The Trade Effects of Anti-Dumping Duties, Non-Tariff Barriers and Maritime Security

Gravity Applications

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Introduction

This dissertation includes four self contained chapters that empirically investigate different trade dampening phenomena. The first two chapters are closely related and constitute the core of the dissertation. Both examine the effects of anti-dumping (AD) duties on trade. Chapter 1 investigates the universe of EU imports to analyse the trade effects of AD duties over exporting countries treated differently in EU AD investigations. Chapter 2 uses Chinese customs data to examine varying effects of AD duties on Chinese exporting firms across different importing countries. Both chapters put a strong focus on addressing endogeneity concerns linked to trade policy in general and AD duties in particular.

Chapter 3 also relates to trade policy, examining the trade dampening effects of non-tariff barriers. Particular emphasis is placed on the estimation of the effects of so called behind-the-border measures, which are difficult to identify since they affect all exporters equally. Finally, Chapter 4 shifts the focus away from trade policy, using Chinese customs data to examine the impact of maritime piracy on Chinese export flows as well as firms' choice of transport mode.

Methodologically, a common theme across all chapters is the use of gravity equations as the foundation for the empirical strategy. Not only does the gravity model have a proven track record of predicting trade flows between countries (Baier and Bergstrand, 2009; Anderson, 2011; Head and Mayer, 2014; Yotov et al., 2016). As discussed in Chapter 2, its theoretical foundations as provided amongst others by Anderson (1979); Eaton and Kortum (2002); Anderson and van Wincoop (2003) and Melitz (2003) constitute a structural framework which helps uncovering potential sources of endogeneity and thus provides guidance for the estimation specification.

With over 1,600 measures in force in 2017, AD duties constitute the most frequently used trade defence instrument that is associated with large welfare costs (Gallaway et al., 1999; Blonigen and Prusa, 2003b).[1] It is therefore of crucial importance to understand and correctly measure their effects. Politically, the subject is highly relevant, as the European Union has

[1] Dumping is defined as exporting a product at a price below its "normal value" (WTO, 1994), where normal value is typically the domestic price of the product in the exporting country (for a detailed discussion see for example Felbermayr et al. (2016)). WTO rules allow member states to counteract dumping practices with anti-dumping duties.

recently adjusted its AD regulation in December 2017. In response to demands from China - the world's largest target of AD duties - the EU has abandoned the concept of Non-Market Economy Status (NMES) for WTO members, which affects the way AD duties are calculated (European Parliament, 2017).[2]

The trade effects of AD duties have already received significant research attention (for an overview over the literature see for example Nelson (2006) and Blonigen and Prusa (2003a, 2016)). Nevertheless, endogeneity concerns threatening the correct identification of the treatment effect of AD duties on trade remain. For example, while AD duties reduce imports, positive import shocks increase the likelihood of an AD investigation being initiated, leading to an underestimation of the treatment effect (Bown and Crowley, 2013). The first two chapters of this dissertation hence propose different strategies to reduce endogeneity - in particular omitted variable bias and simultaneity - in order to correctly measure the effect of AD duties on trade. At the same time, they shed light on aspects of AD duties that so far remain under-researched but are of great relevance for policy makers.

Chapter 1 combines information on AD duties taken from the World Bank's Global Anti-dumping Database (Bown, 2015) with EU import data at the CN8 digit product-level (Eurostat, 2017) to examine the effect of AD duties on exporter producer prices and quantities. In contrast to the effects on export quantities (for recent studies see for example Vandenbussche and Zanardi (2010) or Egger and Nelson (2011)), price effects of AD duties have so far only received limited research attention. Theory predicts that, unlike normal tariffs, AD duties raise producer prices (Blonigen and Haynes, 1999; Blonigen and Park, 2004; Feenstra, 2008). This implies a worsening of the terms of trade of the importing country, accompanied by a shift in rents from the customs authority of the importer towards exporters. However, empirical evidence remains scarce and inconclusive. While Blonigen and Haynes (2002) find that AD duties do indeed raise exporter prices, Lu et al. (2013) fail to find such evidence.

The chapter exploits the EU enlargement of 2004 as a natural experiment to address simultaneity and omitted variable bias inherent in AD policy. Following their accession to the EU, the new member states inherited the Union's AD duties. Under the plausible assumptions that the decision to join the EU is independent of existing AD duties and that the EU did not adjust its AD regulation in anticipation, these duties are exogenous to new members' trade shocks. Hence,

[2] Regulation (EU) 2017/2321. For reasons explained in Chapters 1 and 2, average AD duties imposed using the NMES methodology are larger than those imposed using the Market Economy Status (MES) methodology.

the effect of AD duties can be estimated with the help of a simple difference-in-differences regression with fixed effects.

In line with theoretical considerations, Chapter 1 shows that AD duties raise producer prices on average by 25%, but only for imports originating from countries with Market Economy Status (MES). Import prices from non-MES countries remain unchanged, while quantities fall by more (on average 85% for NMES exporters and 68% for MES exporters). In light of the recent change in EU AD legislation, these results have obvious implications for the design of AD policy. They also align what seem to be inconsistent findings in the literature, by showing that results may be driven by the MES of the exporting country considered in the respective sample. Furthermore, this chapter presents evidence that the trade dampening effects of AD persist over time. Finally, it is shown that duties also indirectly affect non-targeted exporters, a finding that relates to the literature on trade deflection (Bown and Crowley, 2007, 2010; Baylis and Perloff, 2010).

A drawback of using product-level data is that one cannot differentiate between firm responses and composition effects. On the one hand, it is possible that AD duties induce firms to raise prices and reduce export quantities. On the other hand, in line with Melitz (2003), the same observation of falling quantities and increased prices can be driven by exit of low-price exporters, with remaining exporters being unaffected. Chapter 2 therefore moves to the firm-level, using Chinese customs data to investigate the effects of AD duties on Chinese exporters. Estimations are based on a firm-level gravity model that provides information on potential sources of omitted variable bias. In a first step, it is shown that existing firm-level estimations that fail to control for the appropriate fixed effects suggested by the model indeed suffer from omitted variable bias. Following theoretical considerations, endogeneity problems are then minimized by employing a saturated difference-in-differences estimation. By merging firm-level exports to firm-specific AD duties, this chapter exploits differences in AD duties across firms exporting the same product to the same country to identify a treatment effect.

In line with the literature, it is found that AD duties reduce exports, induce firm exit but do not affect producer prices, suggesting complete pass-through of AD duties to consumers. Beyond these basic findings, analyzing the universe of Chinese export destinations enables a comparison of the effectiveness of AD duties imposed by the EU and the US (among others). Imports to the EU react differently compared to those to the US; a finding with obvious implications for the design of AD policies. In particular, the number of exporters reacts more sensitively to EU duties, implying that higher duties are required in the US to yield the same effect. Considering both elasticities as well as average levels of AD duties, US duties have, however, a greater trade dampening effect.

Furthermore, smaller exporters are more heavily affected than larger ones, suggesting important within-industry reallocation effects. Following Vandenbussche and Zanardi (2010), Chapter 2 also tests whether the trade effects of AD duties vary across sectors. It finds significant heterogeneity in estimated effects, suggesting that a one size fits all AD policy may affect different sectors very differently. Finally, there is evidence for trade deflection at the firm-level, as Chinese exports are diverted to third countries through increased market entry.

The second part of the thesis moves away from AD duties and turns towards two different trade dampening phenomena. Chapter 3 remains in the realm of trade policy, shifting attention towards non-tariff barriers (NTBs), which increasingly shape modern trade policy (Datt et al., 2011; Kee et al., 2013; Evenett, 2014). NTBs represent trade policy instruments other than customs duties that can potentially have an economic effect on international trade by affecting import prices or quantities. According to the recently updated Global Trade Alert (GTA) database, around 300 NTBs were implemented worldwide in 2014, with the US being by far the largest user and Canada, Germany and China being targeted most often. Accordingly, NTBs also play an increasing role in negotiations on trade agreements (Felbermayr, 2016; Felbermayr et al., 2017).

Based on a structural gravity equation and using data provided by the GTA database as well as CEPII's BACI trade dataset, Chapter 3 empirically investigates the effect of NTBs on import values. Differentiating between import controls, state aid and subsidy measures, public procurement and localisation policies, and other NTBs such as sanitary and phytosanitary standards, technical barriers to trade and capital controls, the analysis reveals a significant protectionist impact of non-standard trade policy measures. It is shown that the implementation of NTBs reduces imports of affected products by up to 12%. Besides NTBs, the estimations additionally account for traditional trade defence instruments (including AD duties), allowing for a quantitative comparison of different trade policy instruments. It is shown that non-tariff barriers are very diverse, meaning that different types of NTBs affect trade to a different extent. Finally, following Head and Ries (2008); Head and Mayer (2014); Egger and Nigai (2015) and Yotov et al. (2016), Chapter 3 applies a two-step estimation procedure to identify the effect of behind-the-border measures on trade, showing that they significantly reduce the importer's market access.

