Japan, do have an advantage, but that in general these countries have been overtaken by China. However, in contrast, China does not enjoy a large home market as the country only has limited installed capacity of the technology, with most installed capacity being found in Europe. This indicates two findings, this export advantage is not built through a large home market advantage, and countries can be simultaneously importers and exporters, because in contrast to China's net export position, some European countries are net importers even though they simultaneously enjoy a comparative export advantage. The authors also find that foreign income is the main driver of exports, using data from the US, indicating that solar PV components, and potentially RET components in general, can be regarded as a "superior" good, as an increase in income leads to an increase in demand, supporting the environmental Kuznets curve theorem. This could be explained by the notion that when income rises, people are able to be more concerned about the negative effects of energy production.

The research by Kuik, Quirion and Branger (2019), is focussed on the effect of domestic RE support policies on the comparative advantage of domestic firms in the wind and solar PV sector and argue that evidence for a lead market hypothesis is unclear due to many studies finding contrasting effects in terms of the benefits associated by first movers. Instead of including specific policies in their research, the authors use the proportion in installed capacity of the RET to total installed capacity as the proxy for policy effectiveness, as they argue that individual policies are hardly comparable across countries. Their expectations and findings are in line, as they predict that policy success can lead to a larger home market in terms of more installed capacity, which can in turn lead to larger scale advantages and lead to an export advantage as a result, which is also found for both technologies. Their results, however, also indicate that there is no evidence for a lead market hypothesis, with a truly globalized market in which both developed and developing countries are active. Their results show that the comparative advantage found is of dynamic nature, as it changes over time, with the wind power industry enjoying a longer comparative advantage than the solar PV industry. The policies supporting the home market, as argued by the authors, have led to the establishment in the wind power industry, that is competitive at an international level. The dynamic difference found is credited to the "catching-up dynamics" of latecomers, which due to the difference in technologies is easier done in the solar PV than wind power industry. This comes from the technological complexity of wind turbines, which remain design intensive, whereas solar PV modules are much more standardized goods.

The study by Kuik et al. (2019) has been preceded by a study of Groba (2014) who was out to discuss a similar subject, as the research focused on finding evidence for a narrow porter and lead market hypothesis in the solar PV industry, using specific market pull policies to see how these affected exports in the products being traded. The author claims that the market is dominated by OECD countries, and focusses on these countries, as most trade is inter-OECD, and therefore excludes China from its country sample. Groba does mention that there's a decline in OECD export dominance and accredits this to the rise in influence of developing countries, corroborating the claim of Kuik et al. (2019) that we can speak of a global industry, and stating the importance of China in this. The authors main goal is identifying instruments promoting trade in RETs which could aid growth of renewables, and in addition identify trade barriers. The author controls for both input and output-oriented measures of environmental stringency, and in line with Kuik et al. (2019) uses the share of solar electricity as a percentage of total electricity as proxy for environmental policy strictness, while simultaneously controlling for FITs, quotas, and tax measures as the input measures of environmental stringency. Importing country factors such as regulatory frameworks and trade barriers are included to see how these affect exports of solar PV, as the role of regulation in importing countries is ambiguous, as it could increase demand, which could increase their imports from foreign countries, or it could decrease their imports as this demand is supplied by the national industry. The author finds some evidence for weak porter hypothesis as countries with a high share of solar electricity generation (indicating a strong regulatory system by proxy) see higher exports as a result, in line with Kuik et al.(2019). When importing country regulation efforts are considered, FiT existence in the exporting country is weakly significant in explaining export, but the effects of the remaining policies are not significant. Regarding the lead market hypothesis, the results on policy duration do show evidence, as countries that implemented FiTs and tax measures early see higher levels of export. The importing country policy proxy used indicates opposing results, as higher solar PV generation is associated with higher imports, whereas another measure of strictness indicates that stricter importing countries import less. Finally, the author indicates that trade barriers, especially import tariffs, significantly reduce imports in non-OECD countries, whereas amongst OECD members the import tariff is no significant barrier to trade. This indicates the need to overcome trade barriers to stimulate global usage of renewable energy.

Whereas the research by Groba (2014) has omitted China from the country sample, the study by Groba and Cao (2015) has completely focused on Chinese exports of products used for solar PV and wind power generation, while controlling for Chinese and importing country policies promoting renewable energy usage. China has been focused on due to its strong growth as an exporter in both solar PV and wind power components, and the authors take the role of technology innovation into account. This is done since China, contrary to most European countries, have focused on technology push policies, and only more recently initiated market pull policies, with evidence showing that the technology push policies have been much more successful and has increased the knowledge base within the country. In addition to using R&D expenditure as input measure of innovation, the authors use patents as an output measure of innovation. The knowledge stock variable that is calculated using the patent data is used to account for existing knowledge in innovation of both technologies, in order control for the lengthy process of innovation to market, which is expected to increase exports. The results found show that for solar PV exports, foreign market size and import tariff are in line with expectations as they show expected signs of positive and negative impact on Chinese exports, but the results are opposite for wind power exports regarding these two variables. The surprising results for the wind power exports are likely to be due to the small market size of wind power exports, leading to deal with many zero-trade flows, with more exports going to developing markets with higher import tariffs, whereas countries with larger domestic markets for wind energy are supplying their market with domestic products, which leads to lower imports of Chinese products. The results of the change in domestic market electricity production using solar PV show no significant effect, whereas for the wind power electricity production, the variable shows that the increasing domestic market demand reduces the exports of wind power components. The effect of market-pull policies shows that FiT enactment in the importing country leads to significantly higher imports of solar PV products from China whereas, the variable is only weakly significant for the import of wind power components. The remaining importing country policies are insignificant in explaining Chinese exports of wind power components, but it is found that quotas lead to significantly lower imports of Chinese solar PV components. The Chinese knowledge stock seems to be an insignificant factor affected exports.

In line with Groba and Cao, Kim and Kim (2015) also discuss the effects of specific renewable energy policies on trade in solar PV and wind power components as well as the effects of innovation and on innovation, indicating there are both static and dynamic effects taking place. Firstly, the authors show that innovation in solar PV is not driven by exports, whereas innovation in wind power components is significantly driven by exports, and that domestic innovation is also driven significantly by foreign knowledge, indicating that imitation and absorption of non-domestic knowledge accelerates domestic innovation. In addition, evidence is found that FiTs lead to more innovation in both technologies, indicating stable market conditions can accelerated innovations. The results found for trade flows shows that the higher the domestic technology specific knowledge, the more a country imports, which could be due to increased imports of cheaper products, as well as exports, with stronger evidence found for the trade in wind power components and indicate the role of innovation in diffusion of clean technologies. The policy specific variables indicate some interesting findings and differences between the technologies. FiTs remain a policy that promotes exports in solar PV components, in line with Groba (2014) but to a lesser extent than taxes and quotas and are also a driver of export in wind power components, which has not been found by previously discussed literature. In addition, the effects of quotas lead to lower exports of wind power components, which is explained by an increase in the domestic demand for the most mature, thus price competitive, technology as a certain fixed demand is too be expected. This leads the domestic firms to serve their home market rather than foreign markets, in line with the Popp et al. (2011). The results also show that FiTs lead to higher imports of both products, partially in line with what has been found by Groba and Cao (2015), indicating the need to control for both importing and exporting country policy presence. The dynamic effect of policies, which will not be discussed in this research do indicate some interesting interactions between policies, innovation and trade, with the authors providing evidence for a virtuous cycle in wind power industry as there is interaction between innovation and exports of these components. This in turn amplifies the policy effectiveness as they impact both trade and innovation separately, which turn out to amplify one another as well. Sung and Song (2014) also discuss dynamic effects, with two interesting findings. First, the authors find evidence for a positive feedback mechanism in the long run between the technology push policy and export, and a negative mechanism between the market pull policy proxy and exports for wind power technologies, with market pull policies potentially leading to more imports of the wind power products. Second, in the short-run a positive relationship is found for the market pull policy proxy and exports for both wind and solar energy technologies, whereas a negative relation is found between technology-push policy and exports of solar energy technologies. This shows that demand-pull policies can help to quickly expand a domestic market, which in turn can lead to higher exports due to specialization, as an increase in the renewable energy share in a short time with low costs can be affected by such a policy.

The author Constantini has contributed to three papers on the subject as well, with as commonality that the author doesn't disaggregate between the different RETs. In his 2008 paper with Crespi, the authors aim at finding out if more stringent environmental regulation, aids in increasing a country's exporting performance of ''environmentally-friendly'' technologies, which both include renewable energies and energy savings technology. By using multiple proxies for environmental regulation, the authors find that countries implementing more stringent policies lead to higher exports, and in addition show the importance of a countries innovative capabilities, as they play a significant role in terms of total and technology specific knowledge. Overall, the results indicate that environmental regulation could indicate a comparative advantage, depending on how technological advanced the country is, showing some evidence for the narrow porter hypothesis. The authors revisit the subject in 2013 and discuss the differences in terms of renewable energy and energy efficient technologies and how policies affect these. The authors show the necessity of a clear and balanced energy strategy, as a strategy focused on energy savings technologies could lead to an excessive input of scarce resources that could have otherwise been used to be invested in the development of renewable energy technologies or the other way around. This especially harms the development of renewable energy technologies, as these often need policies to change efforts from being put to incremental changes in existing technologies and switch towards development and/or uptake of RETs, which than leads them to become a competitive technology. The results indicate that there is evidence for a narrow porter hypothesis, as exports of both renewable and energy savings technologies are higher in countries with better environmental regulation. Constanini and Mazzanti (2012) stress that in terms of a narrow porter hypothesis, as suggested by Constanini and Crespi (2008), the role of both policies and the innovation systems play a key role in explaining export advantages. This shows that the more these regulatory and innovative efforts complement each other, the more likely it is that virtuous dynamic effects exist between the efforts, which lead to improved competitive advantage in the ‘’ green side’’ of the economy.

Summary and Research Aim

As can be seen from the above discussed studies, the results found are somewhat similar however, also indicate some different outcomes. In terms of which countries, time periods and variables have been used, the studies have deployed different set-ups making comparisons difficult in general. However, what has become clear from the literature is that differences in the outcomes generally depend on the underlying technology studied, due to the difference in technology maturity. Most papers have indicated that economic and market size are positive factors influencing trade, with some papers showing that the level of technological advancements is an important factor and others finding no significant importance. In terms of the effects of policies, varying outcomes have been found. In general, the domestic broad-based policies seemed to have favoured the more mature technologies such as wind power, whereas the more targeted policies seemed to have favoured less mature technologies, such as solar PV. However, it has also been found that foreign policies seemed to have had an influence, however the outcomes vary across the papers. In terms of what has not been discussed, three aspects come to mind. First, policy design, with most studies controlling for policy enactment, using dummy variables, or using proxies or outcome-based measures, such as pollution levels or renewable energy installed capacity (which has also been used as variable to capture market size and demand). As the subject is discussed in the non-trade related literature, and with specific interest in policy effectiveness, it is interesting to see if differences in policy design matter as Groba and Indvik (2013) discussed. Second, controlling for importing country variables, including policies, seems an important addition in the papers controlling for them. Most studies include importing country income, but don’t include many other factors, even though some include knowledge stock, or broad policy stringency proxies. As mentioned, these factors do seem to play an important role, as both Groba (2014) and Kim and Kim (2015) indicate. Third, an interesting addition could be to discuss how do fossil fuels affect trade in RETs. As Popp et al (2011) discuss, domestic levels fossil fuel resource availability determines the costs of electricity for electricity sources that compete with renewable energy. In addition, Kuik et al. (2019) mention that renewable energy promoting subsidies are still much smaller than policies promoting fossil fuels, indicating that if these policies hinder RET development, stopping them might be an easy way to increase world-wide renewable energy usage and thus reduce global emissions.

This research therefore aims to answer the general question, which factors influence trade in RETs, with a specific interest in policy and policy design as the latter are not discussed in trade related literature, while controlling for importing country variables, and additionally discussing how fossil fuels affect the trade in these RETs. The research tries to see if there’s evidence for a positive effect of policy instruments in the diffusion of RETs and see if there’s evidence for a narrow porter hypothesis and lead market hypothesis. To do this, this research will focus on trade in products needed for generation of small hydro, solar PV and wind power, which indicate three different levels of technology maturity according to Johnstone et al. (2010), and in addition are fully durable and non-combustible renewable energy technologies. Small hydro power has been included in some studies that pooled the technologies together, but never separately, while it represents by far the largest portion of installed renewable capacity (Johnstone et al., 2010). The policy focused on, as previously discussed will be FiTs, due to both data availability reasons and the fact that policy design aspects are clearly defined, with a focus on FiT tariff level and contract length. To control for the effect of fossil fuels, a separate estimation will be conducted on a sub-sample for which data on fossil fuel support measures were available. By incorporating these aspects, more recent data than most studies and a country sample that goes beyond solely OECD or EU countries, this research tries to add to the existing literature. The next chapter will discuss the methodology and research setup that will be used in this research, as well as discuss the data sources and some descriptive aspects of certain variables.

Methodology and Data

In this chapter the research setup and data used is discussed. First, the estimation technique used will be discussed followed by a description of the estimated model, the variables included in the model and the expected findings. Subsequently, a description of the data used, and data sources will be given followed by an overview of selected descriptive statistics.

Estimation Method

The previous chapter on the existing literature in the field of trade and environment that has been discussed indicated that the studies have not always been in line with each other in terms of research set-up. However, most studies share the use of a basic model, first introduced by Tinbergen in 1962, the gravity model, as displayed in equation 1. As mentioned by Kuik et al. (2019), this "workhorse" model of international trade has been used in numerous studies on the impact of policies. Similar to Newtons law of gravitational force, the model studies trade flows between two countries, linked to a countries' economic size which is usually measured by gross domestic product, and the geographic distance between the countries, referring to the attracting and separating forces at hand as mentioned by the authors. The economic size of countries attracts trade between the countries, as it can be thought of a domestic supply and foreign demand equation, where an increase in one of them or both would be thought to attract more trade (Constantini and Crespi ,2008). Distance acts as a force in the opposite direction that would decrease trade when the distance increases, as this usually goes hand in hand with increased costs, and it could be thought of as countries which are closer to one another in terms of distance, would engage in more trade than similar sized countries that are more geographically apart due to increased costs of transport.

$$X_{ijt} = \beta_0 \left(\frac{Y_{it}^{\beta_1} \, Y_{jt}^{\beta_2}}{D_{ij}^{\beta_3}} \right) \eta_{ijt} \quad (1)$$

The rise in the uptake of the model came about almost forty years after its introduction, as at first it lacked theoretical background even though it produced reliable findings, after the publication of Anderson and van Wincoop's (2003) paper which introduced multilateral resistance terms to the model. This led to the creation of the ''theoretical'' model, which is shown in its log-linearized form in equation 2 below. The paper added to the original literature and solved issues which couldn't be explained by the original ''intuitive" model, due to its simplicity as it only discussed the size and distance aspects of trade (Shepherd, 2016), by introducing country specific and time fixed effects. Since the publication, the theoretical foundation was acknowledged and due the use of various, more advanced estimation techniques, the model has turned into aforementioned "workhorse" model of international trade literature and thus remains widely used.

$$\ln(X_{ijt}) = \ln\beta_0 + \beta_1 \ln(Y_{it}) + \beta_2 \ln(Y_{jt}) - \beta_3 \ln(D_{ij}) + d_i + d_j + d_t + \ln \eta_{ijt} \quad (2)$$

The inclusion of these multilateral resistance terms by means of fixed effects has divided the studies in terms of how to incorporate them. When analysing bilateral trade flows, as done in this research, one could choose to include either importer and exporter country fixed effects or country pair fixed effects, in addition to deciding whether to control for trends over time separately or linked to the individual countries or the country pair. An influential paper by Baldwin and Taglioni (2006) regarding the multilateral resistance terms has claimed that not including them can be considered a ''gold medal'' mistake and pleads for the use of both exporter and importer time fixed effects in addition to controlling for country pairs. The authors claim that the most effective way to remove any bias coming from not including fixed effects in a panel data setting, research should be conducted using country time-variant and country-pair time-invariant fixed effects, as these remove most biases. However, in this research setting, this would mean that only country specific time invariant variables would be included in the estimation, as all other effects are absorbed through either the country-time or country pair fixed effects, meaning that the variables of interest would be omitted. For this reason, the time invariant country effects will be used, as is done by Groba (2014) and Kuik et al. (2019). Groba (2014), conducted a robustness test including country pair fixed effects and found results indicating no significant difference compared to his exporter, importer, and time fixed effects estimation, which allowed the author to include the gravity variables of interest. It should be noted, that including these fixed effects does not remove all biases, however, it does remove a substantial part compared to omitting them as mentioned by Baldwin and Taglioni (2006).

The gravity model is an adequate model to be used in this study. However, there are still issues that arises from the model in both its intuitive and theoretical form when using simple Ordinary Least Squares (OLS) estimation methods to study bilateral trade flows. As mentioned by Groba (2014) and Burger, van Oort and Linders (2009) two are of importance to this study: the presence of heteroskedasticity when analysing bilateral trade flows, and the problem of extensive zero trade observations, especially occurring when using disaggregated trade data.

As homoscedastic standard errors, indicating that the standard errors are independent of the independent variables is the first assumption of OLS estimation, a violation of this assumption would yield biased results. As pointed out by both Shepherd (2016) and Santos Silva and Tenreyro (2006), this assumption is not realistic in practice, which means heteroscedastic standard errors are prevalent, meaning OLS estimation would be inappropriate. In addition to the violation of this key assumption, OLS in its log-linearized form leads to the exclusion of zero-trade observations, as the log of zero is not defined (Groba and Cao, 2015). As the presence of zero trade flows is quite apparent in the studies of trade in specific sectors or products, this would lead to the exclusion of numerous observations. There are multiple ways to counter this specific problem, that can be encountered in the literature and still use simple OLS estimation, however none of these are adequate. In practice, when using OLS, one could omit the zero trade observations and ignore them, referred to as the truncated method, which is not correct as zero trade flows occur often and don't occur randomly (Groba, 2014). In addition, Constantini and Crespi (2013) applied a method of adding a small number to the trade value, usually one, which leads to the inclusion of the previously zero trade flows when the model is tested in its log-linearized form, whereas the non-zero trade flows are not affected substantially. However, this method remains arbitrary and doesn't account for earlier mentioned heteroscedasticity of the standard errors, and the size of the added value does alter the effects found (Burger et al., 2009). Linders and de Groot (2006) conclude that zero flows can bias the results if not accounted for correctly and state that substituting the zero observations for small values does not suit the gravity model, as the zero trade values do not display unobserved values but non-existing trade due to economic decisions.

To counter the abovementioned problems, other estimation techniques are necessary, of which there are several to choose from. In his manual on estimating the gravity model, Shepherd (2016) mentions that when OLS estimation is biased two methods have more desirable properties and can be found in the trade related literature: a Poisson Pseudo Maximum Likelihood (PPML) estimator or a Heckman Sample Selection (HSS) estimation. The author states that as the literature isn't set on one or the other estimator, both can and/or should be used to provide robust results, which is only done by Kuik et al. (2019), whereas other studies often don't include different estimation techniques or use other estimation techniques.

The PPML estimator has been popularized by Santos Silva and Tenreyro (2006) who argued that standard OLS estimation is biased due to its log-linear transformation when heteroscedasticity is present. The authors state that under much weaker assumptions than needed for OLS estimation, the PPML estimator provides adequate estimates. As this is a pseudo maximum likelihood estimator, it is not necessary to have Poisson distributed data (Shepherd, 2016). By providing simulation results on several estimation techniques, the authors show that other estimation techniques show biased results whereas the PPML estimator showed robust results. The method can be referred to as an exponential model and uses level rather than the logarithmic value of trade, which yields that it is also a natural way to include zero trade observations (Santos Silva & Tenreyro, 2006). In addition, as mentioned by Shepherd (2016), the method allows for similar interpretation as to OLS and is consistent when including fixed effects in the equation.

The HSS estimator was popularized by Helpman, Melitz and Rubinstein (2008) and focused on the many zero trade observations that the authors encountered in research. The authors argue that log-linearizing the model, dropping the zero trade observations, is a way of sample selection which could lead to biased results, as the estimation is now depended on a positive subsample of all observed trade flows (Shepherd, 2016). This could be viewed as an omitted variable bias, violating the OLS assumption, as being ''selected'' depends on an unobserved variable that is likely to be correlated with other variables in the equation. Shepherd (2016) explains that the estimator works by dividing the data in an outcome and selection equation, where the latter is used to describes the probability of positive trade and the independent regressors, indicating if countries engage in trade, and the former is the standard gravity equation, showing the effect for the observations who had a positive probability in the selection equation. Linders and de Groot (2006) have shown that this estimation method is preferred to standard OLS techniques that don't include zero trade flows as well as to the method that adds small values to observed zero trade observations. It must be noted that both Shepherd (2016), Linders and de Groot (2006) and Martin and Pham (2020) find fairly similar results for OLS and Heckman. Martin and Pham (2020) conclude that for their results they favoured the PPML estimation over other options.

In addition to both above mentioned models, the use of zero inflated models, such as the zero inflated Poisson (ZIP) has become more widely used as an alternative to the standard OLS estimation. Like the HSS reasoning, both standard OLS as well as PPML don't deal with zero trade observations correctly according to Burger et al. (2009), with OLS leaving the observations out, as well as PPML not functioning well if the number of zeros in the observations is exceeded by the number of zero's that is predicted by the model. This could be solved by the implementation of a ZIP estimation method, which like the HSS splits the estimation into two parts. The model estimates a first stage in which the probability of zero trade is estimated for all the observations in the sample. Subsequently, the observations that have a positive probability of non-zero trade from the first stage are then included in the second stage Poisson estimation of the gravity model. The authors claim that in comparison to the HSS model, the ZIP model is less restrictive. The authors show that in line with Shepherd (2016), PPML produces significantly different outcomes compared to OLS, and in addition show that for their sample PPML and ZIP are practically identical, which is also found by Martin and Pham (2020).

In this research, the PPML estimator will be used as the main estimation method, with a robustness analysis implementing standard log-linearized OLS, the HSS model as well as the ZIP model for the full model. In line with Kuik et al. (2019) and Linders and de Groot (2006) the selection equation in the HSS model uses the gravity variables in the selection stage except for GDP, and in line with Shepherd (2016) adds an additional variable to be used as an over-identifying variable in this stage as well. For the ZIP model, the same variables will be used in the first stage, including the overidentifying variable. The reasoning for using the PPML as the main estimator comes from the fact that apart from Kuik et al. (2019) none of the other studies on the topic of RETs uses this estimation procedure. The authors find no significant differences between PPML and HSS, however, both Shepherd (2016) and Martin and Pham (2020) do find differences in the estimators. Similar to reasoning by Martin and Pham (2020) the importance of heteroskedasticity leads to favour the PPML model. Table A4.1 displays standard gravity estimation using different estimation methods and uses a Ramsey Reset test for aggregated RET trade data to determine if the model is correctly specified (Santos Silva & Tenreyro, 2006). The results indicate that the ZIP model is the only one that passes the test, however, the PPML estimation is a second-best estimator, and the expectation that PPML and ZIP should closely related is expected to be found for the full model. Furthermore, the findings of Martin and Pham (2020) and Linders and de Groot (2006) are corroborated as OLS and HSS produce very similar estimates.

Model

This research uses panel data to study bilateral trade of components for three different RETs: small hydro power, solar PV and wind power (both on- and off-shore). Contrary to studies by Constanini and Crespi (2008, 2013) and Constantini and Mazzanti (2012), this study clearly separates between the different technologies (denoted by *r* in equation 3 below), as previously discussed these different technologies react differently to certain policies and instruments, including the FiTs studied. As mentioned, not including multilateral resistance terms could be considered the gold medal mistake, and the inclusion of the fixed effects in the model means that basis of this research is Anderson and van Wincoops ‘’theoretical” model displayed in equation 2 above. The additions to this model are included to test the different hypotheses that this research discuss to determine explanatory variables of international trade in renewable energy components. The model includes the basic socio-economic variables (referred to as gravity variables from this point on) and adds variables reflecting market size, knowledge stock, renewable energy policy instrument and import tariff, for both importing and exporting countries to determine trade between countries per year and technology. The inclusion of importing country variables reflects the pulling power of the country due to the state of the renewable energy market, the technological advancement, and the efforts to promote the renewable energy source. Importing country variables are sparsely included in the discussed studies, however, especially when it comes to policy instruments , Kim and Kim (2015) have shown, by separating exporting and importing models, that the policy instruments studied are significant determinants of both outgoing and incoming trade flows. The model is shown in equation three below, with a description of the various variables summarized in table A3.3.

$$X_{ijrt} = \exp\big[\beta_0 + \beta_1\, ln(GDP_{it}) + \beta_2\, ln(GDP_{it}) + \beta_3 Gravity_{ij(t)} + \beta_4 Market\ Size_{irt} + \beta_5 Market\ Size_{jrt} + \beta_6\, Knowledge\ Stock_{irt} + \beta_7\, Knowledge\ Stock_{jrt} + \beta_8\, Policy_{irt(-1)} + \beta_9\, Policy_{jrt(-1)} + \beta_{10}\, ln\big(Import\ Tariff_{jrt}\big) + \alpha_i + \gamma_j + \delta_t\big] + \varepsilon_{ijt} \quad (3)$$

The model shows the trade flow from country *i*¸ the exporter, to country *j*, the importer at time *t*, for technology *r*. The exports are measured in terms of the sum of the trade value of the different products related to the technologies discussed and are expressed in thousands of US dollars.

