How effective are punitive tariffs?

An evaluation of attempts to reduce trade dependency on China in solar panels

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Summary / Abstract

In this paper I conduct an evaluation of a series of trade policy events in the solar panel disputes that have been ongoing since the early 2010s. The main focus is on the US's Safeguard tariffs that were instigated in early 2018. The paper argues that the aim was to counteract the predatory pricing policies that have been made possible due to China's extensive state subsidies directed towards solar panel production. The ordinary trade policy analysis could be hindered by several factors: such as the ocean of related trade policy events that preceded and followed the US Safeguard tariffs, or the circumvention attempts among local and multinational producers in China towards other production outposts in ASEAN. Here a firm survival analysis may be more exact and accurate as a complement to a classical trade policy evaluation. Because the aim with punitive tariffs is ultimately to eradicate or correct the behaviour of producers that base their business models and strategies in unfair practices. However, as the analysis in this paper demonstrates, punitive tariffs may not be very effective in what is now finally also becoming recognised as a series of trade disputes that concern more the systemic (comparative systems or 'bundles' of institutions) level of the economy. Whereas the traditional aim of WTO compliant policies such as countervailing and safeguarding tariffs is the discretionary practice level of individual firms. Under such circumstances, the paper concludes, punitive tariffs and as we know them in the context of the rules-based WTO system, could even prove to be counterproductive.

Keywords

Trade policy analysis, Panel data, Gravity models, Survival models, Solar panels (HS854140), Punitive tariffs, Trade dependency, State subsidies

1-Introduction

During the 2010s there have been three meta-events in the global solar panel disputes: the Obama tariffs in 2012, the EC tariffs in 2013 and again in 2017, and the Trump Safeguards in 2018 (in part still being upheld by the current Biden administration, see also Fajgelbaum and Khandelwal, 2021). The paper seeks to evaluate the impact and effectiveness of the latest event in the first Quarter of 2018, when the US imposed universal Safeguard tariffs for the first time in the relatively brief history of global solar panel trade. This event happened during a period where several countries including the US administration, challenged the global rules-based system and sought increasingly to resort to nationally-based and traditional protectionist policies (Kwan, 2020). Subsequently it has led to a discussion (and especially in the US), whether this was the most intelligible policy response to the situation and problems that had started to occur in a global trading system, where some countries subsidies their firms more than others? Now placing the global system in its current conundrum: as to whether the global trading system is at all sustainable as it leads to the continuation of a situation where we finance political leaders and firms basing their ethics in inhumane practices. In this perspective it is important to understand whether the current trade policy instruments have the intended impact - are these policies having the impact that policy-makers hope and expect?

The literature review shows that while there have been many studies investigating these issues in a nationalist or implementing jurisdiction perspective (especially what has been the impact on the US economy and for US consumers), there has been relatively few studies that have looked at this problem more in the perspective of what happens to the overseas firms that are often the direct target of the policies.

Here I therefore focus in combination on the general export competitiveness of China in solar panels and the specific competitiveness in terms of firm survival of Chinese firms in the wake of these policies. This is made possible by the usage of three different databases in combination.

Section 2 of the paper provides for the background to the ongoing trade disputes in solar panels ending with a clarification of the research questions pursued in the paper. Section 3 provides for a short literature review of earlier similar studies conducting a policy evaluation of current trade policy events in solar panels and other similar related manufacturing industries. The methodology (Section 4) introduces the databases and modelling frameworks employed towards conducting policy evaluation. The results of the two modelling frameworks are presented in Section 5. Section 6 discusses and compares the results across the different methodologies and datasets employed and concludes the paper.

2-Background: the solar panel trade disputes

The solar panel industry is an interesting industry case to investigate in relation to the effectiveness of different trade policy instruments. It is possible to single out a fairly homogeneous product and couple it with exact and common (frequent) trade policy events over the 2010s.

In terms of trade policy the solar case one of the most heavily politicised in recent global economic history. The trade policies have occurred within three policy frames or meta events under the EU Commission in 2013, the Obama Administration in 2012 and the Trump Administration in 2018. The GTA Database which records trade policy events down to the specific country for the 6-digit product level, also confirms that this is a rich case in terms of trade political actions. For example, in the period of study (2008-2020) there were 45 independent events that targeted Chinese PVC producers (HS 6-digit code 854140) solely or in conjunction with other producers in the world.

The first two general events occurred within the WTO framework of trade disputes (Curran, 2015). At about the same time both the EU Commission and the US's Obama administration started to inquire into the background of the fast rising market shares of Chinese firms in solar panels. These early cases were raised at the WTO under the provisions of anti-dumping and anti-subsidy and led also quickly to similar responses and trade policy spillovers among other major trading partners of China in this industry such as Australia, Korea and India. These events are also accounted for more systematically using the GTA Database in Section 4 (methodology) of the paper.

The last major or meta-event, which is also the particular focus of the present study, is the Trump administration's punitive tariffs that were implemented in 2018 (WTO, 2021b, OUSTR, 2021) [1]. While earlier meta-events or trade policy responses to Chinese policies were considered weak, of a temporary nature and in the end withdrawn due to Chinese retaliations, the latest event is considered more severe and likely to have a detrimental impact on Chinese solar panel producers. First of all is the aim of the Safeguard to countervail any potential circumvention attempts that followed from the earlier policies (Yean Tham, Yi & Ann, 2019, Cartwright, 2022).

The paper seeks in particular to evaluate the impact and effectiveness of this latter event in the first Quarter of 2018. Arguably this event happened during a period where several countries including the Trump administration challenged the global rules-based system and sought increasingly to resort to nationally-based policies and traditional protectionist arguments in a rhetoric and response to problems increasingly seen as unamenable under the global WTO-led system. Subsequently it has led to a discussion (especially in the US) whether this was the most intelligible policy response to the situation and problems that had started to occur in a global trading system where some countries subsidies their firms more than others.

All these events exemplify within the global solar panel industry (but far from exclusive to this particular industry), the present conundrum in the global system: as to whether the global trading system is at all sustainable as it leads to the continuation of a situation where we finance political leaders and firms (through our consumption) that base their ethics and practices on values that we fundamentally must consider to be unfair and not in the best interest even of their own constituent populations. In this perspective it is important to understand whether the current trade policy instruments have the intended impact - are these policies having the impact that policy-makers hope and expect?

The literature review shows that while there have been many studies investigating these issues in a nationalist or implementing jurisdiction perspective (especially what has been the impact on the US economy and for US consumers), there has been relatively few studies that have looked at this problem in the perspective of what happens to the overseas firms that are often the direct target of the policies. Here I focus in combination on the general

[1] The Trump tariff was implemented as a Safeguard instrument under the WTO, even though the tariff only became admitted under WTO law ex-post, see WTO (2021a), and is still being disputed by individual players in the US (see e.g. ENR, 2021) and by China at the WTO under a separate filing of appeal made by China to the WTO on September 16, 2021.

export competitiveness of China in solar panels and the specific competitiveness in terms of firm survival of Chinese firms (defined in this paper as firms located in China) in the wake of these policies. This is made possible by the usage of three different databases in combination.