Chapter 4 investigates the relationship between trade and maritime security, more precisely the effect of piracy on firms' choice of transport mode. With 180 actual and attempted attacks in 2017 leading to several killings (ICC IMB, 2018), there is no doubt that piracy poses a significant threat to maritime shipping. Surprisingly, detailed evidence regarding its economic consequences remains scarce, with most studies being descriptive (Endler et al., 2012). The most notable exceptions are Bensassi and Martínez-Zarzoso (2013) and Bensassi and Martínez-Zarzoso (2012), who estimate the effects of maritime piracy on transport cost and overall trade respectively. However, both papers focus on trade between Europe and Asia.

This Chapter adds to the literature by combining the same firm-level Chinese customs data used in Chapter 2 with information on pirate attacks to investigate how exporting firms respond to maritime piracy. It shows that an increase in pirate activity along a particular shipping route induces firms to switch from ocean to air shipping, while the remaining ocean shipments become larger. This is accompanied by a fall in producer prices, indicating that the piracy induced increase in transport costs is not fully passed on to consumers. These results can be linked to the literature on trade and uncertainty (Békés et al., 2017), but also to the discussion on the relationship between fixed costs per shipment and the number of transactions as well as their size (Kropf and Sauré, 2014). Moving beyond individual shipments, the chapter also shows that piracy reduces overall exports. More specifically, the average number of pirate incidents per month on routes connecting China and Europe (26) reduces exports by 2.3%.

To sum up, this dissertation adds four chapters to the empirical literature on the trade effects of anti-dumping duties and non-tariff barriers, as well as maritime piracy. The first two chapters in particular aim to make a methodological contribution by proposing two different strategies to address sources of endogeneity that have long plagued the literature on trade policy in general and anti-dumping in particular. Beyond that, all papers aim to advance our understanding of different trade dampening phenomena in order to enable better informed, welfare enhancing policy responses.

1 The Trade Effects of Anti-Dumping Duties: Evidence from the 2004 EU Enlargement*

1.1 Introduction

Since 2007, the number of anti-dumping (AD) cases initiated has increased from 165 to 300 in 2016, culminating in more than 1,600 measures being in force worldwide in 2017.[1] In December of the same year, the EU has adjusted its AD regulation,[2] abandoning the much disputed Non-Market Economy Status (NMES). This may have important implications because Market Economy Status (MES, assigned to the exporter by the imposing country) determines the way AD duties are calculated.[3]

Theory predicts that AD duties incentivise producers to raise prices in an effort to reduce the applied duty following reviews in consecutive periods. Over time, this results in a worsening of the importer's terms of trade as rents shift from the customs authority of the imposing country towards exporters. Hence, measuring price responses of exporters constitutes an important component when evaluating the effects of AD duties on welfare. However, with the exception of a prominent paper by Blonigen and Haynes (2002), the empirical literature has

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[1] Data on global AD measures in force is taken from the WTO's I-TIP database (WTO, 2018). Dumping is defined as exporting a product at a price below its "normal value" (WTO, 1994), where normal value is typically the domestic price of the product in the exporting country (for a detailed discussion see for example Felbermayr et al. (2016) or Sandkamp and Yalcin (2016)). It is a common phenomenon in international trade, that can have many causes, such as international price discrimination (Viner, 1923), production under demand uncertainty (Ethier, 1982), reciprocal dumping with oligopolistic firms (Brander and Krugman, 1983), dynamic competition (Gruenspecht, 1988; Clarida, 1993), subsidies (Dixit, 1988; Blonigen and Wilson, 2010) or cyclical aspects (Staiger and Wolak, 1992). WTO rules allow member states to counteract dumping practices with anti-dumping duties.

[2] Regulation (EU) 2017/2321 (European Parliament, 2017).

[3] NMES has been abandoned by the EU only for WTO exporters. Other countries such as the US are still applying the NMES methodology to WTO exporters.

not found any evidence in support of the theory.[4] Furthermore, the question of whether the price effects of AD duties depend on whether or not the exporter enjoys MES has so far been completely ignored by existing studies.

This paper aims to fill the gap by exploiting the EU enlargement of 2004 as a natural experiment to investigate the trade effects of AD duties. The accession countries were required to adopt the existing EU AD policy at the time of joining the EU. Under the identifying assumptions that the decision to join the EU is independent of existing AD duties and that the EU did not adjust its AD regulation in anticipation, the enlargement constitutes an exogenous treatment of new member states. The effect of AD duties can hence be estimated without simultaneity and omitted variable bias by applying a simple difference-in-differences regression with fixed effects, exploiting the change over time in import prices and quantities of treated country-product combinations relative to non-treated ones.

Beyond this methodological contribution, the paper demonstrates that the missing evidence for positive price effects in the literature is driven by the MES of the exporter investigated in the respective studies. By looking at the universe of European imports, it is shown that AD duties do raise producer prices on average by 25%, but only for imports originating from countries with MES. Producer prices of imports from non-market economies remain unchanged, while quantities fall by more (on average 85% compared to 68% for MES exporters). Estimated coefficients are not sensitive to several fixed effects specifications, suggesting that the experiment itself also addresses omitted variable bias. The third key contribution of this paper is to show that price as well as quantity effects of AD duties persist over time, even beyond their revocation. Finally, evidence for spillover effects is provided. Producer prices of imports from countries not targeted by AD duties also increase, indicating that AD duties imposed against one country induce exporters in non-targeted countries to update their beliefs regarding the likelihood of becoming subject to AD investigations and raising prices in anticipation.

This paper relates to three strands of literature, namely the impact of AD duties on producer prices, on quantities as well as effects on third countries. Regarding the first, AD duties can affect import prices through two channels. Like tariffs, they directly increase consumer prices (assuming positive pass-through). In addition, and in contrast to ordinary tariffs, they incentivise exporters to raise their prices. Having the official objective to protect the importer's

[4] In contrast to price effects, the effect of AD duties on import volumes has already drawn significant research attention. For an overview see for example Blonigen and Prusa (2003a, 2016) and Nelson (2006).

domestic market from "unfair" foreign competition,[5] AD duties are adjusted if the exporter increases ex-factory prices (Feenstra, 2008).[6] Consequently, theory predicts pass through rates larger than 100 % as exporters increase prices to achieve a reduction of AD duties in subsequent periods (Blonigen and Haynes, 1999; Blonigen and Park, 2004).

This has important welfare implications. While traditional tariff revenue accrues to the customs authority of the importer, the adjustment of AD duties means that if exporters raise prices and the duty is lowered as a result, rents that first went to the customs authority of the importer are transferred to the foreign exporter by means of increased producer prices. If consumer prices (including duties) in the importing country stay constant following a reduction of the duty, the dynamics of AD duties imply a welfare reduction beyond trade destruction over time in the importing country relative to a classic tariff.[7]

Empirically, Blonigen and Haynes (2002) find that AD duties indeed lead to higher import prices (excluding duties) from the point of view of the AD imposer. However, their study looks at a very specific example, namely US iron and steel imports from Canada. Lu et al. (2013) use Chinese customs data to investigate the effect of US AD duties on Chinese exports to the US. The authors do not find positive price effects. Beyond these studies with their focus on a single country pair, investigations of price effects of AD duties remain scarce.[8] This paper adds to the literature by investigating the universe of EU imports, thus extending the scope to many exporting countries. It also examines the effects of AD duties over time and across targeted and non-targeted exporters.

By investigating several exporters, this paper aligns the seemingly conflicting results of Blonigen and Haynes (2002) (increasing producer prices following AD duties) with those of Lu et al. (2013) (no producer price effects) by showing that this difference is driven by China's Non-Market Economy Status (NMES). The way EU and US AD duties against NMES countries are constructed does not incenitivise exporters to raise prices. Specifically, exporters in countries with MES (such as Canada) receive firm specific AD duties that are adjusted when the exporter raises prices. In contrast to that, exporters situated in countries with NMES often only receive a duty constructed using average dumping margins across all firms exporting the

[5] See for example the EU's position on AD in European Parliament (2017) and European Commission (2016).
[6] As explained further down, the effectiveness of this channel however depends on the MES of the exporter.
[7] Duties typically remain in place for at least five years (European Commission, 2013). It will be shown further down that the estimation strategy draws on this persistence.
[8] Gourlay and Reynolds (2012) and Nita and Zanardi (2013) provide indirect evidence for price effects by looking at the change in AD duties following reviews.

same product. Hence, adjusting own export prices does not change the duty the exporting firm faces, providing no incentive to raise prices.[9]

The hypothesis that price effects depend on the AD methodology applied to calculate dumping margins (i.e. MES or NMES) can be tested, and this paper provides evidence in its support, comparing price effects of AD duties for exporters from countries with MES with those from NMES countries. It finds that price increases are driven by exporters from MES countries, indicating that the NMES methodology does not incentivise exporters to raise their prices.[10] By doing so, it is the first study to identify differential trade effects of AD duties by applied AD methodology.[11] This is relevant for policy makers as it allows making predictions on the likely effects of applying either MES or NMES on import prices and quantities.

