ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis: Economics & Business Economics

‘’The impact of non-tariff measures on the imports of solar energy products from China’’

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Abstract

This study examines the relationship between renewable energy policies and the imports of solar products from China. In the past decade, the number of disputes on renewable energy has grown considerably. Several countries accuse each other of imposing harmful measures that exert trade-distorting effects. At the same time, these measures improve the usage of green energy, thus having a positive influence on the environment. This study aims to contribute to the discussion of whether specific policy measures should be allowed because of their positive implications or whether they should be prohibited based on their trade-distorting effects. Two fixed-effects regressions are performed to measure the effect of several non-tariff policies on the imports of solar photovoltaic products from China. The model controls for tariffs imposed by the countries and for exchange rates. The analysis includes 26 countries that are observed over ten years. Significant results have been found for two particular policy measures affecting the growth rate of imports from China, implying a possible relationship between policy measures and imports from China. Furthermore, the paper suggests several relevant implications and considerations for future research.

Contents

1. Introduction

Some of the world's most important natural resources might become the world's biggest scarcity in the current and future generation(s). Among these resources are fossil fuels, which account for the most part (84%) of primary energy production in the world. Therefore life, as we currently know it, is highly dependent on these sources (Rapier, 2020). Multiple scientists have tried to estimate how long the current world can keep using fossil fuels before all reserves are used. If the world keeps using fossil fuels at the current rate, it could just be a matter of decades for fuels like oil and natural gas to run out of supply (Shafiee & Topal, 2009; Ritchie & Roser, 2020). Some scientists argue that it is not likely that the world will run out of fossil fuels since technological improvements make the use of these resources more efficient in generating energy. At the same time, other energy sources that are currently growing could eventually become the primary energy sources, depleting the demand for fossil fuels (Covert et al., 2016). Nevertheless, the current focus on reducing fossil fuels is essential if environmental impact is to be minimalized. Even if there was no concern about the reserves of the resources, the harmful effects of the usage of fossil fuels still create a big problem for the environment. Global warming, natural disasters, pollution, and many other consequences highlight the importance of reducing these ways of energy production. Renewable Energy (RE) offers a solution to this global problem, and it is therefore increasing in popularity across the world.

Maintaining the growth and enlarging the energy production coverage of RE seems desirable for everyone because of its positive impact on the environment. However, it does constitute an extensive economic discussion. To improve the development of RE in their country, governments can charge import tariffs or non-tariff measures that incentivize the consumption of green energy, provide domestic companies with financial support, or restrict imports of RE products from foreign countries. These measures can affect the trade between countries, and therefore such measures are an increasingly discussed topic among trade disputes in the world. Some journalists and researchers even speak of a 'solar trade war'. An issue arises whether the WTO should counteract the support of domestic RE industries or whether the measures should be allowed because of their positive environmental implications (Bougette & Charlier, 2015; Meyer, 2017).

In total, eight disputes concerning RE were reported at the WTO in the past ten years. The most involved countries in these disputes are China, the United States, Canada, India, Japan, and several countries from the EU. However, other countries worldwide are involved as well, since they have reported themselves as third parties at the WTO. The complaining countries report

violations of the General Agreements on Tariffs and Trade (GATT), Subsidies and Countervailing Measures (SCM), and Trade-Related Investment Measures (TRIMs). China is involved in all disputes, being a victim of the measures imposed by the US, Canada, India, and the European countries (WTO, 2018). China is the largest RE producer in the world, accounting for almost one-third of the world production in RE. The other countries being challenged at the WTO account for another third of world production, implying that only a few countries dominate the RE industry. Allowing these countries to implement policies that improve the domestic RE production could accelerate the usage of green energy in the world.

This paper focuses on the solar energy industry since it is one of the fastest-growing and developing industries in RE. Solar energy is expected to play an increasingly important role in future energy demand, making it an interesting product to observe when analyzing policy effects (IRENA, 2020; IEA, 2021). In a paper by Kabir et al. (2018), the potential of solar energy in meeting global demand in the future is analyzed. They conclude that solar energy is one of the most promising RE sources in this matter, especially if investments in the development of solar energy technologies can be guaranteed. Furthermore, they also stress the importance of incentives and rebates in the development process in solar energy, which again raises the question of whether the WTO should counteract these measures.

This paper examines the effect of non-tariff measures regarding the solar industry on imports from China. This is because China is involved in all of the disputes, claiming their industry is affected by the measures of other countries. If the effect is proven to be nihil or non-present, this could imply that the countries imposing the measures should not be restricted to do so. In the same way, if the measures are proven to be significantly affecting the export market of China, further research might have to be done to look into whether these losses outweigh the benefits of the measures or not.

The research question of this paper is as follows:

How do non-tariff measures in the solar industry affect the imports of solar photovoltaic products from China?