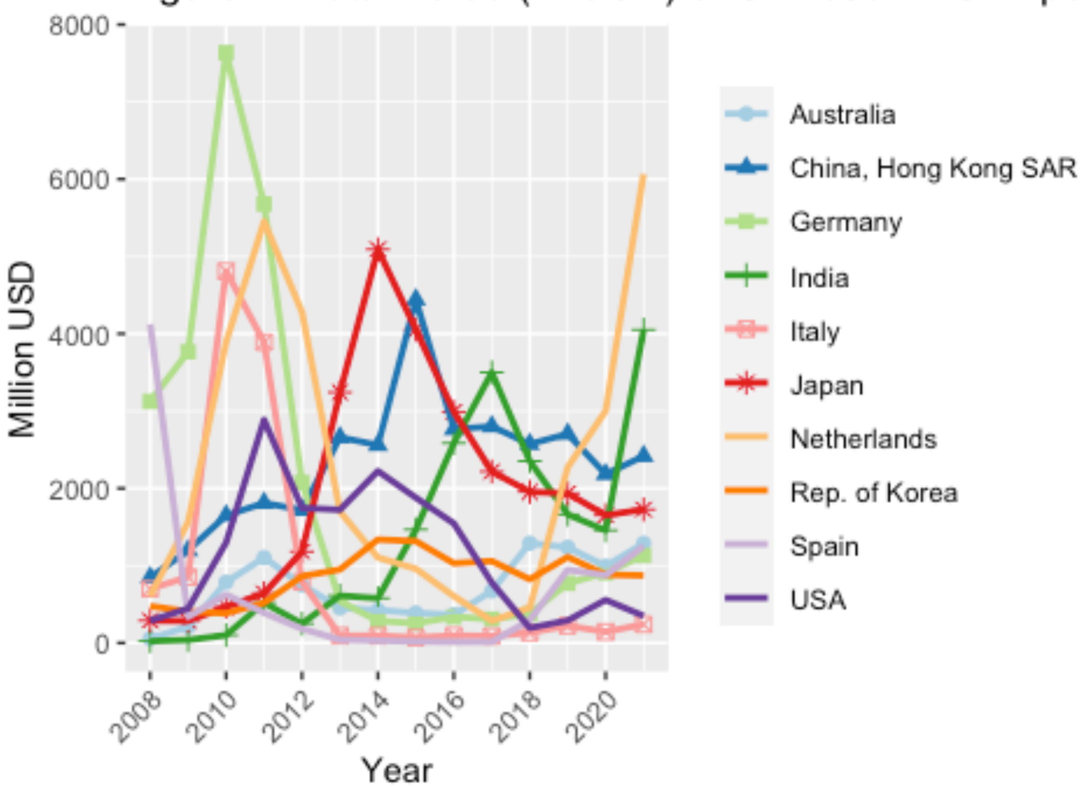
However, as discussed earlier there is considerable inconsistency between observed market shares of Chinese and Asian producers on the one hand and the argument that the punitive tariffs were overall effective in slowing the adoption of solar panels worldwide. For example, it is inconsistent with the latest reports from Frauenhofer showing both the constantly growing output and the continuous increase in the global market share of China and Asia. Fraunhofer reports this market share to be ever increasing (except for a short slump in 2007-08) up till its present level in excess of 92% across the Asian economies and hereof 67% for China alone (Frauenhofer, 2022). Similar numbers were offered in an updated report focusing on solar panels published by the International Energy Agency in mid-2022 (IEA, 2022).

Table 1 shows the developments in export competitiveness using official trade flow records. The table suggests a more modest Chinese market share than other records and databases when using the data reported into the UN's Comtrade database. The global market share of China in PVCs has according to UN data been steadily increasing since 2010. Weighting the global market share with the overall market share of China in merchandise exports also suggests that comparative advantage declined slightly in the early period of the 2010s, but has rebounded in the latter part of the period after 2015. Table 1 along with Figure 1 also shows that the top destinations for Chinese solar panels are drastically changing over the period of study. Due to circumvention by China after the first waves of tariffs instigated by the Obama Administration, many of the solar panels that came into Europe and the US after 2015 typically came from Chinese outposts in ASEAN instead (see also Yean Tham, Yi & Ann, 2019). But overall and after a readjustment in the middle of the period (around 2015-2016), Chinese exports of solar panels have rebounded. Data validity (reliability) creates several challenges for policy evaluation that the paper seeks to tackle by combining several datasets and methodologies.

Table 1: Chinese global market shares in PVCs

Year	**2010**	**2015**	**2020**
Market share PVC	0.35	0.37	0.41
GS MerchExp	0.10	0.14	0.15
RCA PVC	3.38	2.74	2.80
Top1	Germany	Hong Kong	Netherlands
Top2	Italy	Japan	Hong Kong
Top3	Netherlands	USA	Japan
Top4	Hong Kong	India	India
Top5	USA	Korea	Australia

Figure 1: Total Value (m USD) of Chinese PVC Export



Source: UN Comtrade Database

In other words it is not without bias accounting for these different trade developments and policy events using standard trade datasets such as the UN Comtrade database. There can be several reasons for the inherent biases in public trade databases and accounts. One problem can be the likely circumvention exercises that large firms and multinationals use in response to trade policy events.

Another, that is often ignored when analysing trade developments more broadly or beyond the level of individual industry cases, is that despite the possibility of investigating trade in particular products at a very disaggregated level (i.e. down to the 6- and 8-digit product level in official trade data records), there can often be the problem that particular products can be mixed up with other products; and/or; that the customs of different countries treat particular products differently when applying the official nomenclatures to goods arriving at their border. For example, the Semiconductor Industry Association comments with regard to HS groups 8541 and 8542 (where PVCs are mainly traded under the heading or subcategory of 854140) (SIA, 2019, Page 6, last para):

"Despite the benefits of past HS amendments to semiconductor headings 8541 and 8542, there are still situations in which certain jurisdictions interpret the customs definitions differently, leading to non-uniform classification of the same good in different markets."

2.1-Research questions

R1. What were the motivations behind consecutive punitive tariffs on Chinese PVC producers that led up to the US Administration's Safeguards in the 1st Quarter, 2018?

R2. Did the US Safeguards in 2018 have the intended impact? -R2.a Did the US Safeguards reduce trade dependency on China in solar panels? -R2.b Did the US Safeguards lead to a higher death (hazard) rate among Chinese relative to other producers in the rest of the world?

R3. What are the long-term consequences (if any) towards creating a more leveled playing field in global solar panel trade?

3-Literature review

Given its highly politicised character, the global solar panel industry has received significant interest also from researchers. However, to date trade policy evaluations and especially in the perspective of China have been rare. Oppositely has the US-China trade war and other manufacturing industries (such as for example washing machines) spawned a relatively large US-specific literature and in the perspective of US consumers.

In Table 2 are listed the eight most relevant research papers that were identified related with the topic of this paper. Given that the latest wave of Safeguard tariffs is of such a recent date, relatively few studies are available that directly evaluate them or made it possible to draw in data for this recent episode that send a shock wave through the industry. But in the literature review the focus was on this particular event in 2018 as well.

The papers reviewed are also listed alphabetically by author acronyms in Table 2. The rows of Table 2 list the different welfare effects that are evaluated in the papers. Here ordered by the type of effects that are more or less common to study in the evaluation oriented parts of the trade policy literature. The traditional welfare economic arguments related with the usage of tariffs are listed first: impact on trade flows, deadweight loss of tariff and potential terms of trade gains or losses. Next are listed some of the welfare effects that trade analysts have only recently started to consider and drawing in more pluralist perspectives besides the traditional neoclassical welfare gains: carbon leakage or environmental impact; leveling the playing field; and relatedly; firm survival and circumvention or reallocation towards other countries and/or regions. Finally, the top row in the table then summarises the estimated total impact as assessed in the perspective of the individual paper. In other words we cannot immediately compare such 'total effect' across individual papers. But in summary we can see that the papers focusing on the traditional neoclassical arguments (traditional protectionism of import competing industries) find a negative impact of the Safeguards on welfare. Oppositely, in papers that draw in more recent perspectives and arguments (such as carbon leakage or environment, level playing field and reducing overtly dependency on a few countries), the result is more likely that the total welfare effect of the Safeguards could be positive.

Here the papers are briefly presented and discussed individually but in a slightly different order starting from papers that are closest in their focus to the present paper - namely those with a similar industry focus (solar panels and washing machines). Next I shift to review three papers that assessed the impact in a China or Chinese firm perspective, but without any particular industry focus. Finally do I draw in and relate also to the more US specific literature. At the end of the literature review will then be touched upon the more motives-related aspects of this literature. For example, what did different writers ascribe the motives or interests behind these recent trade policy events to be? This is important to know before we can draw conclusions from the analysis and as to whether the objectives of the trade policies were met or not when it comes to solar panels. However, already from the stylized facts presented above we can see that for any attempts to reduce trade dependency on China for global supplies of solar panels, the policies have been futile at best if not even counterproductive.