The second strand of literature to which this paper contributes relates to the effects of AD duties on import values and quantities. Prusa (1997, 2001) investigates the implementation of US AD duties, showing that they reduce US imports from targeted countries by up to 50%. In contrast to that, Egger and Nelson (2011) find much smaller effects.[12] For the European Union, Messerlin (1989); Lasagni (2000) and Konings et al. (2001) estimate treatment effects similar in magnitude to those of Prusa (1997, 2001).[13] Vandenbussche and Zanardi (2010) look at several AD imposing countries, finding that AD duties imposed by the so called “new adopters” have

[9] In addition, the theory of heterogeneous firms (Melitz, 2003) suggests exit of firms with high marginal costs, which would even push average prices down.

[10] An alternative explanation however could be that MES exporters with low prices receive higher AD duties which force them to exit the market. Even if the remaining high price firms do not adjust prices, this selection would raise average prices. In contrast, exporters in NMES countries all receive the same duty. Consequently, low price exporters are not necessarily more likely to be forced to exit the market than high price exporters, leaving average prices unchanged. Testing whether the within firm or between firm effect dominates the results however requires the use of firm level data. As both channels work in the same direction, the exact channels at work are not the primary concern of this paper.

[11] Existing studies are either descriptive, comparing levels of AD duties for MES and NMES exporters (Detlof and Fridh, 2006; Felbermayr et al., 2016) or look at the effect of MES on the number of AD investigations (Urdinez and Masiero, 2015).

[12] Other studies include the investigation of individual stages of the AD process (Staiger and Wolak, 1994) as well as particular sectors (Carter and Gunning-Trant, 2010).

[13] The AD process itself also plays a role for the EU, with Baran (2015) finding that withdrawn or rejected cases only have temporary effects, while trade effects of final duties are strong and lasting.

trade chilling effects on bilateral trade flows. Following the availability of firm level export data, a growing literature is also starting to look at impacts of AD duties on exporting firms.[14]

The above studies potentially suffer from endogeneity bias due to simultaneity of AD duties and imports. AD duties typically increase consumer prices and thus reduce import quantities of targeted products. However, they are by no means exogenous. Being designed to protect domestic industry, they are more likely to be imposed on products with low prices and high import quantities. This simultaneity of imports and AD duties violates the exogeneity assumption as the independent variable is no longer uncorrelated with the error term. OLS results in biased estimates of the treatment effect (Bown and Crowley, 2013), more specifically, an underestimation of the effect of AD duties on import quantities and prices (the latter being the case under the assumption that AD duties do indeed raise prices).[15] This paper adds to the literature by exploiting the EU enlargement of 2004 as a natural experiment to tackle simultaneity and obtain unbiased estimates of the effect of AD on imports. Estimated effects are larger than those found by previous studies, indicating that these may indeed suffer from simultaneity bias, which results in an underestimation of the treatment effect.

Third, the paper contributes to the literature on trade deflection and other effects of trade policies on third countries.[16] Bown and Crowley (2007) find that the imposition of US AD duties on Japanese exports increases Japanese exports to third countries by 5 - 7%. Similarly, Nguyen et al. (2016) show that EU duties imposed on Vietnamese footwear increase Vietnamese exports to the US. The same is true for Mexican exports of tomatoes, which were diverted to Canada following the imposition of US AD duties (Baylis and Perloff, 2010). Chandra (2016)

[14] At the firm level, Besedeš and Prusa (2013) find US AD to induce firm exit. Lu et al. (2013) use firm level data to estimate semi-elasticities for the effects of US AD duties on Chinese exports to the US, showing that a one percentage point increase in preliminary (final) US AD duties reduces Chinese exports to the United States by 0.27% (0.6%). The effects are driven both by reduced firm exports as well as firm exit. Jabbour et al. (2016) show that Chinese exporters reduce exports to the EU following the imposition of EU AD duties, but also become larger and more productive. Felbermayr and Sandkamp (2018) look at the universe of Chinese firm level exports, showing that both EU and US AD duties decrease firm exports and induce exit, with small firms being affected most severely.

[15] Felbermayr and Sandkamp (2018) tackle this problem by combining firm level data with an extensive fixed effects estimation strategy, as time varying product characteristics can be controlled for, so that the treatment effect is identified using variation in duties within products across firms. However, this methodology requires firm level data which is not available for all countries exporting to the EU.

[16] Following Bown and Crowley (2007), trade deflection is defined as an increase in exports from country B to country C, following the imposition of AD duties of country A on imports from country B. Country B's exports are thus deflected from country A to country C. This is in contrast to import diversion, which is defined as an increase in exports from country C to country A following the imposition of AD duties of country A against country B. Country A's imports are thus diverted from country B to country C.

finds evidence for trade deflection following the imposition of US temporary trade barriers against China.[17] In contrast, other studies do not find systematic evidence for larger export volumes to third countries following the imposition of US AD duties (Lu et al., 2013) and more general EU and US import restrictions (Bown and Crowley, 2010) against China.

In light of the above literature, it is possible that the estimated treatment effect of EU AD duties on imports using the natural experiment of the EU enlargement captures not only trade destruction but also a reversal of trade deflection. This would threaten the identification of the treatment effect. If imports targeted by the EU were deflected from EU15 countries to accession countries before 2004, then imports of new member states would be larger in the pre-treatment period than what they would have been without the EU AD duty. An investigation of the pre-treatment period however provides no evidence for trade deflection by means of lower prices or higher import quantities. It also rules out anticipation effects.[18]

Finally, this paper also looks at spillover effects of AD duties on import prices from non-targeted countries. It thus relates to the work of Blonigen and Park (2004), who discuss the role of firms' expectations of AD investigation outcomes in explaining AD recalculations. Dumping allegations for the same product are often investigated separately for different exporting countries. Given the uncertainty surrounding the AD investigation process as explained by Blonigen and Park (2004),[19] the imposition of AD duties against one exporting country may induce producers of the same product in other exporting countries to update their beliefs about the likelihood of being investigated and becoming subject to duties. This paper finds evidence for such behaviour, as producer prices of imports from non-targeted countries increase following the imposition of AD duties against another country.[20]

[17] Felbermayr and Sandkamp (2018) show that trade deflection of AD duties is driven by market entry of exporters into third countries as well as by increased exports to these countries by established exporters.

[18] Anticipation effects could go in both directions. On the one hand prices could fall shortly before the accession to sell as much as possible before AD duties are implemented. On the other hand, prices could be increased to avoid the imposition of AD duties following the accession. Neither effect is observed in the data.

[19] According to Blonigen and Park (2004), uncertainty surrounding the AD investigation process is also the reason why dumping takes place at all. If exporters had perfect foresight and knew they would become subject to AD duties, they would have increased their prices preemptively. Consequently, depending on expectations, some exporters already set higher prices compared to a scenario without the presence of AD, thus affecting welfare in the importing country.

[20] This finding also relates to the work on AD echoing by Tabakis and Zanardi (2016). The authors find that different importing countries tend to echo each others AD policies in the sense that they impose AD duties on products from the same exporter, either simultaneously or consecutively. In contrast, this paper finds evidence for non-targeted exporters echoing price responses of targeted exporters. The possibility of AD echoing would provide further incentives for exporting firms to raise prices.

The remainder of this paper is structured as follows. Section 1.2 presents the estimation strategy, including potential threats to identification and ways to address them. This is followed by an overview of the data used (Section 1.3). Section 1.4 presents descriptive evidence, while Section 1.5 provides the core results of the paper. Section 1.6 offers several extensions and robustness checks and Section 1.7 concludes.

1.2 Estimation Strategy

Identification of the treatment effect relies on a difference-in-differences estimation exploiting the change over time in import prices and quantities of treated exporting country-product combinations relative to the same product imported from untreated exporting countries (within product across country variation) and relative to untreated products imported from the same exporting country (within country across product variation).[21] For the baseline analysis, EU15 importers are dropped and the ten accession states aggregated to one entity.[22] The years 2003 and 2005 are chosen as pre- and post-treatment period respectively, as they constitute a symmetric time period around the accession of the ten new member states in May 2004. The panel is balanced by dropping exporting country-product combinations that were only observed in one year.[23]

Since the time dimension of the panel only consists of two years (a pre- and a post-treatment period), the difference-in-differences specification can be estimated with a first differences regression. The baseline estimation equation is given by

$$\Delta \ln y_{ih} = \delta \Delta AD_{ih} + \nu_i + \nu_h + \epsilon_{ih}. \tag{1.1}$$

The dependent variable $\Delta \ln y_{ih}$ is the change in the natural logarithm of import price (quantity) of product h imported from exporting country i between 2003 and 2005. ΔAD_{ih} is the

[21] Unit values are constructed by dividing import values by quantities. Import quantities rather than values are investigated since they provide a clearer picture of changing trade flows. Import values incorporate price effects, so that changing prices would disguise the impact on real trade flows. Value effects are however estimated as a robustness check.