2. Theoretical framework

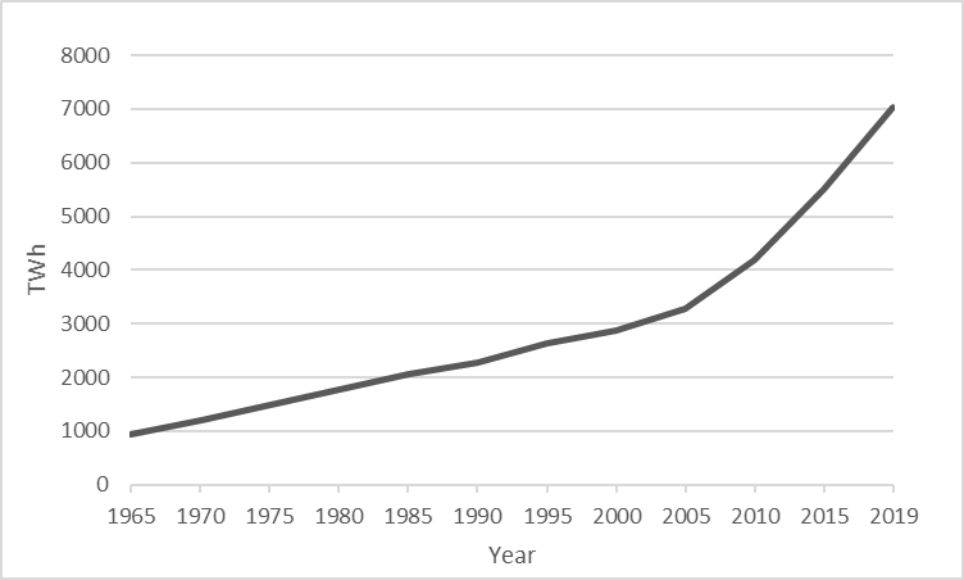
2.1 Renewable Energy

Renewable energy is an increasingly popular energy source worldwide, with its production growing more rapidly each year. As shown in Figure 1, the production of RE has been steadily increasing from 1965 until 2005, after which the production starts to accelerate. This trend indicates the adoption of RE by more and more countries and the advancements in technologies of producing RE. One of the reasons for the growth in the RE sector is a country's dependency on fossil fuel prices (Duffield & Collins, 2006). The demand for energy increases as the population expands, while fossil fuel prices also increase because of difficulty in obtaining these resources and because of the rising demand. These two developments are not viable in the long run, which causes countries to focus on domestic energy production to become less dependent on fossil fuels. Fossil fuels are exhaustible resources with volatile prices, while RE is generated through natural forces such as the sun, wind, or water flows. These resources are less subject to availability since they are expected to be around forever (albeit in different magnitudes because of their weather dependency). Several newspapers and energy agencies discuss these mentioned advantages of replacing fossil fuels with renewables[1]. The arguments for the transition to RE also include environmental implications, as fossil fuels negatively influence the climate. Energy generation with fossil fuels causes global warming, air pollution, and environmental degradation, some of which accelerate as long as fossil fuels keep being used (Dincer, 1999; Martins et al., 2019).

The primary RE sources are hydro-, wind- and solar energy. Hydro energy accounts for most of the RE generation around the world. Next are wind- and solar energy, both of which are developing at a fast pace. Other renewables, such as biofuel and geothermal energy, make up the rest of the total RE generation (IEA, 2021; C2ES, 2021). Figure 2 shows the production of the different types of RE. From this figure, it can be noticed that solar energy is currently growing the fastest of all RE types, on its way to become the second-largest RE source.

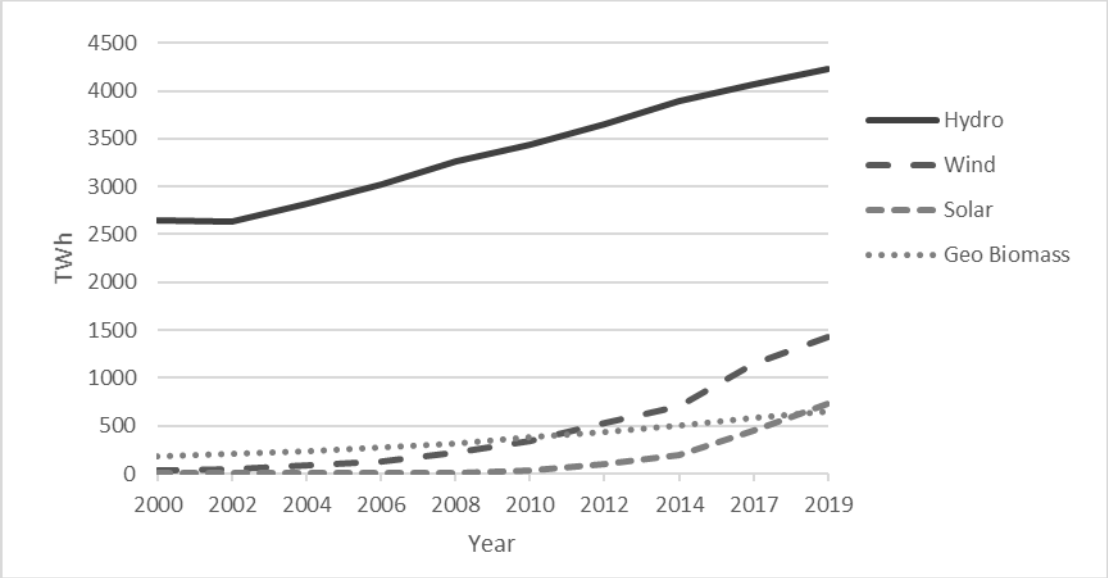
[1] With respect to the volatile prices of fossil fuels, newspapers such as the Guardian and CNBC report that these are partly the reason for the transition to RE sources (Kemper & Roger, 2013; Reuters, 2007).
Furthermore, energy and environmental magazines or agencies describe renewables as a better option than fossil fuels because of the fossil fuels' volatile prices, apart from other advantages of renewables (Davis, 2015; Bellini, 2019).

Figure 1: Total Renewable Energy production in the world.



Source: Reproduced from the annual BP Statistical Review of World Energy report in 2020. Dataset presented at OurWorldInData.org.

Figure 2. Total Renewable Energy production in the world per source



Source: Reproduced from the annual BP Statistical Review of World Energy report in 2020. Dataset presented at OurWorldInData.org.

2.2 Solar energy

This paper focuses on one RE source: solar energy. This is because including multiple RE sources with different trade characteristics would increase the complexity of the research. Furthermore, mainly one RE source stands out when investigating policy effects on trade. As

indicated, the solar photovoltaic (PV) sector is currently the fastest-growing (IEA, 2021; C2ES, 2021; Ritchie & Roser, 2020). Apart from Figures 1 and 2, which were created based on an energy report of BP, several energy agencies have confirmed this development[2]. Some researchers even expect solar energy to be the leading renewable energy source in the future. Whereas some RE sources may today be more efficient than solar energy, it is expected that solar energy will match the efficiency considering its continuing development and growth (Kabir et al., 2018). The costs of producing solar energy are decreasing rapidly, and the product becomes more and more commercially available (Bull, 2001).

