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Chair of International Finance

Prof. Dr. Philip Sauré

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Bachelor Thesis – Trade Policy

Trade deflection on Chinese exports of photovoltaic modules and key components as a reaction to the European Union's 2013 anti-dumping duties

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Supervisor: Victor Gimenez Perales

Roman Titus Höhn

Rathenauplatz 6

65203 Wiesbaden

rohoehn@students.uni-mainz.de

0151/592052511

Student ID: 2712497

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Abstract

This paper empirically examines the effect of trade deflection, an effect that describes the re-routing of exports to alternative markets caused by a trade barrier (Bown and Crowley, 2007), in the case of the European Union's 2013 anti-dumping duties on Chinese manufactured photovoltaic modules and related components. To answer the question if Chinese exports to other countries increased as a reaction to the European anti-dumping regulations I examined Chinese export data from 2006 to 2015 on a six digit HS level for photovoltaic modules with methods of descriptive statistics and interferential statistics based on the gravity model for bilateral trade flows described by Tinbergen (1962). The results of my research suggest that there is a strong indication for a trade deflecting effect caused by the European Union's anti-dumping regulation with a highly statistical significant average increase ranging between +147,81% to +258,02% of Chinese exports for affected HS categories to alternative markets.

Zusammenfassung

Diese Arbeit untersucht den Effekt der Handelsableitung (engl. trade deflection), einen Effekt der die Umleitung von Exporten zu alternativen Märkten verursacht durch Handelsbarrieren beschreibt (Bown & Crowley, 2007), am Fall der europäischen Antidumpingzölle auf chinesische Photovoltaikanlagen und verwandte Erzeugnisse aus dem Jahr 2013. Um die Frage zu beantworten ob chinesische Exporte auf alternative Märkte umgeleitet worden sind, wurden chinesische Exportdaten im Zeitraum von 2006 bis 2015 basierend auf sechsstelligen HS-Codes für Photovoltaikprodukte mit Methoden der deskriptiven Statistik sowie der Interferenzstatistik, basierend auf dem Gravitationsmodell für bilaterale Handelsströme nach Tinbergen (1962), ausgewertet. Die Ergebnisse meiner Untersuchung deuten sehr stark auf einen Handelsableitungseffekt, verursacht durch die europäischen Antidumpingzölle, hin und zeigen einen statistisch hochsignifikanten Effekt von europäischen Antidumpingzölle auf chinesische Exporte zu Alternativmärkten mit einer durchschnittlichen Steigerung dieser zwischen +147,81% und 258,02% für alle betroffenen HS Kategorien im untersuchten Zeitraum.

Introduction

On the second December 2013 the council of the European Union released the council implementing regulation No 1238/2013, which imposed a definitive anti-dumping duty on imports of crystalline silicon photovoltaic modules (hereafter named photovoltaic modules/solar modules) and key components originating in or consigned from the People's Republic of China (hereafter named China) (Regulation No 1238, 2013). Regulation No 1238/2013 followed the commission regulation No 513/2013, that had already imposed a provisional anti-dumping duty on the same commodities on fourth of June the same year[1].

This paper examines the effects this regulation had on Chinese exports of photovoltaic modules focusing on the question if exports of Chinese manufactured photovoltaic modules and key components deflected to third countries by the imposition of the European 2013 anti-dumping duty. The effect of trade deflection describes the distortion or re-routing of exports from a country that is facing an import restriction to alternative third country markets (Brown and Crowley, 2007).

The photovoltaic industry is a highly dynamic, volatile and competitive global market with Chinese manufacturers accounting for nearly 70% of the total worldwide production in the year 2013. The prices for solar modules also declined dramatically over 65-70% in the timespan of 2009 to 2015 (Platzer, 2015). Prior to the European Union, the United States of America imposed anti-dumping duties on Chinese manufactured photovoltaic modules in 2012 justified by the claim that Chinese manufacturers sold their products at below-market prices and that the Chinese government provided illegal subsidies to its domestic industry (Platzer, 2015).

The purpose of this thesis is to find evidence for a trade deflecting effect of Chinese exports to third country markets that was caused by the imposition of the 2013 EU anti-dumping duty.

Protectionism as an economic policy, which includes anti-dumping regulations besides tariffs, import quotas and various other government regulations, restricts imports from other countries with the aim to protect domestic producers and businesses from harmful external influences[2]. The concept of Protectionism has a long history in international trade (Bairoch, 1993) but since the election of US-President Donald Trump in late 2016 there has been a

[1] Commission Regulation (EU) No 513/2013 of 4 June 2013 imposing a provisional anti-dumping duty on imports of crystalline silicon photo- voltaic modules and key components

[2] Encyclopædia Britannica, Definition Protectionism

recent increase in protectionist trade policies. For example recently in June 2018 the United States of America imposed a 25% tariff on 50 billion $ worth of Chinese goods[3]. Even though the imposition of trade barriers can lead to some benefits for domestic industries, the general opinion most economists share is that the long term effects of protectionism on economic growth and welfare are mainly negative[4] (Mankiw, 2015).

The sector of renewable energy production, a rapidly growing global market with photovoltaic energy as one of main technologies, appears to be a sector that is increasingly affected by protectionist trade barriers. The governmental prioritization of developing domestic industries for such technologies, for example in the European Union and the USA, is continuously interfering with the World Trade Organizations (WTO) principles of the trading system (Lewis, 2014). According to the WTO principles all members should gradually work towards freer trade through the process of negotiation to encourage free global trade and also work on maximum transparency to create a predictable and stable environment. Even though the WTO as an organization is promoting free trade, it should also be mentioned that the system does allow different kinds of tariffs and anti-dumping regulations if certain circumstances caused by unfair trade are detected (WTO, 2018).

The motivation for this thesis is to gain further knowledge on the effects protectionism, in this case the European Union's 2013 anti-dumping duties on Chinese produced photovoltaic modules, can have on third countries through trade deflecting effects. If I am able to verify a trade deflecting effect on Chinese Exports of photovoltaic modules caused by the European Union's anti-dumping duty this might also enable us to transfer the results to similar cases[5].

Current state of research and relevant literature

To my best knowledge there has not been published empirical research that investigated the appearance of trade deflection on Chinese exports of photovoltaic modules caused by the European Union's 2013 anti-dumping regulations to this date. Following are some of the papers that lay the theoretical foundation for my research on the topic.

Bown and Cowley (2007) was the first paper that empirically examined the distorting effect of import restrictions on exports to third country markets. They developed a theoretical model

[3] https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-confronting-chinas-unfair-trade-policies/ [Accessed on 03.07.2018]
[4] Open Letter by Gregory Mankiw on Free Trade signed by 14 influential economists
[5] E.g. US trade barriers on Chinese solar panels

and empirically tested it on United States import restrictions on Japanese products and the development of Japanese exports to 37 countries in the timespan of 1992 to 2001. Bown and Crowley identified both a trade depressing and a trade deflecting effect on Japanese trade with an average 5-7% increase in Japanese exports of products affected by US anti-dumping measures to third countries and a 5-19% decrease in Japanese exports to third countries imposed with US antidumping measures (Bown and Crowley, 2007).