Table 2: Estimated welfare effects of the US Safeguards in the literature

Paper	*BCSX*(2020)	*CB*(2021)	*FGKK*(2020)	*FGKKT*(2021)	*FHT*(2020)	*HW*(2021)	*LCYWL*(2021)	*LLF*(2020)
Focus	China	China	US	Global	Washers	Solar	Global	China SMEs
Total_effect	Plus	Plus	Minus	Plus	Mixed	Minus	Mixed	Mixed
Trade_flows	-	-	Minus	Plus	Mixed	Minus	Mixed	-
Traditional_DWL	-	-	Minus	-	Minus	Minus	Minus	-
Terms_of_trade	-	-	Minus	-	Minus	Minus	-	-
Carbon_leakage	-	-	-	-	-	Minus	Plus	-
Level_play	Plus	Plus	-	-	-	-	-	Zero
Circumvent_reallocate	-	-	-	Plus	Plus	-	Plus	-
Firm_survival	-	-	-	-	-	-	-	Zero

Houde and Wang (2021) (HW2021 in Table 2) conduct a neoclassical trade policy analysis of the solar safeguards, but incorporating novel aspects such as global value chain considerations into their analysis and econometric model. For example, resellers or distributors are an additional player considered by HW2021. Their modelling results suggest a pass-through of the tariff with an overall negative terms of trade effect, especially for US consumers. They estimate welfare effects to be negative on all sides of the market and also suggest a negative impact for the global rate of adoption of solar panels. Flaaen, Hortaçsu & Tintelnot (2020) (FHT2020 in Table 2) conducted a similar study, but of washing machines and also taking into account a broader battery of trade policy measures and of somewhat earlier dates (FHT2020 go back to measures instigated as early as 2012). FHT2020 evaluate consumer impact of what is seen as a traditional protectionist policy on

American end consumers, by not only considering pass through or the terms of trade impact of the tariff, but also how the tariff alters domestic pricing policies and including complementary goods to washing machines as well (such as dryers). They demonstrate that the tariffs and new protectionism had a significant impact on US consumers in the form of higher prices (with price hikes up to 213% estimated in FHT20202). However, FHT2020's analysis does suggest that there can be a positive reallocation impact from import tariffs. For example, if trade is concentrated towards a single supplier country. In the case of washing machines, the first round of circumvention impact was by shifting production from Korea to mainland China and by reoptimising the global value chain among some of the global industry's largest players (Samsung, LG and Whirlpool). The 2018 Safeguard also eventually led to some reshoring of these same firms back to the US market according to FHT2020.

Another group of papers take a different and broader approach to the trade policy events that have often targeted China specifically over the 2010s. One example is the study by Benguria, Choi, Swenson & Xu (2020) (BCSX2020 in Table 2). Their estimates indicate that Chinese firms were impacted negatively by the trade policy uncertainty that the US-China trade war had caused. They argue that it led to a reduction in the activity levels of Chinese firms. For example, BCSC2020 report a reduction in both firm-level investment, R&D expenditures, and profits by Chinese firms with 1.4, 2.7, and 8.9 percent, respectively. It is discussable whether this should be reported as a negative or positive welfare effect in the global trading system? I choose to report it as positive, from the perspective that the aim of these policies is to create a more leveled playing field in industries that are often subsidised directly or indirectly by the Chinese state. Furthermore, production takes place at environmental and labour standards that are considerable below those considered socially acceptable both in the European Union and the US. These difference in standards are now increasingly being viewed as indirect ways that businesses located in countries overseas are subsidised (for example in the perspective that it is the polluter that must pay the cost for the act of polluting) (Stiglitz, 2017). Similar results are reported in Chor and Bingjing (2021) (CB2021 in Table 2), but using a completely different type of dataset. With information about night-time light and by tracking economic activity in this way over the trade war, CB2021 suggest that in geographical areas affected more by the policy, there was a considerable lowering of economic activity. However, neither of the two previous studies mentioned, considered firm survival as their dependent variable. Another study that focused more explicitly on Chinese SMEs by Liu, Liu and Flemming (2020) (LLF2020 in Table 2), reported no results of the trade policies for neither leveling the playing field nor firm survival among Chinese producers. In addition did none of the studies focusing on China take into consideration the potential and indirect impact that circumvention may have had for the performance of Chinese producers in a wider perspective that incorporates their overseas interests and production plants in other third countries.

The last group of papers concerns the US economic perspective or broader global issues and perspectives of the same policies. Here the paper by Fajgelbaum, Goldberg, Kennedy & Khandelwal (2020) (FFGK2020 in Table 2) is most similar to the HW2020 paper, but now investigating the impact of the 2018 tariffs and safeguards in the perspective of US consumers. This study confirms the findings in the papers focusing on the industry specific impacts for solar panels and washing machines. Overall it can therefore be concluded, and perhaps somewhat surprisingly due to the buying power of US consumers in many of these affected industries, that pass-through was typically with more than the tariffs on US domestic consumer prices and that therefore there was not a terms of trade effect in favour of the home country as one would expect when there is a considerable concentration of buying power. However, this could also be due to the more than equal match in selling power on the producer side of many of these industries (i.e. often overt reliance on a few firms with highly skewed or concentrated production and towards a few or a single overseas location).

Yet oppositely, and when contemplating the welfare effects of the recent waves in protectionism from a global perspective, can be mentioned the findings in two papers that took such a broader perspective by calibrating and incorporating effects for all countries. For example, the study by Fajgelbaum, Goldberg, Kennedy, Khandelwal and Taglioni(2021) (FGKKT2021 in Table 2) finds that the tariffs led to global reallocations that may have hurt consumers and producers in the immediately implicated countries, but also that the attempts to reduce dependency on singular locations and firms may not have been entirely futile. Here the global total effect on trade flows is estimated to be positive (re. also Table 2 first row after headers) and FGKKT2021 end up concluding that the trade war has created net trade opportunities for many countries that they label as bystanders to the trade war in their analysis. Similarly, does the study by Liu, Creutzig, Yao, Wei & Liang (2020) (LCYWL2021 in Table 2) using a global computable equilibrium model suggest that there are both positive and negative aspects of the new protectionism (that needs to be weighed in a global perspective rather than focusing singularly on impacts in individual countries). Opposite Houde and Wang (2020) does this paper admit that there can be a positive impact for carbon leakage of the new protectionism[2]. While there is found to be the traditional deadweight losses on lowering trade and potential consumption and production from this protectionism, it does come at the gain of reducing leakage and also reallocating trade to other countries. (Such other countries that may in the wake and surge in state subsidies in fact be those who are the truly more naturally comparatively advantaged countries in some of these affected industries.)

From the motives-oriented perspective and besides the papers in Table 2 - most of which discuss or see the policies as traditional protectionism, there are some alternative and more political-economy or stakeholder oriented papers and views that should also be mentioned here. For example, the research by Hughes and Meckling (2017) and also by Flaaen, Hortaçsu & Tintelnot (2020) reveal that there is an interesting contrast between traditional protectionist arguments and the newer literature where multinational firms often spawn global value chains in industries such as solar panels and washing machines and therefore may have more divided views on trade policy (see also Curran, 2015). For example, a new type of stakeholder discussed in the Hughes and Meckling paper are the distributor firms in the US, who often have more to lose than gain from traditional protectionist policies. At the same time does this literature reveal that there can be strategic interests of individual firms involved: trade policy events could fundamentally also be viewed as incentivised or motivated by lobbying of very powerful players. Here, for example, does the research by Hughes and Meckling (2017) reveal that it was a German multinational player that initially

[2] Surprisingly this can also be true for global solar panel trade by reshoring or reallocating some of the production to other countries including major buyer countries, as it can lead to an overall reduction in carbon leakage when consumers and governments at the same time take back the right to regulate the emissions of some of these global industries with a very heavy carbon footprint. Even in solar panel trade there is de facto carbon leakage involved. For example, Yue, You & Darling (2014) find that carbon leakage from placing production in China instead of the US leads to a doubling of emissions. These arguments have now become more legitimate, as they are increasingly cast in the perspective that the green transition is less sensible, if it does not at the same time solve the problem of overtly concentrating seller power to a small handful of countries (as we know it from OPEC in the fossil-based economy). Hence a reduction in trade dependency is now an important additional welfare argument for intervening in international trade under some circumstances and especially promoting longer term thinking about trade and sustainability.

brought the anti-dumping charges to the US courts and thereby started the ball rolling that ultimately resulted in the 2018 Safeguards.

4-Methodology

The study combines a linear panel data model (classical approach and gravity style equation) with a non-linear panel data survival model of firms. First the different datasets are introduced and it is explained how they are merged (ie. the GTA database is combined with Comtrade data). In the first model Chinese exports (quoted in value and weight) is the dependent variable. This is combined with a semi-parametric research design cast in a panel data structure and assuming that there are no additional relevant control factors besides policy and pre-determined structures (ie. geography, trading distance, language etc.).