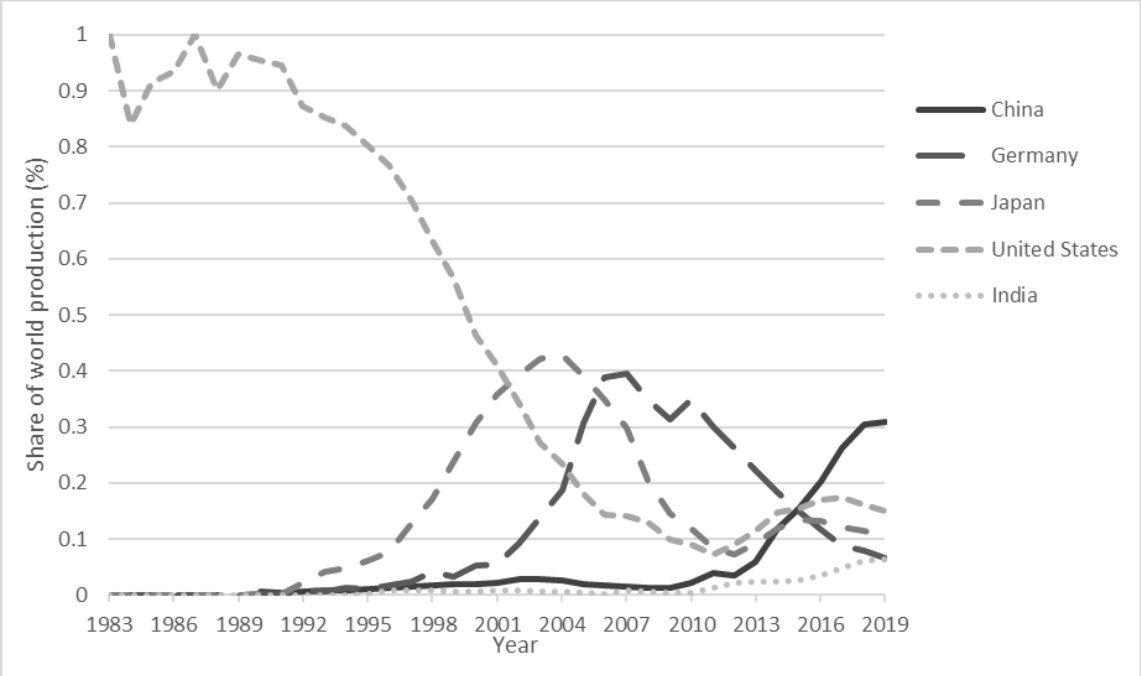
The rapid growth of solar energy is also the cause of an increasing amount of trade conflicts. As more countries start to adopt PV technologies and start producing PV-related goods, the competition increases. This results in countries trying to protect or promote their industries by, for example, subsidizing domestic solar companies or by restricting imports of foreign products (Hjdukiewicz & Pera, 2020). Figure 3 illustrates the country's share in total solar energy production for five of the (currently) biggest producers in solar energy. Solar energy seems to be introduced around 1983, with the US dominating the market for the first two decades. After a few years in which other countries were leading in their production, China became the dominating producer of solar energy, responsible for almost one-third of the total solar energy produced in the world.

Figure 4 illustrates the export shares of the five largest exporters of solar PV products in the world. Again, China establishes the most dominant position in the industry, with its exports hovering around 40% of total world exports in solar PV products. This growth is partly attributed to the production subsidies China has provided for its leading producers. Solar PV companies in China experienced considerable cost advantages because of the investments by the government in technology improvements. This gave Chinese manufacturers an absolute advantage compared to the rest of the world. As a result, four of the five biggest solar cell producers are currently Chinese, which all export most of their products to Europe and the US (Sarathy, 2013; Fang & Li, 2013; PV-Tech, 2021). This rapid growth of Chinese exports has increased the number of disputes between countries regarding renewables. Because of cheap labor in manufacturing and the lower prices in developing countries such as China and Malaysia

[2] According to a report about RE capacity statistics from the International Renewable Energy Agency (2021), solar energy underwent the highest percentual increase in capacity compared to the other major renewable energy sources.
Furthermore, a renewable energy market update from the IEA (2021) reports the highest (total) increases in capacity for Solar PV in the years 2019-2022, followed by wind-, hydro- and other renewable energy capacities.