The same authors (2004) paper tried to find historical evidence for trade deflection effects on Chinese exports from 1992 to 2001. The results of their research was that they could not only find systematic evidence for Chinese trade deflection to alternative markets caused by discriminatory trade restrictions but that the effect might have been the opposite by depressing Chinese exports to alternative markets instead of increasing it (Bown and Crowley, 2004).

Tinbergen's groundbreaking (1962) article "Shaping the World; Suggestions for an International Economic Policy" developed the model used in my research to estimate trade flow between two countries based on the gravity equation. The gravity model for bilateral trade is based on the assumptions that the gross domestic product (=GDP) of two countries and the distance between them can estimate the trade between those two countries based on the same principle as described by Isaac Newton in his law of universal gravitation. The model for bilateral trade was further expanded and approved by economist such as Pöyhönen (1963), Anderson (1979) or Bergstrand (1985).

Platzer's paper (2015) for the US congressional research Service analyzing "U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition, Federal Support" contributes detailed information on the photovoltaic market and global competition. Platzer examined the US domestic production of solar panels and supportive actions imposed by the U.S. Government. The paper also contributes general information on the manufacturing process, its supply chain and a general analysis of international trade conflicts in the photovoltaic market (Platzer, 2015).

Theoretical model for trade deflection

Trade deflection describes an effect of redirecting trade flows to other countries caused by a trade barrier. According to Bown and Crowley (2007) the appearance of trade deflection is one of four theoretical effects caused by the establishment of a trade barrier besides trade

destruction, trade depression and trade creation through import source diversion. The theoretical model constructed by Bown and Crowley is based on a three country model in which each country has one firm that produces one single good that is used for domestic consumption as well as for export to the other two countries. Additional assumption for this model are that each firm's products are strategic substitutes to each other, all firms use the same technology reflecting in identical production costs, an increasing marginal cost of production and a import tariff set between two of the countries. In this model the objective for each firm is to choose an optimal total output level and an optimal level for domestic consumption and export to the other two countries based on the chosen output of the other two countries. Each firm will choose to allocate its total output across it's domestic market and the two rival markets in a way that its marginal revenue (less tariff costs) is identical in all markets because of increasing marginal cost of production (Bown and Crowley, 2007).

The four effects that occur in this model caused by a trade barrier are (figure 6):

- Trade destruction: A trade barrier in country A against imports from country B results in an overall decrease in exports from country B's firm to country A
- Trade creation (via import source diversion): Country A imports more from country C's firm to compensate for the trade destruction on country A
- Trade depression: Country C's firm exports to country B decrease because of increased exports from country C's firm to country A
- Trade deflection: Country B's firm will increase its exports to country C to compensate for the decrease of it's exports to country A

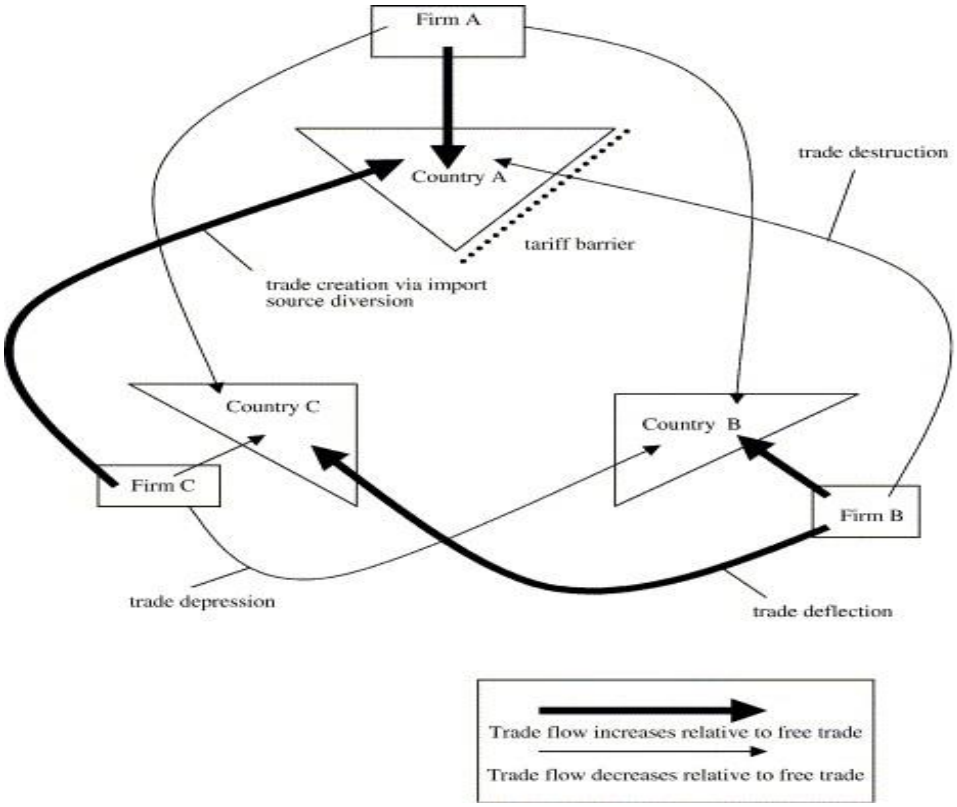

Figure 1 – Trade flows under anti-dumping duty Source: Bown and Crowley, 2007

Method of analysis

To answer the question if exports of Chinese photovoltaic modules to third country markets increased through trade deflection effects I will examine export data from the United Nations comtrade database reported by China in the time span of 2006 to 2015. For specifics on the anti-dumping regulations the European Union's relevant commission regulations and the US federal register will be examined.

The comtrade database enables us to filter the data by six digit HS[6] codes for Chinese exports of the affected commodities. Because the prices of the PV modules declined in the relevant timespan the data will be examined for both the annual quantities in kilogram and the export volume in US Dollar.

The export data will be examined with methods of descriptive statistics to summarize and detect possible first indications for trade deflecting effects to third country markets. To test the hypothesis that Chinese exports deflected in response to the European anti-dumping duties I will perform a regression analysis based on the gravity model that also takes the effect of the

[6] Harmonized Commodity Description and Coding System

earlier imposed US anti-dumping duties into account. The regression analysis will be performed with four different approaches, a random effects panel model, a random effects panel model with additional squared time variable, a random effects panel model that that includes dummy variables for each period and also the first difference model of it (Stock and Watson, 2007). The regression will be tested on the total amount of Chinese exports for photovoltaic modules to third countries once in US-Dollar and once in total quantities in KG in a log-log model.