In the survival model (based on the Enfsolar database which has been obtained from the leading global digital platform for solar panel trade), the dependent variables or object of study are instead individual firm survival and hazard rates. Firm survival and hazard rates are tested using a singular policy effect towards evaluating whether the Safeguards instigated in February 2018 had any significant impact on firm survival of solar panel producers and Chinese solar panel producers specifically.

4.1-Data: The GTA database

The data on trade policy events originates from the GTA database (described in detail in Evenett & Fritz, 2020). The GTA database provides for a systematic approach towards cataloguing these events starting from 2008. The more impressionistic approach provided in the literature review can therefore also be benchmarked with more quantitative types of trade policy events as facilitated by a rigorous database such as the GTA. Here it is possible to single out trade policy events at the 6-digit product level. Further making it possible i.e. to isolate events affecting solar panels in Chinese exports (the primary perspective modeled in this paper). Table 3 gives an overview of the relevant trade policy events in solar panels. The focus is solely on performing a trade policy evaluation of traditional instruments such as ordinary tariffs (including the GTA instrument defintions of import tariffs, anti-dumping, anti-subsidy and safeguard policies). Policies associated with other instruments such as export subisdies and other types of industrial policies including public procurement policies are not included in this study.

The GTA data on trade policy events as summarised in Table 3 is then combined with information about Chinese exports from the UN comtrade dataset to individual trading partners and merging the two datasets by country and year.

Table 3: Trade policies implemented against China in global PVC trade, 2008-2022.

```
##              Anti-dumping Anti-subsidy Import tariff Safeguard
##
## Argentina               0            0             3         0
## Australia               1            0             0         0
## Brazil                  0            0             5         0
## Canada                  1            1             0         0
## Chile                   0            0             1         0
## Ecuador                 0            0             1         0
## EU                      1            1             3         0
## Ghana                   0            0             1         0
## India                   2            0             0         1
## Indonesia               0            0             2         0
## Kenya                   0            0             1         0
## Tanzania                0            0             1         0
## Tunisia                 0            0             1         0
## Turkey                  1            0             0         0
## Uganda                  0            0             1         0
## UK                      1            1             3         0
## US                      3            3             3         1
## Venezuela               0            0             1         0
```

Source: GTA Database.

4.2-Data: UN Comtrade trade data

Figure 1 further above showed the development in Chinese exports by the 15 largest destinations over the period 2008-2021 according to the Comtrade database. Chinese export patterns in solar panels by destination country greatly diversify over the period of study given that total exports in HS 854140 increases (after a slump in 2015-16) (this is not shown directly with Figure 1). Resulting in total exports of solar panels from China being higher than ever before in the Pandemic year of 2020.

4.3-Data: The ENF solar database

For the second part of the analysis a unique firm-level panel dataset has been obtained from the digital platform Enfsolar. Enfsolar is the largest reseller of solar panels in the global marketplace. According to Enfsolar's founder-CEO the firm directory and product catalogue covers up to 90% of the total global market for solar panels. Using simple firm count records suggest a Chinese market share of around 45%. However, this share is reached without accounting for differences in firm size and is therefore also likely to be biased but in different ways than for the Comtrade data.

It is thus anticipated that the more correct size of the real market share of China in the PVC industry is closer to 90% at the close of 2021, and even though there is a lack of direct evidence hereof in the primary datasets employed in this paper.

Based on individual annual firm directories obtained from Enfsolar, covering the period 2013-2021 (i.e. allowing a large interval around the studied trade policy event in the first Quarter of 2018), the individual annual directories are merged into one panel. Subsequently all duplicates of the same firm are removed, ensuring that only the latest most up-to-date record for each firm is kept. An exit dummy is coded for the year when each firm was last seen in the records. When a firm exits the directory panel it takes a value of 1 in the year of exit and otherwise 0. Again according to Enfsolar when a firm disappears from the directory, the most likely explanation is the event of the death of each firm (or in practise often its assets are resold to another company, see also Furr and Kapoor, 2018 on this matter). It is reasonable to assume this is true since Enfsolar, besides facilitating the meeting of buyers and sellers in the global PVC marketplace, sees data intelligence and surveillance of industry developments as its secondary but equally important mission of being the global one-stop marketplace for everything related with PVCs.

The exit dummy is central towards constructing the survival model as it will lead to the measuring of the time to event - i.e. the time that has passed since the firm first entered the directory and until it left the directory again. The data is right censored since the firms remaining alive in the panel at the end of 2021 cannot be further accounted for. Table 4 shows a sample of firms listed in the directory.

Table 4: Sample of firm-level records in the ENF solar database

```
##          ENFID Year Entered_company Updated_company
## 43-2016     43 2016      2007-02-28      2015-01-29
## 101-2013   101 2013      2007-02-28      2013-01-02
## 307-2016   307 2016      2007-02-28      2015-09-01
## 327-2016   327 2016      2007-02-28      2015-10-22
## 329-2021   329 2021      2007-02-28      2020-10-09
## 333-2018   333 2018      2007-02-28      2018-01-17
##                                                           Company_name
## 43-2016                               Innergy Power Corporation, Inc.
## 101-2013                                                      BP Solar
## 307-2016   Entech Solar Inc.(Formerly WorldWater & Solar Technologies)
## 327-2016 SunEdison, Inc. (formerly as MEMC Electronic Materials, Inc.)
## 329-2021                                                     REC Group
## 333-2018                                                        DuPont
##          Country_company Continent_company Staff      Parent Distributors OEM
## 43-2016    United States     North America    NA        <NA>            0   0
## 101-2013   United States     North America    NA        <NA>          183   0
## 307-2016   United States     North America    NA        <NA>            0   0
## 327-2016   United States     North America  7500        <NA>            0   0
## 329-2021       Singapore              Asia    NA Elkem Group          945   0
## 333-2018   United States     North America    NA        <NA>           10   0
##          Seller Installer Application Service      Today Subsidiary entry exit
## 43-2016       0         0           1       0 2021-04-01          0  2013 2016
## 101-2013      0         1           0       0 2021-04-01          0  2013 2013
## 307-2016      0         1           0       0 2021-04-01          0  2013 2016
## 327-2016      0         1           0       0 2021-04-01          0  2013 2016
## 329-2021      0         1           0       0 2021-04-01          1  2013 2021
## 333-2018      0         0           0       0 2021-04-01          0  2013 2018
##          exit_dummy Time_to_event China_dummy Tariff_dummy Subsidiary_dummy
## 43-2016           1      7.923288           0            0                0
## 101-2013          1      5.849315           0            0                0
## 307-2016          1      8.512329           0            0                0
## 327-2016          1      8.652055           0            0                0
## 329-2021          0     13.621918           0            0                1
## 333-2018          1     10.893151           0            1                0
```

The main variables used in this study from the DIR_PANEL are:

- *Year of observation* (the year of the latest record of the firm in the directory)
- *Time to event* (the time that passes from the firm first entered the directory until it left the directory)
- *Exit dummy* (a dummy that takes the value of 1 if the firm has exited the directory)
- *China dummy* (a dummy that takes the value of 1 when the firm is registered as a Chinese company)
- *Tariff dummy* (a dummy that takes the value of 1 for the year of the Safeguard tariff - ie. 2018)
- *Subsidiary dummy* (a dummy that takes the value of 1 when the firm is a subsidiary of a larger parent)
- *China Tariff dummy* (an interaction dummy that takes the value of 1 when both the China dummy and the Tariff dummy take a value of 1)
- *China Subsidiary dummy* (an interaction dummy that takes the value of 1 when both the China dummy and the Subisidiary dummy take a value of 1)
- *Tariff Subsidiary dummy* (an interaction dummy that takes the value of 1 when both the Tariff dummy and the Subsidiary dummy take a value of 1)
- *China Tariff Subsidiary dummy* (an interaction dummy that takes the value of 1 when both the China dummy, the Tariff dummy and the Subsidiary dummy take a value of 1)

4.4-Models: A gravity style panel data model

The first set of models assume that it is possible to estimate the impact of the trade policy events in a gravity style framework but in a non-parametric way (ignoring additional regressors such as GDP per capita, language, culture and distance because they are argued to be structural variables that are highly correlated with the panel structure). For example, it is assumed that policy aside all the relevant information in the model resides in the ‘structure’ of the countries and can therefore be captured by the panel data model setup alone.

The efficiency and model properties (assumptions) of the different models are compared.