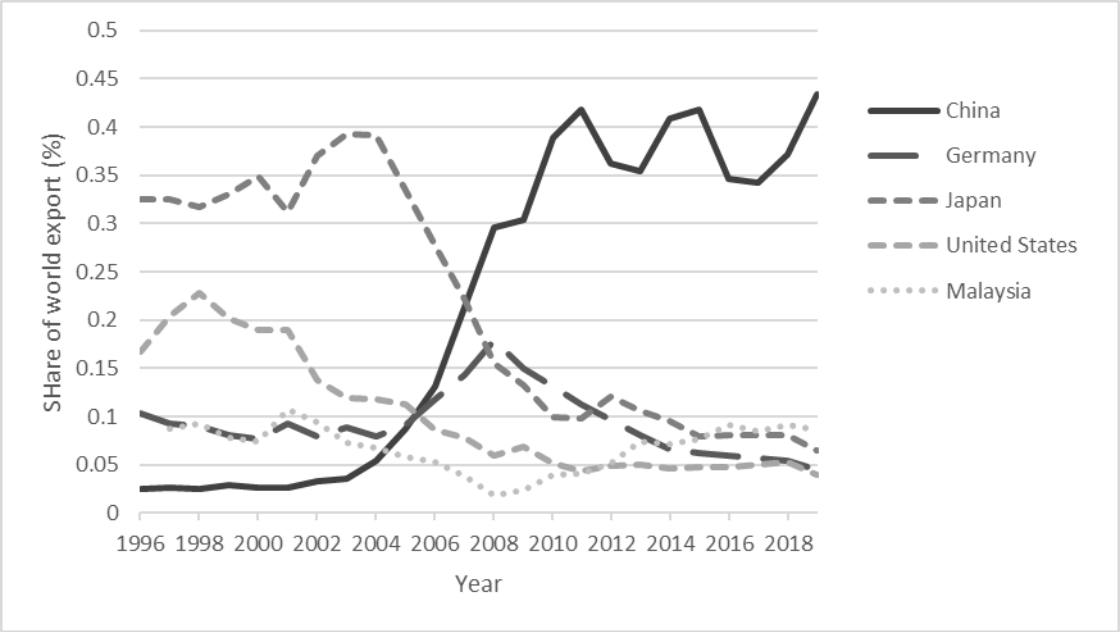
(Krugman Obstfeld, 2018), it is challenging for countries to compete with these developing countries. To protect their industries, countries started to impose several measures. These measures are not always justified or allowed according to the agreements that the WTO sets out, resulting in complaints from countries such as China about violations of trade agreements by others. These so-called disputes, initiated at the WTO, will be discussed more thoroughly in the next section.

Figure 3: Country share of solar energy production in the world.



Source: reproduced from the annual BP Statistical Review of World Energy report in 2020. Dataset presented at OurWorldInData.org.

Figure 4: Country share of total exports in solar photovoltaic products in the world.



Source: reproduced from export data available at the World Bank. The graph shows the export shares of countries for products that belong to the product code HS 854140.

2.3 WTO & Disputes

From all countries in the world, 164 are currently a member of the World Trade Organisation (WTO). The WTO is an intergovernmental organization that enables countries to negotiate by creating specific agreements to which all members should adhere. The WTO encourages free trade but also allows protection to be present when needed. If a country like China experiences negative consequences because of another country not conforming to an agreement, it can request consultations with those countries at the WTO. This dispute is then investigated by the WTO, which tries to settle the conflict between the countries (WTO, 2021).

Starting in 2010, trade disputes in RE (specifically in the solar PV sector) became more frequent as the industry grew more rapidly than before. Since then, eight disputes in RE have occurred at the WTO, with China initiating four and being involved (as a third party) in all the other disputes. In more than half of the disputes, the US is the respondent (the country that is being complained about). Other respondents in the disputes include Canada, India, the European Union, Italy, and Greece. The complainants, among China, are the US, Japan, India, and the Republic of Korea (WTO, 2021; Hajdukiewicz & Pera, 2020).

2.3.1 Domestic content requirements and subsidies

India, Canada, the European Union, Italy, and Greece are all involved in a dispute for setting domestic content requirements or granting subsidies to the domestic RE industry. Domestic content requirements are policies that compel RE producers to use a certain amount of domestically manufactured goods (Rivers & Wigle, 2011). These measures often violate the TRIM's (Trade Related Investment Measures) agreement, which states that investment measures such as local content requirements may not discriminate between imported and exported products. Furthermore, the content requirements often go hand in hand with subsidies in the form of financial contributions (price support) to manufacturers that use domestic goods over imported goods. This kind of subsidy is prohibited by the SCM Agreement and contested by countries in the WTO.

2.3.2 United States

The US has been repeatedly accused of unjustly imposing countervailing duties and anti-dumping measures against imports from other countries, as well as subsidizing their industry or implementing policies that include financial grants and localization incentives. These measures stand in contrast to the agreements between the members of the WTO (which will, later on, be elaborated). The main reasons for taking these measures are: (1) to decrease dependency on fossil fuels; (2) to limit climate change by increasing the alternatives of fossil fuels; (3) to improve the competitiveness of domestic industries (Hajdukiewicz & Pera, 2020; Duffield & Collins, 2006; Rivers & Wigle, 2011).

However, the measures taken by the US are not always proven to be beneficial for the industry. As Hugh and Meckling (2017) describe, many PV companies and government agencies of the US and, for example, China actually cooperate. Some measures deteriorate the cooperation between the two countries and thus counteract the development of the industry. Nevertheless, the measures are still imposed as US law allows disadvantaged companies to request specific trade policies for their benefit, regardless of what is best for the economy.

A total of five disputes regarding measures that are related to RE were initiated against the US. Remarkably, three of these disputes were instituted in 2018. This year, the US imposed tariffs on solar PV products, which led to complaints from China and South Korea. At the same time, China also complained about the domestic content requirements used in the US.

2.4 WTO Agreements

According to the complaining countries, the imposed measures mentioned above violate the GATT, TRIMs, and SCM agreements. First of all, the agreement on Trade Related Investment measures states that no member may impose measures that are not allowed by Article III and XI from the General Agreements on Tariffs and Trade. These articles discuss the legislation around national treatment and quantitative restrictions. The idea of this agreement is that countries cannot take specific investment measures that restrict or distort trade. These measures thus include incentives or requirements that promote local industries. The second agreement that stems from the GATT is the SCM (Subsidy and Countervailing Measures) agreement. This agreement states that providing certain subsidies that are focused on improving domestic industries and that cause injury to foreign industries are prohibited and may be counteracted with a set of new measures imposed by the harmed industry (WTO, 2021; Brewer, 1998).