Descriptive Statistics

The results in this chapter are based on aggregated export data reported by China for each year in US Dollar. The aggregated data consist of the HS numbers that were affected by the European anti-dumping duties[7] (Regulation No 1238 /2013).

To get a first impression on total exports of photovoltaic modules from China I aggregated data for all countries listed in the UN comtrade database. Figure 1 shows the results of this process. The total exports increased strongly from 2006 to 2011 and then declined from 2011 to 2013. During the last two years from 2013 to 2015, after the imposition of the EU anti-dumping duties, there is an increase in the total exports (+20,71%) in 2014 and (+ 16,04%) in 2015.

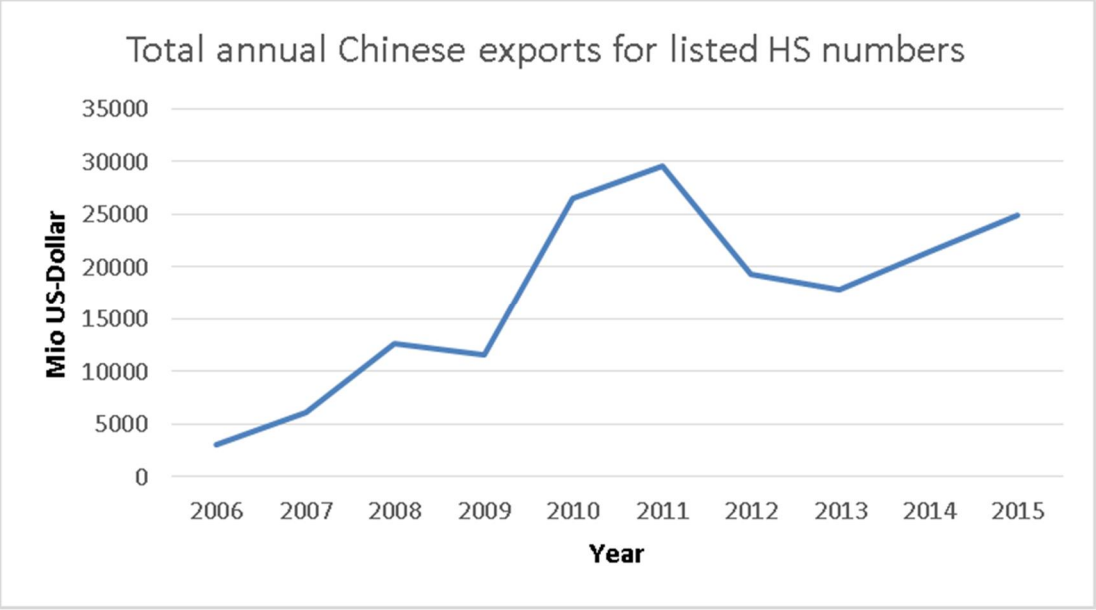

Figure 2 - Total Chinese Exports Source: UN Comtrade Database

[7] HS Codes listed in the EU Regulation No 1238 abbreviated to a six digit level, complete list with descriptions is included in the appendix (table 5)

Ensuing I ranked the five countries that imported most Chinese photovoltaic modules each year, the remaining countries are summarized in the positon third countries. Figure 2 shows that the European Union was the major export destination from 2008 to 2012 with an considerable proportion of total Chinese exports ranging from 75,16% in 2008 to 50,53% in 2012. In the years 2013 to 2015 figure 2 shows that the proportion of the European Union's exports declined significantly ranging from 21,64% in 2013 to 11,89% in 2015. In the same time period from 2013 to 2015, after the imposition of the anti-dumping duties, we see an increase in the export share to countries like Japan, Hong Kong[8], South-Korea and third countries which might be a first indication for a trade deflection effect.

Figure 3 – Percentage share of Chinese Exports Source: UN Comtrade Database

[8] Hong Kong as a special administrative region of China with independent monetary systems and a separate customs territory

After the detection of a possible first indicator for trade deflection based on the percentage share of total Chinese exports, I examined the total export volume comparing exports to the European Union and Japan in Figure 3. We can clearly see an increase in exports to Japan while the exports to the European Union decreased. In 2013, the year of the imposition, exports to the European Union decreased from 9788.70 Mio US-Dollar in 2012 to 3853,09 Mio US-Dollar (-60,64%). In the same time, exports to Japan increased from 1460,72 Mio US-Dollar in 2012 to 3476,64 Mio US-Dollar in 2013 (+238,01%).

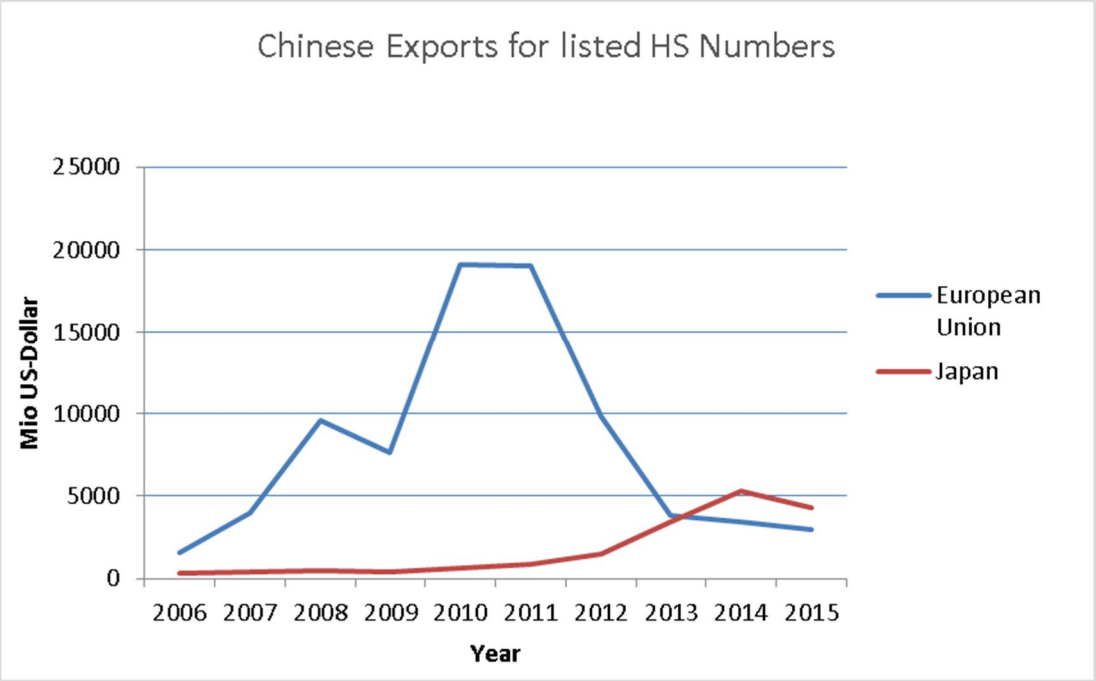

Figure 4 – Chinese exports comparing European Union and Japan Source: UN Comtrade Database

In the next step I compared Chinese exports to the European Union, the USA and all remaining other countries summarized under the category “Others” in Figure 4. The results of this process show that Chinese exports to other countries increased strongly in the year of the EU anti-dumping regulation of 2013 from 7409,54 Mio US-Dollar in 2012 to 11732,11 Mio US-Dollar in 2013 (+58,34%). Also in the next two years we can see a continuing increase of exports to third country markets by +29,46% (15188,88 Mio US-Dollar total exports to other countries) in 2014 and +27,97% (19437,14 Mio US-Dollar total exports to other countries) in 2015.