[22] These are Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. Bulgaria, Romania and Croatia, who joined the EU in 2007 and 2013, are dropped. Treating individual countries as separate entities does not offer any additional information as treatment takes place at the EU level. A robustness check performs the same estimation with individual importing countries. Estimated coefficients remain similar.

[23] Dropping singletons may bias the results if zero trade flows contain information. This is addressed in a robustness check.

treatment dummy that equals one if an exporting country-product combination becomes subject to AD duties in 2005.[24] It tells how import prices (quantities) of treated country-product combinations (for which $\Delta AD_{ih} = 1$) change relative to untreated country-product combinations (for which $\Delta AD_{ih} = 0$) once the AD duty is implemented through accession to the EU. ν_i and ν_h are exporter and product fixed effects respectively.[25] ϵ_{ih} is an error term.

In order to test for differential effects of duties on imports by applied AD methodology, the treatment dummy is nested by AD regime. This is done by interacting the treatment dummy ΔAD_{ih} once with a dummy that is equal to one if the exporter has MES and once with a dummy identifying if the exporter has NMES.[26]

Once implemented, AD duties typically remain in force for at least five years (European Commission, 2013), which allows their effect on trade to be estimated. For the experiment, the paper only considers AD cases for which final duties were implemented by the end of 2003 (i.e. before the accession) and that were in force throughout 2005 (i.e. not revoked in 2005 or before). This yields a clear pre- and post-treatment period. All duties considered were in force in EU15 countries but not in accession states in 2003 (pre-treatment period), entered into force at the same time in 2004 from the perspective of new member states and still were in force in 2005 (post-treatment period).[27]

The advantage of the natural experiment is that the implementation of AD duties already in force in the EU is exogenous from the perspective of new member states. Member states were required to adopt the existing AD policy (treatment) because they joined the EU. Under the plausible identifying assumption that accession states did not join the EU because of its AD

[24] The dummy AD is zero for all ih in 2003 and changes to one in 2005 only for those ih that are subject to EU AD duties.
[25] The first differences approach eliminates all unobserved time invariant country-product variation. Adding exporter (product) fixed effects after taking first differences additionally controls for the change in unobserved exporter (product) characteristics over time.
[26] The resulting estimation equation becomes
$\Delta \ln y_{ih} = \delta^{MES} MES \Delta AD_{ih} + \delta^{NMES} NMES \Delta AD_{ih} + \nu_i + \nu_h + \epsilon_{ih}$.
[27] This is also the reason why the 2007 accession round is not considered. If 2008 was chosen as the post-treatment period so as to include Romania and Bulgaria, all duties implemented or revoked between 2005 and 2008 would have to be removed from the sample. As several duties were revoked during this time period, this would have reduced the size of the treatment group significantly.

policy (independence of decision to join EU and existing EU AD regulation), the difference-in-differences strategy yields unbiased estimates of the treatment effect.[28]

Even though the experimental setup reduces endogeneity bias by addressing simultaneity (new member states' imports do not determine whether AD duties are introduced by EU15 countries before 2004), a threat to clear identification may remain if imports of EU accession states correlate with those of EU15 countries, for which endogeneity is suspected. In order to address this potential problem, this paper additionally uses product fixed effects to control for unobserved demand side variables such as changes in tastes and preferences.[29] They also capture average changes in MFN tariffs over time.[30]

All time invariant unobserved country-product characteristics are eliminated by the first differences approach. Potentially omitted time varying supply side factors are additionally controlled for through exporter country fixed effects. In the context of a first differences estimation, country fixed effects capture time varying exporter characteristics such as non-product specific market distortions and changes in the price index of intermediates in individual exporting countries as well as time-varying multilateral resistance terms (Feenstra, 2008). To sum up, the combination of first differences with country and product fixed effects controls for all unobserved variables that vary across the exporter-product, exporter-time or product-time dimension.

Omitted supply side factors which vary across the exporter-product-time dimension and may cause omitted variable bias cannot be controlled for with fixed effects because this variation is required to estimate the effect of AD duties. However, they should not play a role in the context of the natural experiment. For example, an exporter-product specific subsidy which increases EU imports and consequently induces the EU to impose AD duties would constitute a source of endogeneity. However, only AD cases imposed by (and hence initiated before) 2003 are

[28] This exogeneity is not trivial as Bown and Crowley (2013) show. In the presence of simultaneity (AD duties reduce imports but higher imports increase the likelihood of AD implementation), estimated coefficients may suffer from endogeneity bias. For quantity effects, the bias is likely to be positive, leading to an underestimation of the (negative) treatment effect. For prices, the bias is likely to be negative, as AD duties are more likely to be implemented in sectors where dumping exists, i.e. import prices are low. Felbermayr and Sandkamp (2018) show explicitly that not accounting for demand side effects that are correlated with the decision to implement AD duties results in an underestimation of the true treatment effect.

[29] Since the initial panel only consists of two time periods, the time dimension disappears after taking first differences. Product fixed effects in the first differences model hence capture the change in product specific demand and supply side variables between the two time periods.

[30] Moore and Zanardi (2009, 2011) show a correlation between anti-dumping and trade liberalisation, i.e. an increase in the use of AD following a reduction in MFN tariffs.

included in the sample. Their implementation in the past (including possible reactions by the exporter) should not be correlated with time varying country-product characteristics in 2003 and 2005. The fact that they are inherited by the new member states from 2004 onward does not imply a change in unobserved exporting country-product characteristics between 2003 and 2005. Nevertheless, the potential for unobserved time varying exporting country-product specific variables that correlate with imports and AD duties and may cause omitted variable bias is addressed in a robustness check.

The difference-in-differences setup also ensures that results are not driven by trade diversion effects due to the EU enlargement.[31] As AD duties vary by exporter and product, effects are estimated by exploiting variation across these two dimensions. On the one hand, the change in imports of targeted products from a particular country is compared to the change in imports of a non-targeted product by that same country, exploiting within exporter across product variation. This channel is not affected by trade diversion as long as trade diversion is not systematically larger for products subject to AD duties. On the other hand, the change in imports of a specific product from a country targeted by AD is compared with the change in imports of the same product exported from another un-targeted (EU or non-EU) country. This channel could indeed be affected by trade diversion, which is why all EU exporters are excluded in a robustness check. As a consequence, imports from targeted countries are only compared to imports from non-targeted non-EU countries.

The possibility of the reversal of trade deflection resulting in an overestimation of the treatment effect was already discussed in Section 1.1. Similarly, the existence of anticipation might also constitute a threat to identification. The accession of the ten member states and its consequences for their AD policy was known by importers and exporters years before 2004. If the change in AD regulation was anticipated it is hence possible that firms exporting to the new member states may have adjusted their prices before 2004 in order to avoid the imposition of AD duties once the EU AD rules are in force. Only looking at post-treatment price effects would hence underestimate the treatment effect. Similarly it is also possible that exporters engaged in excessive dumping before 2004 to sell as many dumped products as possible before the regulation enters into force. By looking at treatment effects over time, this paper shows that trade deflection and anticipation effects were absent for duties implemented before 2003.

[31] Trade diversion exists if imports of EU accession countries from non EU countries are diverted to EU15 countries, i.e. accession states substituting non EU imports for EU imports following accession.

A final threat to identification worth discussing is anticipation of the EU enlargement by EU trade authorities in charge of AD investigations. Knowing that the new member states were about to join the EU in 2004, it is possible that EU AD decisions were adjusted even before 2004 in order to accommodate the need for protection of future member states. AD duties imposed before 2004 would thus not be exogenous from the perspective of the accession countries. This claim can however be rejected for three reasons. According to the EU AD legislation, duties can only be imposed if there is proof for material injury of the domestic (i.e. EU15) industry. From a legal perspective, AD duties can therefore not be imposed if only the domestic industry of EU accession states is affected by dumping practices. Second, only four out of the ten new member states imposed AD duties before joining the EU, indicating limited interest in the instrument.[32] Finally, for almost all AD cases that were successfully imposed by the accession states, the EU imposed no case covering similar products and exporting countries, indicating that the EU did not adjust its AD policy before 2004.[33]

1.3 Data

Data on EU trade is obtained from the Eurostat Comext Database (Eurostat, 2017). It supplies data on annual bilateral import values and quantities for all EU member states at the CN8 digit product level. This paper uses data for the years 1999 to 2009, with a focus on 2003 and 2005.[34] For 2003 and 2005 the dataset covers imports of 10,636 CN8 products from 223 countries.