2.5 The debate

The increased number of disputes originating from the agreements has led to the debate of whether current WTO agreements should be adjusted. As mentioned, the increase of the RE industry is partly attributed to the mitigation of climate change and the dependency of countries on fossil fuels (Sharif et al., 2021; Duffield & Collins, 2006). Both of these factors could be a reason to argue that imposing measures focusing on improving the domestic industry in RE should be allowed. On the other hand, the measures that are being imposed might have trade-distorting effects, therefore counteracting the main purpose of the WTO, which is encouraging free trade. Several researchers have already brought up this discussion. For example, Bougette & Charlier (2015) investigate the positive and negative consequences of a program that includes local content requirements in Canada. They conclude that the program is effective in increasing the production of RE. However, the inclusion of local content requirements in these programs may lead to a possible reduction in welfare or a decreased production in RE in the long run. Liu et al. (2019) conducted a similar study, where they included multiple RE policies and evaluated which ones increase the development in RE. They find that several policies help increase RE's capacity and that the market-oriented policies should be further examined to encourage the development of RE. Other researchers, such as Meyer (2017) and Asmelash (2014), have investigated why RE policies have been disputed more often in the past years than fossil fuel policies. All the papers mentioned above have in common that they stress the positive environmental implications of these policies as well as the trade distortions they possibly instigate.

2.6 Hypotheses

Given the increasingly discussed debate on whether the RE policies should be freely implemented or not, this paper assesses the effect of particular non-tariff measures on the imports of the imposing countries. Knowing how much these measures affect trade could contribute to the discussion in a sense that the trade-distorting effects can be weighed against the advantages of these measures.

The industry for renewable energy is, for a large part, dominated by China. As shown in Figure 3 and Figure 4, 30 percent of the total RE production occurs in China, and more than 40 percent of the total exports of solar products are coming from China. Therefore, an investigation into the relationship between specific measures and trade distortion regarding the RE sector does well to focus on China's export market.

The measures are expected to decrease the number of imported solar products from China. In general, subsidies and investments can lower the price of products in domestic countries. This could be, for example, because the monetary support to the companies decreases their production costs or because consumer-based incentives make the purchase cheaper for customers. Both make the domestic industry more competitive in the world market, causing relatively more domestically than foreign-produced goods to be consumed compared to when these measures are not applied. An example of this concept can be found in a paper by Moerenhout (2020), where he argues that fossil fuel subsidies impact trade by, for example, increasing the competitiveness of domestic industries. In another paper by Zhu et al. (2021), trade protectionism by other countries has been shown to decrease China's solar PV exports. Furthermore, regarding RE, the measures are expected to harm the Chinese export market since China requested consultations regarding these measures multiple times, and therefore must have experienced some negative consequences of the measures.

The first hypothesis tested in this paper thus becomes*: The number of non-tariff measures in the solar industry negatively impacts the imports of Chinese solar photovoltaic products.*

A less specific but still relevant hypothesis tests whether there is a correlation between the policy measures and the exports. Knowing about the existence of a relationship between the two can increase awareness of the debate on whether the policy measures should be allowed or not. This might encourage future research to more thoroughly examine the relationship and possibly establish causal relationships.

Therefore, the second hypothesis is: *The number of non-tariff measures in the solar industry is correlated with the imports of Chinese solar photovoltaic products.*

3 Data

To test the hypotheses, this research uses multiple databases. The policy behavior of countries is quantified by taking the number of measures the country has taken from Global Trade Alert. Next, the World Bank provides information on the value of imports of solar products from China by various countries. Furthermore, to add validity to the model, tariffs and exchange rates from all countries will be added as the control variables. The import tariffs are also available at the World Bank. The exchange rates will be retrieved from the International Monetary Fund (IMF).

3.1 Import value

The dependent variable in this research is the imports of solar PV products from China. This data can be retrieved from the World Bank, where the UN Comtrade database is accessed. Gross imports are selected of all countries (the reporters) from China (the partner) in our dataset for 2008 until 2019. Based on previous research that also has examined the solar PV sector, the product group that is selected to represent the solar industry is HS854140[3]. The full description of this product is 'Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light-emitting diodes''. Products that belong to this product group are essential components to create a solar cell, but also solar cells and solar panels as a whole.

After retrieving the data, we are left with data on gross imports in USD of 26 different countries from China. The average imported trade value is around 473 million USD, but it can range between 600 thousand and 8.3 billion USD, although these values are extremes. The set of countries was chosen based on the height of imports of solar PV products from China and the total measures they imposed. Both countries that impose multiple measures and countries that barely impose measures are included. This way, an average effect can be obtained from the analysis based on a diverse group of countries. Regarding the amount of trade in solar PV products, countries that import a considerable amount of products are included in the model.

[3] In a paper by Hajdukiewicz and Pera (2020), recent trade disputes in the PV sector are explored. The analysis uses product HS854140 as a product group.
Zhu et al. (2021) also use the same product code when analysing China's PV export sector. They do however further specify the code into an 8-digit code, to filter out light-emitting diodes (LED). The latter was not possible for this research, because the World Bank does not provide trade data on products with 8-digit codes.

This is because, when observing the available data, countries that import small amounts of the relevant products are more subject to large percentual changes in their imports. These large fluctuations could bias the outcome of the analysis because they could be influenced by single country-specific events rather than by particular trends or measures. Moreover, the data on countries that import small amounts is often incomplete or unavailable for the years examined in this research.

3.2 Measures

The variable of interest in our model is the policy measures imposed by the importing countries. These policy measures include measures related to the solar industry that are harmful to China. The measures are retrieved from Global Trade Alert (GTA), where state interventions and measures are reported for all countries every year since 2009. GTA provides information on all interventions by the government which affect a particular product group. Furthermore, it is possible to select data by the countries that implement the measures and that are affected by the measures. This way, data on policy measures imposed during 2009 until 2019 and affecting China is gathered individually for all countries included in the model. The product code that is selected is 8541. This is a less specific product code than was used in the import data collection, but it still mainly represents solar PV products. All measures that have been imposed at least once will be categorized into six different types of measures/interventions. This makes it possible to determine the effects of particular measure types, providing an idea of which measures exert the most influence on China's exports in solar products. The measure types are prepared based on the Global Trade Alert database handbook (Evenett & Fritz, 2017) and information regarding the international classification of non-tariff measures (UNCTAD, 2019). A table with all the measures is added in Table 1 for convenience. Lastly, GTA does not provide information regarding the period in which the measures are in effect. Hence, the measures will be included in the dataset as flow measures (the number of new measures).