In terms of gravity models, most studies have included either GDP per capita of both countries engaging in trade or the combined value of both countries economic size in a so-called mass variable. Since the former allows for an evaluation of the effect of the different countries, this is preferred in this research, and both are considered to be positive factors of trade, with the variable being presented in terms of current US dollar. In addition, variables that could be considered either geographical or social are included and are denoted as Gravity variables in the equation above. These include the log of geographical distance, which should also be considered a trade barrier, and dummy variables for Common language, Shared border, Colonial relationship, Common Currency and Free/Regional Trade agreements. These variables are indicative of relationships between countries that would positively influence trade, thus are expected to produce positive coefficients. The variable Common Colonizer, indicating a historical bond via a shared colonizer, is used as overidentifying variable in HSS and ZIP estimation conducted as robustness test. These variables were commonly found in the literature to be the most used and often most significant explanatory variables of trade, with most of these used by Shepherd (2016) in his manual or the studies discussing the gravity model.

With respect to the market size variables, two were commonly found in the literature: installed capacity and electricity generated, both measured at the technology level as well as total renewables market. As mentioned in the previous chapter, these variables were not only used as measures to control for a country's market size but were also included as an output-measure indicating policy stringency and or the outcome of policy instruments in studies such as Kuik et al. (2019) and Sung and Song (2014), with the latter using the variable as a proxy for FiTs. The different studies that include any of these measures, show that both exporting countries and importing countries with a bigger market size in terms of renewable energy installed capacity or electricity generation per technology seem to be a driving factor of trade in these technologies (Groba, 2014; Groba & Cao, 2015; Kuik et al., 2019) as it indicates that demand and/or the policy environment for the given technology in these countries was high or strict. Therefore, it could be expected that exporting and importing countries with bigger market sizes are positively related to trade in the technology that is exchanged. However, importing country market size could also indicate that the due to a large home market, no additional imports are needed and therefore import less. In this study, installed capacity will be used and is expressed as the percentage of installed capacity per technology of the total installed capacity. The expected findings are that a higher percentage of installed capacity in the exporting country is associated with more exports and vice versa for the importing country.

The knowledge stock variables are included to discuss how differences in technology advancements affect trade, due to the accumulated knowledge for the given technology. This is preferred to using patent data per year, as it captures the output of the innovative system over multiple years. The knowledge stock variable for the exporting country is expected to be a positive factor influencing trade, as higher levels should indicate higher technology innovative capacity and development. This should lead to a larger home market, which in turn should lead to higher exports due to scale advantages and due to the technology advancement of the products traded indicating a competitive advancement over other countries. Contrastingly, the importing country's knowledge stock is expected to be negatively affecting imports, as it could be seen as that the importing country possesses sufficient knowledge and therefore is not dependent on foreign products, as the country has sufficient know-how to produce domestically. However, Kim and Kim (2015) provided evidence that countries with more technology specific knowledge also imported more due to domestic market expansion, meaning additional imports are needed to fulfil all demand, or due to imports of cheaper products. The variables are computed using the perpetual inventory method, which can be described as the sum of the patent applications in year *t* plus the knowledge stock in year *t-1* which has been depreciated by 15% to account for diminishing returns of the older technology, as used by Groba (2014), Constantini and Mazzanti (2012) and Noailly and Smeets (2015). The data to construct the knowledge stock variables started 1980, twenty years prior to the first observation in the research, and initiated with the patent applications of 1980 and subsequently followed the above-described method to build the variable over time. The expected findings are that a higher level of knowledge in the exporting country is associated with more exports and vice versa for the importing country.

The policy variables in equation 3 refer to multiple variables studied, related to the Feed-in Tariffs that are used in this research. The added value of this research comes from the inclusion of policy design aspects of the national mean tariff level and duration of the contract. However, the research also includes some previously studied variables for comparisons to previous research. The following additional variables are included: Dummy variables indicating FiT presence in the previous period, in order to see if policy presence is a significant driver of trade, the one period lag allows to catch the temporal delay in decision making, as mentioned by Kuik et al. (2019); the number of years that the instrument has continuously been in place, in order to see if stable policies allow for greater export advantages, again lagged by one period. Finally, the number of years since the FiT has been initiated, to test the lead market hypothesis that early adoption leads to greater export advantages is also included. It must be noted that due to the data being available from 2000 onwards, the number of years since first FiT enactment should be interpreted in terms of at least the number of years since it has been enacted, as previous studies have showed that, depending on the technology, some countries initiated FiTs as early as the mid 90's. The variables for tariff level and contract length are also lagged by one period to omit the temporal delay. The effect that these variables will have is difficult to determine a priori. In general, as discussed in the previous chapter, FiTs seem to be more suited to promote less mature technologies such as solar PV, FiT presence is expected to have a positive effect on exports of these products, and that technology differences are apparent. In addition, more stable policies in terms of design, with sufficiently high tariffs, long contracts and longer continuous policy presences are expected to lead to an increase in the domestic industry development and are therefore expected to have a positive effect on exports, specifically for solar PV. Similarly, the expectation is that there's evidence for improved export flows from countries implementing the policies earlier. The expected effect of the importing country policy presence and design is hard to determine, however, importers that had a FiT are generally expected to behave similarly to exporters, and will therefore likely import less due to the FiT presence or more stable policy design aspects, although otherwise proven by Kim and Kim (2015) and Groba and Cao (2015)

The import tariff is included, in line with Groba (2014), to test for additional trade barriers between countries, where transport costs are captured by geographical distance. The variable represents the value weighted Ad Valorem Equivalent applied tariff in percentage points. Similarly, it is expected to act as an export lowering mechanism, as found by Groba, however, it is more likely to be a barrier for developing countries as mentioned by the author.

Two additional extensions are discussed, differences of trade between developed and developing countries and the full sample, as well as the effect of fossil fuel support policies on trade in RETs components. The first extension is done to see if the there's a substantial difference in trade flow behaviour between countries with different degrees of development, which might display how policy instruments might differ in terms of effectiveness between the countries and to see the effect of the import tariff between different types of countries. The second extension, making use of a reduced country sample and period, and is conducted to see how actively supporting fossil fuels effects the trade in RETs. This is done as actively supporting fossil fuels is likely to drive down the electricity price, making RET establishments more difficult, and in turn FiTs more important to establish an export advantage and be a determining factor of trade flows. The IEA has also stated that a stop in fossil fuel support is necessary to achieve zero carbon emissions by 2050, and that additional investments are not needed to supply growing demand (IEA, 2021b). The variable is measured by the per capita total fossil fuel subsidy in USD.

The robustness of the results will be tested in several ways. First, as mentioned, the methodology used in the already discussed literature differs substantially, for this reason the full model, excluding the extensions will be estimated by both OLS, HSS and ZIP methodology to test the robustness of the estimation method. Second, as previous research has adopted multiple definitions when it comes to what products are included per technology, a narrower defined subset of products will be tested, as used by some authors. Third, as the inclusion of China could potentially influence the outcomes significantly, an alternative estimation without China will also be conducted.

In addition to the trade analysis explained above, there will be a simple estimation similar to Dijkgraaf et al. (2018) to see, if for the sample studied, FiTs and their design aspects have played a significant role in terms of increasing added capacity, while controlling for variables that the authors used that are available. This estimation is purely done to see how the different technologies were affected by FiTs for the data studied and is purely meant as a quick control and not as a standalone research.

Data

The data used in this research is a balanced panel data set of exports of products related to the above mentioned RETs studied between 49 countries, for an 18-year period from 2000 until 2017. The full descriptive statistics and correlation tables per RET can be found in appendix 1.

The countries included in this research is displayed in table A3.1 (with ISO-3 codes displayed in table A3.2). The table divides the countries by which geographical regions, and marks which are non-OECD members, developing countries and which countries are included in the extension discussing the effects of fossil fuel support. This leads to a dataset of 42,336 observations per technology (49 exporting countries x 48 importing countries x 18 years), with some estimations with fewer observations due to lagged variables. The choice for this geographical and time scope was data driven, as the FiT data of interest were available for these countries and this timeframe. The geographical coverage is most in line with the research of Kuik et al. (2019) and includes all OECD countries, except for Colombia who joined only recently, and all G20 countries and BRICS countries. The data can be further separated in 37 developed and 12 developing countries based on UN WESP (2020) country classification.

In addition to the reasoning behind the geographical choice of the data, the reasoning for using only FiTs as an input policy measure, was also based on data availability, in terms of period and countries studied. With most of the previously conducted research on specific policy instruments relying on data from the International Energy Agency (IEA), this research deviates from this trend due to inability to access IEA data. Therefore, alternative data was needed, with the OECD providing adequate and available data for Feed-in Tariffs, however, data for alternative specific policy instruments were either not measured by the OECD, or incomplete. Although the OECD provides data for certain broader proxy measures used previously in research, such as environmental taxes or environmental protection expenditure, this data was often incomplete or solely available for the subset of OECD countries. For these data availability and quality reasons, the majority of the previous studies have sought to explain trade flows from an OECD or EU perspective, including substantially more importing countries, however, often explaining driving forces from an exporting country perspective, while using either broad alternative measures to account for the importing country policy situation or leaving them out of the equation. The data has been collected from multiple sources, with a summary per variable in table A3.3, and a discussion in the next section. The included products per technology are displayed in table A3.4 and are based on the products used in previous research, which is displayed in table A3.5.

As mentioned by Kuik et al. (2019) there are multiple problems that arise when using trade data. First, there's an almost certain mismatch between trade flows reported from two countries, in terms of export and import value asymmetries from country one to country two and to country two from country one. Normally, as tariffs are applied to imports, these are deemed more consistent, however, for European countries, due to another way of measuring taxes, this point doesn't hold. Therefore, as suggested by the authors, it's best to take the maximum of the export and import value, as is done in this research. Second, as already pointed out, the different studies conducted have included different products based on the harmonized trade system (HS), meaning there's a need to discuss what products to include. In terms of lowering the number of zero trade flow observations, a broader inclusion is a better option. However, studies by Jha (2009) and Steenblik (2005) include variables that are considered to not be exclusively used for renewable energy generation, and could therefore bias the results. The papers studied have included different approaches, with Groba (2014), Groba and Cao (2015) and Kuik et al. (2019) implementing various products at the disaggregated technology level but less than what has been included by Jha (2009), whereas Kim and Kim (2015) and Diederich (2016) only include one product for both solar PV and wind export flows to reduce this bias. The studies at the aggregated renewable technology level suffer less from zero trade observations and followed the research by Steenblik (2005). As this research is conducted at the technology level, it is therefore more prone to zero trade observations. For this reason, this research has chosen to include all products included in the discussed studies (excluding Jha, 2009) and added some additional products that seemed reasonable to include. Table 1 below displays the zero trade observations per technology. As mentioned, a reduced product sample will be used for a robustness test, with the products included marked in table A3.4

Table 1: Zero Trade Observations

Technology	*Zero trade observations*	*Zero trade % of Total*
Total Trade	17	0.04
Total RET	3090	7.30
Small Hydro	25258	59.66
Solar PV	3980	9.40
Wind	7220	17.05

Source: Own calculations, 42336 observations per Technology

Figure 1 below displays the total trade per technology for the period studied, which shows that trade is largest for solar PV components and much lower trade in small hydro products occurring. The figure shows a trend as trade in all technologies is declining or stabilizing after 2011.

Figure 1: Total Export per RET

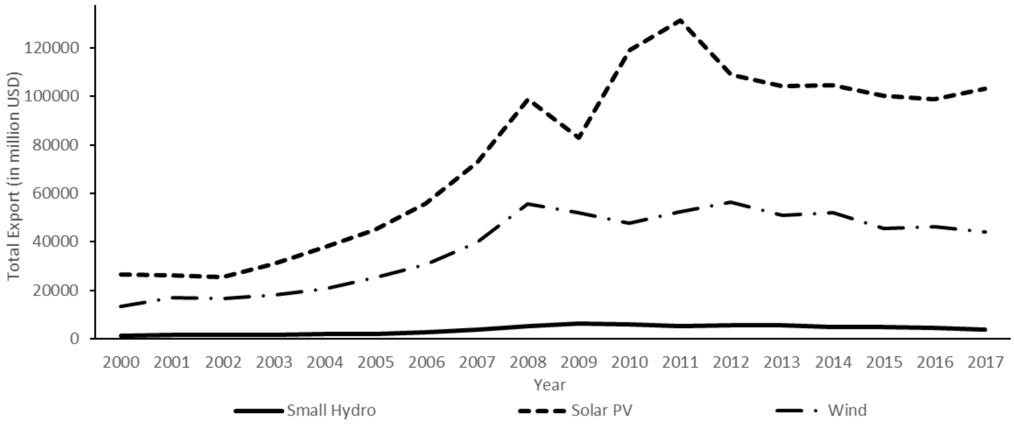


Figure A2.1 displays a more detailed picture of total exports in the different technologies per geographic region, with Europe and Central Asia exporting the largest amount of small hydro products and wind power products, whereas East Asia and the Pacific are the largest exporting region in terms of solar PV products, closely followed by Europe and Central Asia. It must be noted, as can be seen in the table regarding the country sample, that Europe and Central Asia represent the largest number of countries, indicating that East Asia and the Pacific are, in terms of average country exports, more competitive than is displayed in the figures. This can be observed in figures 2 and 3 below. These results indicate that, as mentioned by Algieri et al. (2011), countries can simultaneously import and export products, even if they enjoy large export advantages, indicating intra-industry trade. The figures display the large amount of export in solar PV components from China, but that the country is also among the larger importers. This can also be said of Germany, China and the United States when it comes to trade in wind power components.

Figure 2: Top 5 Importers per RET

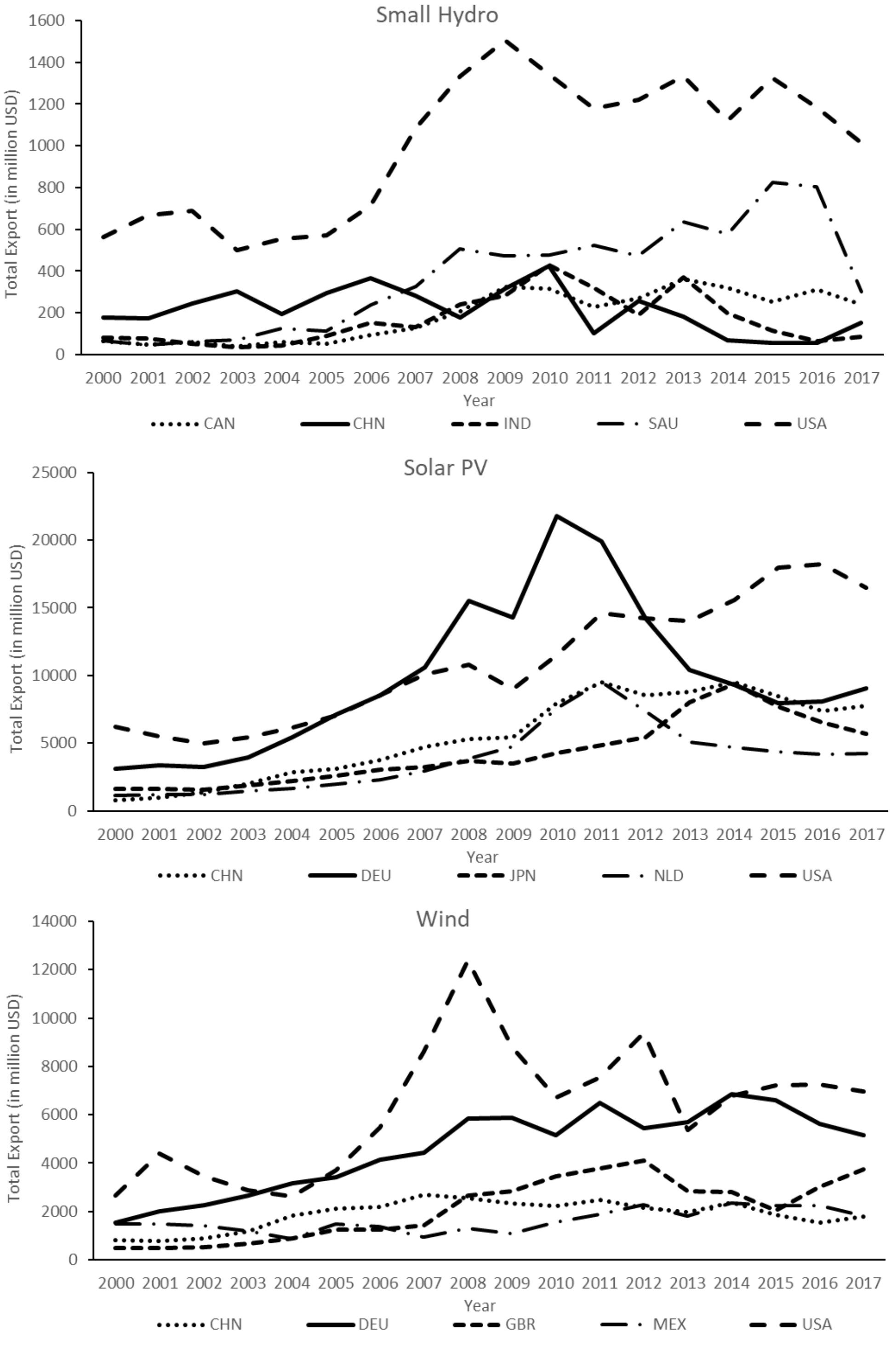
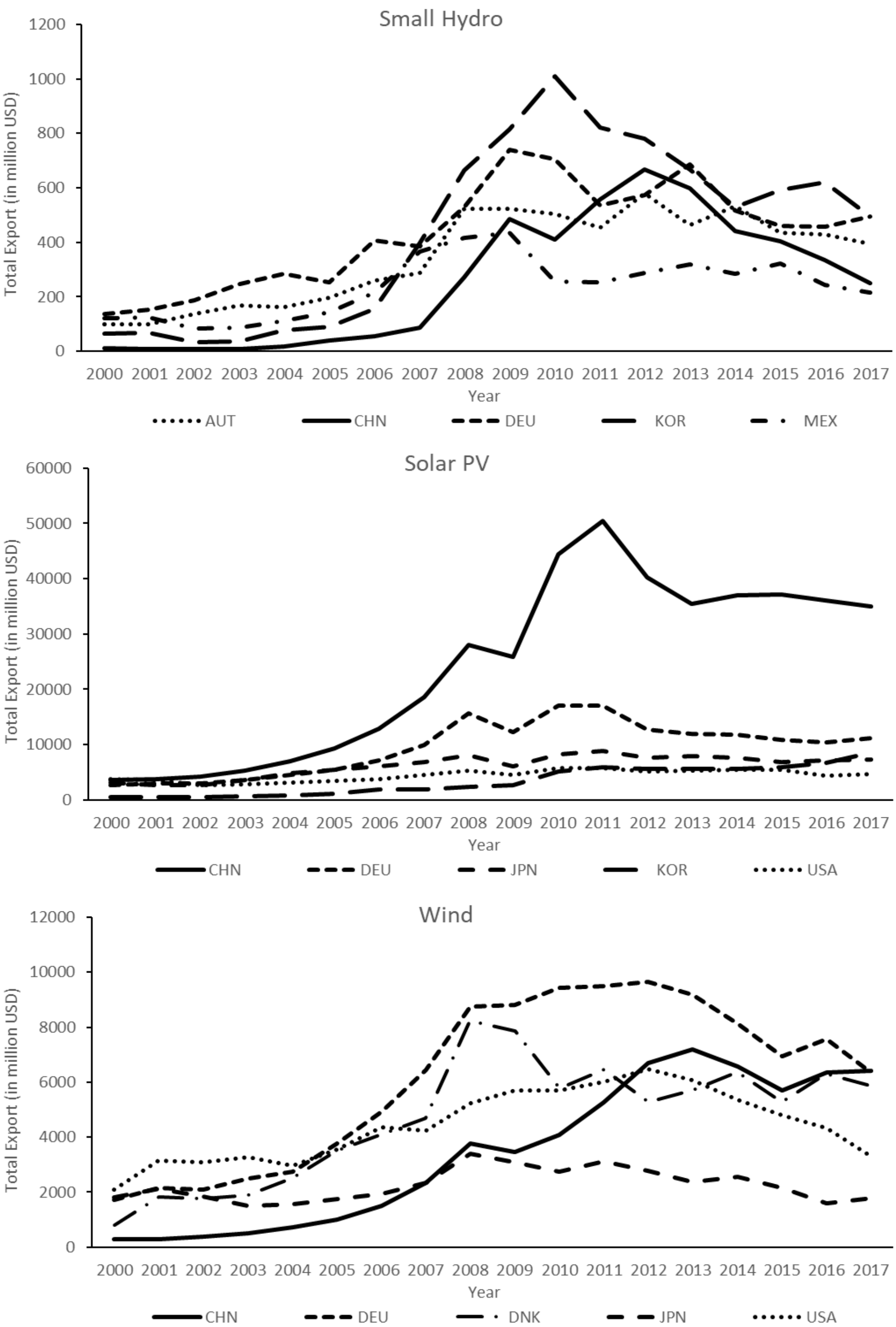


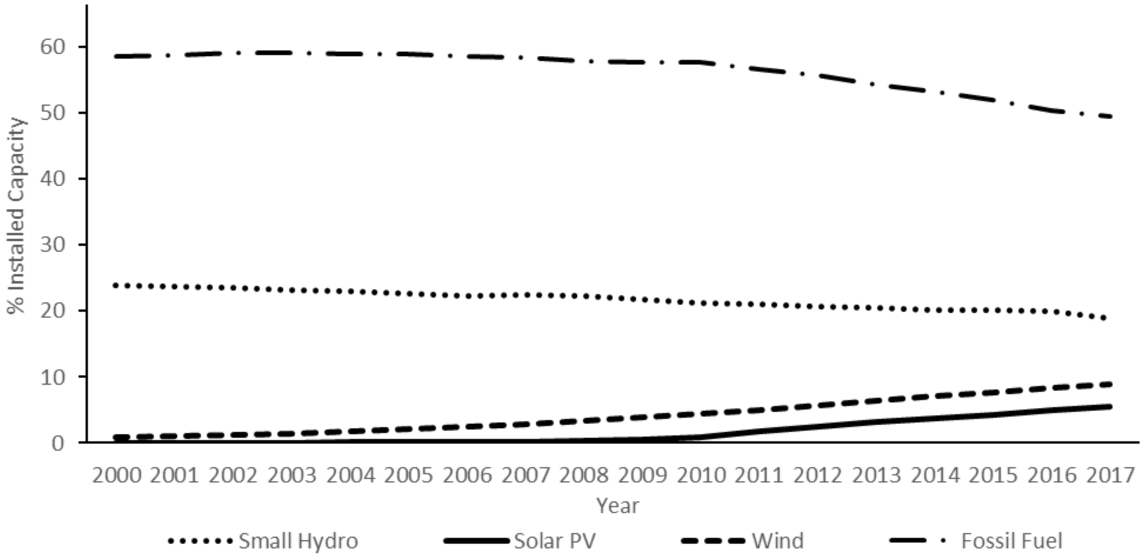
Figure 3: Top 5 Exporters per RET



The gravity variables, excluding GDP per capita, have been obtained from the CEPII (2016), with GDP data obtained via the Worldbank (2021). CEPII provides the most used gravity dataset, including a vast number of variables that can be used to analyse trade flows. The dataset ended prior to the end of the period studied, but as historical and geographic data is time invariant, the only projected problem could come from changes in the trade agreements made between countries, however, in line with Kuik et al. (2019) it is assumed that after the end of the data collection by CEPII, these variables have not changed for the sample.

The market size variables have been computed using data obtained from IRENA (2021), which is based on the installed capacity of the renewable energy technologies studied. For the different technologies, only the techniques that could use the FiTs were included, which directly led to the exclusion of off-grid capacity. Furthermore, this led to the exclusion of pumped storage and mixed hydro plants for small hydro power, as pumped storage is a technology that also relies on using energy and it's unclear what defines a mixed hydro plant. In addition, concentrating solar PV is excluded as the FiT data explicitly states the exclusion of this technique. Contrary, as the FiT data for wind power is the average of both on- and off-shore wind power generation, both are included in the market size for this technology. Figure 4 below displays the evolution of the average installed capacity per technology.