The first basic model is a pooled model, where the panel structure is not accounted for. It takes the form as in Equation 1, where the dependent variable is Chinese exports to country i at time t, followed by a common universal intercept (pooled effect) and vector of j parameters for each j trade policy instruments adopted by countries i implemented at time t (note the dummies TP only take a value of 1 in the intervening year and for the implementing Country i). The last term in Equation 1 is the random error.

Equation 1 - pooled model:

$$CHX_{it} = \alpha + \beta_j \top TP_{it} + u_{it}$$

Subsequent models make more assumptions about the panel data structure.

In the fixed or within effect model it is assumed that each country i and each time t have a fixed effect (intercept) that can be correlated with the other regressors in the model (Equation 2). Alternatively, in the random effect model, assuming that a similar effect structure can be modeled instead using the error term (but then restricted by the assumption that the country and time specific effects cannot be correlated with the other regressors - which in this case are solely the trade policy instruments). This latter random effect version of the model is shown with Equation 3. Finally, a 4th version of the model is the first-difference equivalent to the fixed effect model, but where the fixed effects disappear because of first-differencing. A time-specific effect is included in the differenced model (ad-hoc in the R Package PLM code). The superiority of the first difference model is that it avoids the potential pitfalls of modelling fixed effects (such as heteroscedasticity and autocorrelation including unit roots) and instead only models on the innovations in each variable - here the chocks introduced by the policy dummies.

Equation 2 - fixed effect (within) model:

$$CHX_{it} = \alpha_i + \tau_t + \beta_j \top TP_{it} + \epsilon_{it}$$

Equation 3 - random effect model:

$$CHX_{it} = \alpha + \beta_j \top TP_{it} + \mu_i + \psi_t + \epsilon_{it}$$

Equation 4 - first-difference model:

$$\Delta CHX_{it} = \Delta\tau_t + \beta_j \top \Delta TP_{it} + \Delta\varepsilon_{it} <=> CHX_{it} - CHX_{it-1} = (\alpha_i - \alpha_i) + (\tau_t - \tau_{t-1}) + \left(\beta_j \top TP_{it} - \beta_j \top TP_{it-1}\right) + (\varepsilon_{it} - \varepsilon_{it-1})$$

4.5-Models: Survival style panel data models

4.5.1-The Kaplan Meier Model

The simplest survival function based on Kaplan Meier (Kaplan Meier, 1958) assumes a survival distribution function with right censoring, where the true survival time is assumed to be i.i.d. and following the survival distribution function $S_i(t) = Pr\left(X_i > t\right)$ where X_i is a non-negative random variable of survival time that is not observed directly. Under these assumptions the Kaplan Meier estimator can be expressed as (where D_i is the observation of the critical event and $Y\left(X_i\right)$ is the number of individuals at risk at time *t*:

Equation 5.

$$S(t) = \Pi_{X<=t}\left[1 - \frac{Di}{Y\left(X_i\right)}\right]$$

The estimator is robust in large samples and when censoring is independent of the risk exposure of individuals to the event.

4.5.2-The Cox Box Porportional Hazard Model

The research also adopts the Cox Proportional Hazard Regression Model (Cox, 1972). This model complements well the non-parametric approach since it allows for control factors or covariates. Where the present research and data lends itself better to a parametric approach (since it is not a randomised or controlled experiment but an analysis of a near population or big data set). The Cox model states the hazard function for an individual *i* with covariates Z_i to be:

Equation 6.

$$\alpha_i(t; Z_i) = \alpha_0(t) exp(\beta' Z_i)$$

where $\beta = (\beta_1, ..., \beta_p)'$ is a vector of unknown regression coefficients and $\alpha_0(t)$ is the baseline hazard. Then the regression coefficients can be estimated by maximising the Cox partial likelihood function:

Equation 7.

$$L(\beta) = \Pi_{i=1}^{n}[\frac{exp(\beta' Z_i)}{\sum_{j \in R_i} exp(\beta' Z_j)}]^{D_i}$$

and the partial hazard rates A_i may be obtained by taking the exponent to the estimated parameter estimates from Equation 3: $A_i(t) = exp[\beta_i(t)]$.

Both survival models are implemented using the *Survival* package with the software R (see also Kleinbaum and Klein, 2005).

5-Results

5.1-Results for the trade gravity model

The results of estimating the gravity style model (with the omission of all pure structural factors when modeled in a panel setting) and the time specific impact of the various trade policy events as introduced in Section 3 of the paper are shown with Table 5. The pooling model is merely presented as a benchmark as it does not account for the necessary structures when omitting other ordinary gravity style explanatory factors. Hence the interpretation here concerns mainly the comparison of columns 2, 3 and 4 for the total traded value of solar panels, or the comparison of columns 6, 7 and 8 for the physical weight (Q) of solar panels. While the latter may seem imprecise, it can be more important in the specific systemic setting of Chinese trade. Here it is argued that price is of lesser importance in the case that firms operate with socialist style soft budget constraints. Hence I emphasise both results in the interpretations.

Across the two dependent variables (value and weight of solar panel trade), the results are similar. Punitive tariffs do have a negative effect on the trade value or weight in the year of implementation. The effect is also relatively large and significant. Seemingly, the anti-subsidy tariff is the least effective or counter-effective of the policies. The Hausman test does not lead to a rejection of the random effect model's assumptions (i.e. that the errors are not correlated with the regressors). But this could be violated in the specific case of anti-subsidy. For example, were larger countries more likely than smaller countries to use this particular policy - it would mean that in this aspect, model assumptions are violated. Referring back to Table 3, this suggests that there is a high income country bias for the trade policy instrument anti-subsidy, as it has only been implemented by the US, Canada, the UK and the EU for solar panels during the period of study.

Both the insignificance in the fixed effect models of the parameter estimate for the anti-subsidy policy and the large jump and change in impact of this regressor when moving to columns 4 and 8 for the first-difference version, all suggest this could be the case. Therefore, the interpretations should emphasise the last or first-difference version of the model (which is also more consistent in the expectation that a tariff or trade policy will lead to a one time permanent downwards or upwards adjustment in trade flows). Because, according to these results the anti-subsidy tariff has the largest and most negative impact on trade flows. (As we would also expect since the aim is to target the problem which are state subsidies to solar panel producers in China).

The main problem with the classical trade gravity model is that it could not account for potential circumvention effects of imposing tariffs on solar panels from China. Hence the impact of the trade policy may be to circumvent flows via other countries, relay or offshore production to other countries. A more exact evaluation would therefore look at the implications of the policies and one specific policy in particular - which is the Trump Safeguard implemented in February 2018 and focus instead on firm survival as the dependent variable. The final version of the paper will also consider to further single out the 2018 Safeguard effect, but this is better done in a full gravity model that includes all exporter countries of solar panels and all partner countries as importers of solar panels. The Safeguard as an instrument was only implemented twice (see also Table 3). It could therefore as a point estimator only be weakly identified and given the limitations of this particular version of the gravity model (one exporter - all importers).