3.2.1 Contingent measures

When a country imports its products from another (foreign) country, the importing country might experience negative side effects from importing if the foreign country has imposed certain policy measures. The importing country can counteract these adverse effects by imposing contingent measures. Policy measures that belong to this specific group are anti-dumping measures, countervailing measures, and anti-circumvention measures.

3.2.2 Import restrictive measures

Import restrictive measures are aimed at prohibiting or limiting imports. To do so, governments can impose measures in the form of licensing, predetermined quotas, or import bans. Four different interventions are reported at GTA that belong to this group.

3.2.3 Local content measures

A government can also intervene by focussing on improving or supporting the domestic industry. One way to do so is by imposing local content measures. Here, the government sets various requirements for the origin of purchased products. For example, a solar energy company has to buy a minimum percentage of its solar cells from domestic producers to be eligible for particular benefits. As mentioned in this paper, these local incentives are the reason for many of the trade disputes in RE. They have been frequently used by the US in the past and have proven to help increase the deployment of domestically produced solar energy (Sarzynski et al., 2012).

3.2.4 Subsidies

Other commonly debated measures regarding RE disputes in the WTO are subsidies. Subsidies are financial transfers from governmental institutions to beneficiaries (such as consumers, manufacturers, or energy producers). This monetary support can create various advantages for these beneficiaries. Export subsidies are included separately as a measure type.

3.2.5 Export subsidies

Export subsidies cause domestic producers to gain benefits from exporting products. These benefits can be all sorts of financial support, such as tax exemptions, export incentives, or direct payments.

3.2.6 Government procurement restrictions

A government can also restrict governmental agencies from purchasing goods and services from foreign suppliers. This can be done by limiting market access, setting price preferences for domestic goods, or setting local content requirements.

Table 1. Non-tariff measure types.

Contingent Measures	Import restrictive measures	Local content measures	Subsidies (excl. export subsidies)	Export subsidies	Government procurement restrictions
Anti-dumping	Import licensing requirement	Local sourcing	State loan	Export subsidy (direct payment)	Preference margin
Countervailing measures	Import tariff quota	Localization incentive	Financial grant	Trade finance	Local content requirements
Anti-circumvention	Import ban		Loan guarantee	Tax-based export incentive	
	Import related non-tariff measures		Capital injection		
			Tax- or social insurance relief		
			In-kind grant		
			Interest payment		

Source: Global Trade Alert and UNCTAD

3.3 Import tariffs

The non-tariff measures mentioned above only partly explain the effect of measures on trade. An essential factor that should not be left out of consideration is import tariffs on solar PV products. Next to different types of measures, governments can also impose tariffs to protect the domestic industry. These tariffs are likely to influence the trade between China and the importing countries and will therefore be included in the model. The data on tariffs from all countries on the relevant products can be retrieved from the World Bank database. Most Favored Nation (MFN) tariffs are selected for all countries on the product group 854140 (similar to the product group in the import data collection). MFN tariffs are the tariffs a government imposes on products from all other WTO members. These do not include tariff rates determined under a preferential trade agreement. MFN tariffs are, therefore, the highest possible tariff rate that countries charge to each other. When observing the data, it can be noticed that most tariffs are zero. This is mainly because all countries are members of the WTO and thus charge a zero-tariff. For some countries, the tariff data is not available for all the relevant years in the analysis. For these years, the tariffs will be reported as missing values.

Because the tariffs set by the US from 2018 are determined otherwise than through the MFN principle, these tariffs have been retrieved elsewhere. The tariffs imposed by the US are part of

a 4-year tariff plan. This plan includes imposing a 30% tariff in the first year (2018) and a reduction of 5% in every following year (PIIE, 2021). An exemption to these tariffs is the solar cell, of which the first 2.5 gigawatts imported are free of tariffs. Because there is too little numerical information on what effect this has on the imports from China specifically, this exemption will not be included in the model. According to the US Energy Information Administration, the US imported about 13 gigawatts of solar PV modules in 2016. Considering that the exemption accounts for roughly 20% of the whole imports and that it is also divided among all countries that export to the US, the exemption on the solar cells is expected to have little influence on the trade with China.

3.4 Exchange rates

The second control variable added to the model is the exchange rate between the importing country and the US. The import values in the dataset used for the analysis are reported in US dollars by the World Bank. The World Bank converted the value of imports from countries to US dollars by using yearly local price indexes and US dollar price values. To capture the effect of price levels in the model, the exchange rate of one US dollar in local currencies is added to the analysis. These exchange rates are retrieved from the data available at the IMF. The IMF reports yearly exchange rates by calculating period averages of national currency per US dollar.

4 Methodology

To investigate the relationship between imposing specific measures and the trade with China, a fixed effects regression is performed in Stata using Ordinary Least Squares. This particular method helps to control for time-invariant omitted variables by including within-country variation. Country-specific dummy variables are created to capture these unmeasured variables. To create the different country groups from the data set, a dyad (pair) is constructed of all the importing countries and China, and converted to numerical values for each dyad. Furthermore, time-fixed effects are also included in the analysis to account for general events that affect all groups similarly. In this research, these events could be all sorts of worldly influences (crises/pandemics) that affect the economies of countries in the data.