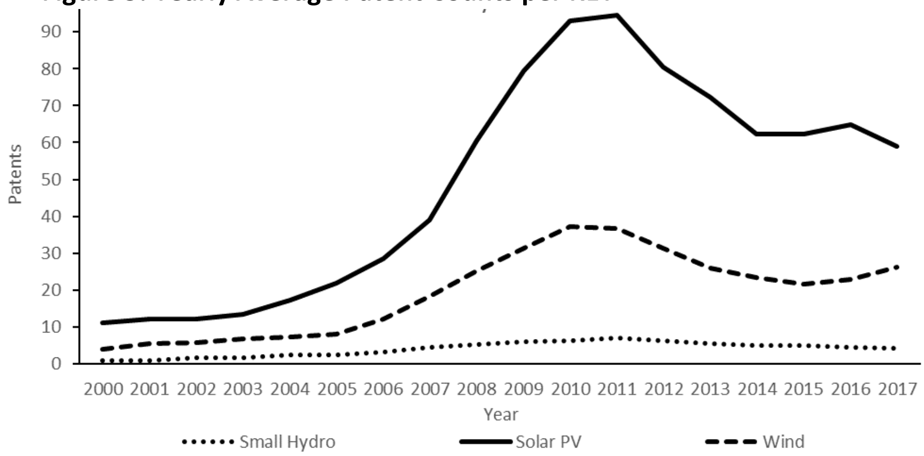
Figure 4: Average Market Size per RET



The figure indicates that over time, both fossil fuels and small hydro saw a decline in installed capacity, whereas both solar PV and wind power saw an increase in uptake of the technology. The total installed capacity does not add up to a 100% due to the exclusion of the aforementioned techniques. Figure A2.2 displays the top 5 countries in terms of market size per technology, with the countries displayed being the ones with highest average installed capacity over the sample period. The figure displays first and foremost that hydro power is the most established technology, as some countries such as Norway and Brazil have most of their total installed capacity being hydro power sources. However, this figure also displays a decline over time. In addition, the figure shows the rapid uptake of solar PV, as at the beginning of the sample period, the technology was not even one percent of total capacity in the top 5 countries of the sample, with a huge rise in the uptake taking place from 2008 onwards, with Germany showing almost 20% of installed capacity at the end of the sample period. Finally, the figure shows that wind power is more established than solar PV, with a higher share of total installed capacity coming from wind power at the start of the sample period, and the countries such as Germany and the Czech Republic displaying 25% and 35% respectively at the end of the sample period. In addition, the figure shows that the increase in market size was steadier compared to solar PV.

The knowledge stock variables have been computed using patent data from the OECD (OECD Green Growth, 2021) with the patents included, being of family size 2 and greater using patents applied for by residents of the country. This is done to exclude the low-value patents that would be included if family size one and greater would be used. If patents have been applied for by residents of different countries, the patent count is divided equally amongst the countries to avoid double counting. The patents included have been based on the OECD ENV-Tech Patents (2021) search strategy, which can be found in table A3.6. Figure A2.3 displaying the regional differences in the total regional knowledge stock per RET. The figure shows that Europe and Central Asia led to way in terms of accumulated knowledge in hydro and wind power technologies, whereas East Asia and the pacific showed the largest amounts of accumulated knowledge in solar PV. The accumulated knowledge in all technologies increased substantially from 2005 onwards, likely due to the ratification of the Kyoto protocol, whereas a stagnation or even decline is displayed from around 2012, indicating a decrease in patenting activity of RETs in general as well as the depreciation of existing knowledge which is taken into account. Only East Asia and the Pacific saw a steady growth in patenting activity of all technologies, even hydro power. Figure below displays the average patenting activity per RET over the sample period and shows the technology maturity clearly as a substantial dissemination between the yearly number of patents per technology is found.

Figure 5: Yearly Average Patent Counts per RET



The FiT data was provided by the OECD (OECD Environmental Policy, 2021), providing both tariff level and contract length data, allowing the average national policy design to be studied. These variables both reflect the average of all national FiTs per technology, expressed in current USD/kWh for the tariff and years for the contract length. The values included both Tariffs and Premiums, which are made comparable by adding the average industrial user electricity market price to the premium. The values represent the starting tariff levels and do not include the decrease in price paid during the length of contract, known as the degression rate.

Figure 6: Yearly Average FiT Tariff level per RET

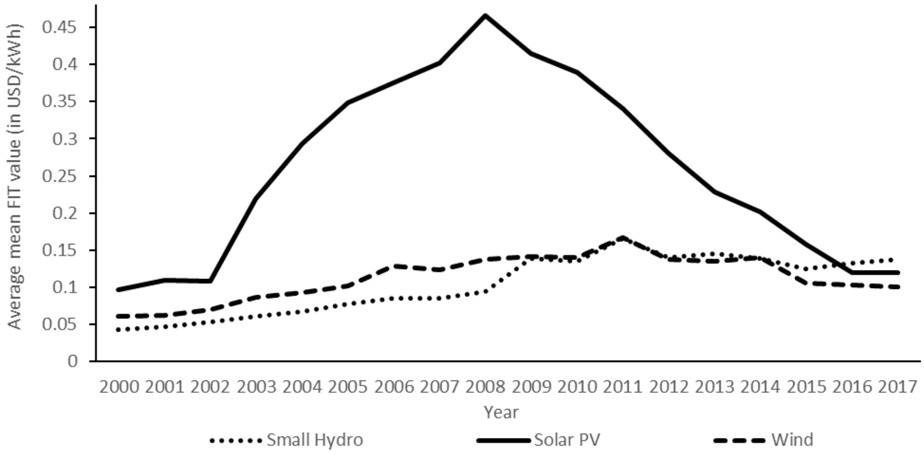
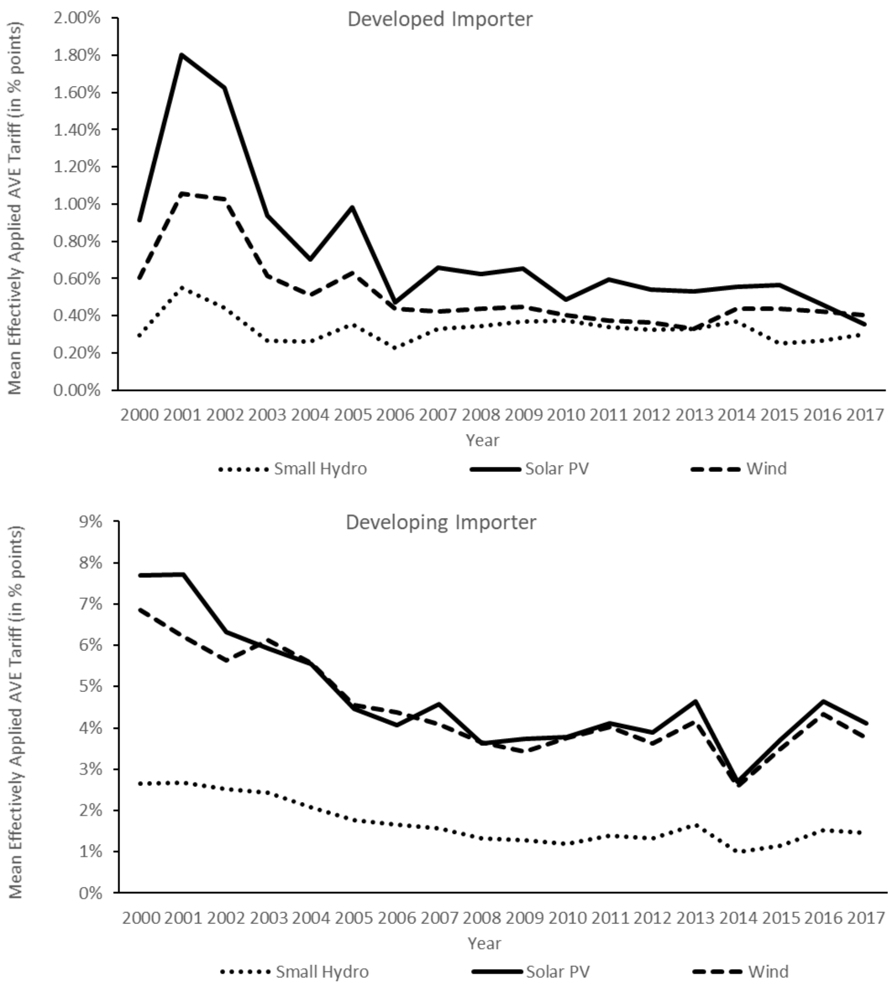


Figure 6 above displays the yearly average FiT level value per RET over the sample period, with the average only calculated over the countries that had a FiT in the year. The figure displays the much more steady and low values of small hydro and wind power tariffs, which is in line with the lower cost of electricity generation for these technologies, indicating a lower tariff is needed to bridge the gap between electricity price and generation costs. The average solar PV FiT level displays an initial rapid increase, followed by an equally as impressive decrease. This shows the initial promotion of the technology, with high FiTs paid to close the price-cost gap, whereas over time, the generation costs came down quite rapidly, indicating the decreased need for high tariff levels to promote the technology. Figures A2.4, A2.5 and A2.6 display the top 5 countries per technology in terms of largest average FiT over the sample period, the number of countries that had a FiT per region/RET and the average FiT level per region/RET. The figures display the differences in both tariff levels as well as duration of policy enactment, with different strategies becoming apparent, as some countries/regions offer higher FiT tariff levels, likely exceeding the generation cost, but do this for a shorter period, whereas others offer lower tariff levels for longer, with the last few years seeing a decline for all technologies in terms of the number of the countries implementing a FiT.

The last variable included in the main analysis is the import tariffs applied to the different technologies. These were obtained from the UN TRAINS (2021), obtained via WITS, similar to the trade data. Figure 7 below displays the value weighted Effectively Applied AVE tariffs per technology for the different development statuses of the importing country.

Figure 7: Import-tariff per country development status/RET



The figure shows the decrease in tariffs over time for all technologies, regardless of development status, with the lowest tariffs being applied to components needed for small hydro electricity generation, and the highest tariffs being applied to solar PV components. As mentioned by Groba (2014) the tariffs applied proved to be a significant barrier to trade for non-OECD countries, which is quite understandable due to the substantial differences between developed and developing country import tariffs being displayed, with tariffs being on average a factor 10 higher in developing countries.

The fossil fuel extension of this research makes use of data obtained from the OECD (OECD Policy Indicators, 2021) with data being available for a subset of countries for the period 2007-2015, as marked in table A3.1. The values used represent the total support levels per capita, calculated using WDI (Worldbank, 2021) population data. The next chapter will discuss the results found for the different estimations conducted in this research, place them amongst the results found in previous studies and discuss the potential conclusions that can be drawn from them in terms of the driving factors of trade and the influence of FiTs.

Results

In this chapter, the results of the previously discussed estimation process will be displayed. All trade estimations were conducted using a Poisson Pseudo Maximum Likelihood, using time, exporting and importing country dummies to control for time trends and country specific fixed effects covering the multilateral resistance terms as explained by Anderson and van Wincoop (2003), of which the importance has been stressed by Baldwin and Taglioni (2007). Standard errors are clustered by country pair using the Distance variable (Shepherd, 2016), in order to allow for correlation within country pairs and to allow the standard errors to be heteroskedasticity and autocorrelation-consistent, but not across country pairs (Stock & Watson, 2012). All (non-logarithmic) dummy coefficients should be interpreted as a one-unit change in the variable is associated with an ((exp $^{\beta}$ - 1)*100) % change of export of the products studied. The logarithmic coefficients can be interpreted as a one percentage change in the variable is associated with a β percentage change in export of the products studied and the non-logarithmic coefficients should be interpreted as a one-unit change in the variable is associated with a β*100% percent change in export of the products studied. The chapter will start with a discussion of the effects of domestic variables, including FiTs, on the development of installed capacity similar to Dijkgraaf et al. (2018), followed by the trade analysis as described in the previous chapter.

Added Capacity Estimation

In line with Dijkgraaf et al. (2018), this section discusses the estimation results of the effects of FiTs, installed capacity and knowledge stock on the added capacity of the RETs. The results are displayed in table A4.2 and corroborate the findings of Dijkgraaf et al., as both FiT presence and Tariff level display positive and significant coefficients for solar PV, and display that FiT presence is positive and significant for wind power added capacity. The policy presence indicates a 0.1 percentage point increase in solar PV added capacity, and 0.29 percentage point increase in added capacity of wind power, with a one cent increase in the tariff level increasing added capacity with 0.01 percentage points, indicating policy effectiveness. The negative value of FiT presence for small hydro could be due to simultaneous enactment of FiTs for the other technologies in countries that used FiTs to promote hydro power uptake. The already existing market size is a positive and significant driver of additional installed capacity, with existing technological knowledge being an important factor in solar PV uptake. Furthermore, countries with a higher GDP per capita also install more wind power, which could be due to the higher costs of wind power products. The positive and significant value of FiT contract length for this technology displays similar reasoning, that longer support takes away investment risks, which could aid in investments in technologies that are expensive to install. In general, the positive effect of FiT on solar PV and wind power development can be assumed.

Aggregated vs. Disaggregated RET Exports

Table 2: below shows the baseline gravity equation for both the total and disaggregated trade flows of the RETs studied. The results indicate the need to study the technologies separately, as the baseline gravity coefficients show varying signs and significance across the technologies.

Exporting country GDP shows similar results across the estimations in terms of significance, however, differing size effects, with a one percentage increase in GDP associated with a 0.54% to 0.87% increase in trade flow, but shows similar significance at a 1% level. This is lower than what has been found by some studies, with a traditional belief that the value should be close to 1, however multiple studies have found differing results, with both higher values found by Kuik et al. (2019) and lower values found by Kim and Kim (2015). Importing country GDP shows different results across the technologies in terms of significance and coefficient size, with a negative although insignificant coefficient for small hydro exports, a positive and significant coefficient for solar PV, where a one percent change in GDP is associated with a 0.67% increase in exports which is significant at the one percent level, and a positive and insignificant result for wind exports. The negative value found for small hydro could solely be related to the sample, with larger importers being developing countries such as India and China.

Distance has the expected sign and significance across the technologies, although the coefficients being lower than what has previously been found by studies of Constantini and Crespi (2008, 2013), whereas the results for solar PV and wind are similar but slightly lower to what has been found by Kuik et al. (2019). The coefficients range between 0.56% and 0.80% percent increase in exports when distance increases with one percent. Traditionally, the results were thought to be larger for wind power exports, due larger size of the products that are transported, which is not supported be the results found.

The coefficient for Shared Border shows an interesting result, as all coefficients are significant at a 1% level, the size is similar for both Solar PV and Wind, at around 21% ($(exp^{0.192}$-1) *100) to 23%, whereas the coefficient for Small Hydro indicates that if two countries are adjacent, exports increase with 123% compared to when they don't share a border. As electricity generation from small hydro is dependent on natural endowments to an extent beyond that of solar PV and wind, it is probable that countries that share a border might have similar natural endowments, and therefore engage in more trade. In addition, the coefficient could also have taken some of the effects of the lower distance coefficient into its size, as similarly to wind power components often larger products are exported, making exporting to nearby countries cheaper.

Common Language only shows to have a significant influence in exports of solar PV components, increasing exports of these components with 54%, significant at a 1% level when countries share an official language, which is lower than found by Groba (2014), but as significant. Colonial Relationship seems to be an insignificant explanatory variable when it comes to exports in all technologies, with coefficients being insignificant and low, with wind exports being most affected, showing a 16% increase in exports between countries that have historical colonial ties. Common Currency is found to be an insignificant driver of exports for both small hydro and wind products, however, the coefficient for solar PV indicates that when both countries use the same currency, exports decrease with 23%, which is only significant at the 10% level. This is likely due to the sample used, as all 17 countries that share a currency are EU members, indicating therefore they also share an FTA/RTA. The result can therefore be interpreted as being an EU member, which Groba (2014) found to be a positive yet insignificant driver of exports in solar PV products and is found to be a weakly significant deterrent of exports in solar PV components.

The FTA/RTA variable shows the expected positive and significant (at 1% level) results across the technologies. Ranging from 30% for solar PV to 89% for small hydro, exports in these environmental goods is thus significantly higher amongst countries implementing a trade agreement and thus reducing trade barriers, indicating trade barriers need to be overcome to increase international diffusion in these products.

Table 2 - Estimation of Baseline Gravity Models by Technology

Technology$_r$:	Total RET	Small Hydro	Solar PV	Wind
ln(GDP$_{it}$)	0.684***	0.542***	0.648***	0.886***
	(11.47)	(3.48)	(9.21)	(8.07)
ln(GDP$_{jt}$)	0.471***	-0.173	0.673***	0.166
	(5.53)	(-0.89)	(5.93)	(1.31)
ln(Distance)	-0.769***	-0.563***	-0.799***	-0.717***
	(-16.26)	(-3.90)	(-14.70)	(-13.16)
Shared Border	0.249***	0.806***	0.285***	0.192**
	(3.00)	(4.57)	(2.78)	(2.23)
Common Language	0.350***	0.0867	0.435***	0.125
	(4.05)	(0.60)	(4.22)	(1.19)
Colonial Relationship	0.0833	-0.124	0.0981	0.148
	(1.18)	(-0.71)	(1.16)	(1.53)
Common Currency$_{ijt}$	-0.213*	0.120	-0.262*	-0.0219
	(-1.83)	(0.61)	(-1.89)	(-0.19)
FTA/RTA$_{ijt}$	0.231***	0.640***	0.265***	0.369***
	(3.28)	(3.89)	(3.03)	(4.08)
Country Effects	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes
pseudo R-sq	0.895	0.692	0.902	0.833
Log Likelihood	-5.02E+08	-5.97E+07	-3.45E+08	-2.60E+08
N	42336	42336	42336	42336

*t-statistics in parentheses * p<0.10, ** p<0.05 *** p<0.01*

Market Size

Table 3 displays the estimation of the baseline gravity equation with the addition of domestic and foreign market size as variables to capture the effect of controlling for the importing country as well.

Table 3 - Market Size

	Small Hydro		Solar PV		Wind	
Installed Capacity$_{irt}$	0.027**	0.027**	0.006	0.006	0.032***	0.032***
	(0.014)	(0.014)	(0.006)	(0.006)	(0.011)	(0.011)
Installed Capacity$_{jrt}$		-0.000		-0.008		0.015*
		(0.009)		(0.006)		(0.008)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	42336	42336	42336	42336	42336	42336
pseudo R-sq	0.692	0.692	0.902	0.902	0.833	0.834
Log Likelihood	-5.963e+07	-5.963e+07	-3.446e+08	-3.444e+08	-2.583e+08	-2.580e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, baseline gravity variables included in estimation but omitted from output*

The results indicate, as expected that the larger the market size of the respective RET in the exporting country, the larger the exports that this country will see in the respective technology. The coefficients are positive and significant at the 5% and 1% level for small hydro and wind, displaying that a one percentage point increase in the installed capacity of the technology in the exporting country is associated with 2.7% and 3.2% higher exports. The coefficient is a positive but not significant driver of export of Solar PV components in the exporting country. Results are weakly in line with Kuik et al. (2019), but do not support the findings by Groba (2014) for the solar PV industry, who have both used this measure as policy strictness proxy and claim that countries with stricter policies enjoy export advantages.

When additionally controlling the importing country, the results show the expected sign for small hydro and solar PV, although not being significant and displaying only small effects. For wind power the coefficient displays that a larger market size in the importing country is a positive and significant driver of exports at the 10% level. This could be explained by the fact that large exporters of wind power components are simultaneously large importers of similar components, as discussed previously, with China, Germany and the United States being amongst the top five exporters and importers.

Knowledge Stock

Table 4 below displays the estimation of the baseline gravity equation with the addition of domestic and foreign knowledge stock to discuss the effects on exports. First the total knowledge stock is tested, to show the importance of a country's general innovative strength on trade in the different technologies studied, as a measure if institutional strength. Second, the technology specific knowledge is tested to see if countries with higher levels of technology specific knowledge are at an advantage when it comes to trade. The unit in which the variables are measured is 1000 patents.

Table 4 - National Knowledge Stock

	Small Hydro		Solar PV		Wind	
Total Knowledge Stock$_{it}$	0.001	0.001	-0.002**	-0.002**	-0.002***	-0.003***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Total Knowledge Stock$_{jt}$		-0.005***		-0.001		-0.004***
		(0.001)		(0.001)		(0.001)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	42336	42336	42336	42336	42336	42336
pseudo R-sq	0.692	0.695	0.902	0.902	0.833	0.835
Log Likelihood	-5.970e+07	-5.912e+07	-3.433e+08	-3.430e+08	-2.587e+08	-2.562e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, baseline gravity variables included in estimation but omitted from output*

The results indicate that a country's general innovative capacity is not a positive but negative driver of trade in renewable energy components, as the results show that only small hydro exports seem to be positively affected by an increase in the domestic knowledge stock although being insignificant, whereas both the results for solar PV and wind power components is negatively affected by an increase in total knowledge stock, showing significant coefficients. The size of the coefficients is however relatively small, as a one unit increase in domestic patents, increases exports only with 0.1% for small hydro, and decreases exports with 0.2% and 0.3% for solar PV and wind respectively. The results are opposing the results of Constantini and Crespi (2008), who found that an exporters' general innovative capacity is crucial to be successful in the international market. The results for the importing country display a negative factor of approximately similar size. These results indicate that general innovative capacity is not necessarily a deterring force to import the products, which was also found by Constantini and Mazzanti (2012).

Table 5 - Technology Specific Knowledge Stock

	Small Hydro		Solar PV		Wind	
Knowledge Stock$_{irt}$	-0.179	-0.497	-0.074**	-0.074**	0.049	-0.019
	(1.203)	(1.116)	(0.034)	(0.034)	(0.108)	(0.107)
Knowledge Stock$_{jrt}$		-3.319***		-0.041		-0.345***
		(0.843)		(0.033)		(0.103)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	42336	42336	42336	42336	42336	42336
pseudo R-sq	0.692	0.694	0.902	0.902	0.833	0.834
Log Likelihood	-5.971e+07	-5.930e+07	-3.438e+08	-3.435e+08	-2.596e+08	-2.582e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, baseline gravity variables included in estimation but omitted from output*

The results for technology specific knowledge displayed in table 5 above show similar findings, however, as previously found for solar PV and wind, small hydro now shows a negative coefficient as well. The higher the knowledge stock in the exporting country the lower the exports in all technologies, however, only a significant coefficient is found for solar PV, as a one unit increase in technology specific patents is associated with a decrease in exports of 7.4%, with a higher but insignificant effect found for hydro specific knowledge. The displayed solar PV coefficient could reflect the significant improvement in the technology, with countries with a lower stock of technology specific knowledge that is compiled of more recent knowledge seeing an advantage over countries with higher levels of perhaps ''older'' knowledge. Similarly, this could indicate a favourable position of late movers. The coefficient for wind power specific knowledge in the exporting country is positive, yet insignificant.

Similar as to total knowledge, technology specific knowledge is a significant deterring force when it comes to importing products, as countries with higher levels of technology specific knowledge import significantly less. The results show a one unit increase in technology specific knowledge in the importing country is associated with a 332% decrease in imports for hydro power components, and 35% for wind power components, both being significant at the one percent level, indicating that higher domestic technology specific knowledge means fewer imports are likely necessary to fulfil all demand, in line with Diederich (2016). Similar as to total knowledge, trade in solar PV components is not significantly affected by a larger knowledge stock in the importing country. This contradicts to the results of Kim and Kim (2015) who found positive and significant coefficients of knowledge on both exporting and importing activities of solar PV and wind power products.

Policy

The following two sections discuss the effect of FiTs on trade, split in FiT presence and policy design and. The effects are split into two separate estimations due to high correlation of the FiT presence variables with the FiT design variables.

FiT: Policy Presence

Table 6 below displays the estimation of the baseline gravity equation with the addition of domestic and foreign dummy variables indicating FiT presence one year prior to when the trade was observed.

Table 6 - Policy: FiT Presence

	Small Hydro		Solar PV		Wind	
$DFiT_{irt-1}$	0.089	0.086	-0.226***	-0.218***	-0.158***	-0.160**
	(0.084)	(0.083)	(0.071)	(0.071)	(0.055)	(0.055)
$DFiT_{jrt-1}$		-0.070		0.112**		-0.044
		(0.069)		(0.048)		(0.050)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	39984	39984	39984	39984	39984	39984
pseudo R-sq	0.691	0.691	0.903	0.903	0.832	0.832
Log Likelihood	-5.817e+07	-5.815e+07	-3.329e+08	-3.320e+08	-2.528e+08	-2.527e+0

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, baseline gravity variables included in estimation but omitted from output*

The results indicate, that exporting countries that have a FiT in place in the previous period see significantly lower exports in solar PV and wind power components, as having a FiT is associated with a 20.2% and 14.6% decrease in exports of the respective components, being significant at a one percent level. These results are opposing findings to what has been found by both Kim and Kim (2015), who found that countries with a FiT in place exported more solar PV and wind power products, as well as findings of Groba (2014) who found weakly significant positive evidence for FiT presence on export of solar PV products. A possible explanation, considering the added capacity estimation results, could be that due the FiT functioning well, the domestic market generated a large demand which could only be fulfilled if all domestically produced products would be consumed domestically, which could lead to fewer products being available for exports. This is similar to reasoning by Diederich (2016), as it is highly improbable market-pull policies have a positive immediate effect on exports if the earlier stages of technology development are not simultaneously or priorly being promoted, with the author finding a similar effect. However, this short-term disadvantage could potentially lead to an increased export advantage, due to a larger home market.

The inclusion of importing country FiT presence displays the expected signs for the coefficients of hydro and wind power components, however showing insignificant coefficients. The coefficient found for the presence of a Solar PV FiT in the importing country shows the most interesting result as the size and significance indicate that countries that have a FiT in place import significantly more Solar PV products than countries without a FiT in place. This would indicate that, contrary to commonly believed, FiTs presence would lead to increase in imports instead of exports. In addition to the above stated argument, when demand for these products increases, this could lead to the total domestic consumption of what is domestically produced. If this is subsequently not sufficient, additional imports are needed. Groba and Cao found similar results when it comes to imports from China, and Kim and Kim (2015) also found evidence of a significant positive effect of domestic FiT presence and imports of both solar PV and wind power components. It could, however, also be argued that FiT presence leads to increased demand, but rather than producing domestically, cheaper products are imported from developing countries, as argued Kim and Kim (2015). It can be concluded that the static short-term effect of the instrument is technology dependent and does not cause higher export values. In terms of diffusion, it could be argued that countries lacking an existing market and/or specific technological knowledge could benefit from FiTs due promoting imports, which in turn could potentially lead to a domestic market creation, if the market situation is favourable.