Information on EU AD duties is taken from the World Bank's Global Anti-dumping Database (Bown, 2015). The European AD process involves three stages: Initiation of a case, preliminary (temporary) duties and final duties. Only cases in which final duties were implemented are considered. The estimation strategy requires a degree of persistence of AD duties, meaning they have to remain in force for several years. More specifically, only cases for which final

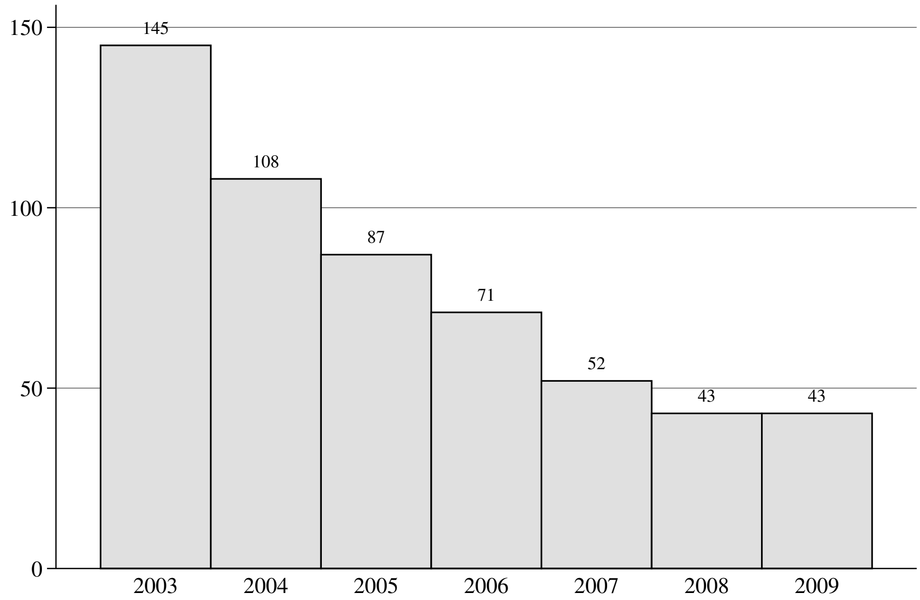
[32] These are the Czech Republic (one case), Latvia (one), Lithuania (seven) and Poland (nine). Slovenia started one investigation which however was withdrawn. All data from Bown (2015).

[33] One exception is the case of graphite electrodes from India that were investigated by Poland and the EU simultaneously in 2003 and became subject to AD duties by both economies. On the other hand, pocket lighters exported by China, Taiwan, Indonesia and Vietnam that became subject to Polish AD duties in 2000 were investigated by the EU in 2002. However, no final duties were imposed by the EU. Similarly, styrene-butadiene rubber from Russia became subject to Polish AD duties in 2003 and was subsequently investigated by the EU in 2004 and 2005. Even though dumping was determined to take place, no evidence for injury was found so that no duties were imposed.

[34] 1999 is the first year for which Eurostat provides trade data for EU member states that joined in 2004. Using data until 2009 provides a symmetric five year window around the treatment year 2004.

duties were implemented by the end of 2003 and that remained in force until at least 2005 (i.e. not revoked in 2005 or earlier) are considered. This leaves 87 AD cases covering 82 CN8 products from 17 exporting countries.[35] The persistence of AD duties implemented by 2003 is illustrated in Figure 1.1.

Figure 1.1: AD Duties imposed by 2003 and remaining in force



Note: Cases in force both in 2003 and onward (several products per case)

The datasets are merged by exporting country, CN8 product and year. Using import (rather than export) data has the advantage that the importer's product nomenclature is used, which coincides with the nomenclature reported in Bown (2015) who also relies on importers' declaration of AD duties. As HS codes are only comparable across countries up until the HS6 digit level (Lu et al., 2013; Bown and Crowley, 2016), studies using exporter data have to restrict their analysis to this higher level of aggregation. Since AD duties are however often implemented at a more disaggregated level, using aggregated data means that HS6 products which are assigned AD treatment incorporate trade flows that are in fact not subject to AD duties, leading to attenuation bias and hence an underestimation of the treatment effect. After the merge, the balanced baseline sample includes imports of 8,366 CN8 products from 149 countries.[36]

35 Overall, 145 (115) cases were in force in 2003 (2005). Only those in force in both years are included in the analysis. Each case can cover several products, while several cases may cover the same product, but for different exporting countries. Except for one case, all AD cases involve duties imposed at the CN8 digit level.

36 Not every product is exported by every country.

55 products imported from 13 countries are subject to EU AD duties.[37] Information on NMES of exporters is taken from Detlof and Fridh (2006) and (Felbermayr et al., 2016).[38]

1.4 Descriptive Evidence

Figures 1.2 and 1.3 present an event analysis, providing descriptive evidence for the effect of AD duties on import quantities and prices.[39] For the years 1999 to 2009, they show average quantities (prices) in logarithms of imports into the ten EU accession states (grouped together) of six specific products that are subject to EU AD duties. The treatment group consists of imports of the respective CN8 product from the country (countries) targeted by EU AD duties, while the control group is given by the same product, imported from non targeted countries.[40] Looking at the top left panel of Figure 1.2, it can be seen that imports of Silicon Metal from targeted and non targeted countries followed the same trend before the year of accession (2004). However, once the new member states joined the EU in 2004 and EU AD policy was implemented, imports from targeted countries drop, while those from non targeted countries increase. The other panels of Figure 1.2 illustrate similar developments.

The impact of AD duties on prices is not that clear. Looking at the top middle panel of Figure 1.3, it can be seen that prices of targeted Ethanolamine imports increased rapidly relative to the control group following the imposition of AD duties in 2004. On the other hand import prices of television camera systems and parts fell following the imposition of AD duties (bottom right panel). In addition prices of both treated and untreated imports of iron tubes (bottom middle panel) increased following the accession. This could be evidence for spillover effects from treated to untreated countries.

Prices may also be affected by exchange rate fluctuations. This should however only be the case if the currency of countries subject to AD duties reacted differently to the EU enlargement

[37] AD duties are product and country specific, so that the same product may be subject to AD duties if imported from one country, but not the other.

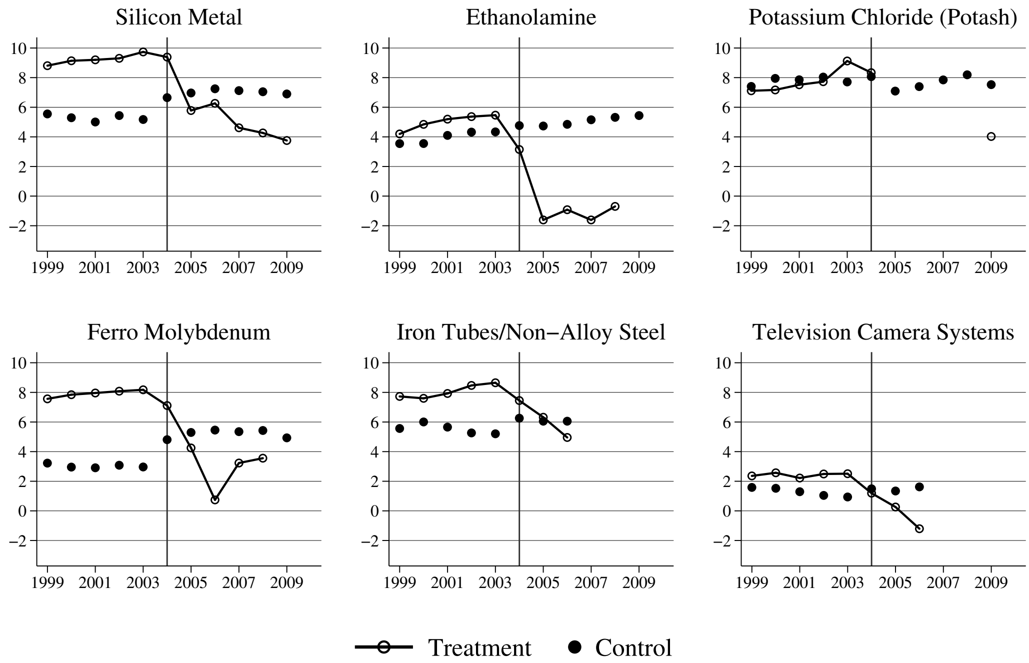
[38] Countries that are assigned NMES by the EU in the period of investigation are Albania, Armenia, Azerbaijan, Belarus, China, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Mongolia, North Korea, Tajikistan, Turkmenistan, Uzbekistan and Vietnam. Out of these 15 countries, only five (Armenia, Belarus, China, Kazakhstan and Vietnam) have ever become subject to EU AD duties and two (Belarus and China) are targeted in the sample period.

[39] Value effects are similar to quantity effects. They are illustrated in Figures A.1 (including EU exporters) and A.4 (excluding EU exporters) in the Appendix.