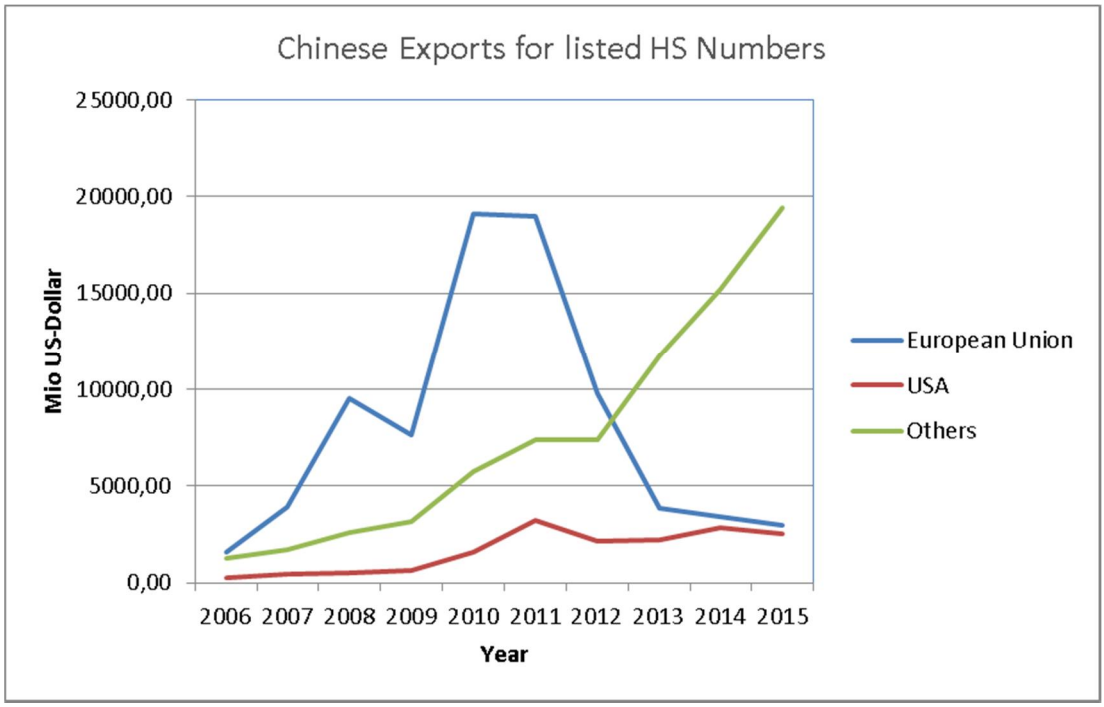

Figure 5- Chinese exports comparing EU, USA and other countries Source: UN Comtrade Database

Following the previous results I compared Chinese exports to third countries aggregated for all HS categories that have been listed in the European anti-dumping regulations with Chinese exports of similar HS categories for photovoltaic related goods that have not been affected by either the European or the US anti-dumping regulations[9]. Figure 5 shows that while Chinese exports to third countries for all affected categories increased strongly from 2013 to 2015, the exports of related parts that have not been affected by anti-dumping duties to other countries decreased dramatically in 2013 (-93,43%), stayed on a similar level in 2014 and than increased in 2015 to a similar level it had been in 2012. The results of this comparison might indicate a trade depressing effect on Chinese exports for related parts to third countries that were not affected by anti-dumping duties as described by Bown and Crowley (2007).

[9] HS Codes for commodities not affected by EU or US anti dumping regulations, complete list with descriptions is included in the appendix (table 7)

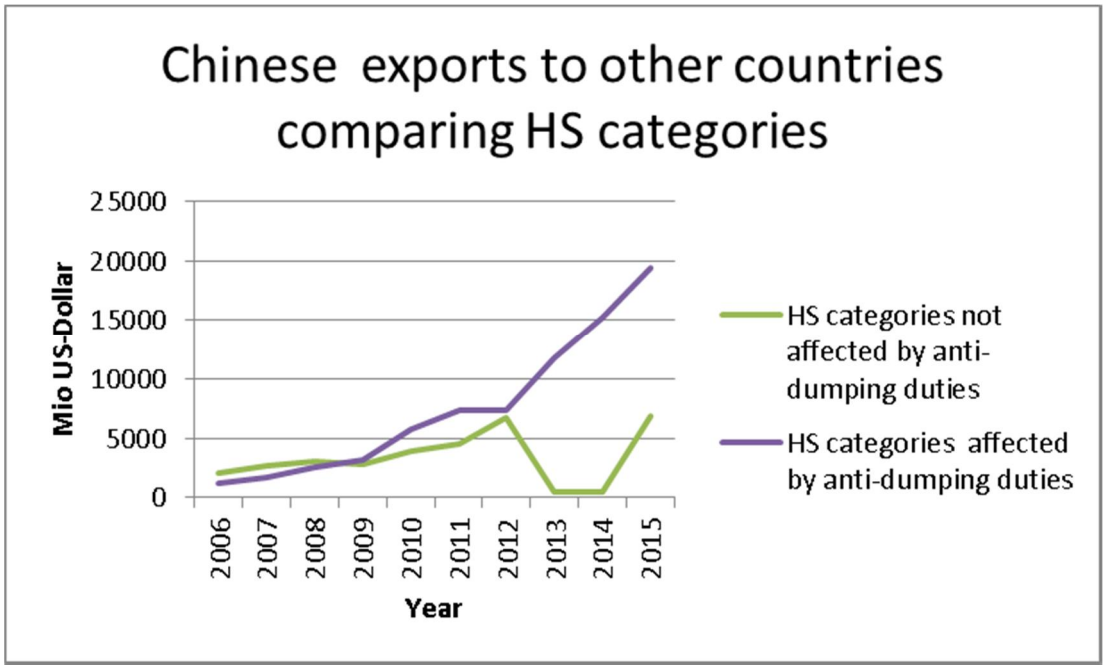

Figure 6 - Chinese exports to other countries comparing HS categories Source: UN Comtrade Database

Based on the results of this chapter I detected a strong indication for the appearance of trade deflecting effects on Chinese exports of photovoltaic modules that were listed in the European Union's 2013 regulation.