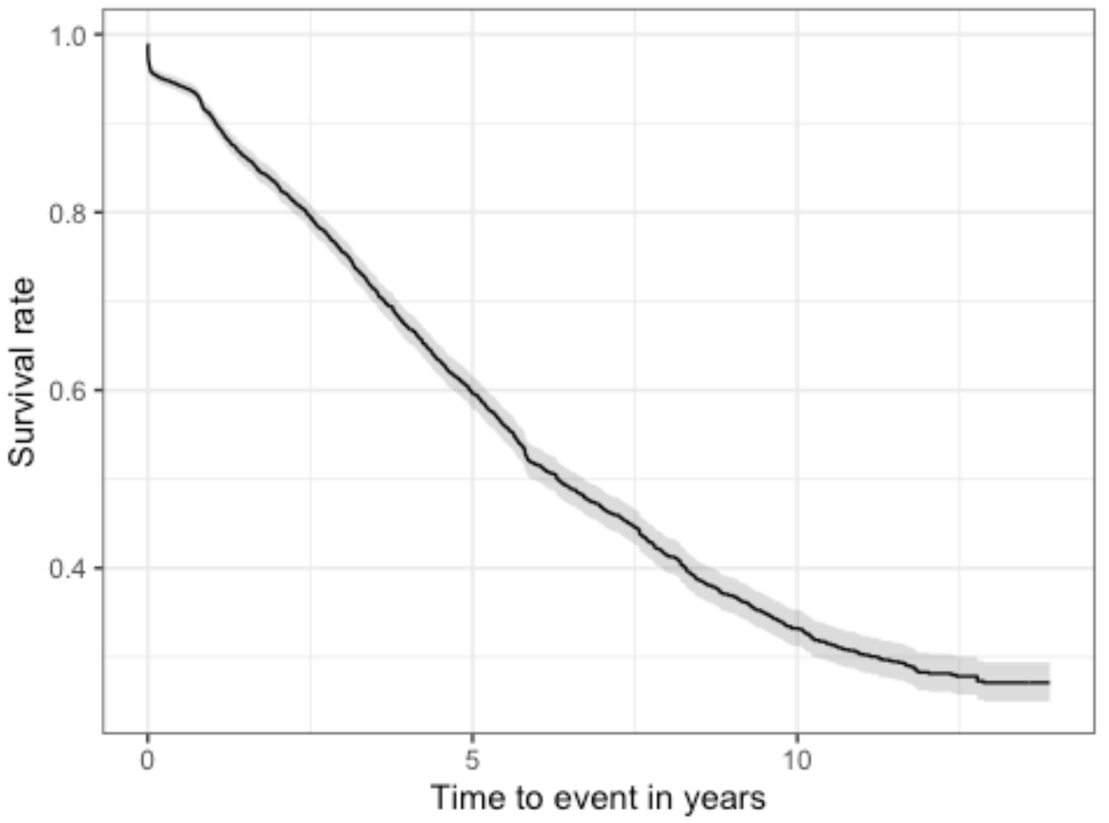
```
##
## Table 5: The impact of tariffs on Chinese solar PVC exports
## ==================================================================================================
##                                                 Dependent variable:
##                 ----------------------------------------------------------------------------------
##                         Chinese PVC exports in mio USD           Chinese PVC exports in ths tonnes
##                     (1)         (2)         (3)        (4)        (5)       (6)       (7)       (8)
## --------------------------------------------------------------------------------------------------
## Tariff             -4.95    -213.91***  -185.64***  -78.20***    4.45    -23.66*** -17.84*** -19.89***
##                   (55.17)     (44.39)     (0.13)     (24.17)   (10.78)    (9.04)    (0.18)    (4.59)
## Anti_dumping       93.95     -118.60*    -99.07***  -114.97***   0.91     -15.85   -11.91***   -4.78
##                   (85.93)     (67.16)     (0.20)     (37.92)   (12.62)   (10.62)    (0.21)    (5.45)
## Anti_subsidy     893.02***     90.16     165.40***  -199.12**   83.47*    -23.91    -3.97***  -33.16*
##                  (234.15)    (181.34)     (0.55)     (92.70)   (47.71)   (39.64)    (0.78)   (19.30)
## Safeguard      2,250.77*** 1,043.13*** 1,146.34***  -231.52   453.39*** 145.72*** 196.85*** -76.51***
##                  (468.02)    (340.57)     (1.04)    (184.97)   (67.45)   (52.86)    (1.05)   (27.26)
## Constant         101.88***               100.40***     9.70    13.99***            13.58***    3.70
##                   (9.22)                  (0.07)     (18.21)    (1.56)              (0.09)    (3.50)
## --------------------------------------------------------------------------------------------------
## Panel model      Pooling      Within      Random       FD      Pooling    Within    Random      FD
## Country effect      No          Yes         Yes        Yes        No        Yes       Yes       Yes
## Time effect         No          Yes         Yes        Yes        No        Yes       Yes       Yes
## Observations      2,683       2,683       2,683      2,468      1,940     1,940     1,940     1,725
## R2                 0.01        0.01       0.004       0.02       0.02      0.01      0.01      0.02
## Adjusted R2        0.01       -0.08       0.002       0.02       0.02     -0.12      0.01      0.01
## ==================================================================================================
## Note:                                                              *p<0.1; **p<0.05; ***p<0.01

##
##  Hausman Test
##
## data:  trade_value_musd ~ Tariff + Anti_dumping + Anti_subsidy + Safeguard
## chisq = 0.69515, df = 4, p-value = 0.9519
## alternative hypothesis: one model is inconsistent

##
##  Hausman Test
##
## data:  netweight_thton ~ Tariff + Anti_dumping + Anti_subsidy + Safeguard
## chisq = 1.6557, df = 4, p-value = 0.7988
## alternative hypothesis: one model is inconsistent
```

5.2-Results for the firm survival models

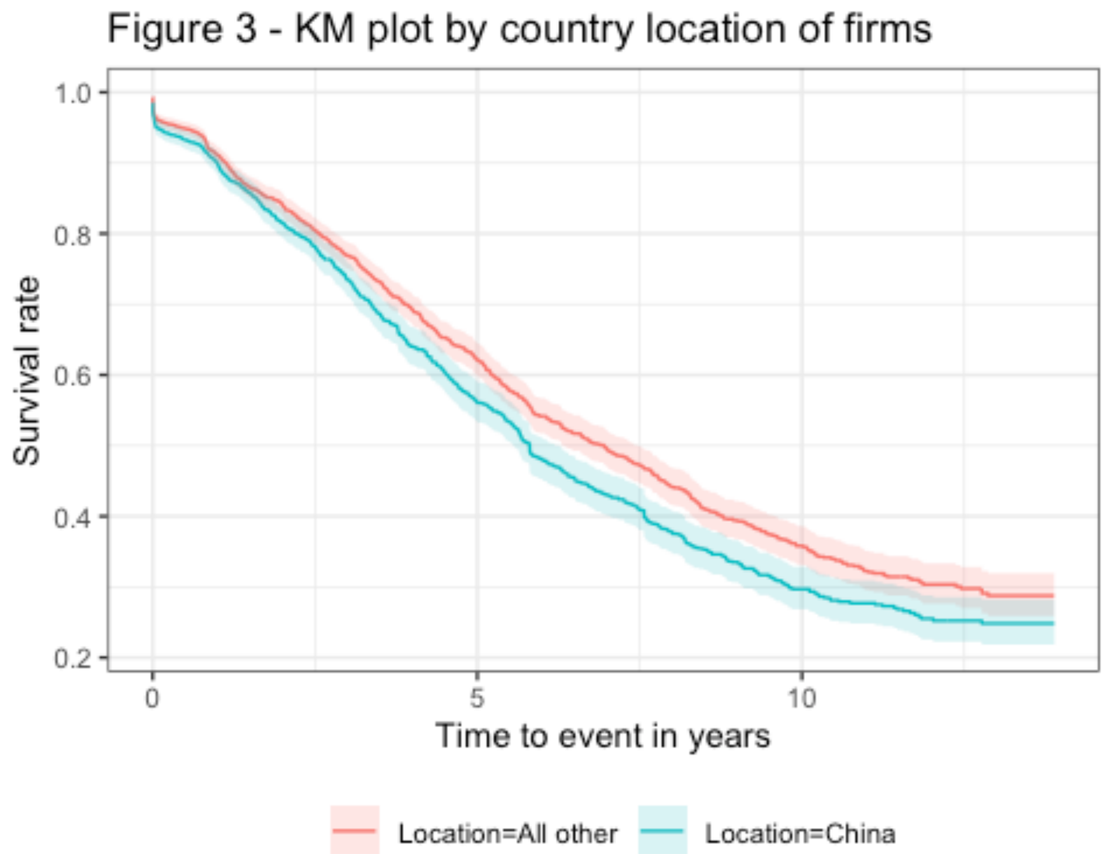
5.2.1-Kaplan Meier results

Using the variables: *Time_to_event* and *Exit_dummy*, the survival function was estimated with R software. The Kaplan Meier Survival Curve (Figure 2) is shown for an average of all firms in the Enfsolar firm directory. According to these results on average around 10% of firms die in the first year, 60% of firms survive after 5 years and around 30% of firms survive after 10 years. Beyond 10 years the survival function starts to level out - in the 13th year 27% of all solar panel firms still survive.