[40] The descriptive analysis hence ignores the second identification channel of variation within countries across products.

than currencies of countries not subject to AD duties. The difference-in-differences specification relies on variation within countries across products as an additional identification channel which is not affected by exchange rate fluctuations. In addition, country fixed effects capture average exchange rate fluctuations by exporting country.[41]

Figure 1.2: Average Import Quantities by Treatment Status



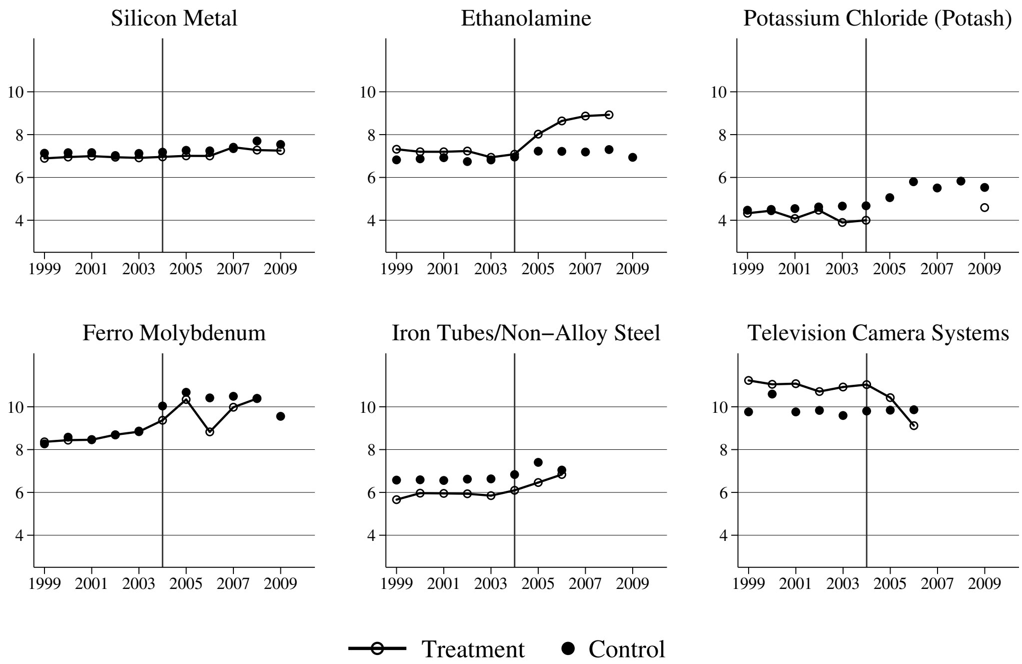
Note: EU accession (beginning of treatment) in May 2004. Ln import quantity on vertical axis, year on horizontal axis. For example, a change in imports of Silicon Metal from almost 10 in 2003 to 4 in 2009 indicates a trade reduction of $\frac{e^{10}-e^{4}}{e^{10}} * 100 = 99.75\%$ Missing observations represent non-reported quantities and can be interpreted as zero trade flows.

It is, however, not obvious whether the drop in imports of treated products stems from AD or is simply a consequence of the EU accession. As imports of untreated products include imports from EU countries, the graphs above could simply show import diversion from non EU exporters towards EU exporters. Figures A.2 and A.3 in the Appendix hence show import quantities and prices for the same products, excluding imports from EU exporters. The control group only consists of non EU exporters not subject to AD and exporting the same product.

[41] Since most EU accession states had their own currencies during the period of investigation, exporter fixed effects only capture average changes in the currency of the exporter relative to all currencies of the importing countries. When importing countries are assessed individually in a robustness check, additional importer fixed effects however also control for each importer's individual currency.

The overall picture remains similar, indicating that results are not driven by trade diversion following the accession.

Figure 1.3: Average Import Prices by Treatment Status



Note: EU accession (beginning of treatment) in May 2004. Ln import price on vertical axis, year on horizontal axis. Missing observations represent non-reported prices and can be interpreted as zero trade flows.

Table 1.1 provides results of a descriptive regression of import prices and quantities on an AD dummy (nested by year) with product fixed effects.[42] It thus shows prices and quantities of products that become subject to AD duties in 2005 relative to the same product exported from countries not targeted by AD duties (within product across countries), both in the pre- and post-treatment period. Looking at Column (1), the coefficient of the AD dummy is negative and statistically significant in 2003, indicating that products subject to AD duties were on average 38% cheaper than the same product exported from a country not subject to AD duties.[43] This difference shrunk to 23% in 2005 following the imposition of the AD duty, providing some

[42] The sample is the same as the one used in the baseline regression, before taking first differences.
[43] $100 * (e^{\delta} - 1)\%$

preliminary evidence that the imposition of AD duties is associated with higher exporter prices. The difference is statistically significant at the 5% level.[44]

Table 1.1: Import Prices and Quantities of EU Accession States, 2003 and 2005

	(1)	(2)	(3)	(4)
Dependent variable	ln price	ln price	ln quantity	ln quantity
AD (2003)	-0.4716***		2.0112***	
	(0.0886)		(0.2603)	
AD (2005)	-0.2658***		0.9756***	
	(0.0960)		(0.2847)	
AD (MES, 2003)		-0.4251***		1.8357***
		(0.1066)		(0.3009)
AD (MES, 2005)		-0.1615		0.9526***
		(0.1236)		(0.3276)
AD (NMES, 2003)		-0.5802***		2.4266***
		(0.1452)		(0.4768)
AD (NMES, 2005)		-0.5123***		1.0278*
		(0.1120)		(0.5427)

Note: OLS regression with product fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Same products subject to AD duties in 2003 and 2005. 144,998 observations per year. The sample is the same used in the baseline regression (before first differencing).

When interacting the time invariant dummy with market economy status of the exporter (Column 2), it can be seen that the NMES coefficient is larger in terms of magnitude than the MES coefficient both in 2003 and in 2005. Interestingly, the difference in the size of the coefficient between MES and NMES countries is not statistically significant in 2003, while it increases and turns significant in 2005 (5% level). This provides preliminary evidence that the imposition of AD duties correlates with an increase in import prices from MES exporters, going so far as to eliminate the price differential relative to products not subject to AD duties (as indicated by the insignificant coefficient of AD for MES exporters in 2005). This is not the case for NMES exporters, for whom the coefficient hardly changes between 2003 and 2005.

[44] When not controlling for product fixed effects, the coefficient becomes even more negative. This indicates that products subject to AD duties are both cheaper than products of the same CN8 product classification not subject to AD (within product) and cheaper than untargeted products of different CN8 product classifications (across product), providing some insights regarding the type of product typically targeted by AD.

Regarding import quantities, Column (3) shows that the AD coefficients are positive and significant, indicating that country-product combinations targeted by AD duties experience higher import quantities. The coefficient is significantly smaller in 2005, indicating that the gap in import quantities between targeted and non-targeted products falls following the imposition of AD duties.[45] The same difference between pre- and post-treatment is true when looking at exports from NMES and MES countries separately (Column 4). In contrast to prices, the difference between MES and NMES coefficients of the same year is not statistically significant.

1.5 Econometric Baseline Results

1.5.1 Effects on Prices

Table 1.2 provides the baseline estimation results, with the change in the logarithm of import price, quantity and value as dependent variable. Column (1) of Table 1.2 shows the price effects of AD duties following the basic difference-in-differences estimation as given in Equation 1.1. The coefficient of the AD dummy (0.2206) is positive and statistically significant. It indicates that import prices (before tariffs and duties) increase by 25% following the imposition of AD duties.[46]

The baseline estimation already includes product and exporter fixed effects. Interestingly, not controlling for these fixed effects does not significantly alter the results.[47] The positive estimated treatment effect is robust to all possible fixed effects specifications. This indicates that the quasi-experimental setup addresses omitted demand and supply side variables that typically have to be controlled for using fixed effects.

The results are in line with Blonigen and Haynes (2002), who also find pass-through rates of more than 100%, but not with Lu et al. (2013), who do not find any price effects for imports from China. To check whether this difference stems from the specific AD procedure applied to non-market economies such as China, the AD dummy is additionally interacted with a

[45] Similar to the price effects discussed before, the magnitude of the estimated coefficient increases when not controlling for product fixed effects, indicating that it is driven both by within product variation (higher import quantities of products imported from countries subject to AD compared to the same product imported from countries not subject to AD duties as shown in the table) as well as across product variation (larger ex ante import quantities of products subject to AD duties).

[46] $100 * (e^{\delta} - 1)\%$

[47] Results for varying fixed effects specifications are provided in Table A.1 in the Appendix.

dummy indicating whether the exporter has MES, and a (mutually exclusive) dummy indicating whether the exporter has NMES.

Table 1.2: The Effect of AD Duties on Imports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.	$\Delta \ln price$	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln quantity$	$\Delta \ln value$	$\Delta \ln value$	$\Delta \ln value$	$\Delta \ln value$
AD	0.2206**		-1.3518***		-1.1312***		-1.1384***	
	(0.0943)		(0.2362)		(0.2174)		(0.2179)	
AD*MES		0.2518**		-1.1253***		-0.8736***		-0.9057***
		(0.1151)		(0.2934)		(0.2589)		(0.2593)
AD*NMES		0.1471		-1.8852***		-1.7381***		-1.7582***
		(0.1578)		(0.3448)		(0.3525)		(0.3504)
R^2	0.1223	0.1223	0.1359	0.1359	0.1703	0.1704	0.1420	0.1420

Note: OLS regressions (first differences) with exporter and product fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. (1) - (6): 144,998 observations. (7) - (8): 184,889 obs.