FiT: Policy Design

Table 7 below displays the estimation of the baseline gravity equation with the addition of domestic and foreign variables that represent specific FiT design aspects. The results discuss if national differences in the instrument design significantly affect trade flows.

The results for the exporting and importing continuous years of FiT enactment shows that stable policy presence has been a significant driver of trade in hydro power components. The results are in line with expectations, as an additional year of FiT presence in the exporting country increases exports with 2.2% whereas the same effect of an additional year of importing country FiT presence has shown to be a negative driver decreasing imports with 2.4%, indicating a stable policy environment could lead to develop a domestic market for hydro power components. This could in turn generate an export advantage and/or lower imports. Contrary to what was expected the sign and size for the solar PV and wind power are negative, with wind power showing a significant coefficient as an additional year of continuous FiT presence decreases exports with 1.6%. The solar PV coefficients are negative for the exporter and positive for the importer, yet insignificant. The expectations were that especially for less mature technologies, continuous enactment would aid development and lead to larger exports over time.

The results for the years since enactment are in line with expectations and provide some evidence to the lead market hypothesis, as for all technologies, an additional year since the FiT has first been enacted in the exporting country is associated with higher exports of 4.2% for hydro, 1.2% for solar PV and 3.5% for wind power components. The results are however only significant for hydro and wind power. Similarly, from the importing country perspective, the longer since the FiT has been enacted for the first time the lower the imports of the components of all technologies, however, only hydro shows a weakly significant coefficient as an additional year is associated with a decrease in imports of 3.2%. The results point in the direction of a lead market hypothesis in the hydro power industry and wind power industry, which as mentioned by Kuik et al. (2019) could come from the fact that first-mover dynamic advantages are technology dependent, with the authors mentioning that wind turbines are much more complex goods compared solar PV modules and could therefore be harder to imitate by late-comers and allow for a possible first mover advantage. Contrary, the authors argue that for the solar PV industry, if there’s a consensus on design, production can be scaled up and imitated, providing possibilities for late movers.

The coefficient for tariff level in the exporting country has the expected sign, however, is not significant for all technologies studied. This indicates that higher tariffs don’t lead to significantly higher exports in the short run. Contrary, importing country tariff level is also found to be positive for both hydro and solar PV components, whereas for wind power an expected negative coefficient is found. The striking and significant coefficient found for Solar PV shows that an additional cent/kWh increase in the FiT tariff is associated with 1% increase in imports of solar PV components, indicating this aspect of instrument design plays an important role, and could promote imports of cheaper imports as stated by Kim and Kim (2015)

In addition, the length of the FiT contract in the exporting country, which could be interpreted as an additional measure of stability due lower investment risk as the tariff is paid longer, shows unexpected negative coefficients for all technologies, with solar PV and wind power coefficients being significant at the 1% and 10% level. An additional year of the FiT contract is associated with 1.4% lower exports for solar PV products, and 0.8% lower exports of wind power components. However, as mentioned before, given the success of FiTs in promoting the domestic uptake of these technologies, this could reflect that longer instrument contract could create domestic markets, however these markets don't enjoy an advantage in term of export performance.

The importing country instrument aspects of a positive effect for the tariff level and negative effect for the contract length for solar PV give way to two interpretations. First it could be argued that when policies are guaranteed for a long period, the level of the tariff is set lower than what might be necessary for the technology to be profitable, providing insufficient incentive to develop a home market. With solar PV and wind power having higher generation costs compared to small hydro, this could explain the negative significant and insignificant coefficients found for each technology. Second, the longer contracts could provide lower investment risk and therefore be successful in terms of generating domestic demand, leaving less products available for exports. This second explanation could, however, only potentially explain the significant negative value for the wind power coefficient since domestic contract length was a significant variable in explaining added capacity solely for this technology. The importing country contract length does show the expected negative sign for all technologies, with significant coefficients found for hydro and solar PV, with an additional year of contract length being associated with 0.7% and 0.8% lower imports in the components of both technologies. This indicates that longer contracts at least prevent imports from taking place which could be due to a bigger domestic market because of stable conditions.

Contrary to what has previously been found, FiTs appear to be a less useful instrument in promoting exports in products needed for the less mature the technologies such as solar PV, than more mature technologies such as Hydro power, at least in the short run, opposing the findings from Groba (2014) and Kim and Kim (2015)

Table 7- Policy: FiT Design

	Hydro						Solar PV						Wind					
FiT continous years$_{irt-1}$	0.022**	0.021**					-0.012	-0.011					-0.016**	-0.016***				
	(0.011)	(0.011)					(0.008)	(0.008)					(0.006)	(0.006)				
FiT continous years$_{jrt-1}$		-0.024*						0.011						-0.008				
		(0.012)						(0.007)						(0.006)				
FiT Years since enactment$_{irt}$			0.042***	0.043***					0.012	0.012					0.035***	0.035***		
			(0.015)	(0.014)					(0.010)	(0.010)					(0.012)	(0.012)		
FiT Years since enactment$_{jrt}$				-0.032*						-0.003						-0.009		
				(0.017)						(0.010)						(0.012)		
FiT Tariff$_{irt-1}$					0.003	0.003					0.001	0.001					0.000	0.000
					(0.002)	(0.002)					(0.001)	(0.001)					(0.004)	(0.004)
FiT Contract Length$_{irt-1}$					-0.004	-0.004					-0.013***	-0.014***					-0.008*	-0.008*
					(0.005)	(0.005)					(0.004)	(0.003)					(0.004)	(0.004)
FiT Tariff$_{jrt-1}$						0.005						0.010***						-0.001
						(0.003)						(0.001)						(0.002)
FiT Contract Length$_{jrt-1}$						-0.007*						-0.008***						-0.003
						(0.004)						(0.003)						(0.003)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	39984	39984	42336	42336	39984	39984	39984	39984	42336	42336	39984	39984	39984	39984	42336	42336	39984	39984
pseudo R-sq	0.692	0.692	0.693	0.693	0.691	0.691	0.902	0.902	0.902	0.902	0.903	0.906	0.832	0.832	0.833	0.833	0.832	0.832
Log Likelihood	-5.81E+07	-5.80E+07	-5.95E+07	-5.94E+07	-5.82E+07	-5.81E+07	-3.359e+08	-3.353e+08	-3.446e+08	-3.446e+08	-3.327e+08	-3.226e+08	-2.53E+08	-2.53E+08	-2.59E+08	-2.59E+08	-2.53E+08	-2.53E+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, baseline gravity variables included in estimation but omitted from output*

Import Tariff

Table 8 below displays the effect of import tariffs on the export of the different technologies studied. In line with expectations, the coefficient is negative and significant at one and five percent for solar PV and wind power exports, however the effect is small, as a 1% increase in the tariff is associated with 0.06% and 0.021% decrease in exports respectively, meaning that doubling of the tariff would "only" lower exports with 5.9% and 2.1%. The coefficient for hydro power, shows an interesting result, since a one percent increase in the tariff is associated with 0.13% increase in exports, which similar to Groba and Cao (2015) could be solely because more is exported to markets that apply higher tariffs, such as China, and in addition with almost 60% of the observations being zero, the sample size is small. The coefficients found for solar PV and wind indicate that, as generally believed, trade liberalization, by lowering or discarding tariffs, would lead to increased trade and promoting diffusion.

Table 8: Import Tariff

	Small Hydro	Solar PV	Wind
ln(Import Tariff)$_{jrt}$	0.130***	-0.059***	-0.021*
	(0.016)	(0.016)	(0.011)
Country Effects	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes
N	42336	42336	42336
pseudo R-sq	0.703	0.903	0.833
Log Likelihood	-5.755e+07	-3.402e+08	-2.593e+08

Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, baseline gravity variables included in estimation but omitted from output

Full Model

Table A4.3 displays the results from the full model, including all the above discussed variables. Both a full model using the dummy variable to capture the effect of Feed-in Tariff presence as well as a full model using the specific FiT design variables are displayed. The variable *FiT continuous years* is omitted from the model due to the high correlation with *Fit Years since enactment*, with the latter showing more significant coefficients.

In general, the coefficients don't deviate substantially from the previous estimations which included the variables separately. It can be concluded that, as indicated by the varying coefficients found for the gravity variables, there is a necessity to study the technologies separately. In addition, the inclusion of importing country variables has proved to be useful, as displayed by significant coefficients. The gravity variables show that economic size and geographic distance are major factors influencing trade, with the remaining variables have a more technology specific effect.

Market size is a significant determining factor in export performance of trade in hydro and wind power components as the larger the domestic market the increases exports significantly, with China being a prime example as to why this isn't necessarily the case for solar PV exports. Technology specific knowledge stock is not found to be a significant driver of exports, but a significant deterring force of imports of hydro and wind power components, as exports are significantly lower to countries with higher levels of technology specific knowledge stock whereas the recent development of solar PV makes this less important in terms of determining trade.

Regarding the effect of FiTs, if a country has implemented its policy earlier, the higher the exports and the lower the imports, although hydro power shows a significant coefficient in the full model, given some support to a lead market hypothesis for this specific technology. The presence of FiT leads to lower exports of solar PV and wind power components, whereas it also leads to significantly higher imports to countries that implement a FiT for solar PV electricity generation, with a strong argument that the FiT actually works in terms of domestic market creation as shown by its importance of the added capacity, whereas simultaneously for solar PV, a FiT also is associated with larger imports, either to supply increased demand, or due to increased imports of cheaper products to satisfy demand. Tariff level is not a significant driver of exports but is a significant driver of imports of solar PV components, leading to promote the latter of the arguments. The contract length is found to have a significant negative effect on export of solar PV and wind power components and a significant negative effect of imports of solar PV components. Finally, the import tariff shows to be a significant barrier to trade in solar PV and wind power components, in addition to distance and not belonging to a free or regional trade agreement.

Temporal Effects

As it is argued that policies take time to be implemented and be successful, especially market-pull policies according to Diederich (2016), this section will discuss the effects of different measures over time by using the lagged variables for several periods. Both the policy input instruments, and an output measure, market size as used by Kuik et al.(2019), are used to determine policy effectiveness over time in terms of improved export performance.

FiT: Policy Presence

Table A4.4 displays the effects using different lagged variables for FiT presence in the exporting country in years prior to the when the trade is observed, while controlling for importing country FiT presence. The results indicate that the longer a fit has been present, the higher the export in hydro power components, although only the five-year lag is significant, and the effect diminishes after five years when it leads to insignificantly lower exports. For both solar PV and wind power components, FiT presence leads to an increase in exports over time in the sense that the strong negative values observed for the one-year lag do diminish over time. The coefficients become positive after seven years for both technologies, although only the coefficient found for solar PV is significant. After seven years the coefficient decreases for both technologies and even shows a significant negative coefficient for wind power. The importing country one period lagged FiT presence variables remain similar, positive and significant for solar PV, indicating that although weak evidence is found for improved export performance over time, the current pulling force from the importing country remains the significant driver of solar PV trade, apart from the gravity variables. This indicates, that even when a market should have been established, the fact that exports might increase is due to importing country policy instrument presence. In general, no strong evidence is found in favour of a narrow Porter hypothesis, in terms of a better export performance of the "green side of the economy" due to this specific policy.

FiT: Policy Design

Table A4.5 displays the effects of using different lagged variables for the FiT design characteristics in the exporting country. Most of the lagged variables for the tariff level display positive yet insignificant coefficients, indicating tariff level differences do not lead to more exports of the components needed for electricity generation of the different technologies studied, with only the seven-year lagged hydro power, three-year lagged solar PV and nine-year lagged wind power coefficients returning significant positive values. The contract length variables display mostly negative but insignificant coefficients. Similarly, to the main results and as indicated by the FiT presence analysis, the driving force behind the trade in solar PV components are the importing country FiT design characteristics, with countries that implement higher tariffs significantly importing more, whereas longer contracts, indicating the country aims for stable market conditions, significantly lowers the imports. This persistent strong dissemination between the policy design aspects leads to believe that in general the longer policies are likely to have lower tariff levels. Therefore, countries given longer contracts are more likely to establish a domestic market through stable market conditions, whereas higher tariffs are most likely used to import foreign products to increase installed capacity in a limited amount of time. In general, no significant evidence in favour of the narrow porter hypothesis is found due to differences in policy design.

Market Size

In line with Kuik et al. (2019) the output measure of policies, market size is also analysed. The authors show that the export advantage due to larger home markets where significant for both solar PV and wind power trade, however that solar PV market size became an insignificant driver of export over time whereas the wind power advantage persisted. The results in table A4.6 display a similar analysis and finds some similar and some contradicting results. The installed capacity of both hydro power and solar PV is not significant driver of export over time with the coefficient found for solar PV becoming negative after two years. Contrastingly, the installed capacity it is a positive driver of exports in wind power components, although the variable becomes insignificant after six years. The installed capacity in the importing country is not a significant driver of trade for both hydro power and wind power, whereas the larger the installed capacity of solar PV in the importing country, the country imports significantly less products. In conclusion, only some evidence for a competitive advantage through policy effectiveness, measured as installed capacity can be concluded.

Discussion

The results indicate some weak evidence that FiTs take time to develop a domestic market, but that is only able to limit the immediate export disadvantage of solar PV and wind power component exports, however hydro power components see a disadvantage over time in terms of trade competitiveness due to FiT presence. FiT presence in the importing country remains the main driver of exports of solar PV components. The design characteristics do not play a significant role over time for the exporting country, even though some arbitrary significant values can be observed. For solar PV exports, importing country FiT tariff levels remain the main driver. The policy design aspects indicate that both tariff levels and contract length are driving forces of imports of these products in the opposite direction. The results indicate that, in general, FiT and FiT design in the exporting country do not necessarily promote export performance, not in the short-run nor in the long-run. The analysis of the market size of each technology, which could be interpreted as the outcome of policy effectiveness, indicates that exporting country market size is only a significant driver of exports in wind power components, which does diminish over time, whereas the importing country market size of solar PV is a significant force to deter exports to countries with larger percentages of installed capacity. This could indicate, that even if market size was used to measure policy effectiveness and one would accept it's a driving force of exports, the results are driven by policies other than or in addition to Feed-in Tariffs, as the separate effect of FiT presence and design provides no evidence of improved export performance.

Extensions

Trade Flow Direction

Table A4.7 displays the different trade flows for the technologies studied, looking at trade from developed to developing countries and vice versa. The table displays fairly similar results as to the full model.

For small hydro components export we can observe that when the exporter is developed, the developing importer is importing significantly less, the longer since the FiT has been enacted for the first time, at 5.8% per additional year. The opposite can be said when the exporter is developing, as the developed importer seems to import more the longer since the FiT has been enacted for the first time, at 8% per additional year. Interestingly, there is no difference in the effect of import tariffs across the different trade flows, and FiT presence in the previous year is no significant driver of exports in either situation for both the exporting and importing country. However, from the size and sign of the coefficients, it seems that developing countries import less due to the FiT whereas developed countries import more. This result can be interpreted similar as to the earlier drawn conclusion for solar PV, FiTs might be used to import cheaper products from abroad.

For solar PV components export, when the exporter is developed, the longer since the FiT has been enacted for the first time in both the exporting and importing country significantly increases trade at 3.9% for exports and 2.7% for imports respectively per each additional year since first enactment. When the exporter is developing, the longer since the FiT has been enacted for the first time, the less it exports to developed countries (3.5% per each additional year), which could indicate that a home market has been established and the home market is supplied by domestically produced components. Interestingly, even though not significant, the presence of a FiT in the previous year in the developing exporting country is also a factor that decreases exports to developed countries, indicating developing countries act similar to developed countries. Contrary, the imports of developed countries are substantially driven by the presence of a FiT in the previous period, increasing imports with 32%. This leads to believe that, even when a home market is established as can be observed by the larger exports from developed countries with a longer period since the FiT was first enacted, FiTs are used to import from developing countries, likely because of cheaper products due to lower labour costs. This evidence is further boosted by the difference in the effect of the import tariff, as a developing importer doesn't seem to see a tariff as a barrier to trade, whereas the developed importer decreases its imports from the developing exporter significantly due to an increase, as a doubling of the tariff decreases imports with 8.2%, even though they apply relative low tariffs. This indicates that price plays an important role for developed countries. This finding is opposing the findings of Groba (2014) who argued that import tariffs were a significant barrier to trade from OECD countries to non-OECD countries.

For Wind exports, we can observe that when the exporter is developed or developing, the longer a FiT has been in place doesn't significantly influence the trade in the wind power components. The only significant influence of a FiT can be found when the exporter is developed, and there is a FiT in place in the previous period, the coefficient shows that exports to developing countries decreases significantly with 34%, which is larger than the coefficient found for the full model of 18%. Similar to the results for hydro export, the import tariff is not necessarily a trade barrier for developing importing countries.

Fossil Fuel Support

Table A4.7 displays the effects of fossil fuels support in the exporting and importing country based on the OECD inventory method. Due to the limited sample size, both geographically and in terms of years analysed, the comparison with the full model is difficult, and the variables reflecting the policy presence need be interpreted with caution. The fossil fuel support variables show the expected sign for most situations. A one unit increase in exporting country fossil fuel support is associated with a decrease in exports of the technologies ranging from 0.13% to 0.02%, showing a significant impact on the export of hydro and wind power components. This shows that actively supporting the non-renewable competitive source of energy, is likely to hurt the market establishment and potential export performance of RETs. Similarly, a one unit increase in importing country fossil fuel support is associated with a decrease in imports of both hydro and wind power components, but to a smaller effect of only 0.04%, and only being a significant variable for the trade in hydro power components. This indicates that indirectly lowering the electricity price also disincentives the imports RET components, even those comparable with existing fossil fuels. The solar PV coefficient is positive and significant, which could indicate that when countries support fossil fuels to a certain extent, the potential non-existence of a domestic market able to supply the demand means that imports must fulfil the demand. This view is strengthened by the even larger effect FiT presence in the importing country, even though it's effect should be interpreted with care due to the reduced sample.

Robustness

Tables A4.9 and A4.10 display the results for the estimation of the two full models, controlling for FiT presence and FiT design and characteristics, for different estimation techniques. Similar to what has been displayed in table A4.1, the results differ depending on the estimation method. Both OLS and HSS as well as PPML and ZIP show very similar results in general. This indicates that the results discussed are robust for a ZIP estimation, but not necessarily for non-Poisson estimation methods. The signs of the coefficients seldomly change between the Poisson and non-Poisson estimations, but the size and the significance do differ and quite substantially, with the biggest difference being found for the gravity models. Table A4.11 displays the results of the FiT Design model for both the sample including all products per technology, as well as the reduced sample using a more stringent definition of the products included. The analysis shows that applying a more stringent definition does lead to significantly different coefficients, with different size, significance and in some instances also signs, indicating that comparing previous research, a similar technology trade flow definition in terms of products included is needed. Table A4.12 displays the results of the FiT design model for the total country sample, as well as a sample that excludes China. In general, the coefficients do not display very different outcomes, however, due to China's presence in trade in hydro power and the already extensive zero trade observations, its exclusion altered some coefficients substantially. In addition, an interesting observation is that across all technologies, the economic size variables have substantially changed, whereas the policy variables haven't altered substantially. The findings indicate that in terms of external validity and research comparability, both the estimation method and product definition are important factors influencing the outcomes found. This calls for a more standardized approach in the field, as the existing literature applies different estimation methods and product definitions, as well as the use of different variables to measure policies and/or policy effectiveness, making comparisons and drawing conclusions a difficult task.

Conclusion

This research has looked at determinants of trade in components used in the electricity generation process of renewable technologies for a sample of 49 countries for a period of 18 years starting in 2000, with a focus on the effects of Feed-in Tariffs. The aim of the research was to find out which variables affected trade, if evidence for a narrow porter hypothesis and lead market hypothesis could be found, which in turn could indicate if policy instruments can enhance diffusion of renewable energy technology products. The technologies discussed are small hydro power, solar PV and wind power, chosen as these are the most widely installed renewable technologies, and all are completely durable non-combustible alternatives to existing fossil fuel electricity sources. By using a gravity model that controls for specific socio-economic and historical factors affecting trade in general, as well as including country and time specific fixed effects as additional measures, this study has aimed to estimate the true effect of country specific factors that are commonly found to influence trade and with a special focus on Feed-in Tariffs. In addition to most previously conducted studies, this research has also discussed the effects of the same variables in the importing country, implementing a completely balanced panel data set. By using a PPML estimator for the balanced panel data set, the results are controlled for heteroskedasticity in addition to allow for intra-panel autocorrelation, as well as to naturally include zero-trade flows observations providing in general more adequate results than previous studies using OLS estimation. The research has tried to add to the existing literature by studying a more recent period, which is especially important regarding RETs studies as the importance of combating climate change has increased substantially in recent years, especially after the signing of the Kyoto protocol and the Paris agreement. In addition, the research included a more varied country sample than most previous studies, including OECD, G20 and BRICS countries and developed and developing countries being included. The research has aimed to discuss not only the effectiveness of FiT presence, but also two specific aspects of policy design, tariff levels and contract length, as well as discuss the importance of consistent FiT presence and the number of years since the FiT was first enacted. The research included two extensions for sub-sets of the data, discussing the effects of fossil fuel support in both the exporting and importing country as well as the differences in trade flows between developed and developing countries.

The results indicate first and foremost two common findings: the need to study RETs separately and the need to control for importing country variables. In general, it can be concluded that FiTs promote the domestic uptake of certain technologies. However, the policy instrument presence or specific design aspects do not significantly lead to a better export position, not instantaneously nor after several years, with only some weak marginal evidence for enhanced trade performance over time. The clearest effect of the FiT was found for importing country presence and tariff level, both significantly increasing imports. The remaining variables studied indicate mixed effects. Domestic market size is a significant export influencing variable, with countries with larger markets in both hydro and wind power seeing larger exports, whereas wind power market size is also a pulling force of foreign products, as it increases imports. Technology specific knowledge stock on the other hand, displaying unexpected negative yet insignificant coefficients for exporting countries indicating knowledge does not lead to enhanced export performance. The importing country level of technology specific knowledge does show a large negative effect on imports of components needed for small hydro and wind power generation, indicating the countries might be self-sufficient. Import tariffs, turn out to be deterring factors of trade in solar PV and wind power components imports, as expected, but shows a significant positive effect for imports of hydro power components, which is most likely sample related.

The research extensions showed that active fossil fuel support leads to lower exports of some technologies and subsequently could drive imports, as no domestic market could potentially be established due to low energy prices. In addition, different behaviour can be observed between develop and developing countries, with especially developed countries using the FiTs to import more solar PV components from developing countries. The results don't indicate towards evidence for a narrow porter hypothesis, nor substantial evidence for a lead market hypothesis, concluding that FiTs do not aid in diffusing technologies from an exporting perspective. This indicates that policy makers aiming to benefit from an improved export position will likely not see this occurring, whereas on the other hand policymakers aiming to quickly increase the domestic market size might find FiTs and especially high tariff levels beneficial in their pursuit of this goal through increased imports.

To test the robustness of the results, additional estimation methods and data have been tested. The different estimation methods have shown that the results using a PPML estimator are robust to using a ZIP estimator, whereas both standard OLS and a HSS model have provided different results, although most significantly different results were not found for the policy measures studied. The use of a more stringent definition of products used for RES-E generation have proofed to show different outcomes in terms of size and significance, but seldom in terms of the sign of the coefficients. The exclusion of China has proofed to show different size of specific coefficients but has not significantly altered the sign and significance of the individual variables in general.

In general, as has become clear from the various robustness analyses, the external validity of this research is questionable in the sense that alternative estimation methods, products included, and country sample drive the results in terms of coefficient size, and in some case significance. This stresses the difficulty of comparing the results found in this research with existing literature, but also comparing the results of the existing literature with one another. In addition, as previous studies have not necessarily set out a certain research setup, the comparability of these studies is very difficult, due to the specific country samples, the choice of variables to control for, the inclusion or exclusion of importing country variables and the measures used to study policy impact. It must be mentioned that this research has been conducted using limited data available to the author, whereas previous studies had access to some of the prime data sources, such as the data collected by the IEA. This has also prohibited the inclusion of multiple policy instrument variables, as data on other measures was either not available, or not complete. To the same extent, the research could not control for country specific electricity prices to generate the specific extent to which countries went to promote the renewable energy technologies. In addition, data on technology specific generation costs could not be included.

Future research could overcome the limitations of this research and focus on other aspects such as how the presence of a fossil fuel industry could affect the performance of policies promoting renewable energy. Inclusion of recent data could further aid in understanding the specific driving factors of trade in the RETs studied as both generation costs have come down, as well as the awareness of the necessity to act sooner rather than later to combat climate change has increased substantially in the most recent years. Furthermore, the interactions between certain policy instruments and dynamic effects in general are of interest to see how policies and other variables might affect and/or complement one another. To conclude, future research would benefit from a more unified and therefore comparable research setup, as currently, comparisons with previous studies are difficult.

Bibliography

Algieri, B., Aquino, A., & Succurro, M. (2011). Going “green”: trade specialisation dynamics in the solar photovoltaic sector. *Energy Policy*, *39*(11), 7275-7283.

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American economic review, 93*(1), 170-192.

Bahar, H., Egeland, J., & Steenblik, R. (2013). Domestic incentive measures for renewable energy with possible trade implications.

Baldwin, R., & Taglioni, D. (2007). Trade effects of the euro: A comparison of estimators. *Journal of Economic Integration*, 780-818.

Burger, M., Van Oort, F., & Linders, G. J. (2009). On the specification of the gravity model of trade: zeros, excess zeros and zero-inflated estimation. *Spatial Economic Analysis, 4*(2), 167-190.