With fixed effects, we assume that the omitted variables previously mentioned are correlated with the dependent or the independent variable(s) and that these variables are not correlated with each other.

The simple regression can be presented as follows:

$$L.Solar.imports.from.China_{it} = \alpha_i + \beta_1 * contingent\_1_{it} + \beta_2 * importrestrictive\_1_{it} + \beta_3 * localcontent\_1_{it} + \beta_4 * subsidies\_1_{it} + \beta_5 * exportsubsidies\_1_{it} + \beta_6 * gvnmentprocurement\_1_{it} + \partial_i + \tau_t + \varepsilon_{it}$$

Here, the dependent variable represents the imports of countries of solar products from China. These imports are log-adjusted because these coefficients would otherwise be less meaningful. Without log-adjusting, there is less accounted for the difference in the size of the countries' trade with China. For example, the imports of the US from China can be up to 10 times the imports of Mexico from China. Not taking the log with such different values among countries does not provide us with meaningful coefficients that are representative for individual countries (only an average effect for all countries).

β_x represents the coefficients of the independent variables, which is a set of particular non-tariff measures imposed by other countries on solar products. The policy measures will not be log-adjusted, so when interpreting the results, the effect of an increase of 1 particular measure can be obtained. Furthermore, since it takes time for measures to be implemented and effective, a lag of one year is applied to these variables. Some of the measures are imposed during the second half of the year, and it can also take time for policy measures to be fully implemented or influence the trade with other countries. Therefore, applying a lag of one year gives a better representation of reality than when the measures are assumed to be immediately effective.

The *i* represents the countries, and *t* indicates the year of the observation. The intercept is given by α_i and varies per country. ∂ and τ indicate the country- and time-fixed effects, respectively. Lastly, an error term is added to the regression to account for the incompleteness of the model.

To improve the model, a regression is formulated where it controls for variable bias caused by import tariffs on solar products and exchange rates. As mentioned before, the data on tariffs mainly consists of zero's. This is because most country members of the WTO trade freely with each other and charge tariffs according to the MFN principle. These zero-values are relevant to include as well in the model, and thus the log of the tariffs plus one, ln(x+1), is taken. Furthermore, the exchange rate will also be log-adjusted to show percentual changes. This is done because this data is also not normally distributed and ranges from rates of under 1 up until over the 10.000. Furthermore, it enables us to show the percentage changes of the independent variable when the exchange rate changes by a certain percentage.

The new model in the analysis thus becomes:

$$L.Solar.imports.from.China_{it} = \alpha_i + \beta_1 * contingent\_1_{it} + \beta_2 * importrestrictive\_1_{it} + \beta_3 * localcontent\_1_{it} + \beta_4 * subsidies\_1_{it} + \beta_5 * exportsubsidies\_1_{it} + \beta_6 * gvnmentprocurement\_1_{it} + \beta_7 * L.import.tariff + \beta_8 * L.exchange.rate + \partial_i + \tau_t + \varepsilon_{it}$$

Log adjusting the import values and the control variables already help to make the data less subject to heteroskedasticity problems. Nevertheless, to further prevent the standard errors from being biased and inconsistent, robust standard errors are used when performing the regression in Stata. Moreover, as a robustness check, a second regression is performed similar to the one above, but with the log growth rates of imports from China as the dependent variable. If the results from both analyses show similar implications, the estimates could be argued to be less susceptible to bias.

5 Results

Table 2 presents the results of the first fixed-effects model. First of all, there seems to be no consistency among the different coefficients of the measure types. Both positive and negative coefficients can be observed, which is different from the expectations stated in the first hypothesis. However, no significant coefficients have been found for the measure types. The coefficients can be interpreted as a percentual increase (or decrease) of the import value when importing countries impose one extra policy measure. So, for example, if a country imposes one extra contingent measure, the solar PV imports of that country from China decreases by 6.9%.

The tariff variable is the only variable that seems to have produced a significant coefficient. On a 10% significance level, a growth of tariffs seems to be decreasing the imports of solar products from China by a considerable percentage. This finding is not very surprising, as an import tariff directly increases the price of products and could thus be expected to influence the imports of those products negatively. Furthermore, a higher exchange rate is also expected to decrease the imports. The reason for this expectation is that the exchange rate is presented as the local currency over the US dollar, and therefore an increase would mean a devaluation of the local currency. This, in turn, causes imports from a foreign country (China in this case) to become more expensive. However, the results from Table 2 cannot confirm this relationship, for the coefficient of the exchange rates is not significant nor negative.

Lastly, the R-squared shows how well the models fit the observed data. The within estimator of the R-squared explains how much of the within-country variation in imports from China is captured by the model.

Table 2 Fixed effects regression results

Dependent variable: Log imports of solar products from China	**Coefficients**
Contingent.measures_1	-0.069
	(0.113)
Import.restrictive.measures_1	-0.027
	(0.145)
Local.content.measures_1	0.395
	(0.309)
Subsidy.measures_1	0.053
	(0.164)
Export.subsidies_1	-0.193
	(0.286)
Government.procurement.measures_1	0.278
	(0.365)
Ln.tariff	-0.671*
	(0.403)
Ln.exchange.rate	0.054
	(0.111)
Constant	11.366***
	(0.539)
R-squared (within)	0.054
Country FE	Yes
Year FE	Yes
Observations	238

Standard errors are in parenthesis, ***=*P<0.01*, **=*P<0.05*, *=*P<0.1*

In Table 3, the measures are regressed on the log-adjusted growth rate of imports. The purpose of this regression is to serve as a robustness check for the first model. It also gives an idea of how the growth rate of imports from China change when particular measures are imposed. What immediately stands out is that all measure variables are negative. This indicates that, based on the observations in the panel data, the measures seem to be negatively correlated with the import growth rate. However, only two types of measures show significant coefficients. An interesting change compared to Table 2 is that the coefficients of the control variables are both significantly

positive. It appears that an increase in tariffs or the exchange rate increases the growth rate as well.