Data description

The data that is used to perform the empirical analysis is sourced from the UN comtrade database like the data in the previous chapters, however to create more observations the different HS categories are now included separately on a six digit level which models our data as a panel. The dependent variables ln_exports_chn_others represent the logarithm of annual Chinese export volumes to third countries excluding all exports to the European Union and the United States of America. Since the quantities reported for some HS categories have zero values in some years, the logarithm is calculated by an ln(x+1) transformation (Fletcher et al, 2005). An increase in the dependent variables indicates a trade deflecting effect. The dependent variables are measured in US-Dollar and kilogram. Table 1 describes the most relevant independent variables.

hs_group	Assigns each six digit HS Code a number between 1 and 15. Used as panel variable
t	Assigns each year a number between 1(=2006) and 10 (=2015). Used as time variable[10]
ln_GDP_CHN	Logarithm of annual Chinese GDP measured in current US-Dollar
ln_GDP_others	Logarithm of annual GDP for other countries (excluding EU, CHN and USA) measured in current US-Dollar
t_square	Square of time variable
eu_ad	Dummy variable, eu_ad=1 if European anti-dumping duty affects hs_group in t; eu_ad=0 if not affected
us_ad	Dummy variable, us_ad=1 if US anti-dumping duty affects hs_group in t; us_ad=0 if not affected
D07, D08,….	Dummy variable for each period; D07=1 in year 2007; in others years D07=0

Table 1 - Dependent variables

Based on the assumptions of the gravity model (see equation 2) I expect that both variables ln_gdp_chn and ln_gdp_others have a positive coefficient meaning that an increase in their GDP would lead to an increase in exports from China to other countries. These assumptions are based on the Idea described by Tinbergen (1962) that an increase in GDP increases the countries demand and supply for trade. I also expect that both dummy variables for anti-dumping duties, eu_ad and us_ad, have a positive coefficient based on the effect of trade deflection described by Bown and Crowley (2007) and the initial results I discovered in my descriptive statistics (see Figure 4 - Chinese exports comparing EU, USA and other countries).

Additional to the HS categories listed in European Union's anti dumping regulation, I included all six digit HS Codes that were affected by the 2012 US anti-dumping regulation[11] (Federal Register 73018, 2012).

The comparison of the affected HS categories shows that only three of the HS numbers listed in the US anti-dumping regulation match the European anti-dumping regulation. The US regulation only affects AC generators of an output up to 7,5 kVA, while the European regulation lists three additional categories of AC generators up to 750 kVA (HS codes 850162, 850163, 850164). The same applies to DC motors and generators (HS numbers 850132, 850133, 850134). Lead acid accumulators summarized under HS number 850720 are only listed in the US regulation.

[10] hs_group*t uniquely identifies each observation

[11] HS Codes listed in the US Regulation abbreviated to a six digit level, complete list with descriptions is included in the appendix (table 6)

To create a larger number of observations for the regression analysis I included additional HS categories[12] to my panel data. The products in these categories are part of the category 8541[13], therefore they are related to the affected commodities while not currently being listed by either European or American anti-dumping duties.

Table 2 summarizes the statistical key figures for the main variables of the panel data rounded to four decimal figures. The data includes 150 total observations (N=150) for 15 different HS numbers (n=15) over ten time periods (T=10). The mean for the logarithm of total Chinese exports in US-Dollar to third countries amounts 18,9597 with an overall standard deviation of 1,8531. The between variation of Chinese exports accounts for a larger part of the variance than the within variation which shows that the export volume varies more between different HS categories than it varies over time. The logarithm of the Chinese GDP has a mean of 29,4743 and varies with a standard deviation of 0,4532 over time, the logarithm of other countries GDP has a mean of 30,9372 with a standard deviation of 0,1807 over time. The dummy variable for the European Union's anti-dumping regulation has a mean of 0,16 which shows that 16% percent of all 150 observations were affected by an active EU anti-dumping duty (24 observations total, eight affected HS categories for three time periods). The US anti-dumping dummy variable has a mean of 0,1067 which shows that 10,67% of all observations were affected by an active US anti-dumping duty (16 observations total, four affected HS categories for four time periods).

[12] HS Codes for commodities not affected by EU or US anti dumping regulations, complete list with descriptions is included in the appendix

[13] Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels (excl. photovoltaic generators); light emitting diodes "LED"; mounted piezoelectric crystals; Source: https://www.zolltarifnummern.de/

Variable		Mean	Std. Dev.	Min	Max	Obs.	
hs_group	overall	8	4,3350	1	15	N =	150
	between		4,4721	1	15	n =	15
	within		0	8	8	T =	10
t	overall	5,5	2,8819	1	10	N =	150
	between		0	5,5	5,5	n =	15
	within		2,8819	1	10	T =	10
LN_Exports_others	overall	18,9597	1,8531	14,3247	23,6087	N =	150
	between		1,6449	15,5752	21,9948	n =	15
	within		0,9443	16,7871	24,0503	T =	10
ln_GDP_CHN	overall	29,4743	0,4532	28,6434	30,0348	N =	150
	between		0	29,4743	29,4743	n =	15
	within		0,4532	28,6434	30,0348	T =	10
ln_GDP_others	overall	30,9372	0,1807	30,5929	31,1262	N =	150
	between		3,68E-15	30,9372	30,9372	n =	15
	within		0,1807	30,5929	31,1262	T =	10
eu_ad	overall	.16	0,3678	0	1	N =	150
	between		0,1549	0	0,3	n =	15
	within		0,3358	-0,14	0,86	T =	10
us_ad	overall	0,1067	0,3097	0	1	N =	150
	between		0,1831	0	0,4	n =	15
	within		0,2538	-0,2933	0,7067	T =	10

Table 2 – Data summary
Source: UN Comtrade Database; Federal Register 73018; EU Regulation No 1238, Worldbank Database[14]

Gravity model and econometrical adaption

To analyze the deflection of Chinese exports to third countries I based my research on the gravity model first described by Tinbergen (1962) that describes the trade flow between two economies based on the size of their gross domestic product and the distance between both countries. The gravity model has been one of the most used approaches to measure trade effects and allows to modify the basic equation by adding additional variables to test for specific trade effects (e.g. trade barriers, custom unions) and also for other variables like language barriers or common borders (Magee, 2008). The simplest form of the gravity model designed by Tinbergen is based on Newton's Law of universal gravitation which describes the

[14] Data for GDPs are sourced from the Worldbank Database - https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?end=2015&start=2006 [Accessed on 20.07.2018]

attractive force between two objects as a product of their masses divided by their distance and then multiplied by the gravitational constant (equation 1).

$$1.)\ F_{ij} = G * \frac{M_i * M_j}{D_{ij}}$$

Where F_{ij}=attractive force between i and j;