The results are presented in Column (2). When comparing the estimated coefficients for MES and NMES countries, it is evident that aggregate results presented in Column (1) are driven by MES countries. The interaction coefficient of the treatment dummy and the MES dummy is positive and statistically significant, while the interaction coefficient of the treatment dummy and the NMES dummy is smaller and not statistically significant. This provides evidence that producer prices of products imported from MES countries increase following the imposition of AD duties. On the other hand, one cannot reject the hypothesis that producer prices of products exported from NMES countries do not change following the imposition of AD duties. The policy implication of this finding is that the MES methodology increases the likelihood that AD duties achieve an increase in import prices, which is the official objective of the instrument.[48]

[48] As mentioned before, product level data does not allow the determination of whether the price increase for MES exporters stems from exporting firms increasing their prices or from low price exporters receiving high duties and thus exiting the market, leaving only high price exporters behind. From the perspective of the importer, the result is the same. It may nevertheless have long term implications if the exporter composition is affected (e.g. inefficient exporters driven out of the market, leaving only efficient ones behind. See for example Lu et al. (2013), Jabbour et al. (2016) and Felbermayr and Sandkamp (2018) for a more detailed discussion).

1.5.2 Effects on Quantities

Columns (3) and (4) of Table 1.2 summarise the effects of AD duties on import quantities. Column (3) shows regression results for the basic difference-in-differences specification following Equation 1.1. The coefficient of the AD dummy is negative and statistically significant at the 1% level, indicating that the imposition of AD duties reduces import quantities of EU accession states. As with price effects, the result is robust to all possible fixed effects specifications. In terms of magnitude the coefficient of -1.3518 in Column (3) indicates that imports fall by 74% following the imposition of AD duties.[49] This estimate is at the high end of the existing literature.

Column (4) presents the estimated effect of AD duties on import quantities separated by MES and NMES. It shows that while both coefficients are highly statistically significant, the estimated treatment effect for NMES countries is larger in terms of magnitude than the one for MES countries. The difference is statistically significant at the 10% level. This result is to be expected given the higher average AD duties imposed on NMES exporters observed in the literature.

1.5.3 Effects on Values

The baseline regression focuses on quantity effects to estimate the impact of AD duties on real trade flows. For completeness, value effects (in EUR) are also estimated. By construction, $value = price * quantity$ so that $\Delta \ln value = \Delta \ln price + \Delta \ln quantity$. This is also true for the estimated coefficients which are reported in Columns (5) and (6) of Table 1.2. They are similar to quantity effects but smaller in magnitude. This is due to the positive price effects of AD duties which are incorporated in the value effects and reduce the magnitude of the (negative) coefficient. The difference between estimated coefficients for MES and NMES countries increases in significance (5%) relative to the quantity regression. An advantage of using import values is the resulting increase in sample size, as information on import values is more frequently available than information on import quantity. Running the same regression with a larger sample (Columns 7 and 8) however yields coefficients of similar magnitude, indicating that results are robust to a change in sample composition.

[49] $100 * (e^{\delta} - 1)\%$

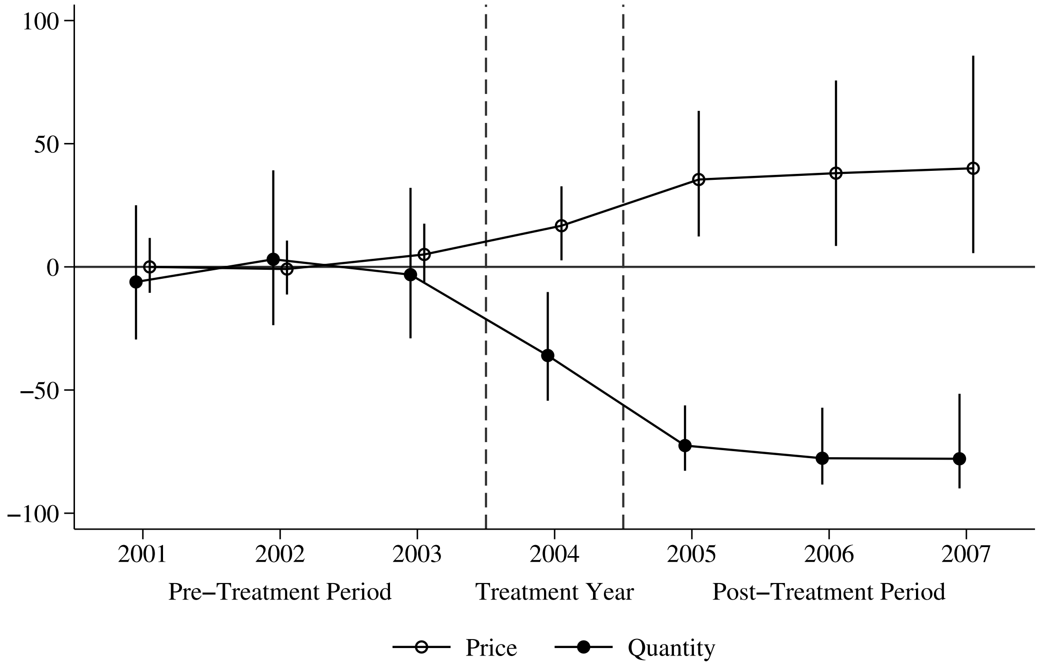
1.5.4 Effects over Time

By comparing import flows in 2003 and 2005 for treated and untreated products, the baseline regression provides a snapshot of the trade effects of AD duties. In order to investigate whether the effect of AD duties persists over time, the sample is extended, covering trade flows for the years 1999 to 2007. The AD cases included in the sample are the same as in the baseline. Instead of estimating one treatment effect, separate treatment effects are estimated for each year from 2001 to 2007.[50] This is done by interacting the AD dummy (which varies across products and exporters) with year dummies. Each of the resulting dummies hence only switches from zero to one in one year, identifying the effect of AD duties on import prices and quantities in that specific year.[51]

The results are illustrated graphically in Figure 1.4.[52] The graph already provides transformed effects, so that the point estimates depicted show percentage changes in import prices and quantities of treated exporting country-product combinations for each year relative to non treated ones.[53] It can be seen that both price and quantity effects are not statistically significant before the new member states joined the EU in 2004. Both coefficients become significant in 2004 (the new member states officially joined the Union in May 2004) and increase in magnitude in 2005. From 2005 onwards, effects remain stable. Since only a part of 2004 is treated, the smaller coefficient for this year is to be expected. The results imply that AD duties quickly unfold their full effect on trade. Small delays could be driven by contracts which fix prices and quantities in the short run. On the other hand the results could be taken as evidence that exporters adjust their prices in steps. Firm-level data is necessary to decompose these potential channels.

[50] Symmetric around the treatment year 2004, relative to 1999 and 2000.
[51] Effects over time are estimated using fixed effects rather than first differences. With t=2, first differences and fixed effects estimations are identical (Wooldridge, 2010). The fixed effects specification is given by $\ln y_{iht} = \delta(AD_{ih}post_t) + \nu_{ih} + \nu_{it} + \nu_{ht} + \epsilon_{iht}$. The dependent variable $\ln y_{iht}$ is the natural logarithm of import price (quantity) of product h imported from country i at time t. AD_{ih} identifies the treatment group and is a time invariant dummy that is equal to one if imports from country i of product h are subject to EU AD duties and zero otherwise. $post_t$ is a time dummy that equals zero in 2003 and one in 2005 and $AD_{ih}post_t$ is the treatment dummy that is an interaction of the AD dummy and the time dummy so that δ identifies the treatment effect. ϵ_{iht} is an error term. ν_{ih}, ν_{it} and ν_{ht} are exporter-product, exporter-time and product-time fixed effects respectively. Effects over time are estimated using the specification $\ln y_{iht} = \sum_{T=2001}^{2007} \delta^{year_T}(AD_{ih}year_T) + \nu_{ih} + \nu_{it} + \nu_{ht} + \epsilon_{iht}$ with $year_T = 1$ if $t = T$ and zero otherwise. The three two dimensional fixed effects are implemented simultaneously using the “reghdfe” stata command by Correia (2016) for OLS and the “poi2hdfe” stata command by Guimarães and Portugal (2010) and Figueiredo et al. (2015) for PPML.
[52] Detailed coefficients for each year are provided in Columns (1) and (2) of Table A.2 in the Appendix.
[53] $100 * (e^{\delta} - 1)\%$

Figure 1.4: Effect of AD Duties on Import Prices and Quantities, by Year



Note: EU accession (beginning of treatment) in May 2004. Percentage change in import prices and quantities of treated products on vertical axis, year on horizontal axis. The plot shows point estimates with 95% confidence intervals, indicating large and significant price and quantity effects of AD duties since their introduction in 2004.

1.6 Extensions & Robustness Checks

1.6.1 The Persistence of AD Duties

Figure 1.4 has illustrated that the trade dampening effects of AD duties persist over several years. The estimated coefficients show the average effect over time of AD duties that were in force 2005. However, they may underestimate the treatment effect for the years 2006 and 2007 because the baseline sample only includes AD cases that were in force until at least 2005. Cases revoked in 2006 or 2007 are still treated as being subject to AD duties in the baseline sample, even though they are not in force anymore. A robustness test hence performs the same regression, estimating treatment effects by year, but only including cases in force until at least 2007. The results (provided in Columns (3) and (4) of Table A.2 in the Appendix) show that estimated treatment effects on quantity and price increase for all post-treatment years. Estimated coefficients for 2004 become insignificant, which is not surprising given the smaller number of cases used to identify the treatment effect and since some products that were treated in 2004 and 2005 are not assigned treatment anymore.