CEPII (2016), Gravity Data, Retrieved from: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8

Constantini, V., & Mazzanti, M. (2012). The Dynamics of Environmental and Economic Systems: Innovation, Environmental Policy and Competitiveness.

Costantini, V., & Crespi, F. (2008). Environmental regulation and the export dynamics of energy technologies. *Ecological economics*, *66*(2-3), 447-460.

Costantini, V., & Crespi, F. (2013). Public policies for a sustainable energy sector: regulation, diversity and fostering of innovation. *Journal of Evolutionary Economics*, *23*(2), 401-429.

Diederich, H. (2016). Review of the Porter Hypothesis and the related literature. In *Environmental Policy and Renewable Energy Equipment Exports* (pp. 19-59). Springer Gabler, Wiesbaden.

Dijkgraaf, E., van Dorp, T. P., & Maasland, E. (2018). On the effectiveness of feed-in tariffs in the development of solar photovoltaics. *The Energy Journal*, *39*(1).

Groba, F. (2014). Determinants of trade with solar energy technology components: evidence on the porter hypothesis?. *Applied Economics, 46*(5), 503-526.

Groba, F., & Cao, J. (2015). Chinese renewable energy technology exports: the role of policy, innovation and markets. *Environmental and Resource Economics, 60*(2), 243-283.

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating trade flows: Trading partners and trading volumes. *The quarterly journal of economics*, *123*(2), 441-487.

IEA (2020a), Clean Energy Innovation, IEA, Paris. Retrieved from: https://www.iea.org/reports/clean-energy-innovation

IEA (2020b), Renewables 2020, IEA, Paris. Retrieved from: https://www.iea.org/reports/renewables-2020

IEA (2021a), Electricity Market Report - July 2021, IEA, Paris. Retrieved from: https://www.iea.org/reports/electricity-market-report-july-2021

IEA (2021b), Net Zero by 2050, IEA, Paris. Retrieved from: https://www.iea.org/reports/net-zero-by-2050

IPCC (2021), Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press.

IRENA (2021), IRENA's renewable electricity capacity and generation statistics, retrieved from: https://www.irena.org/Statistics/Download-Data

Jaffe, A. B., & Palmer, K. (1997). Environmental regulation and innovation: a panel data study. *Review of economics and statistics*, *79*(4), 610-619.

Jenner, S., Groba, F., & Indvik, J. (2013). Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries. *Energy policy*, *52*, 385-401.

Jha, V. (2009). Trade flows, barriers and market drivers in renewable energy supply goods. *ICTSD, Issue Paper*, *10*.

Johnstone, N., Haščič, I., & Popp, D. (2010). Renewable energy policies and technological innovation: evidence based on patent counts. *Environmental and resource economics*, *45*(1), 133-155.

Kim, K., & Kim, Y. (2015). Role of policy in innovation and international trade of renewable energy technology: Empirical study of solar PV and wind power technology. *Renewable and Sustainable Energy Reviews*, *44*, 717-727.

Kuik, O., Branger, F., & Quirion, P. (2019). Competitive advantage in the renewable energy industry: Evidence from a gravity model. *Renewable energy*, *131*, 472-481.

Linders, G. J., & De Groot, H. L. (2006). Estimation of the gravity equation in the presence of zero flows.

Martin, W., & Pham, C. S. (2020). Estimating the gravity model when zero trade flows are frequent and economically determined. *Applied Economics*, *52*(26), 2766-2779.

Noailly, J., & Smeets, R. (2015). Directing technical change from fossil-fuel to renewable energy innovation: An application using firm-level patent data. Journal of Environmental Economics and Management, 72, 15-37.

OECD Environmental Policy (2021), Feed-in Tariff Data, retrieved from: https://stats.oecd.org/

OECD Green Growth (2021), Patents in Environmental related technologies, retrieved from: https://stats.oecd.org/

OECD ENV-Tech Patents (2021), Patents on environment technologies (indicator), retrieved from: https://www.oecd.org/env/indicators-modelling-outlooks/green-patents.htm

OECD Policy Indicators (2021), Fossil Fuel Support data, retrieved from: https://stats.oecd.org/index.aspx?r=482810#

Planbureau voor de Leefomgeving PBL (2020), Klimaat- en Energieverkenning 2020. Retrieved from: https://www.pbl.nl/publicaties/klimaat-en-energieverkenning-2020

Popp, D., Haščič, I., & Medhi, N. (2011), Technology and the diffusion of renewable energy, *Energy Economics*, *33*, 648-662.

Porter, M. E., & Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of economic perspectives*, *9*(4), 97-118.

Shepherd, B. (2016). The gravity model of international trade: A user guide (An updated version). United Nations. Retrieved from: https://www. unescap. org/resources/gravity-model-international-trade-user-guide-updated-version.

Silva, J. S., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and statistics, 88*(4), 641-658.

Steenblik, R. (2005). *Environmental goods: A comparison of the APEC and OECD lists* (No. 2005/4). OECD Publishing.

Stock, J. H., & Watson, M. W. (2012). *Introduction to econometrics* (Vol. 3). New York: Pearson.

Sung, B., & Song, W. Y. (2014). How government policies affect the export dynamics of renewable energy technologies: A subsectoral analysis. *Energy*, *69*, 843-859.

Tinbergen, J. (1962). Shaping the world economy; suggestions for an international economic policy.

UN (2019). UN emissions report: World on course for more than 3-degree spike, even if climate commitments are met. Retrieved from: https://news.un.org/en/story/2019/11/1052171

UN COMTRADE (2021), Trade data, acquired via WITS, retrieved from: http://wits.worldbank.org/WITS/WITS/AdvanceQuery/RawTradeData/QueryDefinitio

UN TRAINS (2021), Import tariff data, acquired via WITS, retrieved from: http://wits.worldbank.org/WITS/WITS/AdvanceQuery/TariffAndTradeAnalysis/AdvancedQueryDefinition

UN WESP (2020), Country development data, retrieved from: https://www.un.org/development/desa/dpad/resources.html?target=major-publications

Worldbank (2021), World Development Indicators (WDI) data, retrieved from: https://databank.worldbank.org/source/world-development-indicators/

Appendices

Appendix 1: Descriptive Tables

Table A1.1 - Summary Statistics

Common Variables	Obs	Mean	Std. Dev	Min	Max
ln(Distance)	42,336	8.230	1.072	5.081	9.880
ln(GDP)$_{it}$	42,336	9.801	1.026	6.094	11.685
Shared Border	42,336	0.048	0.213	0	1
Common Language	42,336	0.063	0.243	0	1
Colonial Relationship	42,336	0.032	0.177	0	1
Common Currency$_{ijt}$	42,336	0.086	0.281	0	1
FTA/RTA$_{ijt}$	42,336	0.519	0.500	0	1
Common Colonizer$_{ijt}$	42,336	0.008	0.087	0	1
Total Knowledge Stock$_{t}$	42,336	32.102	86.578	0.024	501.803
Small Hydro	Obs	Mean	Std. Dev	Min	Max
X$_{ijrt}$	42,336	1654.603	10550.340	0	441517
ln(Import Tariff)$_{jrt}$	42,336	0.657	2.415	0	25
Installed Capacity$_{rt}$	42,336	21.730	23.530	0	94.99
Knowledge Stock$_{rt}$	42,336	0.019	0.039	0	0.28
DFiT$_{rt-1}$	39,984	0.371	0.483	0	1
FiT continous years$_{rt-1}$	39,984	2.138	3.676	0	17
FiT Years since enactment$_{rt}$	42,336	3.149	4.560	0	17
FiT Tariff$_{rt-1}$	39,984	4.292	11.168	0	110.82
FiT Contract Length$_{rt-1}$	39,984	6.908	9.956	0	35
Solar PV	Obs	Mean	Std. Dev	Min	Max
X$_{ijrt}$	42,336	32415.740	215227.200	0	9480247
ln(Import Tariff)$_{jrt}$	42,336	1.691	3.915	0	38.331
Installed Capacity$_{rt}$	42,336	1.563	3.432	0	19.80
Knowledge Stock$_{rt}$	42,336	0.214	0.723	0	5.40
DFiT$_{rt-1}$	39,984	0.406	0.491	0	1
FiT continous years$_{rt-1}$	39,984	2.330	3.661	0	17
FiT Years since enactment$_{rt}$	42,336	3.304	4.583	0	17
FiT Tariff$_{rt-1}$	39,984	11.899	19.882	0	82.95
FiT Contract Length$_{rt-1}$	39,984	7.370	9.443	0	25
Wind	Obs	Mean	Std. Dev	Min	Max
X$_{ijrt}$	42,336	16157.480	76706.630	0	2844828
Import Tariff$_{jrt}$	42,336	1.451	3.399	0	38.403
Installed Capacity$_{rt}$	42,336	4.155	6.396	0	38.32
Knowledge Stock$_{rt}$	42,336	0.084	0.224	0	1.43
DFiT$_{rt-1}$	39,984	0.423	0.494	0	1
FiT continous years$_{rt-1}$	39,984	2.528	3.941	0	17
FiT Years since enactment$_{rt}$	42,336	3.668	4.822	0	17
FiT Tariff$_{rt-1}$	39,984	5.194	9.460	0	73.08
FiT Contract Length$_{rt-1}$	39,984	6.923	8.641	0	25

Note: the research uses balanced panel data, therefore country i and j come from the same group, and adding both would be uninformative as they display the same values

Table A1.2 - Correlation Table Small Hydro

	X_{ijrt}	ln(Import Tariff)$_{jrt}$	ln(GDP)		ln(Distance)	Shared Border	Com. Language	Col. Relationship	Com. Currency$_{ijt}$	FTA/RTA$_{ijt}$	Com. Colonizer$_{ijt}$	Installed Capacity		Total Knowledge Stock		Knowledge Stock		DFiT		FiT continous years		FiT Years since enactment		FiT Tariff		FiT Contract Length	
			it	jt								irt	jrt	it	jt	irt	jrt	irt-1	jrt-1	irt-1	jrt-1	irt	jrt	irt-1	jrt-1	irt-1	jrt-1
X_{ijrt}	1																										
ln(Import Tariff)$_{jrt}$	0.154	1																									
ln(GDP)$_{it}$	0.0362	0.0599	1																								
ln(GDP)$_{jt}$	0.0311	-0.1548	0.0723	1																							
ln(Distance)	-0.0131	0.2041	-0.1703	-0.1703	1																						
Shared Border	0.1317	-0.0267	0.0222	0.0222	-0.3747	1																					
Common Language	0.0339	0.0405	0.0709	0.0709	0.0088	0.1887	1																				
Colonial Relationship	0.0036	0.0692	0.0216	0.0216	-0.0939	0.2301	0.2893	1																			
Common Currency$_{ijt}$	0.0126	-0.1077	0.1824	0.1824	-0.3106	0.1386	0.0446	-0.0102	1																		
FTA/RTA$_{ijt}$	-0.0082	-0.2798	0.2336	0.2336	-0.6556	0.141	-0.0285	0.0099	0.2944	1																	
Common Colonizer$_{ijt}$	-0.0137	-0.0218	-0.0509	-0.0509	-0.0947	0.072	0.0978	-0.016	-0.0072	0.0036	1																
Installed Capacity$_{irt}$	-0.006	0.0017	0.0501	-0.0162	0.0748	-0.0013	-0.025	-0.0265	-0.1232	-0.0501	-0.0425	1															
Installed Capacity$_{jrt}$	-0.0196	0.0017	-0.0162	0.0501	0.0748	-0.0013	-0.025	-0.0265	-0.1232	-0.0501	-0.0425	-0.0172	1														
Total Knowledge Stock$_{it}$	0.0873	0.2866	0.2357	0.0133	0.137	0.0028	0.0333	0.0164	-0.0283	-0.1599	-0.028	-0.1815	-0.0001	1													
Total Knowledge Stock$_{jt}$	0.1208	0.2477	0.3002	0.0606	0.0931	0.0215	0.0707	0.0474	0.0031	-0.0853	-0.0337	-0.1388	-0.0118	0.8175	1												
Knowledge Stock$_{irt}$	0.1737	0.062	0.0133	0.2357	0.137	0.0028	0.0333	0.0164	-0.0283	-0.1599	-0.028	-0.0001	-0.1815	-0.0164	-0.0008	1											
Knowledge Stock$_{jrt}$	0.2004	0.0835	0.0606	0.3002	0.0931	0.0215	0.0707	0.0474	0.0031	-0.0853	-0.0337	-0.0118	-0.1388	-0.0008	0.0431	0.8175	1										
DFiT$_{irt-1}$	0.0589	0.0739	0.0349	0.0767	-0.0659	0.0383	0.0055	0.0099	0.1343	0.0362	-0.011	-0.1097	-0.0119	0.1329	0.2425	0.0135	0.0622	1									
DFiT$_{jrt-1}$	0.041	0.0244	0.0767	0.0349	-0.0659	0.0383	0.0055	0.0099	0.1343	0.0362	-0.011	-0.0119	-0.1097	0.0135	0.0622	0.1329	0.2425	0.0617	1								
FiT continous years$_{irt-1}$	0.0759	0.0767	0.0183	0.0965	-0.0418	0.0404	0.0151	-0.0024	0.1433	0.0232	0.0044	-0.1333	-0.0189	0.1433	0.2949	0.021	0.0871	0.7574	0.0819	1							
FiT continous years$_{jrt-1}$	0.0419	0.029	0.0965	0.0183	-0.0418	0.0404	0.0151	-0.0024	0.1433	0.0232	0.0044	-0.0189	-0.1333	0.021	0.0871	0.1433	0.2949	0.0819	0.7574	0.1177	1						
FiT Years since enactment$_{irt}$	0.1127	0.0702	0.0934	0.1261	-0.067	0.0451	-0.0168	-0.0039	0.1506	0.0783	-0.0161	-0.0766	-0.0308	0.0878	0.2674	0.0334	0.1254	0.4877	0.1121	0.68	0.1815	1					
FiT Years since enactment$_{jrt}$	0.0254	0.0153	0.1261	0.0934	-0.067	0.0451	-0.0168	-0.0039	0.1506	0.0783	-0.0161	-0.0308	-0.0766	0.0334	0.1254	0.0878	0.2674	0.1121	0.4877	0.1815	0.68	0.2781	1				
FiT Tariff$_{irt-1}$	0.0262	0.0067	0.0955	0.0604	-0.1041	0.0298	-0.0278	-0.0018	0.1381	0.0885	-0.0173	-0.0022	-0.0126	0.0179	0.0472	0.0135	0.058	0.5005	0.0601	0.3276	0.0789	0.2114	0.1043	1			
FiT Tariff$_{jrt-1}$	-0.0102	-0.0441	0.0604	0.0955	-0.1041	0.0298	-0.0278	-0.0018	0.1381	0.0885	-0.0173	-0.0126	-0.0022	0.0135	0.058	0.0179	0.0472	0.0601	0.5005	0.0789	0.3276	0.1043	0.2114	0.0422	1		
FiT Contract Length$_{irt-1}$	0.0408	0.0892	-0.0553	0.0619	-0.0559	0.0338	0.0312	0.0061	0.1118	0.0183	0.0052	-0.0927	-0.0088	0.1225	0.2256	0.0099	0.0465	0.8991	0.0447	0.7606	0.0585	0.492	0.0816	0.4142	0.0453	1	
FiT Contract Length$_{jrt-1}$	0.052	0.0655	0.0619	-0.0553	-0.0559	0.0338	0.0312	0.0061	0.1118	0.0183	0.0052	-0.0088	-0.0927	0.0099	0.0465	0.1225	0.2256	0.0447	0.8991	0.0585	0.7606	0.0816	0.492	0.0453	0.4142	0.0283	1

Table A1.3 - Correlation Table Solar PV

	X_{ijrt}	ln(Import Tariff)$_{jrt}$	ln(GDP)		ln(Distance)	Shared Border	Com. Language	Col. Relationship	Com. Currency$_{ijt}$	FTA/RTA$_{ijt}$	Com. Colonizer$_{ijt}$	Installed Capacity		Total Knowledge Stock		Knowledge Stock		DFiT		FiT continous years		FiT Years since enactment		FiT Tariff		FiT Contract Length	
			it	jt								irt	jrt	it	jt	irt	jrt	irt-1	jrt-1	irt-1	jrt-1	irt	jrt	irt-1	jrt-1	irt-1	jrt-1
X_{ijrt}	1																										
ln(Import Tariff)$_{jrt}$	0.0059	1																									
ln(GDP)$_{it}$	-0.0089	-0.0074	1																								
ln(GDP)$_{jt}$	0.0572	-0.3355	0.0723	1																							
ln(Distance)	-0.0434	0.4515	-0.1703	-0.1703	1																						
Shared Border	0.1319	-0.0837	0.0222	0.0222	-0.3747	1																					
Common Language	0.0268	0.0562	0.0709	0.0709	0.0088	0.1887	1																				
Colonial Relationship	0.0179	0.012	0.0216	0.0216	-0.0939	0.2301	0.2893	1																			
Common Currency$_{ijt}$	0.0357	-0.2129	0.1824	0.1824	-0.3106	0.1386	0.0446	-0.0102	1																		
FTA/RTA$_{ijt}$	-0.024	-0.5282	0.2336	0.2336	-0.6556	0.141	-0.0285	0.0099	0.2944	1																	
Common Colonizer$_{ijt}$	-0.0124	-0.0117	-0.0509	-0.0509	-0.0947	0.072	0.0978	-0.016	-0.0072	0.0036	1																
Installed Capacity$_{irt}$	0.0745	-0.0404	0.2207	0.0972	-0.1044	0.0446	0.0194	-0.0058	0.1784	0.1334	-0.0103	1															
Installed Capacity$_{jrt}$	0.0799	-0.1379	0.0972	0.2207	-0.1044	0.0446	0.0194	-0.0058	0.1784	0.1334	-0.0103	0.2778	1														
Total Knowledge Stock$_{it}$	0.163	0.1741	0.2357	0.0133	0.137	0.0028	0.0333	0.0164	-0.0283	-0.1599	-0.028	0.1647	0.0288	1													
Total Knowledge Stock$_{jt}$	0.1636	0.1283	0.1985	0.0437	0.1335	-0.0065	0.0118	0.0051	-0.0279	-0.1236	-0.023	0.2375	0.0891	0.8968	1												
Knowledge Stock$_{irt}$	0.1792	-0.044	0.0133	0.2357	0.137	0.0028	0.0333	0.0164	-0.0283	-0.1599	-0.028	0.0288	0.1647	-0.0164	-0.0066	1											
Knowledge Stock$_{jrt}$	0.1735	-0.029	0.0437	0.1985	0.1335	-0.0065	0.0118	0.0051	-0.0279	-0.1236	-0.023	0.0891	0.2375	-0.0066	0.0158	0.8968	1										
DFiT$_{irt-1}$	0.0537	0.0198	0.1487	0.0835	-0.0863	0.0338	0.0032	0.0235	0.1281	0.076	0.0057	0.279	0.0838	0.1652	0.1927	0.0129	0.0475	1									
DFiT$_{jrt-1}$	0.079	-0.1223	0.0835	0.1487	-0.0863	0.0338	0.0032	0.0235	0.1281	0.076	0.0057	0.0838	0.279	0.0129	0.0475	0.1652	0.1927	0.087	1								
FiT continous years$_{irt-1}$	0.0583	-0.0034	0.1566	0.1054	-0.088	0.0478	0.0113	0.0205	0.1757	0.0861	0.0064	0.4635	0.1797	0.1669	0.2106	0.0222	0.0734	0.7703	0.1044	1							
FiT continous years$_{jrt-1}$	0.099	-0.1034	0.1054	0.1566	-0.088	0.0478	0.0113	0.0205	0.1757	0.0861	0.0064	0.1797	0.4635	0.0222	0.0734	0.1669	0.2106	0.1044	0.7703	0.1506	1						
FiT Years since enactment$_{irt}$	0.0362	-0.0449	0.2242	0.1309	-0.1271	0.0395	-0.0164	0.019	0.164	0.1635	-0.0017	0.4823	0.2973	0.0979	0.1738	0.0352	0.1026	0.4863	0.1129	0.6767	0.2044	1					
FiT Years since enactment$_{jrt}$	0.0701	-0.157	0.1309	0.2242	-0.1271	0.0395	-0.0164	0.019	0.164	0.1635	-0.0017	0.2973	0.4823	0.0352	0.1026	0.0979	0.1738	0.1129	0.4863	0.2044	0.6767	0.3141	1				
FiT Tariff$_{irt-1}$	0.0326	-0.0085	0.2284	0.0789	-0.0863	0.0335	-0.001	0.0134	0.1673	0.0966	-0.0135	0.2199	0.001	0.073	0.1002	0.0092	0.0316	0.7243	0.0935	0.5758	0.0746	0.3751	0.0457	1			
FiT Tariff$_{jrt-1}$	0.0646	-0.1423	0.0789	0.2284	-0.0863	0.0335	-0.001	0.0134	0.1673	0.0966	-0.0135	0.001	0.2199	0.0092	0.0316	0.073	0.1002	0.0935	0.7243	0.0746	0.5758	0.0457	0.3751	0.1307	1		
FiT Contract Length$_{irt-1}$	0.0613	0.0363	0.1284	0.078	-0.0799	0.0294	0.0219	0.0203	0.1184	0.0731	0.0098	0.3163	0.0736	0.1818	0.2039	0.0112	0.0433	0.9409	0.0817	0.7409	0.096	0.474	0.102	0.71	0.0891	1	
FiT Contract Length$_{jrt-1}$	0.0854	-0.125	0.078	0.1284	-0.0799	0.0294	0.0219	0.0203	0.1184	0.0731	0.0098	0.0736	0.3163	0.0112	0.0433	0.1818	0.2039	0.0817	0.9409	0.096	0.7409	0.102	0.474	0.0891	0.71	0.0745	1

Table A1.4 - Correlation Table Wind

	X_{ijrt}	ln(Import Tariff)$_{jrt}$	ln(GDP)		ln(Distance)	Shared Border	Com. Language	Col. Relationship	Com. Currency$_{ijt}$	FTA/RTA$_{ijt}$	Com. Colonizer$_{ijt}$	Installed Capacity		Total Knowledge Stock		Knowledge Stock		DFiT		FiT continous years		FiT Years since enactment		FiT Tariff		FiT Contract Length	
			it	jt								irt	jrt	it	jt	irt	jrt	irt-1	jrt-1	irt-1	jrt-1	irt	jrt	irt-1	jrt-1	irt-1	jrt-1
X_{ijrt}	1																										
ln(Import Tariff)$_{jrt}$	0.0479	1																									
ln(GDP)$_{it}$	0.0921	0.0165	1																								
ln(GDP)$_{jt}$	0.0596	-0.3048	0.0723	1																							
ln(Distance)	-0.0591	0.4376	-0.1703	-0.1703	1																						
Shared Border	0.1801	-0.0775	0.0222	0.0222	-0.3747	1																					
Common Language	0.0366	0.0621	0.0709	0.0709	0.0088	0.1887	1																				
Colonial Relationship	0.0373	0.0211	0.0216	0.0216	-0.0939	0.2301	0.2893	1																			
Common Currency$_{ijt}$	0.0359	-0.1967	0.1824	0.1824	-0.3106	0.1386	0.0446	-0.0102	1																		
FTA/RTA$_{ijt}$	0.0085	-0.5099	0.2336	0.2336	-0.6556	0.141	-0.0285	0.0099	0.2944	1																	
Common Colonizer$_{ijt}$	-0.018	-0.0111	-0.0509	-0.0509	-0.0947	0.072	0.0978	-0.016	-0.0072	0.0036	1																
Installed Capacity$_{irt}$	0.1964	-0.0231	0.2885	0.0883	-0.1299	0.015	0.006	0.0232	0.1723	0.1748	-0.0219	1															
Installed Capacity$_{jrt}$	0.0781	-0.1322	0.0883	0.2885	-0.1299	0.015	0.006	0.0232	0.1723	0.1748	-0.0219	0.137	1														
Total Knowledge Stock$_{it}$	0.2302	0.242	0.2357	0.0133	0.137	0.0028	0.0333	0.0164	-0.0283	-0.1599	-0.028	0.0297	0.0251	1													
Total Knowledge Stock$_{jt}$	0.3382	0.1215	0.2679	0.0561	0.0186	0.0317	0.0336	0.0234	0.0231	-0.0302	-0.0278	0.4556	0.0815	0.67	1												
Knowledge Stock$_{irt}$	0.2143	-0.0047	0.0133	0.2357	0.137	0.0028	0.0333	0.0164	-0.0283	-0.1599	-0.028	0.0251	0.0297	-0.0164	0.0012	1											
Knowledge Stock$_{jrt}$	0.2492	-0.009	0.0561	0.2679	0.0186	0.0317	0.0336	0.0234	0.0231	-0.0302	-0.0278	0.0815	0.4556	0.0012	0.037	0.67	1										
DFiT$_{irt-1}$	0.0922	0.0204	0.1403	0.0718	-0.1166	0.0403	0.0123	0.0246	0.1681	0.0924	-0.0025	0.3046	0.0776	0.125	0.2657	0.0125	0.0571	1									
DFiT$_{jrt-1}$	0.0685	-0.087	0.0718	0.1403	-0.1166	0.0403	0.0123	0.0246	0.1681	0.0924	-0.0025	0.0776	0.3046	0.0125	0.0571	0.125	0.2657	0.0652	1								
FiT continous years$_{irt-1}$	0.1063	0.0015	0.1708	0.1005	-0.1156	0.0537	0.0288	0.022	0.2014	0.097	0.0011	0.3946	0.1437	0.1199	0.3127	0.023	0.0889	0.75	0.0888	1							
FiT continous years$_{jrt-1}$	0.0839	-0.0705	0.1005	0.1708	-0.1156	0.0537	0.0288	0.022	0.2014	0.097	0.0011	0.1437	0.3946	0.023	0.0889	0.1199	0.3127	0.0888	0.75	0.1406	1						
FiT Years since enactment$_{irt}$	0.1372	-0.0231	0.2227	0.133	-0.1288	0.0434	-0.0112	0.0082	0.1883	0.149	-0.0124	0.5628	0.2195	0.0636	0.3255	0.0362	0.126	0.4685	0.1119	0.6827	0.2074	1					
FiT Years since enactment$_{jrt}$	0.0715	-0.0751	0.133	0.2227	-0.1288	0.0434	-0.0112	0.0082	0.1883	0.149	-0.0124	0.2195	0.5628	0.0362	0.126	0.0636	0.3255	0.1119	0.4685	0.2074	0.6827	0.3179	1				
FiT Tariff$_{irt-1}$	0.0246	-0.0132	0.0796	0.073	-0.1069	0.0214	-0.0102	0.0213	0.0766	0.112	-0.0038	0.1257	0.0735	0.0276	0.0803	0.0137	0.0581	0.6418	0.073	0.4529	0.0903	0.2801	0.1042	1			
FiT Tariff$_{jrt-1}$	0.0178	-0.1237	0.073	0.0796	-0.1069	0.0214	-0.0102	0.0213	0.0766	0.112	-0.0038	0.0735	0.1257	0.0137	0.0581	0.0276	0.0803	0.073	0.6418	0.0903	0.4529	0.1042	0.2801	0.0692	1		
FiT Contract Length$_{irt-1}$	0.1239	0.0452	0.1357	0.061	-0.1054	0.038	0.0308	0.024	0.1609	0.0811	-0.0027	0.3267	0.0619	0.1743	0.3253	0.009	0.0452	0.9327	0.0535	0.6972	0.0726	0.4484	0.0902	0.5736	0.0617	1	
FiT Contract Length$_{jrt-1}$	0.0871	-0.0815	0.061	0.1357	-0.1054	0.038	0.0308	0.024	0.1609	0.0811	-0.0027	0.0619	0.3267	0.009	0.0452	0.1743	0.3253	0.0535	0.9327	0.0726	0.6972	0.0902	0.4484	0.0617	0.5736	0.0414	1