G=gravitational constant;

M=mass;

D=distance

Tinbergen formulated his formula (equation 2) for the trade flow between two countries based on the GDPs of each country and their distance. The basic assumptions for his model are that, ceteris paribus, an increase in GDP increases the bilateral trade flow and that an increase in distance between two countries decreases trade between those two countries. Tinbergen justifies his assumptions by the fact that an increase in a countries GDP allows for additional import and export for this country based on an increase in both demand and supply. The negative effect of an increase in distance between two trade partners is based on the assumption of growing transactions costs for trading over larger distances. The exponents $\propto$ are indicating that there is not necessarily a direct proportionality between dependent and independent variables (Tinbergen, 1962).

$$2.)\ E_{ij} = \propto_0 * Y_i^{\propto_1} * Y_j^{\propto_2} * D_{ij}^{\propto_3}$$

Where E_{ij}=exports of country i to country j;

Y_i=GDP for country i;

D_{ij}=distance between country i and country j;

$\propto_n$=exponents

To adjust to gravity model to my research question I added two dummy variables to simulate the European and US anti-dumping regulations. Since I want to test the effect of trade deflection to third countries I summarized all countries besides the European Union, USA and China as one unit (other countries=world-USA-EU-CHN). In this setting the distance variable introduced by Tinbergen is purposeless so I excluded it from the equation. To modulate the time in my regression analysis I will test four different approaches, a panel regression with

random effects[15] (equation 3), an added squared time variable to equation 3 (equation 4) and a random effects panel regression with additional dummy variables for each year (equation 5). For the model with dummy variables for each year I will also test a regression based on the first difference value for each period (equation 6). All regressions are performed as a log-log model so that the results for each coefficient can be interpreted as the percentual change in the dependent variable (Stock and Watson, 2007). The results for each coefficient will be marked for significance levels of α =1%, α =5% and α =10%.

3.) $\ln(E_{ijth}) = \beta_0 + \beta_1 * \ln(Y_{it}) + \beta_2 * \ln(Y_{jt}) + \beta_3 * EuAd_{th} + \beta_4 * UsAd_{th} + u_{ijth}$

4.) $\ln(E_{ijth}) = \beta_0 + \beta_1 * \ln(Y_{it}) + \beta_2 * \ln(Y_{jt}) + \beta_3 * EuAd_{th} + \beta_4 * UsAd_{th} + \beta_5 * t^2 + u_{ijth}$

5.) $\ln(E_{ijth}) = \beta_0 + \beta_1 * \ln(Y_{it}) + \beta_2 * \ln(Y_{jt}) + \beta_3 * EuAd_{th} + \beta_4 * UsAd_{th} + \beta_5 * D07 + \cdots + \beta_{10} * D12 + u_{ijth}$

6. $\ln(\Delta E_{ijth}) = \beta_0 + \beta_1 * \ln(\Delta Y_{it}) + \beta_2 * \ln(\Delta Y_{jt}) + \beta_3 * EuAd_{th} + \beta_4 * UsAd_{th} + \beta_5 * D07 + \cdots + \beta_{10} * D12 + u_{ijth}$

Where E_{ijth}=exports of country i to country j in period t for HS number h;

Y_{it}=GDP for country i in period t;

$EuAd_{th}$=dummy variable, =1 if active EU anti-dumping duty in t for HS category h, =0 if not;

$UsAd_{th}$=dummy variable, =1 if active US anti-dumping duty in t for HS category h, =0 if not;

D07=dummy variable, =1 in t=2007, =0 in all other t; the following dummy variables have the same function for each time period;

t^2= square of t;

u_{ijth} = error term

Results

Table 3 summarizes the results for each tested model for the logarithm of Chinese exports to third countries in US Dollar. The first figure for each independent variable shows the estimated value for the coefficients, the second figure shows the value of the standard error. All figures are rounded for four decimal places. The highest coefficient of determination is

[15] Breusch and Pagan Lagrangian multiplier test for random effects suggest the use of a random effects model, results are included in the Appendix (table 8)

archived with the model based on equation 6 with 41,32% of the variance being predicted by the independent variables (43,02% within groups and 14,45% between groups). The second best model fit is archived by the model based on eq.5 (time dummy variables with random effects, R^2=0,0641). The two models for eq. 3 and 4 only archive a very low model fit (model 3, R^2=0,0272; model 4, R^2=0,0277). In model 6 the coefficients for the Chinese GDP is positive with a value of 5,2577 as expected but not statistically significant on any significance level (the coefficient for Chinese GDP is statistically significant in model 5 on a 1% level). Model 6 therefore predicts that an increase in Chinese GDP by 1% leads to an +5,2577% increase of Chinese exports to third countries (+3,1441% predicted by model 5). The coefficient for the GDP of other countries has a negative value of – 11,4536 and is statistically significant on a significance level of 5%. The negative effect for other countries GDP differs from my expectation based on the gravity model and is also present in model 4 and 5. A possible explanation for a negative effect of other countries GDP on Chinese exports to other countries might be the fact that I summarized other countries GDP in one variable which might account for a distorted interpretation of their effect. The coefficient for the European anti-dumping variable in model 6 is 2,5802 and highly significant on a significance level of 1%. The interpretation for this value is that in time periods of an active anti-dumping regulation the Chinese exports for affected HS categories to other countries increased by +258,02 % which supports my hypothesis that the European anti-dumping regulation caused a trade deflecting effect on Chinese exports to other countries. The coefficient for the European anti-dumping variable is also positive and highly significant in model 5 (+147,81% increase of Chinese exports to other countries). Model 3 predicts an +36,71% increase and model 4 an +53,42% increase for Chinese exports to other countries if an active EU anti-dumping duty was present but the effect is not statistically significant in both models. The coefficient predicted for the US anti-dumping regulation is positive in all models as expected. Model 6 predicts a trade deflecting effect of Chinese exports to third countries by +163,33% for affected HS categories in periods of an active US anti-dumping duty and is highly significant on a 1% level (+53,65% in model 5 on a 10% significance level).