Figure 2 - KM plot for all solar firms

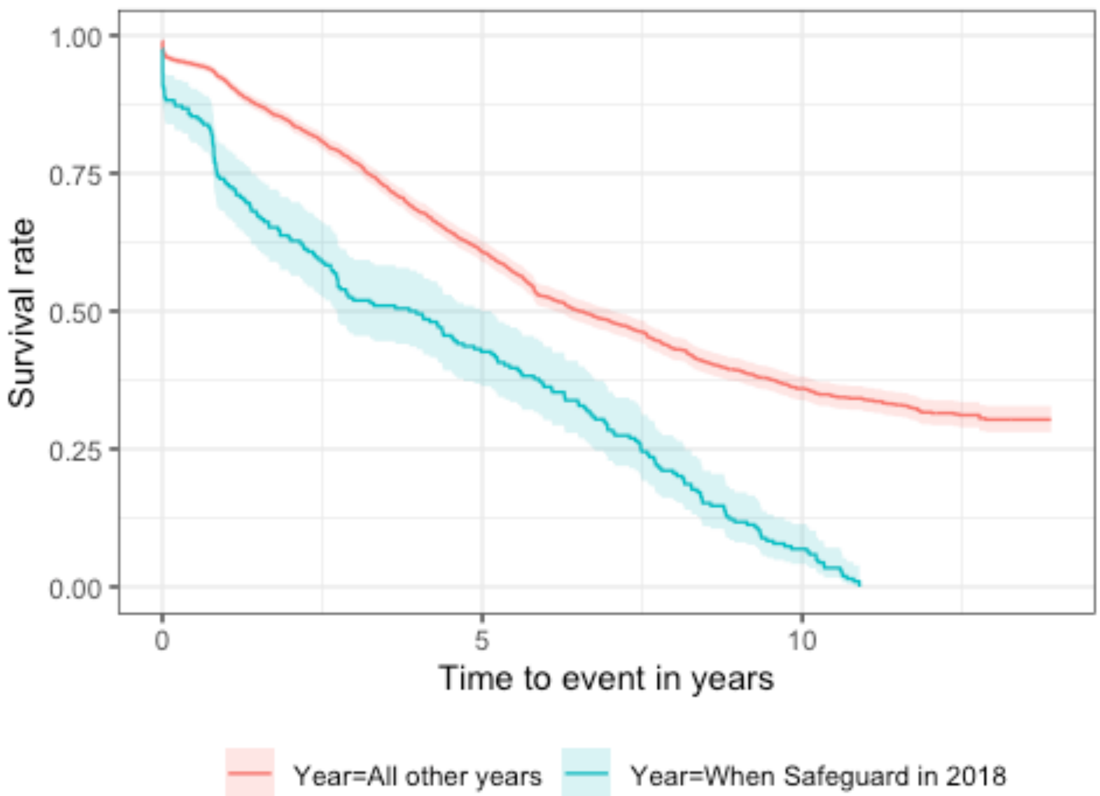


Next, survival curves are estimated by treatment (groups). First the simple factor coding on the country origin (location) of firms is used to demonstrate whether or not selection is stronger for Chinese firms in general. These results are shown with Figure 3. Here is compared Chinese firms with all other firms in the PVC business. According to the results the average Chinese firm is subject to stronger selection and when compared to all other PVC firms in the global solar panel industry. For example, after 5 years the difference is around 5% stronger selection on Chinese firms, whereas at 10 years the difference has widened further to around 8% after which the both surival functions level out with a constant difference at or above 10 years into entry. The log rank test (chi-square) was also calculated to test the significance of the difference.The obtained value (Chisq= 11 on 1 degrees of freedom, p= 9e-04) shows that the difference is highly significant.



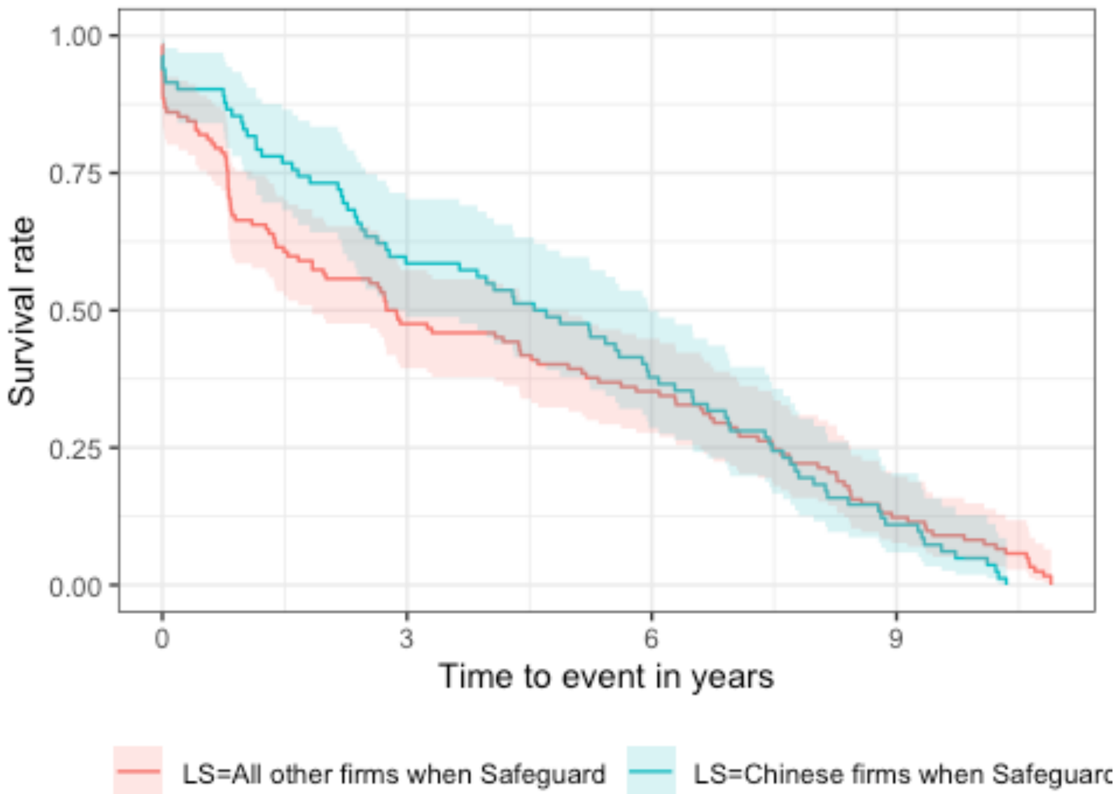
Next was tested the hypothesis whether selection was stronger in the year of the Safeguard tariff and relative to all other sampled years. These result are shown in Figure 4. While the confidence interval around selection widens when sampling specifically on the Safeguard year as the selection mechanism, there is a dramatic difference. Across all firms independent to their origin, selection is much stronger in the year of the Safeguard tariff. The largest difference (in excess of 25%) observed for firms into their 3rd year of existence and then again at or above their 8th year, where selection rapidly drives nearly all firms older than 10 years out of the industry during the Safeguard year 2018. Again was the log rank test (chi-square) calculated to investigate whether this difference is statistically significant by groups. The obtained value (Chisq= 132 on 1 degrees of freedom, p= <2e-16) shows that the difference is highly significant.

Figure 4 - KM plot by year of intervention



Finally do we in Figure 5 combine the two previous hypothesis test in the Kaplan Meyer Model as a difference-in-difference test. For example, we ask in this Figure whether Chinese firms were more targeted by the Safeguard tariffs relative to all other firms? Surprisingly, Chinese firms were less prone for selection or exhibited stronger survival during the Safeguard year 2018. This result in the Kaplan Meyer model suggests that the Safeguard tariffs were ineffective, in so far that the primary objective was to harm Chinese firms receiving subsidies and leveling the playing field by making selection stronger among this group of firms. The findings with the survival model here applied to the Enfsolar Big Dataset covering 90% of the industry shows that this was the case for relatively young Chinese firms and up until firms in their 6th-8th year of life after which there is indication that any selection difference levelled out. The log rank test confirmed the intuition of the result, for example now the obtained test value (Chisq= 0 on 1 degrees of freedom, p= 0.9) also tells us that for the Safeguard year 2018 selection was not stronger on Chinese firms relative to other solar panel firms worldwide.

Figure 5 - KM plot by location during Safeguard year



5.2.2-Cox Proportional Hazard results

The same hypothesis is tested next using a parametric modelling approach by switching to the Cox Proportional Hazards Model. The potential advantage of this model is that it produces specific parameter estimates and is also useful when there is a need to introduce other covariates (control factors). Here the model set up is as in the previous and last version of the Kaplan Meyer Model - as a difference-in-difference design and otherwise assuming that the data is strongly representative of its population approaching saturation as a big dataset. Again do the results reported with Table 6a demonstrate the same tendency in the data. While the Safeguard year 2018 greatly increased the hazard rate among solar panel producers worldwide and the average hazard rate is also typically higher among Chinese firms relative to their peers worldwide this was not the case during the Safeguard year. The interpretation here is that in the Safeguard year the hazard rate among Chinese firms was lower with around 26% when compared to all other PVC producers worldwide. In the context of the Cox Proportional Hazards Model which is more robust as it inserts this result into a more elaborate model with control variables, the result also obtains that the difference for Chinese firms in the Safeguard year is somewhat signficant (and again in the opposite direction of what is intended with the Safeguard).