Appendix 2: Figures

Figure A2.1 - Total Export per RET/Region

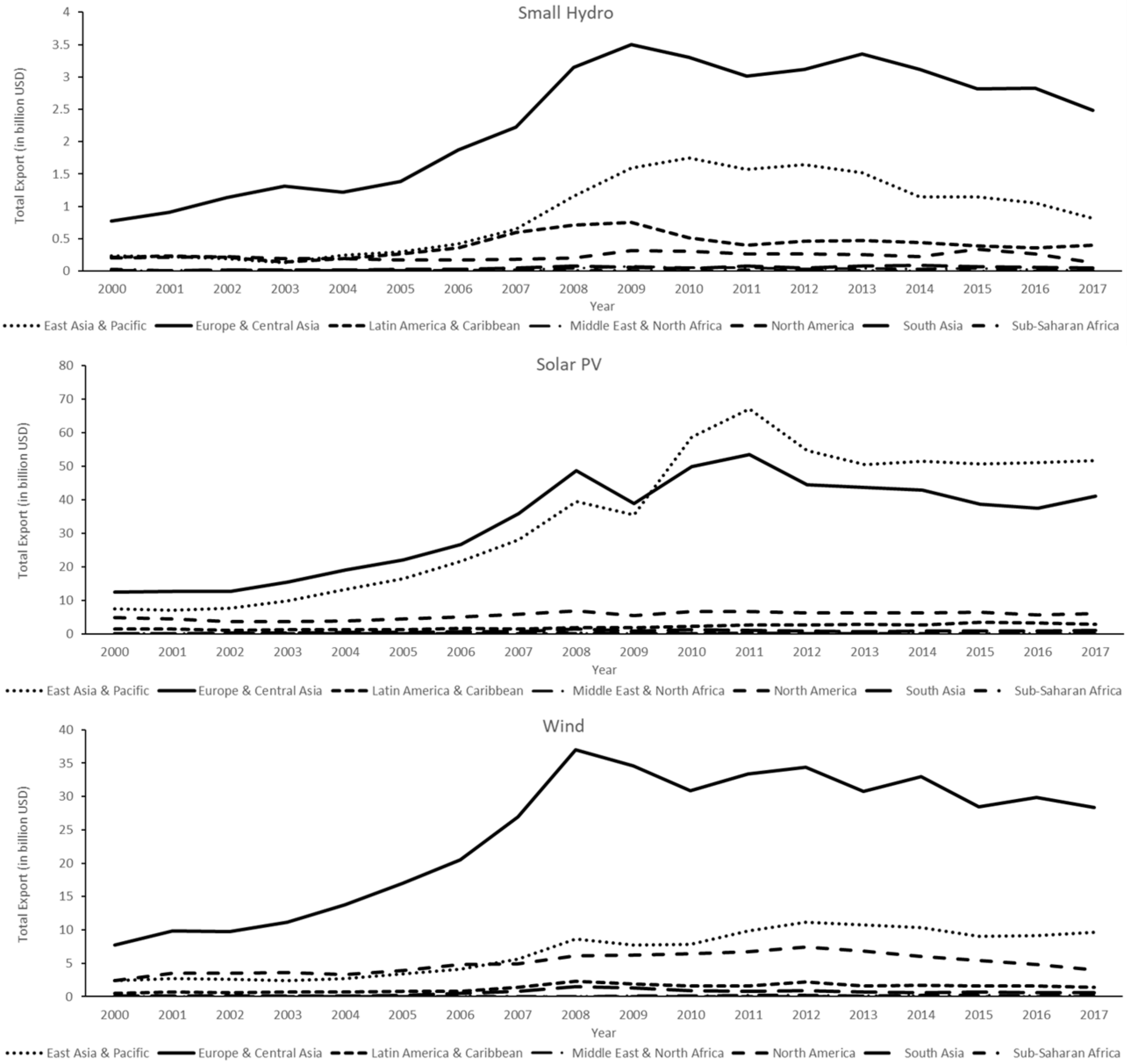


Figure A2.2 - Top 5 Market Size per RET

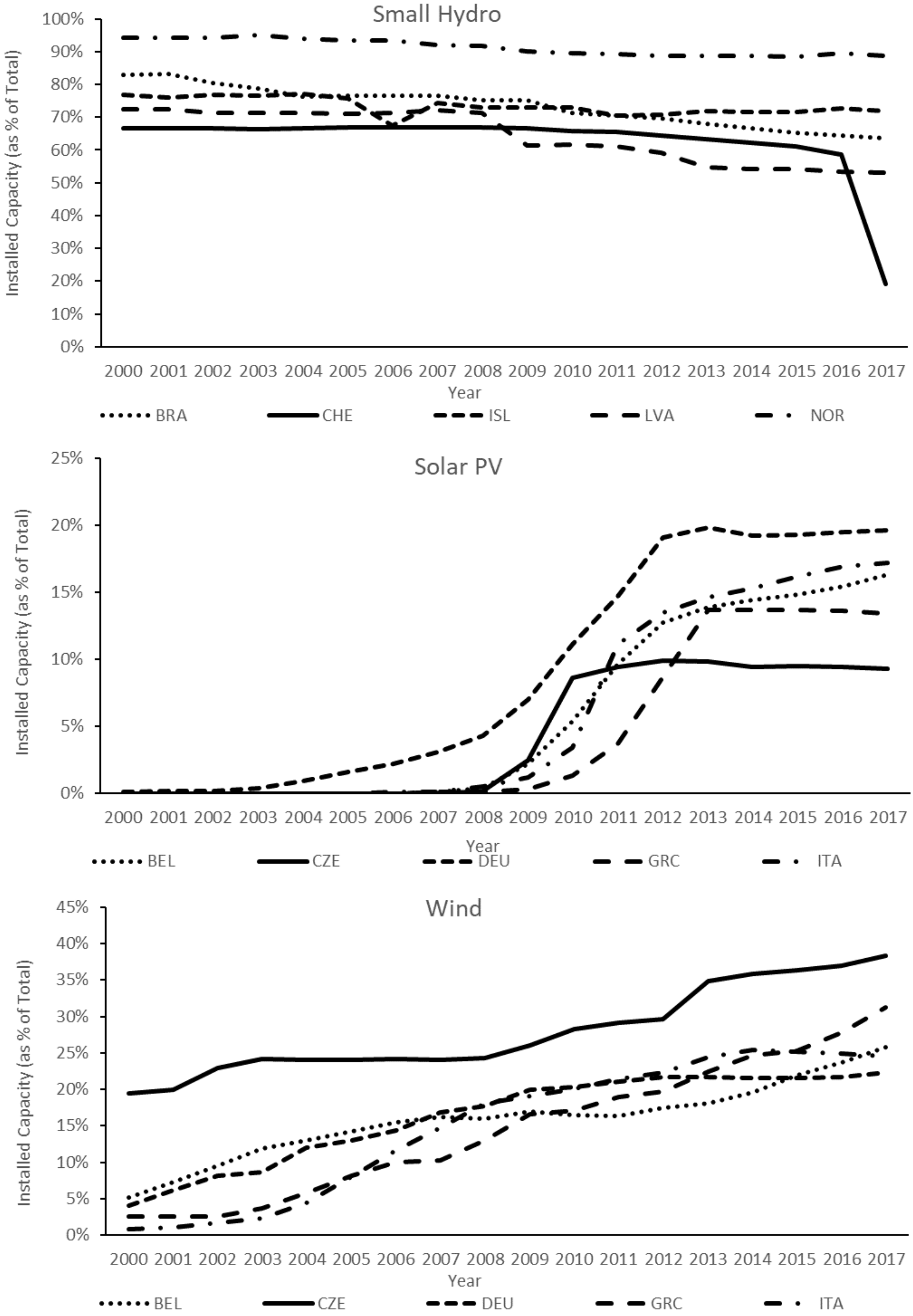


Figure A2.3 - Knowledge Stock per region/RET

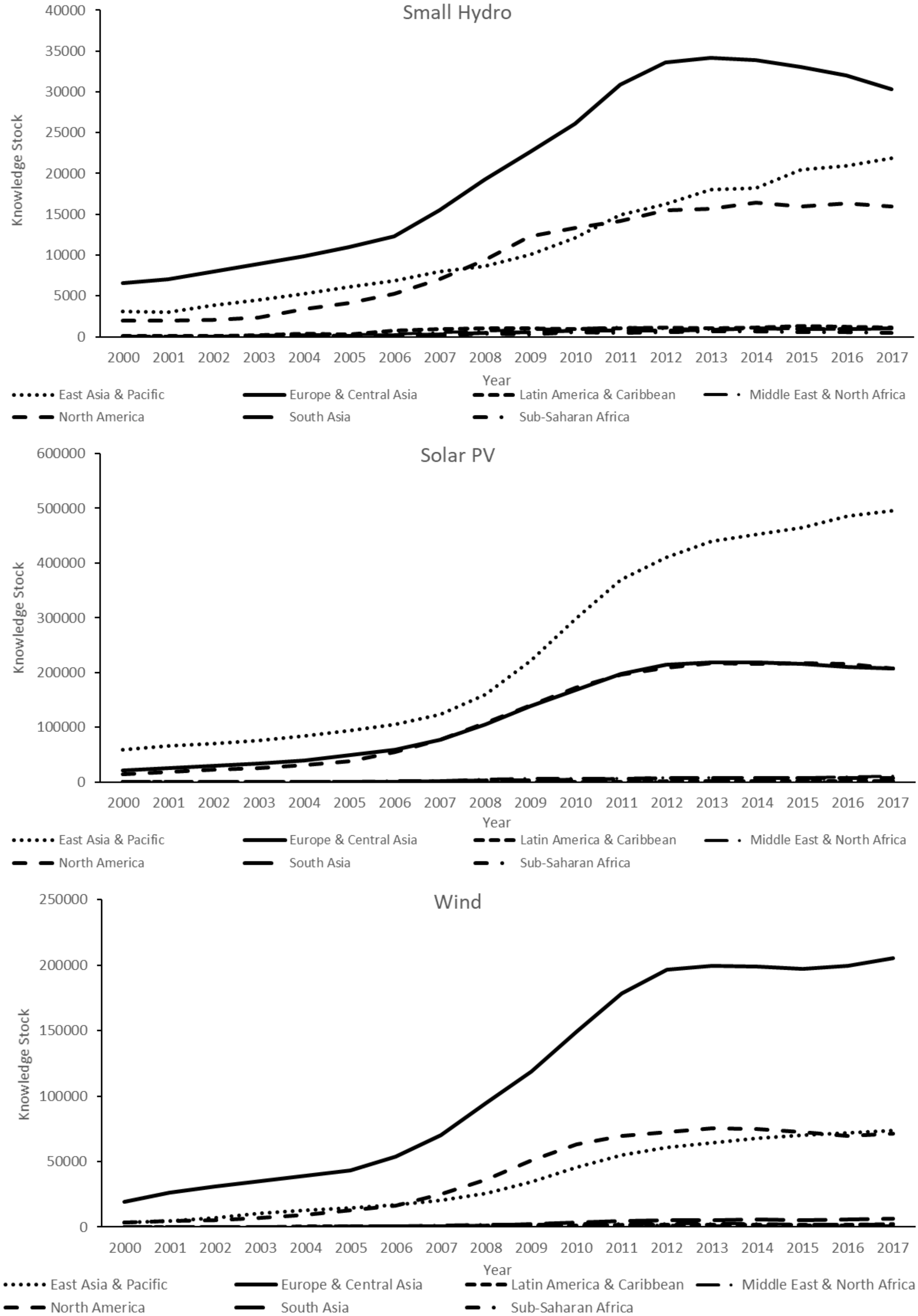


Figure A2.4 - FiT top 5 per RET

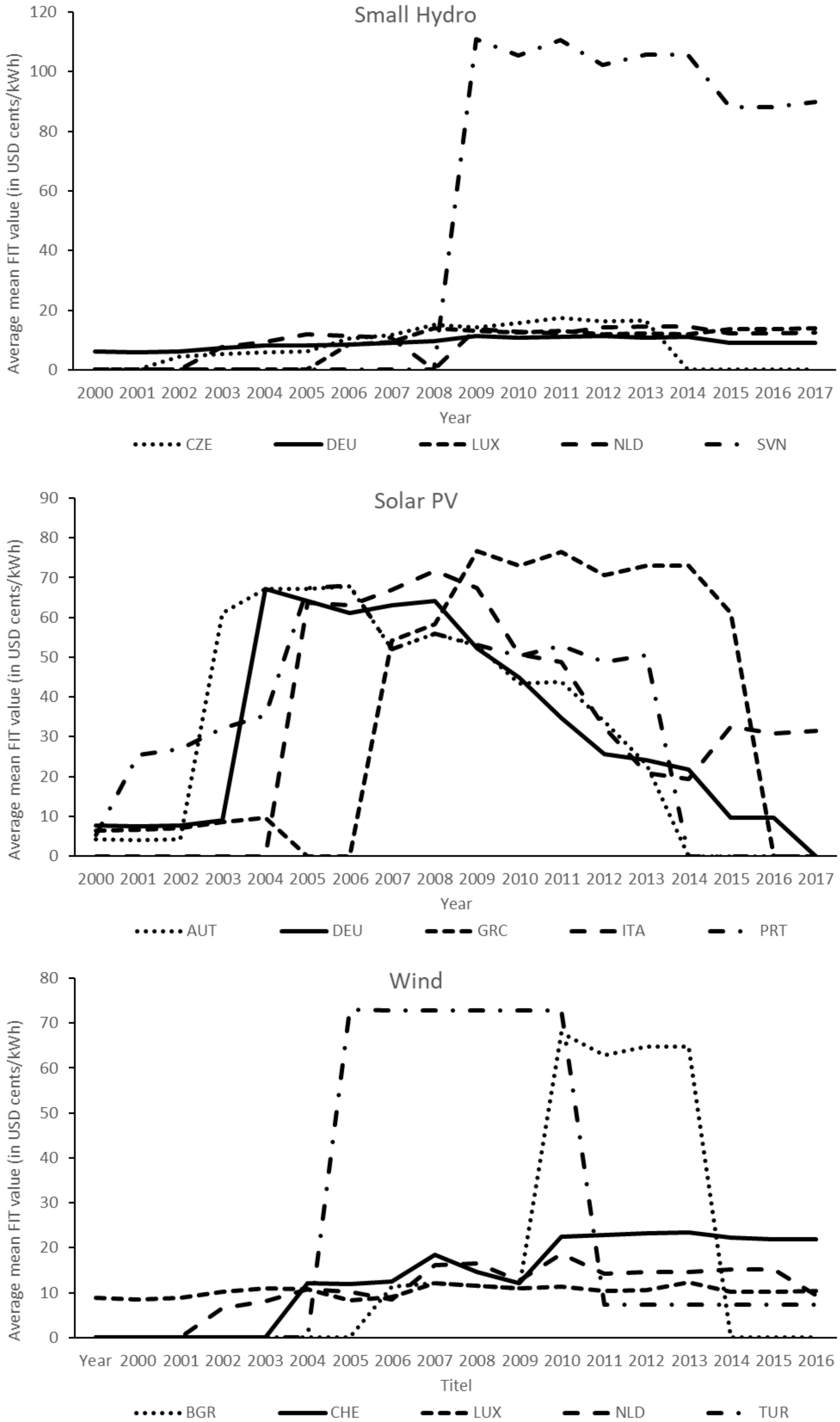


Figure A2.5 - FiT Presence per RET/Region

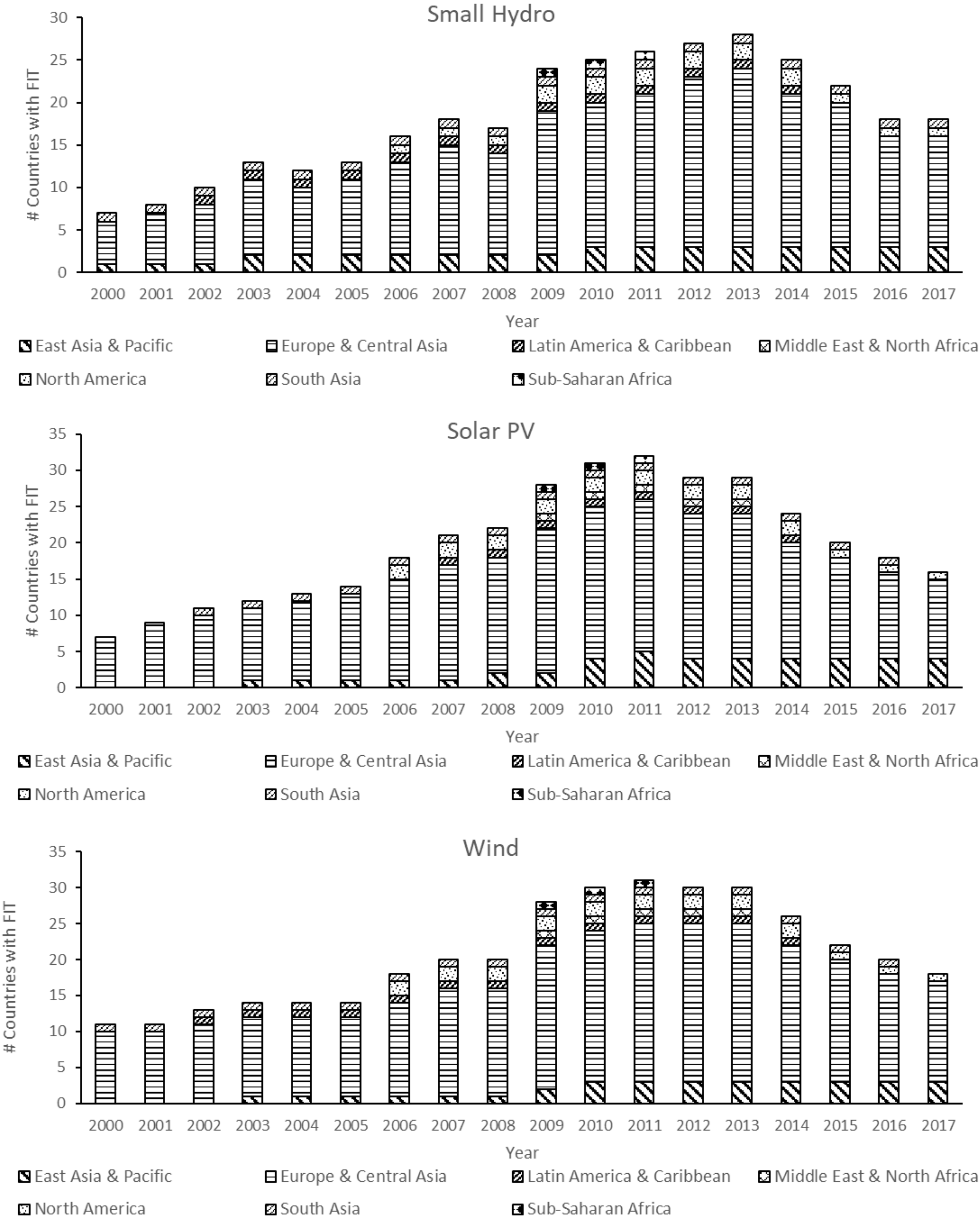
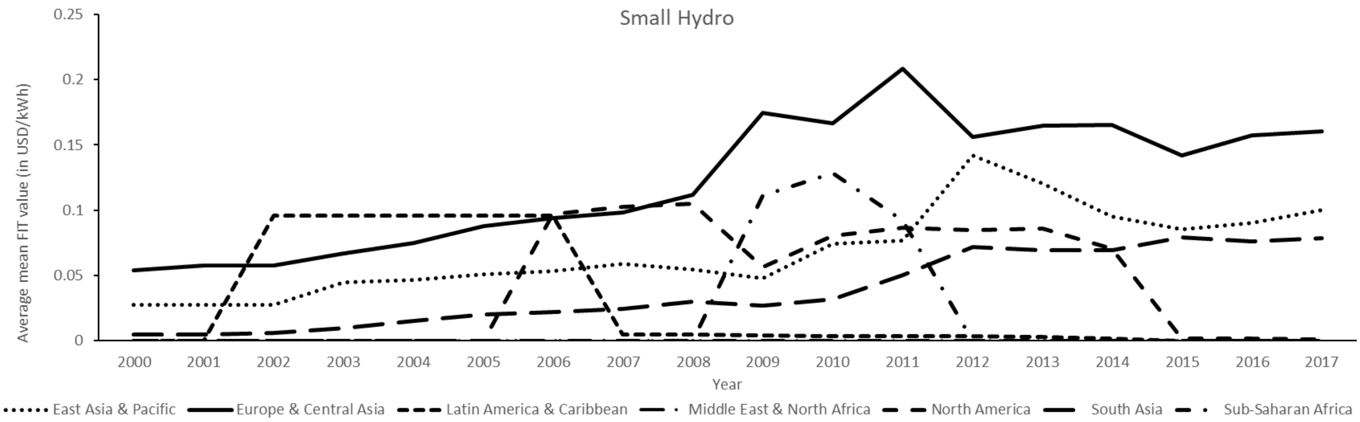
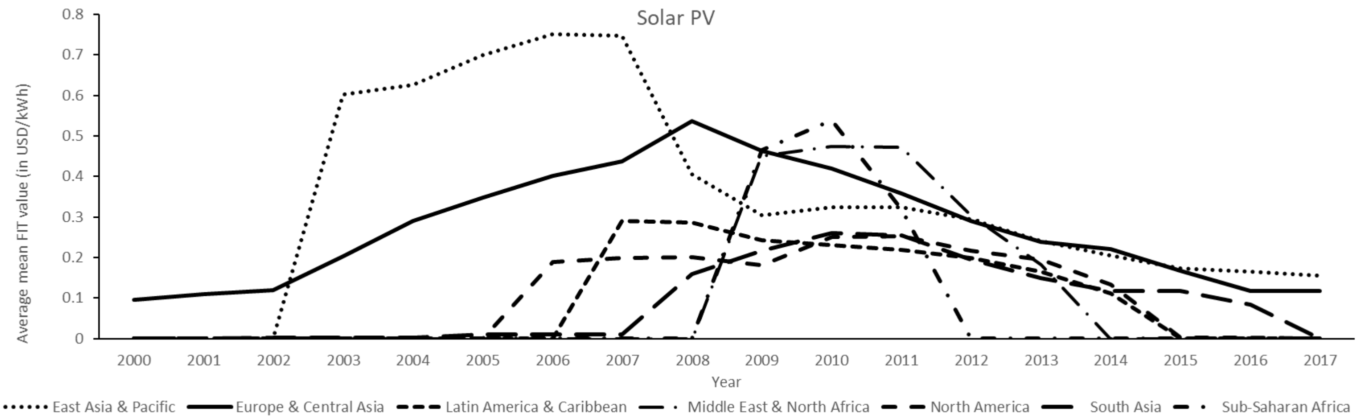
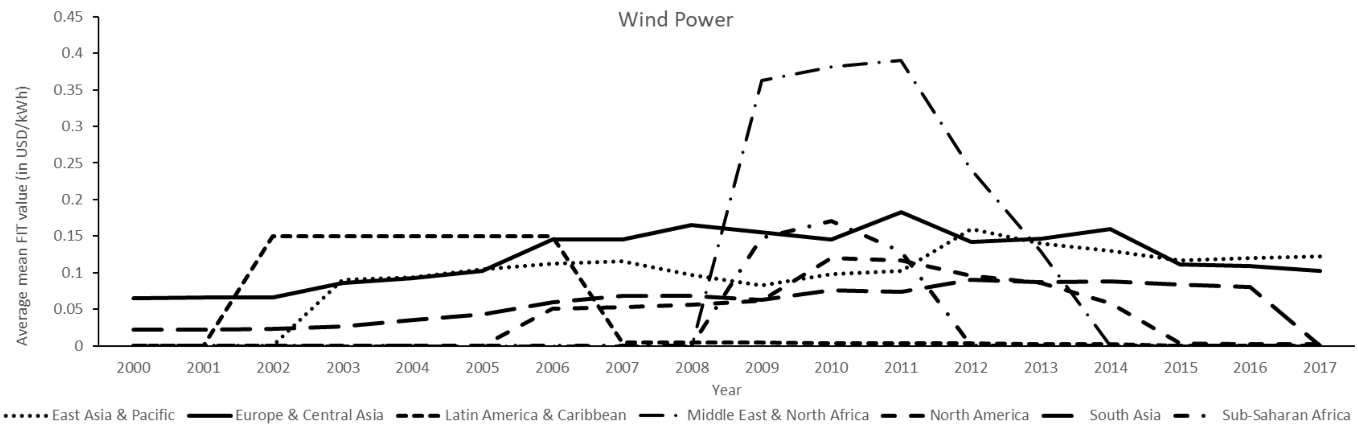