Tested model for log exports in US-Dollar [16]	panel, re (eq. 3)	+time_square, re (eq. 4)	+time_dummyvar., re (eq. 5)	dif.(time_dummyvar.), re (eq. 6)
Observations	150	150	150	135[17]
R_square	0,0272	0,0277	0,0641	0,4132
R_square within	0,0934	0,1201	0,4911	0,4302
R_square between	0,004	0,0001	0,0577	0,1445
ln_GDP_CHN	-0,2526/ 0,5947	1,927/ 1,3500	3,1441***/ 0,8050	5,2577/ 7,4806
ln_GDP_others	1,4800/ 1,3707	-1,1332/ 1,9918	-9,4427***/ 2,2864	-11,4536**/ 5,6716
eu_ad	0,3671/ 0,3184	0,5342/ 0,3282	1,4781***/ 0,2872	2,5802***/ 0,5052
us_ad	0,3956/ 0,3661	0,4802/ 0,3661	0,5365*/ 0,3014	1,6333***/ 0,5700

Table 3- Results for tested models (in US-Dollar)
Source: UN Comtrade Data

The results for the tested models on the quantities of Chinese exports are summarized in Table 4. The highest coefficient of determination is again archived with the model based on equation 6 with 35,85 % of the variance being predicted by the independent variables (36,54% within groups and 48,21% between groups). The fits of models 3, 4 and 5 are very similar with an R^2 ranging between 0,1259 and 0,1296. In contrast to our prior results model 4 and 6 predict a negative effect of the Chinese GDP on exports to other countries which contradicts our expectations based on the gravity model even though none of the negative coefficients are significant up to a 10% level. Model 5 predicts a positive effect of an 1,3026% increase in exports to other countries for a 1% increase in Chinese GDP on a 10% level of significance. The coefficients for the GDP of other countries are positive in three of the four tested models in contrast to the prior results that mainly detected a negative effect. The effect of the European anti-dumping regulation is again predicted positive in model 6

[16] * marks p-value <=0,1; ** marks p-value<=0,05; *** marks p-value<=0,01
[17] For first difference regression number of observations dropped to 135 because one time period is lost

(87,38% increase of exports to other countries if active EU anti-dumping/ significant on a 10% level), the other models predict a positive but low increase between 15,59% and 30,57% which are not statistically significant. All models predict a positive trade deflecting effect for the US anti-dumping duty.

Tested model for log exports in kilograms	panel, re	+trend_square, re	+time_dummyvar., re	dif.(time_dummyvar.), re
Observations	120	120	120	90
R_square	0,1271	0,1259	0,1296	0,3585
R_square within	0,5113	0,5199	0,5529	0,3654
R_square between	0,1942	0,1641	0,1692	0,4821
ln_GDP_CHN	0,3461/ 0,3859	-0,5272/ 0,8758	1,3026*/ 0,6676	-0,1597/ 4,4447
ln_GDP_others	1,5910*/ 0,9031	2,6708**/ 1,3227	-1,2557/ 1,9524	0,01458/ 3,3883
eu_ad	0,2343/ 0,2317	0,1559/ 2,411	0,3057/ 0,2377	0,8738*/ 0,4606
us_ad	0,5609*/ 0,3065	0,5061*/ 0,3065	0,5391*/ 0,2957	0,3885/ 0,4606

Table 4- Results for tested models (in KG)
Source: UN Comtrade Data

Conclusion

To answer the question if the imposition of the 2013 European Union anti-dumping regulation caused a trade deflecting effect as described by Bown and Crowley (2007) on Chinese exports of photovoltaic related commodities, I examined Chinese export data both with methods of descriptive and interferential statistics. Both approaches confirmed my hypothesis for a trade deflecting effect. The graphs comparing Chinese exports to the European Union, the United States of America to Japan and other countries showed a very strong indication for trade deflection by a strong decrease of exports to the EU and a strong increase of exports to other countries in the year of and after the imposition (see figure 3 and 4). Also based on the shift in

the main Chinese exports destinations for the affected HS categories I detected a strong indication for a trade deflecting effect from the European Union as the main export destination before 2013 to mainly other Asian countries like Japan, South Korea, India and Hong Kong[18] after the imposition of the European anti-dumping duty in 2013 (see figure 2). To test the hypothesis that the European anti-dumping duty deflected Chinese exports I constructed four econometrical models based on the gravity model for bilateral trade flow described by Tinbergen (1962). All models predicted a trade deflecting effect caused by the European anti-dumping regulations, the two models with the highest coefficient of determination found a highly significant (level of significance =1%) effect by increasing Chinese exports to other countries by +147,81% to +258,02% if an HS category was affected by a European anti-dumping regulation (see table 3). To verify the results of the first regression analysis based on Chinese exports in US Dollar, I also tested the econometrical models on the Chinese export volume measured in kilogram. The results of the second analysis were not as strong as the prior results but still predicted a trade deflecting effect of an +87,38% increase of Chinese exports to other countries on a 10% level of significance in the model with the highest coefficient of determination (see table 4). Additional to the verifying results for a trade deflecting effect caused by the European anti-dumping duty, I also found strong evidence for a trade deflecting effect caused by the earlier imposed 2012 US anti-dumping regulations on Chinese exports (+163,33% increase of Chinese exports to other countries in US-Dollar; significant on a 1% level).

Based on the data I examined and the statistical methods used in this thesis the hypothesis that Chinese exports were deflected by the 2013 EU anti-dumping regulations can not be rejected and therefore seems to verify a trade deflecting effect as described by Bown and Crowley (2007). However it should be pointed out that my approach was limited in certain aspects of the research design and did not consider factors like for example Chinese methods of bypassing the anti-dumping regulations or the general reliability of Chinese economic data which are shortly explained in the critical appraisal of this thesis.

Critical appraisal

The purpose of this chapter is to point out additional elements that have not been examined in this thesis. As seen in figure 2 there had been a large increase in Chinese exports of photovoltaic modules to its special administrative region Hong Kong after the year 2013.

[18] The special role of Hong Kong is briefly addressed in the critical appraisal

Since the European Union's anti-dumping regulation only affected Chinese exports and not those from Hong Kong, this might have been a way for Chinese manufacturers to bypass the European Union's anti-dumping duties by exporting their products via Hong Kong to the European Union. Also in 2015 EU ProSun, an association of EU solar manufacturers accused China of bypassing the European anti-dumping regulations by exporting their products via other third countries, especially Taiwan and Malaysia, claiming that up to 30% of Chinese solar imports bypassed the regulation via this channels (Lee, 2015). To further verify a trade deflecting effect, it should be considered to examine Chinese exports to the EU via third countries like Taiwan, Malaysia and Hong Kong.

Another critical aspect not considered in this thesis is the general reliability of Chinese economic data which is often described as containing many errors and not being trustworthy in many aspects as pointed out by Rawski (2007). The results of this thesis should therefore be considered under this aspect of potential errors in the reported exports volumes.

An additional point of criticism in my data approach is the abbreviation of all HS categories to a six digit level while the relevant anti-dumping regulations registered all commodities on an eight digit level (Regulation No 1238, 2013). This abbreviation for the HS categories included in my data might have caused a distortion of the results since some categories were not as clearly specified as possible and therefore might have included other commodities that were not affected by the anti-dumping regulations.