Table 3 Fixed effects regression results

Dependent variable: Log-adjusted imports growth rate of solar products from China	**Coefficients**
Contingent.measures_1	-0.556***
	(0.194)
Import.restrictive.measures_1	-0.268*
	(0.149)
Local.content.measures_1	-0.078
	(0.200)
Subsidy.measures_1	-0.014
	(0.104)
Export.subsidies_1	-0.268
	(0.209)
Government.procurement.measures_1	-0.360
	(0.223)
Ln.tariff	0.146**
	(0.025)
Ln.exchange.rate	0.054**
	(0.111)
Constant	0.645***
	(0.201)
R-squared (within)	0.211
Country FE	Yes
Year FE	Yes
Observations	236

Standard errors are in parenthesis, ***=*P<0.01*, **=*P<0.05*, *=*P<0.1*

An important consideration to take into account when discussing the results is the existence of endogeneity. Endogeneity mainly implies that explanatory variables (policy measures, import tariffs, and exchange rates) are correlated with the error term, creating a bias in the estimators of these variables. One cause for possible endogeneity is simultaneity. For example, in Table 2, the relationship between policy measures and imports from China seems positive. This is remarkable because it might be expected that imposing these particular measures would harm the imports that originate from countries that are affected by these measures. However, it is also possible that higher imports simultaneously influence the number of policy measures imposed by a country. For example, a country that sees its imports of solar products from China increase

drastically might want to impose measures to protect or improve their domestic industries. This simultaneity might thus be why in Tables 1 and 2, the coefficients of policy measures are different from what was expected. These implications insist that caution should be exercised when making claims about the results from the different regressions.

6 Conclusion and Discussion

Renewable Energy (RE) is on its way to become the most important power source in the world. In fact, if the usage of diminishing energy sources like fossil fuels stays at its current rate, RE sources might eventually become the only sources for producing energy. Apart from the necessity of increasing the production of RE because of scarce alternatives in the future, another important reason for investing in RE is because the current energy production with fossil fuels has a devastating influence on climate. According to scientists, the most promising RE source is solar energy since it is growing fast in capacity and increasing in efficiency. Moreover, this particular energy source is commercially available and therefore more easily accessible to different types of customers.

The advancement of solar energy, however, is dependent on many factors, including the policy measures imposed by governments. For example, investment measures such as subsidies or localization incentives can accelerate the development of solar energy capacity and improve the efficiency of solar energy. A downside to these measures is, however, that they can counteract free trade between countries. This research aimed to investigate the effects of non-tariff measures on trade, specifically in the case of solar photovoltaic imports from China (the largest producer of solar products in the world). Two hypotheses were constructed to study these effects. To test these hypotheses, a panel data set consisting of 26 various countries was analyzed over ten years with information on trade with China, policies, the import tariffs on Chinese products, and the exchange rates.

After performing a fixed effects regression on the panel data, the different types of measures show varying effects. The results show that no significant effect of the measures on imports has been found. Nevertheless, the directions of the coefficients do pose some interesting implications. First of all, half of the measure coefficients coincide with an increase in imports of solar products, which seems contradictory because the measures are often imposed to protect the domestic industry. One possible explanation could be that despite a country's policymaking, the imports might still increase because of stronger forces that are not included in this model. Future research could focus on identifying these forces and finding ways to quantify these so

they can be included in the analysis. Examples of such forces are Chinese investments in the solar industry or imports from other countries than China. Furthermore, the presence of endogeneity can also be a possible explanation for the positive coefficients. The analysis cannot be used to make any claims with respect to causal relationships.

The second analysis regressed the growth rate of imports on the different measure types. The negative coefficients of all the measure types indicate a negative relationship between these measures and the import value. Only contingent measures show a strong significant relationship with the growth rate of imports. The direction of the relationship is different from that in the first regression. This difference can be explained because the imports might be increasing despite the imposition of the measures, albeit at a lower rate. Furthermore, the significant coefficients of the control variables imply that import tariffs and exchange rates should be included when estimating the effects of non-tariff measures on trade.

Regarding the first hypothesis, the results do not provide enough evidence that any particular non-tariff measures imposed by a country negatively affect their imports of solar products from China. The second hypothesis, which states that a correlation exists between the non-tariff measures and the imports from China, must also be rejected based on the analysis in this paper. Nevertheless, the significant results of contingent- and import restrictive measures in the second performed regression seem to support the existence of a relationship between particular measures and the growth rate of solar imports from China.

To determine the actual effect of non-tariff measures on solar imports from China, additional databases on policy measures should be consulted to improve the completeness of the model. The data used in this paper comes from Global Trade Alert, which reports the flow of policy measures that are announced by governments since 2009. If available, data on stock measures, which takes into account how long the measures are in effect, would enhance the validity of the results. Furthermore, the measures in this paper are assumed to be of equal magnitude. To remove the bias created by this assumption, various policy measures levels could be constructed according to their estimated impact.

To obtain more significant results, the dataset could be enlarged by including more countries. Moreover, extensive research is needed to investigate which variables are relevant to include (next to import tariffs and exchange rates). This would help in accounting for omitted variable bias in the model. A further examination of this research should also look into the possible co-

dependency of the number of measures and the import value and try to control for this by, for example, using an instrumental variable.

All in all, this paper provides some structure to future researchers that are interested in the effects of solar-related policy measures on the imports of solar photovoltaic products from China. Additionally, it brings to light the economic discussion about whether these policy measures should be allowed or not. The particular effect of non-tariff measures on the imports from China, and to what extent this effect exists, should be further explored because of its environmental and trade-related implications. Future adaptations of this analysis could aid the World Trade Organisation in making decisions about the regulations in renewable energy policies.

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