Figure A2.6 - FiT Tariff per RET/Region







Appendix 3: Data and Model

Table A3.1 - Country Sample

	Region							
	East Asia & Pacific	*Europe & Central Asia*		*Latin America & Caribbean*	*Middle East & North Africa*	*North America*	*South Asia*	*Sub-Saharan Africa*
Country	Australia	Austria	Latvia	Argentina[*#]	Isreal	Canada	India [*#]	South Africa [*#]
	China [*#]	Belgium	Lithunia [+]	Brazil [*#]	Malta [*+]	United States [+]		
	Indonesia [*#]	Bulgaria [*+]	Luxembourg	Chile [#]	Saudi Arabia [*#]			
	Japan	Croatia [*+]	Netherlands	Mexico [#]				
	Korea [#+]	Cyprus [*+]	Norway					
	New Zealand	Czech Republic [+]	Poland					
		Denmark	Portugal					
		Estonia	Romania [*+]					
		Finland	Russian Federation [*#]					
		France	Slovak Republic [+]					
		Germany	Slovenia					
		Greece	Spain					
		Hungary	Sweden					
		Iceland	Switzerland					
		Ireland	Turkey [#]					
		Italy	United Kingdom [+]					

Source: regional classification based on UN COMTRADE; [*] indicates country is not an OECD member, [#] indicates country classiefied as developing based on UN WESP (2020), [+] indicates country is excluded from fossil fuel support extension

Table A3.2 - Country ISO3-Codes

Country	*ISO3-Code*	*Country*	*ISO3-Code*
Argentina	ARG	Iceland	ISL
Australia	AUS	Israel	ISR
Austria	AUT	Italy	ITA
Belgium	BEL	Japan	JPN
Bulgaria	BGR	Korea	KOR
Brazil	BRA	Lithuania	LTU
Canada	CAN	Luxembourg	LUX
Switzerland	CHE	Latvia	LVA
Chile	CHL	Mexico	MEX
China	CHN	Malta	MLT
Cyprus	CYP	Netherlands	NLD
Czech Republic	CZE	Norway	NOR
Germany	DEU	New Zealand	NZL
Denmark	DNK	Poland	POL
Spain	ESP	Portugal	PRT
Estonia	EST	Romania	ROU
Finland	FIN	Russia	RUS
France	FRA	Saudi Arabia	SAU
United Kingdom	GBR	Slovak Republic	SVK
Greece	GRC	Slovenia	SVN
Croatia	HRV	Sweden	SWE
Hungary	HUN	Turkey	TUR
Indonesia	IDN	United States	USA
India	IND	South Africa	ZAF
Ireland	IRL		

Table A3.3 - Variable Description

Variable	*Variable Description*	*Source*	*Notes*
X_{ijrt}	Export of country *i*, to country *j*, for technology *r*, in year *t*, expressed in thousand USD	UN COMTRADE (2021)	Total of all products per technology, obtained via World Integrated Trade Solutions, with development status applied in accordance with UN WESP (2020)
Shared Border	Dummy variable indicating if countries are adjacent, by land or sea		
Common Language	Dummy variable indicating if countries have the same official language		
Colonial Relationship	Dummy variable indicating if countries ever in a colonial relationship		
Common Currency$_{ijt}$	Dummy variable indicating if countries have a common currency in year *t*	CEPII (2016)	
FTA/RTA$_{ijt}$	Dummy variable indicating if countries have a free trade agreement in year *t*, based on WTO agreements		
Common Colonizer$_{ijt}$	Dummy variable indicating if countries shared a common colonizer post 1945		Solely used as overidentifying variable in HSS and ZIP first stage equation
ln(Distance)	Natural Logarithm of population-weighted distance between countries		
ln(GDP)$_{t}$	Natural logarithm of GDP per Capita for country *i* and *j*, expressed in current USD	Worldbank (2021)	Calculated using GDP and Population data from World Development Indicators (WDI)
Total Knowledge Stock$_{t}$	Total accumulated knowlege stock of all patents, for country *i* and *j*	OECD Green Growth (2021)	Starting in 1980, calculated using patent data from residents with family size two and greater, with 15% depreciation rate
Knowledge Stock$_{rt}$	Accumulated knowlege stock of patents per technology, for country *i* and *j*		Starting in 1980, calculated using OECD ENV-Tech Patents (2021) patent data from residents with family size two and greater
Installed Capacity$_{rt}$	Percentage of installed electricity capacity by technology of total installed electricity capacity, for country *i* and *j*	IRENA (2021)	Using only on-grid installed capacity, excluding Pumped Storage; Mixed Hydro Plants; Concentrating Solar PV
DFiT$_{rt-1}$	Dummy variable indicating if country had a Feed-in Tariff in place in previous year, per technology *r*, for country *i* and *j*		
FiT continous years$_{rt-1}$	Number of years of continous FiT in place per technology in previous year, for country *i* and *j*		
FiT Years since enactment$_{rt}$	Number of years since first year of FiT in place per technology, for both country *i* and *j*	OECD Environmental Policy (2021)	
FiT Tariff$_{rt-1}$	Tariff level per technology in previous year, for country *i* and *j*, expressed in USD cents/ kWh,		Tariff represents a mean tariff within a country, when a premium is used instead of a tariff the electricity price is added to make values comparable
FiT Contract Length$_{rt-1}$	Length of purchasing agreement per technology in the previous year, for country *i* and *j*, expressed in years		
ln(Import Tariff)$_{jrt}$	Natural logarithm of (import tariff in percentage + 0.01) applied by country *j,* for technolgy *r,* in year *t*	UN TRAINS (2021)	Weighted value of effectively applied AVE tariff using HS Combined nomenclature, missing data replace with the nearest year, with earlier year winnig the tie
Fossil Fuel Support$_{t}$	Total fossil fuel support per capita, for country *i* and *j*, expressed in current USD	OECD Policy Indicators (2021)	

Table A3.4 - Nomenclature

Renewable Energy Technology	*HS6 Product Code*	*Description*
Solar PV	730890	Iron or steel; structures and parts thereof, n.e.c. in heading 7308
	850440	Electrical Static converters
	850720	Electric accumulators; lead-acid, (other than for starting piston engines), including separators, whether or not rectangular (including square)
	854140 *	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light-emitting diodes (LED)
Wind	730820	Metal Towers And Lattice Masts Of Iron Or Steel
	841280	Power Generating Engines And Motors
	841290	Parts Of Reaction Engines (Except Turbojet)
	841381	Pumps For Liquids
	850164	AC generators (alternators) : Of an output exceeding 750 kVA
	850231*	Electric Generating Sets
	850239	Electric Generating Sets: Other
	850240	Electric Rotary Converters
	850300	Parts suitable for use solely or principally with the machines of heading No. 85.01 or 85.02.
Small Hydro	841011*	Hydraulic Turbines And Water Wheels
	841012*	Hydraulic Turbines And Water Wheels
	841013*	Hydraulic Turbines And Water Wheels
	841090	Turbines; parts of hydraulic turbines and water wheels, including regulators
	850423	Liquid Dielectric Transformers

*Source: 1996 Harmonized Commodity Description and Coding Systems (HS) applied via WITS, * indicates product is used in reduced sample robustness analysis*

Table A3.5 - Overview products included in other studies

Renewable Energy Technology	*HS Product Code*	*Studies* Groba & Cao (2015)	Groba (2014)	Kuik et al. (2019)	Kim & Kim (2015)	Sung & Song (2014)[#]	Constantini & Crespi (2008)*	Constantini & Crespi (2013)*	Constantini & Mazzanti (2012)*	Diederich (2016)
Solar PV	730890									
	850440	X	X	X						
	850720	X	X							
	854140	X	X	X	X		X	X	X	X
Wind	730820	X		X		X				
	841280	X								
	841290	X		X		X				
	841381	X					X	X	X	
	850164			X		X				
	850231	X			X	X	X	X	X	X
	850239	X								
	850240	X					X	X		
	850300			X		X				
Small Hydro	841011						X	X	X	
	841012						X	X	X	
	841013						X	X	X	
	841090						X	X	X	
	850423									

*Source: Own summary, [#] indicates authors included more variables based on Jha (2009); * Indicates authors included more variables based on Steenblik (2005)*

Table A3.6 - OECD ENV-Tech Patents

Patent Topic	*IPC Code*
Renewable Energy Generation	Y02E10/00
Wind	
Wind energy	Y02E10/70
Wind turbines with rotation axis in wind direction	Y02E10/72
Offshore wind turbines	Y02E10/727
Onshore wind turbines	Y02E10/728
Wind turbines with rotation axis perpendicular to the wind direction	Y02E10/74
Power conversion electric or electronic aspects	Y02E10/76
Solar PV	
Photovoltaic [PV] energy	Y02E10/50
PV systems with concentrators	Y02E10/52
CuInSe2 material PV cells	Y02E10/541
Dye sensitized solar cells	Y02E10/542
Solar cells from Group II-VI materials	Y02E10/543
Solar cells from Group III-V materials	Y02E10/544
Microcrystalline silicon PV cells	Y02E10/545
Polycrystalline silicon PV cells	Y02E10/546
Monocrystalline silicon PV cells	Y02E10/547
Amorphous silicon PV cells	Y02E10/548
Organic PV cells	Y02E10/549
Power conversion systems, e.g. maximum power point trackers	Y02E10/56
Hydro	
Hydro energy	Y02E10/20

Source: OECD Env-Tech Patents (2021)

Appendix 4: Regression Tables

Table A4.1 - Standard Gravity Estimation: Model Testing

Estimator:	OLS	OLS	HSS	PPML	PPML	ZIP
Dependent Variable:	ln(X_{ijt})	ln(1+X_{ijt})	ln(X_{ijt})	X_{ijt}>0	X_{ijt}	X_{ijt}
ln(GDPit)	0.918***	1.684***	0.927***	1.284***	1.288***	0.720***
	(0.046)	(0.072)	(0.071)	(0.219)	(0.218)	(0.125)
ln(GDPjt)	0.921***	1.727***	0.929***	0.914***	0.918***	0.490***
	(0.044)	(0.069)	(0.071)	(0.181)	(0.181)	(0.098)
ln(Distance)	-1.726***	-2.849***	-1.740***	-1.601***	-1.605***	-0.806***
	(0.031)	(0.038)	(0.080)	(0.289)	(0.289)	(0.104)
Shared Border	0.538***	0.492***	0.545***	0.602***	0.602***	0.261***
	(0.038)	(0.047)	(0.131)	(0.151)	(0.151)	(0.091)
Common Language	0.402***	0.549***	0.406***	0.797***	0.801***	0.362***
	(0.033)	(0.049)	(0.099)	(0.195)	(0.195)	(0.094)
Colonial Relationship	0.837***	1.556***	0.845***	0.175**	0.178**	0.083
	(0.043)	(0.056)	(0.139)	(0.080)	(0.080)	(0.071)
Common Currency$_{ijt}$	-0.042	-0.139***	-0.042	-0.433***	-0.435***	-0.222*
	(0.033)	(0.050)	(0.076)	(0.163)	(0.163)	(0.122)
FTA/RTA$_{ijt}$	0.245***	0.523***	0.249***	0.459***	0.466***	0.239***
	(0.031)	(0.051)	(0.068)	(0.116)	(0.117)	(0.079)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Test value	217.3	2584.89	39.72	7.82	7.96	0.13
Ramsey Reset Test p-value	0.000	0.000	0.000	0.0052	0.0048	0.7147
N	39246	42336	42336	39246	42336	42336

*Standard errors in parentheses * p<0.10, ** p<0.05 *** p<0.01, using total RET exports as the dependent variable, the HSS and ZIP models use the gravity variables in their respective first stage equation (ommited from output), with the addition of Common Colonizer used as overidentifying variable*

Table A4.2 - Added Capacity Estimation

	Small Hydro				Solar				Wind			
ln(GDP)$_{it}$	-0.051	0.040	-0.006	-0.081	0.133	0.178	0.146	0.191	0.275***	0.313***	0.269***	0.306***
	(0.290)	(0.317)	(0.301)	(0.285)	(0.127)	(0.128)	(0.121)	(0.123)	(0.100)	(0.101)	(0.095)	(0.101)
Installed Capacity$_{irt}$	0.352**	0.345**	0.351**	0.353**	0.105***	0.110***	0.110***	0.106***	0.066***	0.065***	0.072***	0.066***
	(0.173)	(0.171)	(0.176)	(0.173)	(0.024)	(0.025)	(0.024)	(0.023)	(0.013)	(0.014)	(0.014)	(0.013)
Knowledge Stock$_{irt}$	-2.221	-1.378	-3.469*	-1.595	0.099*	0.115**	0.117**	0.127**	-0.381	-0.277	-0.157	-0.424*
	(1.621)	(1.375)	(2.063)	(1.454)	(0.057)	(0.056)	(0.056)	(0.057)	(0.242)	(0.254)	(0.243)	(0.247)
FiT continous years$_{irt-1}$	-0.057*				-0.007				0.001			
	(0.031)				(0.012)				(0.012)			
FiT Years since enactment$_{irt}$		0.031				-0.013				-0.039***		
		(0.025)				(0.012)				(0.012)		
DFiT$_{irt-1}$			-0.473**				0.106*				0.296***	
			(0.198)				(0.054)				(0.076)	
FiT Tariff$_{irt-1}$				0.001				0.010***				-0.004
				(0.006)				(0.003)				(0.002)
FiT Contract Length$_{irt-1}$				-0.032**				-0.006				0.020***
				(0.015)				(0.006)				(0.005)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	833	833	833	833	833	833	833	833	833	833	833	833
R-sq	0.397	0.393	0.401	0.404	0.350	0.351	0.352	0.368	0.365	0.374	0.382	0.384

*Robust standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, simple Fixed Effects OLS regression with added capacity (change in installed capacity) as dependent variable*

Table A4.3 - Full Model

	Hydro		Solar PV		Wind	
	FiT Presence	*FiT Design*	*FiT Presence*	*FiT Design*	*FiT Presence*	*FiT Design*
ln(GDP)$_{it}$	0.435***	0.409***	0.753***	0.748***	0.915***	0.919***
	(0.153)	(0.155)	(0.073)	(0.071)	(0.124)	(0.125)
ln(GDP)$_{jt}$	-0.359**	-0.368**	0.563***	0.571***	0.076	0.077
	(0.166)	(0.167)	(0.117)	(0.097)	(0.122)	(0.122)
ln(Distance)	-0.522***	-0.524***	-0.791***	-0.789***	-0.706***	-0.706***
	(0.137)	(0.137)	(0.054)	(0.054)	(0.055)	(0.055)
Shared Border	0.879***	0.879***	0.269***	0.268***	0.184**	0.184**
	(0.172)	(0.172)	(0.104)	(0.104)	(0.087)	(0.087)
Common Language	0.150	0.150	0.427***	0.426***	0.120	0.121
	(0.141)	(0.141)	(0.104)	(0.104)	(0.107)	(0.107)
Colonial Relationship	-0.245	-0.246	0.108	0.107	0.163	0.163*
	(0.170)	(0.170)	(0.083)	(0.082)	(0.099)	(0.099)
Common Currency$_{ijt}$	0.217	0.219	-0.270*	-0.270**	-0.021	-0.022
	(0.194)	(0.194)	(0.138)	(0.137)	(0.118)	(0.118)
FTA/RTA$_{ijt}$	0.968***	0.959***	0.140	0.145*	0.332***	0.332***
	(0.157)	(0.157)	(0.086)	(0.087)	(0.099)	(0.098)
Installed Capacity$_{irt}$	0.048***	0.049***	0.004	0.006	0.030***	0.031***
	(0.016)	(0.017)	(0.006)	(0.005)	(0.011)	(0.011)
Installed Capacity$_{jrt}$	0.004	0.004	-0.012*	-0.001	0.017**	0.018**
	(0.007)	(0.008)	(0.006)	(0.007)	(0.008)	(0.008)
Knowledge Stock$_{irt}$	-1.824	-1.787	-0.047	-0.038	-0.051	-0.058
	(1.203)	(1.274)	(0.031)	(0.032)	(0.088)	(0.089)
Knowledge Stock$_{jrt}$	-3.383***	-3.335***	-0.033	0.004	-0.353***	-0.349***
	(0.973)	(1.002)	(0.034)	(0.033)	(0.099)	(0.100)
FiT Years since enactment$_{irt}$	0.055***	0.053***	0.007	0.001	0.007	0.008
	(0.020)	(0.020)	(0.010)	(0.010)	(0.011)	(0.011)
FiT Years since enactment$_{jrt}$	-0.016	-0.015	0.004	-0.000	-0.005	-0.006
	(0.017)	(0.017)	(0.010)	(0.010)	(0.011)	(0.011)
DFiT$_{irt-1}$	0.060		-0.181***		-0.168***	
	(0.064)		(0.069)		(0.047)	
DFiT$_{jrt-1}$	0.073		0.118**		-0.009	
	(0.061)		(0.050)		(0.046)	
FiT Tariff$_{irt-1}$		0.001		0.001		0.003
		(0.002)		(0.001)		(0.003)
FiT Contract Length$_{irt-1}$		-0.002		-0.013***		-0.009***
		(0.004)		(0.003)		(0.004)
FiT Tariff$_{jrt-1}$		0.001		0.009***		-0.002
		(0.004)		(0.001)		(0.002)
FiT Contract Length$_{jrt-1}$		0.003		-0.009***		-0.001
		(0.004)		(0.003)		(0.003)
ln(Import Tariff)$_{jrt}$	0.132***	0.132***	-0.053***	-0.054***	-0.021**	-0.021**
	(0.016)	(0.016)	(0.016)	(0.015)	(0.010)	(0.010)
Constant	11.299***	11.721***	5.678***	5.605***	6.554***	6.495***
	(2.122)	(2.119)	(1.374)	(1.317)	(1.757)	(1.760)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	39984	39984	39984	39984	39984	39984
pseudo R-sq	0.706	0.706	0.904	0.907	0.835	0.834
Log Likelihood	-5.538e+07	-5.539e+07	-3.271e+08	-3.186e+08	-2.495e+08	-2.496e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, FiT Continous years ommited from equation due to high correlation with FiT Years since enactment*

Table A4.4 - Temporal Effect: FiT Presence

	Hydro					Solar PV					Wind				
$DFiT_{irt-1}$	0.060					-0.181***					-0.168***				
	(0.064)					(0.069)					(0.047)				
$DFiT_{irt-3}$		0.079					-0.104					-0.092**			
		(0.053)					(0.064)					(0.046)			
$DFiT_{irt-5}$			0.114**					-0.041					-0.021		
			(0.057)					(0.061)					(0.052)		
$DFiT_{irt-7}$				-0.074					0.121***					0.007	
				(0.070)					(0.041)					(0.055)	
$DFiT_{irt-9}$					-0.086					0.052					-0.103*
					(0.091)					(0.049)					(0.061)
$DFiT_{jrt-1}$	0.073	0.045	0.034	0.011	0.006	0.118**	0.135***	0.150***	0.190***	0.136**	-0.009	0.003	-0.024	-0.062	-0.093*
	(0.061)	(0.061)	(0.061)	(0.060)	(0.060)	(0.050)	(0.05)	(0.05)	(0.053)	(0.065)	(0.046)	(0.046)	(0.048)	(0.054)	(0.054)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	39984	35280	30576	25872	21168	39984	35280	30576	25872	21168	39984	35280	30576	25872	21168
pseudo R-sq	0.706	0.705	0.706	0.708	0.710	0.904	0.903	0.903	0.904	0.91	0.835	0.832	0.831	0.829	0.828
Log Likelihood	-5.538e+07	-5.214e+07	-4.844e+07	-4.374e+07	-3.654e+07	-3.271e+08	-3.14E+08	-2.95E+08	-2.68E+08	-2.14E+08	-2.495e+08	-2.36E+08	-2.19E+08	-1.99E+08	-1.64E+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, full FiT Presence model tested, remaining variables included in estimation but ommitted from output*

Table A4.5 - Temporal Effect: FiT Design

	Hydro					Solar PV					Wind				
FiT $Tariff_{irt-1}$	0.001					0.001					0.003				
	(0.002)					(0.001)					(0.003)				
FiT Contract $Length_{irt-1}$	-0.002					-0.013***					-0.009***				
	(0.004)					(0.003)					(0.004)				
FiT $Tariff_{irt-3}$		0.000					0.002**					-0.002			
		(0.002)					(0.001)					(0.002)			
FiT Contract $Length_{irt-3}$		-0.001					-0.010***					-0.004			
		(0.004)					(0.003)					(0.003)			
FiT $Tariff_{irt-5}$			0.003					0.001					-0.002		
			(0.002)					(0.001)					(0.003)		
FiT Contract $Length_{irt-5}$			-0.000					-0.004					0.000		
			(0.004)					(0.003)					(0.003)		
FiT $Tariff_{irt-7}$				0.004*					0.001					0.003	
				(0.002)					(0.001)					(0.003)	
FiT Contract $Length_{irt-7}$				-0.006					0.004					-0.001	
				(0.005)					(0.003)					(0.003)	
FiT $Tariff_{irt-9}$					-0.013					0.000					0.008***
					(0.019)					(0.001)					(0.003)
FiT Contract $Length_{irt-9}$					0.003					0.002					-0.011**
					(0.009)					(0.003)					(0.004)
FiT $Tariff_{jrt-1}$	0.001	0.002	0.002	0.003	0.003	0.009***	0.010***	0.011***	0.011***	0.011***	-0.002	-0.002	-0.002	-0.003	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FiT Contract $Length_{jrt-1}$	0.003	0.001	-0.000	-0.003	-0.003	-0.009***	-0.009***	-0.011***	-0.012***	-0.013***	-0.001	0.001	-0.001	-0.001	-0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	39984	35280	30576	25872	21168	39984	35280	30576	25872	21168	39984	35280	30576	25872	21168
pseudo R-sq	0.706	0.705	0.706	0.708	0.710	0.907	0.906	0.905	0.906	0.912	0.834	0.832	0.831	0.829	0.828
Log Likelihood	-5.539e+07	-5.216e+07	-4.846e+07	-4.373e+07	-3.654e+07	-3.186e+08	-3.055e+08	-2.879e+08	-2.623e+08	-2.105e+08	-2.496e+08	-2.360e+08	-2.193e+08	-1.988e+08	-1.634e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, full FiT Design model tested using lagged exporter FiT Tariff and Contract Length, remaining variables in cluded in estimation but omitted from output*

Table A4.6 - Temporal Effect: Market Size

	Hydro				Solar PV				Wind			
Installed Capacity$_{irt-2}$	0.008				0.002				0.043***			
	(0.017)				(0.006)				(0.010)			
Installed Capacity$_{irt-4}$		0.000				-0.004				0.048***		
		(0.017)				(0.007)				(0.011)		
Installed Capacity$_{irt-6}$			0.012				-0.041				0.038***	
			(0.017)				(0.061)				(0.013)	
Installed Capacity$_{irt-8}$				0.030				-0.012				0.019
				(0.022)				(0.009)				(0.013)
Installed Capacity$_{jrt}$	0.003	-0.001	-0.003	-0.001	-0.012*	-0.017**	-0.022***	-0.032***	0.014*	0.009	0.013	0.011
	(0.008)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	37632	32928	28224	23520	37632	32928	28224	23520	37632	32928	28224	23520
pseudo R-sq	0.703	0.705	0.705	0.708	0.903	0.903	0.903	0.904	0.833	0.832	0.831	0.828
Log Likelihood	-5.425e+07	-5.038e+07	-4.661e+07	-4.084e+07	-3.228e+08	-3.067e+08	-2.849e+08	-2.513e+08	-2.422e+08	-2.271e+08	-2.088e+08	-1.848e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, full model tested without FiT variables, remaining variables included in estimation but omitted from output*