As a final robustness check on this result the two-way difference-in-difference model was expanded with a third factor which is the group belonging of solar panel producers as measured with the *Subsidiary* variable in the Enfsolar dataset. Ideally this variable will indicate whether a solar panel producer is part of a multinational group of firms. However, there is also the possibility that group belonging could indicate a solar panel producer being part of a larger nation-wide state owned firm. The last version of the Cox Model reported here with Table 6b shows the relevance of including information about *Subsidiary* or group belonging of producers. The impact is highly significant and reduces the hazard rate downwards with nearly 40%. This result is to be expected. But it does not change the previously obtained result for the interaction between the China and the Safeguard dummies. In the three-way interaction of this variable with the subsidiary dummy the result shows that subsidiaries in China during the Safeguard year did suffer relative to other firms from a higher hazard rate. However, this last difference is not significant.

Table 6a - Cox Proportional Hazard model (2-way diff-in-diff)

```
## Call:
## coxph(formula = Surv(Time_to_event, exit_dummy) ~ China_dummy +
##     Tariff_dummy + China_Tariff_dummy, data = DIR)
##
##   n= 3695, number of events= 1811
##    (1 observation deleted due to missingness)
##
##                        coef exp(coef) se(coef)      z Pr(>|z|)
## China_dummy         0.18335   1.20124  0.05021  3.652 0.000261 ***
## Tariff_dummy        0.96164   2.61598  0.09666  9.949  < 2e-16 ***
## China_Tariff_dummy -0.30628   0.73618  0.15140 -2.023 0.043076 *
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                     exp(coef) exp(-coef) lower .95 upper .95
## China_dummy            1.2012     0.8325    1.0887    1.3255
## Tariff_dummy           2.6160     0.3823    2.1645    3.1616
## China_Tariff_dummy     0.7362     1.3584    0.5472    0.9905
##
## Concordance= 0.55  (se = 0.007 )
## Likelihood ratio test= 115.2  on 3 df,   p=<2e-16
## Wald test            = 138.4  on 3 df,   p=<2e-16
## Score (logrank) test = 146.5  on 3 df,   p=<2e-16
```

Table 6b - Cox Proportional Hazard model (3-way diff-in-diff)

```
## Call:
## coxph(formula = Surv(Time_to_event, exit_dummy) ~ China_dummy +
##     Tariff_dummy + Subsidiary_dummy + China_Tariff_dummy + China_Subsidiary_dummy +
##     Tariff_Subsidiary_dummy + China_Tariff_Subsidiary_dummy,
##     data = DIR)
##
##   n= 3695, number of events= 1811
##    (1 observation deleted due to missingness)
##
##                                   coef exp(coef) se(coef)      z Pr(>|z|)
## China_dummy                    0.21645   1.24167  0.05337  4.056 5.00e-05 ***
## Tariff_dummy                   0.96949   2.63661  0.10372  9.347  < 2e-16 ***
## Subsidiary_dummy              -0.38662   0.67935  0.09757 -3.962 7.42e-05 ***
## China_Tariff_dummy            -0.39316   0.67492  0.16368 -2.402   0.0163 *
## China_Subsidiary_dummy        -0.32488   0.72262  0.15982 -2.033   0.0421 *
## Tariff_Subsidiary_dummy       -0.05441   0.94704  0.28540 -0.191   0.8488
## China_Tariff_Subsidiary_dummy  0.67209   1.95832  0.43468  1.546   0.1221
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                               exp(coef) exp(-coef) lower .95 upper .95
## China_dummy                      1.2417     0.8054    1.1183    1.3786
## Tariff_dummy                     2.6366     0.3793    2.1516    3.2310
## Subsidiary_dummy                 0.6794     1.4720    0.5611    0.8225
## China_Tariff_dummy               0.6749     1.4817    0.4897    0.9302
## China_Subsidiary_dummy           0.7226     1.3839    0.5283    0.9884
## Tariff_Subsidiary_dummy          0.9470     1.0559    0.5413    1.6569
## China_Tariff_Subsidiary_dummy    1.9583     0.5106    0.8354    4.5908
##
## Concordance= 0.581  (se = 0.007 )
## Likelihood ratio test= 173.4  on 7 df,   p=<2e-16
## Wald test            = 188.1  on 7 df,   p=<2e-16
## Score (logrank) test = 200.7  on 7 df,   p=<2e-16
```

6-Discussion and conclusion

The research focus of different authors demonstrates that there is little agreement about the question concerning what motivated the new protectionism exemplified in this study with the consecutive trade policy events that have impacted the global solar panel industry. Explanations in the literature vary from traditional protectionism to shelter firms from foreign competition in import competing industries, over strategic lobbying by multinational firms and among industry players that are not necessarily nationals to the governments they lobby with and for. Finally, also towards more altruistic leaning motivations such as those of protecting the natural environment against further leakages due to outsourcing of production to fossil-fuel intensive and unregulated locations such as China.

In balance I conclude that many of the policies we have seen and in particular in the solar panel industry, concerned the desire of the consecutive EU and US administrations during the 2010s towards ensuring their own companies a more levelled playing field and in vital industries such as renewable energies. Also because these will be the most strategic for Europe and the US in the future when it comes to pushing forward the transition towards a new and green energy system. Only of a recent date has the focus shifted more towards the problem of overtly relying or being dependent on a few countries for the supplies of key technologies that also in part concern the transition towards renewable energy sources.

Having reached this conclusion for the motives-based aspect of the research, I proceed to conduct the policy evaluation in the perspective of reaching a more levelled playing field for solar panel producers worldwide. Yet the simple stylised facts presented in the paper demonstrate the incapacity of existing trade policy instruments under the rules-based system, such as anti-dumping, anti-subsidy and even general Safeguards, to achieve these aims. While there has been some diversification of solar panel production towards Chinese outposts in ASEAN, there has been no significant overall impact on Chinese market shares or revealed comparative advantage over the full period of study.

The analysis of trade flows in a reduced form (limited to one exporter and all importer countries), suggests that the early policies prior to the Safeguards had some impact at least of redirecting trade flows away from China towards other exporter countries (i.e. the reallocation effect that has also been observed in other research that focused on the impact of the US-China trade war).

Here the difference-in-difference panel data model may be indicative of showing the downwards readjustment in the value of Chinese exports that happened - but also that the Safeguard after earlier more limited attempts at leveling the playing field had little impact on Chinese solar panel exports.

The more reliable difference-in-difference estimator when applied to data in quantities or tonnage (which may be a better measure of exports from a socialist style or heavily state subsidised economic system), demonstrates less of an impact on Chinese exports. However, the gravity style model presented in the paper needs to be improved to include a fully fledged many exporter-many importer set of bilateral relations towards introducing the policy effect in a more correct difference-in-difference design. A future version of the final paper will include such a modification.

Oppositely in the survival model analysis which is more developed in this working paper version, the data available from the online platform Enfsolar makes it possible to estimate the difference-in-difference impact that the Safeguard tariffs had for the survival rates of all firms relative to Chinese-based solar panel producers in general and during the year of the Safeguard tariffs (2018).

These results strongly confirm the stylised facts: that the punitive tariffs were futile in terms of reaching the objective of creating a more levelled playing field; as it was the firms in the rest of the world that were more likely to exit the industry during the year 2018 when the Safeguards were implemented on solar panels.

As an additional robustness check was also added to the survival model information about Chinese-based firms that had subsidiaries in other Chinese regions and overseas territories and countries. While the result indicates that subsidiaries were more exposed relative to other Chinese-based firms from the Safeguards, the effect is not significant.

Overall it must therefore be concluded that the trade policies instigated towards changing and leveling the playing field in the global solar panel industry have been unsuccessful and unable to subside the strategic industrial policies of China. For some individual comparatively advantaged countries on the export side of the industry this is lamentable as it does not bode well for their inclusion on reasonable terms in the current trading system. At the same time is the current system with overt reliance on a single or limited number of supplier countries for key technologies such as solar panels worrying for all countries on the user and importer side of the industry.

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