Bibliography

Anderson, J., (1979). *A Theoretical Foundation for the Gravity Equation*. American Economic Review, 1979, Vol. 69, Issue 1, pp 106-16

Avsar, V., (2012*). The Anatomy of Trade Deflection*, Economics Research Working Paper Series 23

Bairoch, P., (1993). *Economics and World History: Myths and Paradoxes*, Harvester Wheatsheaf Publisher

Bergstrand, J., H., (1985). *The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence*. The Review of Economics and Statistics Vol. 67, No. 3 (Aug., 1985), pp. 474-481

Bown, C. P., Crowley, M. A., (2004*). China's Export Growth and the China Safeguard: Threats to the World Trading System*, Federal Reserve Bank of Chicago

Bown, C. P., Crowley, M. A., (2007*). Trade deflection and trade depression*. Journal of International Economics Vol 72 (2007) pp176-201

Council Implementing Regulation No 1238/2013, (2013). Official Journal of the European Union L325/1

Curran, L., (2015*). The impact of trade policy on global production networks: the solar panel case*. Journal Review of International Political Economy, Volume 22, 2015 - Issue 5, pp 1025-1054

Encyclopedia Britannica, (2018). *Protectionism*. Economics. Available at: https://www.britannica.com/topic/protectionism [Accessed on 15.07.2018]

Federal Register, (2012). *Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled Into Modules, From the People's Republic of China: Countervailing Duty Order*, Notices; #73017 Vol.77, No. 236, Friday, December 7, 2012

Fletcher, D., MacKenzie, D., Villouta, E., (2005). *Modelling skewed data with many zeros: A simple approach combining ordinary and logistic regression.* Environmental and Ecological Statistics, March 2005, Volume 12, Issue 1, pp 45–54

Lee, A., (2015). *EU ProSun complains to EU over 'fraudulent' Chinese PV imports London & Brian Publicover*, Shangha; Available at: http://www.rechargenews.com/solar/862629/eu-prosun-complains-to-eu-over-fraudulent-chinese-pv-imports [Accessed on 22.07.2018]

Lewis, I. J., (2014). *The Rise of Renewable Energy Protectionism: Emerging Trade Conflicts and Implications for Low Carbon Development*. Global Environmental Politics, Volume 14 Issue 4 November 2014, pp 10-35

Magee, S., P., (2008*). New measures of trade creation and trade diversion*. Journal of International Economics 75 (2008), pp 349–362

Mankiw, G., (2015). *An Open Letter*. Greg Mankiw's Blog - Random Observations for Students of Economics, Available at: http://gregmankiw.blogspot.com/2015/03/an-open-letter.html [Accessed on 28.07.2018]

Platzer, M. D., (2015*). U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition*, Federal Support, Congressional Research Service

Pöyhönen, P., (1963*). A Tentative Model for the Volume of Trade between Countries*. Weltwirtschaftliches Archiv Bd. 90 (1963), pp. 93-100

Rawski, T., G., (1976). *On the reliability of Chinese economic data*. The Journal of Development Studies, Volume 12, 1976 - Issue 4, pp 438-441 [Published online: 23 Nov 2007]

Stock, J., H., Watson, M., W., (2007). *Introduction to Econometrics.* Pearson Educational Edition. Second Edition

Tinbergen, J., (1962). *Shaping the World Economy; Suggestions for an International Economic Policy.* Books (Jan Tinbergen). Twentieth Century Fund, New York.

World Trade Organization (WTO), (2014). *United States-Countervalting Duty Measures on certain products from China*, AB-2014-8, December 18, 2014

World Trade Organization (WTO), (2018). *Principles of the trading system.* Available at: https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact2_e.htm [Accessed on 22.07.2018]

Appendix

6 digit HS Code	Description
850131	DC motors of an output > 37,5 W but <= 750 W and DC generators of an output <= 750 W
850132	DC motors and DC generators of an output > 750 W but <= 75 kW
850133	DC motors and DC generators of an output > 75 kW but <= 375 kW
850134	DC motors and DC generators of an output > 375 kW
850161	AC generators "alternators", of an output <= 7,5 kVA
850162	AC generators "alternators", of an output > 75 kVA but <= 375 kVA
850163	AC generators "alternators", of an output > 375 kVA but <= 750 kVA
850164[19]	AC generators "alternators", of an output > 750 kVA
854140	Diodes, transistors and similar semi-conductor devices; Photosensitive semi-conductor devices, including photovoltaic cells whether or not assembled in modules or made-up into panels; Light emitting diodes; Mounted piezo-electric crystal - Photosensitive semi-conductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; Light emitting diodes

Table 5 - List of HS Codes affected by EU anti-dumping duty
Source: EU Regulation No 1238, 2013; https://www.zolltarifnummern.de/

[19] Excluded from data since no reported exports from China in the relevant timespan

6 digit HS Code	Description
850161	AC generators "alternators", of an output <= 7,5 kVA
850720	Lead acid accumulators (excl. spent and starter batteries)
850131	DC motors of an output > 37,5 W but <= 750 W and DC generators of an output <= 750 W
854140	Diodes, transistors and similar semi-conductor devices; Photosensitive semi-conductor devices, including photovoltaic cells whether or not assembled in modules or made-up into panels; Light emitting diodes; Mounted piezo-electric crystal - Photosensitive semi-conductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; Light emitting diodes

Table 6 - List of HS Codes affected by US anti-dumping duty
Source: Federal Register 73018, 2012; https://www.zolltarifnummern.de/

6 digit HS Code	Description
854130	Thyristors, diacs and triacs (excl. photosensitive semiconductor devices)
854150	Semiconductor devices, n.e.s.
854160	Mounted piezoelectric crystals
854190	Parts of diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices, light emitting diodes and mounted piezoelectric crystals, n.e.s.
854129	Transistors with a dissipation rate >= 1 W (excl. photosensitive transistors)
854121	Transistors with a dissipation rate < 1 W (excl. photosensitive transistors)

Table 7 –List of additional HS Codes not affected by EU or US anti dumping duties
Source: https://www.zolltarifnummern.de/

Breusch and Pagan Lagrangian multiplier test for random effects

LN_Exporte_CHN_Others[hs_group,t] = Xb + u[hs_group] + e[hs_group,t]

Estimated results:

	Var	sd = sqrt(Var)
LN_Exp~rs	3.433999	1.853105
e	.9148657	.9564861
u	1.08837	1.043249

Test: Var(u) = 0

chibar2(01) = 218.44

Prob > chibar2 = 0.0000

Table 8 - Breusch and Pagan Lagrangian multiplier test results

Statutory Declaration

Herewith I, ……..…….. ,

with Student ID: ……..…….

declare that I have completed the present thesis, entitled:

independently, making use only of the specified literature and aids; it is entirely the product of my own scholarly work, unless stated otherwise. Any inaccuracies of fact or faults in reasoning are my own and accordingly I take full responsibility. Sentences or parts of sentences quoted literally are marked as quotations; identification of other references with regard to the statement and scope of the work is quoted. The thesis in this form or in any other form has not been submitted to an examination body and has not been published. I certify that the printed version of this paper is equivalent to the submitted electronic version.

I am aware that false statements may also entail legal disadvantages.

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