Table A4.7 - Extension: Trade Flow Analysis

	Hydro			Solar PV			Wind		
	Total	Developed-Developing	Developing-Developed	Total	Developed - Developing	Developing-Developed	Total	Developed - Developing	Developing-Developed
FiT Years since enactment$_{irt}$	0.055***	0.025	-0.017	0.007	0.039**	-0.035*	0.007	0.007	0.012
	(0.020)	(0.022)	(0.039)	(0.010)	(0.017)	(0.020)	(0.011)	(0.020)	(0.015)
FiT Years since enactment$_{jrt}$	-0.016	-0.057*	0.079**	0.004	0.027*	0.004	-0.005	0.011	0.011
	(0.017)	(0.029)	(0.037)	(0.010)	(0.015)	(0.036)	(0.011)	(0.026)	(0.033)
DFiT$_{irt-1}$	0.060	0.022	0.139	-0.181***	-0.054	-0.146	-0.168***	-0.292***	0.057
	(0.064)	(0.120)	(0.121)	(0.069)	(0.073)	(0.180)	(0.047)	(0.088)	(0.093)
DFiT$_{jrt-1}$	0.073	-0.102	0.077	0.118**	-0.038	0.281*	-0.009	-0.050	0.090
	(0.061)	(0.104)	(0.111)	(0.050)	(0.082)	(0.149)	(0.046)	(0.080)	(0.074)
ln(Import Tariff)$_{jrt}$	0.132***	0.134***	0.136***	-0.053***	0.015	-0.082***	-0.021**	0.016*	-0.021
	(0.016)	(0.023)	(0.027)	(0.016)	(0.010)	(0.026)	(0.010)	(0.009)	(0.017)
N	39984	7361	7106	39984	7582	7106	39984	7582	7106
pseudo R-sq	0.706	0.607	0.888	0.904	0.937	0.940	0.835	0.819	0.915
Log Likelihood	-5.538e+07	-1.223e+07	-5444833.534	-3.271e+08	-2.579e+07	-8.067e+07	-2.495e+08	-4.797e+07	-2.052e+07

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, full model tested, remaining variables included in estimation but omitted from output*

Table A4.8 - Extension: Fossil-Fuel Support

	Hydro		Solar PV		Wind	
Fossil Fuel Support$_{it}$		-0.0014**		-0.0002		-0.0005*
		(0.001)		(0.000)		(0.000)
Fossil Fuel Support$_{jt}$		-0.0004**		0.0004**		-0.0003
		(0.000)		(0.000)		(0.000)
DFiT$_{irt-1}$	0.060	0.1202*	-0.181***	-0.0490	-0.168***	-0.1701**
	(0.064)	(0.070)	(0.069)	(0.126)	(0.047)	(0.066)
DFiT$_{jrt-1}$	0.073	0.0544	0.118**	0.2065**	-0.009	-0.2100**
	(0.061)	(0.079)	(0.050)	(0.099)	(0.046)	(0.083)
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	39984	12654	39984	12654	39984	12654
pseudo R-sq	0.706	0.650	0.904	0.900	0.835	0.803
Log Likelihood	-5.538e+07	-2.073e+07	-3.271e+08	-1.3663e+08	-2.495e+08	-9.7103e+07

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, full model tested, remaining variables included in estimation but omitted from output, reduced sample is marked in table A3.1 and uses the time period 2007-2015*

Table A4.9 - Robustness: Estimation Method – FiT Presence

Technology:	Small Hydro				Solar PV				Wind			
Estimator:	***OLS***	***HSS***	***ZIP***	***PPML***	***OLS***	***HSS***	***ZIP***	***PPML***	***OLS***	***HSS***	***ZIP***	***PPML***
ln(GDP)$_{it}$	0.696***	0.696***	0.432***	0.435***	0.743***	0.743***	0.754***	0.753***	0.786***	0.788***	0.914***	0.915***
	(0.114)	(0.149)	(0.150)	(0.153)	(0.049)	(0.069)	(0.073)	(0.073)	(0.058)	(0.083)	(0.124)	(0.124)
ln(GDP)$_{jt}$	0.045	0.039	-0.353**	-0.359**	0.663***	0.663***	0.561***	0.563***	0.681***	0.680***	0.071	0.076
	(0.114)	(0.153)	(0.162)	(0.166)	(0.049)	(0.068)	(0.117)	(0.117)	(0.059)	(0.078)	(0.122)	(0.122)
ln(Distance)	-0.704***	-0.710***	-0.376***	-0.522***	-1.449***	-1.449***	-0.791***	-0.791***	-1.280***	-1.279***	-0.704***	-0.706***
	(0.040)	(0.079)	(0.134)	(0.137)	(0.017)	(0.050)	(0.054)	(0.054)	(0.021)	(0.057)	(0.055)	(0.055)
Shared Border	0.891***	1.081***	0.841***	0.879***	0.447***	0.447***	0.271***	0.269***	0.394***	0.400***	0.187**	0.184**
	(0.074)	(0.170)	(0.161)	(0.172)	(0.039)	(0.134)	(0.104)	(0.104)	(0.046)	(0.152)	(0.086)	(0.087)
Common Language	0.238***	0.304*	0.198	0.150	0.371***	0.371***	0.426***	0.427***	0.237***	0.241**	0.120	0.120
	(0.076)	(0.165)	(0.135)	(0.141)	(0.035)	(0.105)	(0.104)	(0.104)	(0.041)	(0.115)	(0.107)	(0.107)
Colonial Relationship	0.204**	0.339**	-0.296*	-0.245	0.613***	0.613***	0.106	0.108	0.832***	0.840***	0.161	0.163
	(0.082)	(0.163)	(0.163)	(0.170)	(0.043)	(0.141)	(0.083)	(0.083)	(0.050)	(0.158)	(0.099)	(0.099)
Common Currency$_{ijt}$	0.245***	0.243	0.217	0.217	-0.037	-0.037	-0.270*	-0.270*	-0.230***	-0.231**	-0.023	-0.021
	(0.082)	(0.169)	(0.191)	(0.194)	(0.034)	(0.082)	(0.138)	(0.138)	(0.043)	(0.099)	(0.118)	(0.118)
FTA/RTA$_{ijt}$	0.884***	1.047***	0.757***	0.968***	0.228***	0.229***	0.134	0.140	0.265***	0.275***	0.316***	0.332***
	(0.081)	(0.149)	(0.154)	(0.157)	(0.036)	(0.077)	(0.086)	(0.086)	(0.042)	(0.088)	(0.099)	(0.099)
Installed Capacity$_{irt}$	0.032***	0.032***	0.042***	0.048***	0.015***	0.015***	0.004	0.004	0.029***	0.028***	0.030***	0.030***
	(0.007)	(0.007)	(0.015)	(0.016)	(0.003)	(0.004)	(0.006)	(0.006)	(0.004)	(0.006)	(0.011)	(0.011)
Installed Capacity$_{jrt}$	-0.004	-0.004	0.002	0.004	-0.002	-0.002	-0.012*	-0.012*	-0.001	-0.001	0.017**	0.017**
	(0.007)	(0.008)	(0.007)	(0.007)	(0.004)	(0.005)	(0.006)	(0.006)	(0.004)	(0.006)	(0.008)	(0.008)
Knowledge Stock$_{irt}$	-0.196	-0.321	-1.543	-1.824	-0.085***	-0.085***	-0.046	-0.047	-0.010	-0.017	-0.040	-0.051
	(0.710)	(0.902)	(1.195)	(1.203)	(0.018)	(0.026)	(0.031)	(0.031)	(0.065)	(0.096)	(0.088)	(0.088)
Knowledge Stock$_{jrt}$	-1.596*	-1.695*	-2.687***	-3.383***	0.013	0.013	-0.032	-0.033	-0.024	-0.028	-0.344***	-0.353***
	(0.852)	(1.019)	(0.955)	(0.973)	(0.021)	(0.029)	(0.034)	(0.034)	(0.073)	(0.109)	(0.100)	(0.099)
FiT Years since enactment$_{irt}$	0.071***	0.071***	0.052***	0.055***	0.037***	0.037***	0.008	0.007	0.029***	0.029***	0.007	0.007
	(0.010)	(0.013)	(0.020)	(0.020)	(0.004)	(0.006)	(0.010)	(0.010)	(0.005)	(0.007)	(0.011)	(0.011)
FiT Years since enactment$_{jrt}$	0.011	0.011	-0.015	-0.016	0.008*	0.007	0.004	0.004	-0.001	-0.001	-0.005	-0.005
	(0.009)	(0.012)	(0.017)	(0.017)	(0.004)	(0.006)	(0.010)	(0.010)	(0.005)	(0.007)	(0.011)	(0.011)
DFiT$_{irt-1}$	-0.131**	-0.128**	0.062	0.060	-0.027	-0.027	-0.182***	-0.181***	-0.133***	-0.133***	-0.168***	-0.168***
	(0.055)	(0.059)	(0.070)	(0.064)	(0.022)	(0.027)	(0.069)	(0.069)	(0.028)	(0.032)	(0.047)	(0.047)
DFiT$_{jrt-1}$	0.035	0.035	0.051	0.073	0.086***	0.086***	0.117**	0.118**	0.010	0.010	-0.010	-0.009
	(0.055)	(0.061)	(0.060)	(0.061)	(0.023)	(0.027)	(0.050)	(0.050)	(0.028)	(0.032)	(0.046)	(0.046)
ln(Import Tariff)$_{jrt}$	0.126***	0.126***	0.068***	0.132***	0.024***	0.024***	-0.054***	-0.053***	0.025***	0.026***	-0.024**	-0.021**
	(0.010)	(0.014)	(0.014)	(0.016)	(0.005)	(0.007)	(0.016)	(0.016)	(0.006)	(0.009)	(0.010)	(0.010)
N	16235	41493	39984	39984	36424	40404	39984	39984	33333	40553	39984	39984
(pseudo) R-sq	0.385			0.706	0.770			0.904	0.703			0.835
Log Likelihood	-36821.988	-52197.900	-4.722e+07	-5.538e+07	-65247.343	-70865.465	-3.259e+08	-3.271e+08	-65225.915	-73349.356	-2.476e+08	-2.495e+08

(*Clustered) standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, First stage estimation of HSS and ZIP using the gravity variables and Common Colonizer as overidentfying variable omitted from output, estimations showed the expected signs for both estimators, apart from a negative effect found for Common Currency*

Table A4.10 - Robustness: Estimation Method – FiT Design

Technology:	Small Hydro				Solar PV				Wind			
Estimator:	***OLS***	***HSS***	***ZIP***	***PPML***	***OLS***	***HSS***	***ZIP***	***PPML***	***OLS***	***HSS***	***ZIP***	***PPML***
ln(GDP)$_{it}$	0.721***	0.721***	0.403***	0.409***	0.742***	0.742***	0.748***	0.748***	0.771***	0.772***	0.917***	0.919***
	(0.115)	(0.149)	(0.153)	(0.155)	(0.049)	(0.069)	(0.071)	(0.071)	(0.058)	(0.084)	(0.125)	(0.125)
ln(GDP)$_{jt}$	0.044	0.037	-0.360**	-0.368**	0.682***	0.682***	0.569***	0.571***	0.683***	0.682***	0.071	0.077
	(0.114)	(0.153)	(0.164)	(0.167)	(0.049)	(0.067)	(0.097)	(0.097)	(0.059)	(0.078)	(0.122)	(0.122)
ln(Distance)	-0.704***	-0.711***	-0.379***	-0.524***	-1.447***	-1.447***	-0.788***	-0.789***	-1.280***	-1.278***	-0.704***	-0.706***
	(0.040)	(0.079)	(0.133)	(0.137)	(0.017)	(0.050)	(0.054)	(0.054)	(0.021)	(0.057)	(0.055)	(0.055)
Shared Border	0.895***	1.085***	0.841***	0.879***	0.448***	0.448***	0.270***	0.268***	0.394***	0.400***	0.187**	0.184**
	(0.074)	(0.170)	(0.161)	(0.172)	(0.039)	(0.134)	(0.104)	(0.104)	(0.046)	(0.152)	(0.086)	(0.087)
Common Language	0.236***	0.302*	0.198	0.150	0.371***	0.371***	0.425***	0.426***	0.237***	0.241**	0.121	0.121
	(0.076)	(0.165)	(0.135)	(0.141)	(0.035)	(0.105)	(0.104)	(0.104)	(0.041)	(0.115)	(0.107)	(0.107)
Colonial Relationship	0.204**	0.340**	-0.297*	-0.246	0.613***	0.613***	0.105	0.107	0.832***	0.840***	0.161	0.163*
	(0.082)	(0.163)	(0.163)	(0.170)	(0.043)	(0.141)	(0.082)	(0.082)	(0.050)	(0.158)	(0.099)	(0.099)
Common Currency$_{ijt}$	0.224***	0.222	0.221	0.219	-0.038	-0.037	-0.270**	-0.270**	-0.230***	-0.231**	-0.024	-0.022
	(0.082)	(0.169)	(0.192)	(0.194)	(0.034)	(0.082)	(0.137)	(0.137)	(0.043)	(0.099)	(0.117)	(0.118)
FTA/RTA$_{ijt}$	0.885***	1.048***	0.748***	0.959***	0.234***	0.235***	0.138	0.145*	0.267***	0.277***	0.317***	0.332***
	(0.081)	(0.149)	(0.154)	(0.157)	(0.036)	(0.077)	(0.087)	(0.087)	(0.042)	(0.088)	(0.099)	(0.098)
Installed Capacity$_{irt}$	0.030***	0.030***	0.043***	0.049***	0.015***	0.015***	0.006	0.006	0.029***	0.029***	0.031***	0.031***
	(0.007)	(0.007)	(0.016)	(0.017)	(0.003)	(0.005)	(0.005)	(0.005)	(0.004)	(0.006)	(0.011)	(0.011)
Installed Capacity$_{jrt}$	-0.003	-0.003	0.002	0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.018**	0.018**
	(0.007)	(0.008)	(0.007)	(0.008)	(0.004)	(0.005)	(0.007)	(0.007)	(0.004)	(0.006)	(0.008)	(0.008)
Knowledge Stock$_{irt}$	0.406	0.285	-1.621	-1.787	-0.084***	-0.084***	-0.036	-0.038	0.018	0.010	-0.047	-0.058
	(0.732)	(0.925)	(1.264)	(1.274)	(0.018)	(0.025)	(0.032)	(0.032)	(0.066)	(0.097)	(0.089)	(0.089)
Knowledge Stock$_{jrt}$	-1.490*	-1.597	-2.727***	-3.335***	0.024	0.024	0.005	0.004	-0.016	-0.020	-0.340***	-0.349***
	(0.865)	(1.023)	(0.977)	(1.002)	(0.021)	(0.029)	(0.033)	(0.033)	(0.074)	(0.110)	(0.101)	(0.100)
FiT Years since enactment$_{irt}$	0.070***	0.069***	0.050**	0.053***	0.037***	0.037***	0.001	0.001	0.028***	0.027***	0.008	0.008
	(0.010)	(0.013)	(0.019)	(0.020)	(0.004)	(0.006)	(0.010)	(0.010)	(0.005)	(0.007)	(0.011)	(0.011)
FiT Years since enactment$_{jrt}$	0.010	0.010	-0.015	-0.015	0.006	0.006	0.000	-0.000	-0.002	-0.002	-0.005	-0.006
	(0.009)	(0.012)	(0.017)	(0.017)	(0.004)	(0.006)	(0.010)	(0.010)	(0.005)	(0.007)	(0.011)	(0.011)
FiT Tariff$_{irt-1}$	0.008***	0.008***	-0.001	0.001	0.000	0.000	0.001	0.001	0.003*	0.003*	0.003	0.003
	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
FiT Contract Length$_{irt-1}$	-0.012***	-0.012***	-0.001	-0.002	-0.002	-0.002	-0.013***	-0.013***	-0.010***	-0.010***	-0.009***	-0.009***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)	(0.004)
FiT Tariff$_{jrt-1}$	0.000	0.000	0.000	0.001	0.004***	0.004***	0.010***	0.009***	0.003	0.003	-0.002	-0.002
	(0.003)	(0.003)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
FiT Contract Length$_{jrt-1}$	-0.000	-0.000	0.002	0.003	-0.000	-0.000	-0.009***	-0.009***	-0.001	-0.001	-0.001	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
ln(Import Tariff)$_{jrt}$	0.126***	0.126***	0.068***	0.132***	0.024***	0.024***	-0.055***	-0.054***	0.026***	0.026***	-0.025**	-0.021**
	(0.010)	(0.014)	(0.014)	(0.016)	(0.005)	(0.007)	(0.015)	(0.015)	(0.006)	(0.009)	(0.010)	(0.010)
N	16235	41493	39984	39984	36424	40404	39984	39984	33333	40553	39984	39984
(pseudo) R-sq	0.386			0.706	0.770			0.907	0.703			0.834
Log Likelihood	-36816.417	-52192.225	-4.723e+07	-5.539e+07	-65233.943	-70852.062	-3.174e+08	-3.186e+08	-65221.778	-73345.185	-2.477e+08	-2.496e+08

*(Clustered) standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, First stage estimation of HSS and ZIP using the gravity variables and Common Colonizer as overidentfying variable omitted from output, estimations showed the expected signs for both estimators, apart from a negative effect found for Common Currency*

Table A4.11 - Robustness: Reduced Product Subsample

	Hydro		Solar PV		Wind	
	Full Sample	*Reduced*	*Full Sample*	*Reduced*	*Full Sample*	*Reduced*
ln(GDP)$_{it}$	0.409***	0.316	0.748***	1.225***	0.919***	0.883**
	(0.155)	(0.239)	(0.071)	(0.198)	(0.125)	(0.345)
ln(GDP)$_{jt}$	-0.368**	-0.555**	0.571***	0.807**	0.077	-0.440
	(0.167)	(0.270)	(0.097)	(0.316)	(0.122)	(0.462)
ln(Distance)	-0.524***	-0.623***	-0.789***	-0.762***	-0.706***	-0.619***
	(0.137)	(0.136)	(0.054)	(0.085)	(0.055)	(0.191)
Shared Border	0.879***	0.392	0.268***	0.063	0.184**	0.993***
	(0.172)	(0.241)	(0.104)	(0.188)	(0.087)	(0.349)
Common Language	0.150	0.109	0.426***	0.035	0.121	0.632*
	(0.141)	(0.298)	(0.104)	(0.224)	(0.107)	(0.355)
Colonial Relationship	-0.246	0.240	0.107	0.385**	0.163*	0.138
	(0.170)	(0.271)	(0.082)	(0.195)	(0.099)	(0.290)
Common Currency$_{ijt}$	0.219	0.582*	-0.270**	-0.201	-0.022	-0.020
	(0.194)	(0.314)	(0.137)	(0.230)	(0.118)	(0.286)
FTA/RTA$_{ijt}$	0.959***	0.541	0.145*	0.464**	0.332***	0.608*
	(0.157)	(0.397)	(0.087)	(0.182)	(0.098)	(0.331)
Installed Capacity$_{irt}$	0.049***	0.015	0.006	0.012	0.031***	0.050
	(0.017)	(0.026)	(0.005)	(0.015)	(0.011)	(0.037)
Installed Capacity$_{jrt}$	0.004	-0.008	-0.001	-0.011	0.018**	0.004
	(0.008)	(0.011)	(0.007)	(0.019)	(0.008)	(0.023)
Knowledge Stock$_{irt}$	-1.787	2.024	-0.038	-0.191***	-0.058	-0.047
	(1.274)	(2.217)	(0.032)	(0.068)	(0.089)	(0.373)
Knowledge Stock$_{jrt}$	-3.335***	-6.060***	0.004	0.118	-0.349***	-1.586***
	(1.002)	(1.452)	(0.033)	(0.106)	(0.100)	(0.347)
FiT Years since enactment$_{irt}$	0.053***	0.062	0.001	0.013	0.008	-0.002
	(0.020)	(0.042)	(0.010)	(0.031)	(0.011)	(0.070)
FiT Years since enactment$_{jrt}$	-0.015	-0.093***	-0.000	0.008	-0.006	-0.047*
	(0.017)	(0.033)	(0.010)	(0.028)	(0.011)	(0.025)
FiT Tariff$_{irt-1}$	0.001	-0.003	0.001	0.004	0.003	-0.064**
	(0.002)	(0.004)	(0.001)	(0.003)	(0.003)	(0.026)
FiT Contract Length$_{irt-1}$	-0.002	0.007	-0.013***	-0.018**	-0.009***	0.017
	(0.004)	(0.008)	(0.003)	(0.007)	(0.004)	(0.016)
FiT Tariff$_{jrt-1}$	0.001	0.001	0.009***	0.022***	-0.002	-0.006
	(0.004)	(0.005)	(0.001)	(0.004)	(0.002)	(0.004)
FiT Contract Length$_{jrt-1}$	0.003	0.012	-0.009***	-0.013	-0.001	0.006
	(0.004)	(0.007)	(0.003)	(0.009)	(0.003)	(0.008)
ln(Import Tariff)$_{jrt}$	0.132***	0.193***	-0.054***	-0.028	-0.021**	0.079***
	(0.016)	(0.043)	(0.015)	(0.055)	(0.010)	(0.026)
N	39984	39984	39984	39984	39984	39984
pseudo R-sq	0.706	0.553	0.907	0.878	0.834	0.804
Log Likelihood	-5.539e+07	-7719447.650	-3.186e+08	-2.088e+08	-2.496e+08	-8.434e+07

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01, the reduced sample is based on fewer products included per technology, which is indicated in the Nomenclature*

Table A4.12 - Robustness: Excluding China

	Hydro		Solar PV		Wind	
	Inc. China	*Exc. China*	*Inc. China*	*Exc. China*	*Inc. China*	*Exc. China*
ln(GDP)$_{it}$	0.409***	-0.143	0.748***	0.594***	0.919***	0.429***
	(0.155)	(0.184)	(0.071)	(0.144)	(0.125)	(0.152)
ln(GDP)$_{jt}$	-0.368**	0.405**	0.571***	0.777***	0.077	0.465***
	(0.167)	(0.162)	(0.097)	(0.137)	(0.122)	(0.170)
ln(Distance)	-0.524***	-0.866***	-0.789***	-0.853***	-0.706***	-0.747***
	(0.137)	(0.091)	(0.054)	(0.056)	(0.055)	(0.062)
Shared Border	0.879***	0.602***	0.268***	0.383***	0.184**	0.137
	(0.172)	(0.139)	(0.104)	(0.098)	(0.087)	(0.093)
Common Language	0.150	0.143	0.426***	0.339***	0.121	0.096
	(0.141)	(0.152)	(0.104)	(0.086)	(0.107)	(0.113)
Colonial Relationship	-0.246	-0.376**	0.107	-0.021	0.163*	0.159
	(0.170)	(0.165)	(0.082)	(0.081)	(0.099)	(0.103)
Common Currency$_{ijt}$	0.219	0.102	-0.270**	-0.094	-0.022	0.004
	(0.194)	(0.185)	(0.137)	(0.113)	(0.118)	(0.126)
FTA/RTA$_{ijt}$	0.959***	0.787***	0.145*	0.373***	0.332***	0.322***
	(0.157)	(0.148)	(0.087)	(0.101)	(0.098)	(0.122)
Installed Capacity$_{irt}$	0.049***	0.033**	0.006	0.008	0.031***	0.030**
	(0.017)	(0.015)	(0.005)	(0.005)	(0.011)	(0.012)
Installed Capacity$_{jrt}$	0.004	0.019*	-0.001	-0.005	0.018**	0.019**
	(0.008)	(0.010)	(0.007)	(0.007)	(0.008)	(0.008)
Knowledge Stock$_{irt}$	-1.787	-0.540	-0.038	-0.038	-0.058	-0.090
	(1.274)	(1.295)	(0.032)	(0.039)	(0.089)	(0.087)
Knowledge Stock$_{jrt}$	-3.335***	-1.970**	0.004	0.017	-0.349***	-0.371***
	(1.002)	(0.991)	(0.033)	(0.037)	(0.100)	(0.101)
FiT Years since enactment$_{irt}$	0.053***	0.047***	0.001	0.013	0.008	0.019
	(0.020)	(0.016)	(0.010)	(0.009)	(0.011)	(0.011)
FiT Years since enactment$_{jrt}$	-0.015	0.007	-0.000	-0.006	-0.006	-0.003
	(0.017)	(0.018)	(0.010)	(0.009)	(0.011)	(0.011)
FiT Tariff$_{irt-1}$	0.001	0.002	0.001	0.002	0.003	0.004
	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.003)
FiT Contract Length$_{irt-1}$	-0.002	-0.005	-0.013***	-0.012***	-0.009***	-0.013***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
FiT Tariff$_{jrt-1}$	0.001	0.002	0.009***	0.007***	-0.002	-0.004
	(0.004)	(0.004)	(0.001)	(0.001)	(0.002)	(0.002)
FiT Contract Length$_{jrt-1}$	0.003	0.001	-0.009***	-0.002	-0.001	0.005*
	(0.004)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)
ln(Import Tariff)$_{jrt}$	0.132***	0.146***	-0.054***	-0.007	-0.021**	-0.028**
	(0.016)	(0.017)	(0.015)	(0.014)	(0.010)	(0.013)
N	39984	38352	39984	38352	39984	38352
pseudo R-sq	0.706	0.731	0.907	0.872	0.834	0.829
Log Likelihood	-5.539e+07	-4.546e+07	-3.186e+08	-2.216e+08	-2.496e+08	-2.246e+08

*Clustered standard errors in parentheses, * p<0.10 ** p<0.05 *** p<0.01*