In order to investigate an even longer time horizon, treatment effects are also estimated for the years 2000 - 2008 (using the baseline sample) as well as for 2000 - 2009. Results are reported in Columns (5) to (8) of Table A.2 and graphically in Figure A.5 in the Appendix. Both price and quantity effects remain significant until the end of the sample period, despite half of the cases being revoked before (Figure 1.1). The magnitude of the price coefficient remains almost constant between 2005 and 2008, indicating that the effect of AD duties on prices persists beyond their revokement. Even though the estimated quantity coefficient falls over time, it does by no means halve, as would be expected if AD duties only affected trade as long as they are in force.

In fact, the removal of AD duties constitutes a source of variation that has so far not been used to identify the treatment effect. An extension hence departs from the baseline setting and only looks at cases that were revoked between 2006 and 2009. The treatment dummy switches from one to zero in the revoke year and remains zero afterwards. Columns (1) and (2) of Table A.3 in the Appendix report the results. Estimated coefficients of the time varying AD dummy are insignificant, implying no change in import prices and quantities following revokement of AD duties. One possible explanation for this observation is that large AD duties completely eliminate imports, as indicated by the large coefficients reported in Table 1.2. Once an exporter is eliminated, it is impossible for her to re-enter the market quickly following the elimination of the duty. The trade destructing effect of AD duties thus persists beyond their duration. This could be due to market entry costs or a strengthening of the domestic industry during the protection period. Looking at lagged effects provides some evidence that import values recover slightly one year after a case is being revoked, while producer prices fall only three years after the AD duty has been removed (Columns 3 - 5 of Table A.3 in the Appendix).

1.6.2 Elasticities & Semi-Elasticities

By using dummies to identify the treatment, the baseline regressions estimate average changes in import prices and quantities following the impositions of AD duties. These effects depend on the average size of the duty as well as the implied elasticity. To investigate how import prices and quantities react to a change in the size of AD duties, an extension uses information on average product specific duty rates to estimate elasticities.[54] Columns (1) to (4) of Table 1.3 provide estimates for semi-elasticities. The estimated coefficient in Column (1) shows that a one percentage point increase in AD duties leads to an increase in (producer) import prices of 0.34%. As was the case in the baseline regression, the results are driven by MES countries (Column 2). There is no evidence that import prices from NMES countries react to AD duties.

Table 1.3: The Effect of AD Duties on Import Prices and Quantities, Elasticities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.	$\Delta \ln price$	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln quantity$	$\Delta \ln price$	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln quantity$
Treat. var.	Duty	Duty	Duty	Duty	$\ln(1+\frac{Duty}{100})$	$\ln(1+\frac{Duty}{100})$	$\ln(1+\frac{Duty}{100})$	$\ln(1+\frac{Duty}{100})$
Duty	0.0034**		-0.0209***		0.4854**		-2.8718***	
	(0.0015)		(0.0043)		(0.2162)		(0.5815)	
Duty*MES		0.0038**		-0.0199***		0.5500**		-2.6858***
		(0.0017)		(0.0051)		(0.2446)		(0.7027)
Duty*NMES		0.0023		-0.0243***		0.3028		-3.3973***
		(0.0033)		(0.0079)		(0.4457)		(0.9916)
R^2	0.9099	0.9099	0.9016	0.9016	0.9099	0.9099	0.9016	0.9016

Note: OLS regressions with first differences, including exporter and product fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. 144,998 observations.

Looking at the impact of AD duties on import quantities (Columns 3), the coefficient of -0.02 means that import quantities fall on average by 2% for each percentage point increase in AD duties. Coefficients for MES and NMES countries are not significantly different from each other (Column 4), indicating that the difference observed in the baseline regression is indeed driven by differences in average AD duty rates. Given the same estimated elasticity, imports from NMES countries on average fall by more following the imposition of AD due to the higher average duty rates they face. Elasticity estimates provided in Columns (5) to (8) yield similar results.

1.6.3 Trade Diversion and Spillover Effects

The baseline sample includes imports from EU member countries (both EU15 as well as the ten accession states). If AD duties strengthen intra EU trade relatively more than imports from non-targeted non EU countries, this could affect the results. Similarly, increased imports from

[54] As duties are often firm specific, the duties used in the regression are the maximum duties imposed as provided by Bown (2015).

EU15 countries as a consequence of the accession (trade diversion) may affect one of the two identification channels, resulting in an overestimation of the treatment effect (see discussion in Section 1.2).

To exclude this possible channel, the baseline regression is performed on a sample that excludes imports from EU member states. The results are presented in Columns (1) and (2) of Table 1.4. The estimated coefficient for the effect of AD on import quantities (Column 2) remains stable and even increases in magnitude, indicating that trade diversion does not drive the results.

Table 1.4: The Effect of AD Duties on Imports, Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	no EU exporters	no EU exporters	non-targeted countries	non-targeted countries	PPML: zero trade flows	excluding China	excluding China
Dep. var.	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln price$	$\Delta \ln quantity$	$quantity$	$\Delta \ln price$	$\Delta \ln quantity$
AD	0.1374	-1.5504***	0.1240*	0.1546	-1.4421***		
	(0.1171)	(0.2873)	(0.0651)	(0.1388)	(0.3223)		
AD*MES						0.2511**	-1.1164***
						(0.1151)	(0.2939)
AD*NMES						0.1208	-2.0290**
						(0.1615)	(1.0177)
Obs.	51,962	51,962	144,900	144,900	440,606	140,381	140,3812
R^2	0.9149	0.9014	0.9098	0.9016		0.9103	0.9018

Note: OLS regression with first differences unless indicated otherwise. All regressions include exporter and product fixed effects. PPML regression includes exporter-product, exporter-time and product-time fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

The estimate for the treatment effect of AD duties on prices (Column 1) remains positive but turns insignificant, indicating that prices of targeted products increase relative to imports from EU countries (baseline), but not relative to imports from non-targeted non EU countries. This observation can be explained by spillover effects. Allegations of dumping concerning the same product are often split by exporting country and investigated in separate cases either simultaneously or sequentially. If one country is found guilty of dumping a particular product, then other exporters of the same product may expect to become the subject of investigations in the future and raise prices in anticipation. Such spillover effects would mean that non-targeted countries raise prices following the imposition of anti-dumping duties against one particular country. This would violate the stable unit treatment assumption and cause underestimation of the treatment effect. As EU exporters are never subject to EU AD duties, no anticipation spillovers are to be expected for them.

The hypothesis of price spillovers can be tested by investigating the effect of AD duties on imports of targeted products from non-targeted countries. To do this, all product-country combinations subject to AD duties are removed from the sample. AD treatment is then assigned to imports of targeted products from the remaining non-targeted non-EU countries.[55] Imports of targeted products from EU countries receive a zero treatment. The treatment effect is hence identified by using variation in imports from non-targeted non-EU countries (where spillovers due to anticipation of further AD cases may be expected) relative to imports from non-targeted EU countries (which will never be subject to EU AD duties).

The results are reported in Columns (3) and (4) of Table 1.4. The estimated coefficient for the effect of AD duties on import prices from non-targeted countries is indeed positive and statistically significant, indicating that prices of imports from non-targeted countries do increase following the imposition of AD duties against other countries. The magnitude of the price change is roughly half the effect for treated countries (Column (1) of Table 1.2), indicating significant spillover effects. Quantity effects (Column 4) are insignificant. These results provide evidence that exporting countries react to AD duties imposed against different exporters. AD duties thus seem to have a signalling effect, as they induce non-targeted exporters to raise prices. At the same time, the insignificant quantity coefficient in Column (4) indicates that the baseline results are not driven by import diversion away from non-EU countries towards EU countries following the enlargement as this should result in a significantly positive coefficient in Column (4).

1.6.4 Further Robustness Checks

In the baseline analysis, zero trade flows are omitted as they are not reported in the trade statistic. If a country-product combination is only observed in one year, it is dropped in order to balance the panel as pre- and post-treatment observations are needed to estimate a treatment effect. However, these non observed zero trade flows potentially contain information, because AD duties are expected to reduce imports. If duties are prohibitively high, eliminating trade flows entirely, the observation drops out of the sample, leading to an underestimation of the

[55] The removal of targeted product-country combinations is necessary due to collinearity within products across countries which would mean that coefficients would be the same as in the baseline, only with opposite sign.

treatment effect. Rather than balancing the panel by dropping country-product combinations that are only observed once, the sample is expanded by filling up the missing years with zero trade flows. Since the natural logarithm of zero is not defined and OLS yields unreliable results when zero trade flows are included (Santos Silva and Tenreyro, 2006), quantity effects are estimated using poisson-pseudo-maximum-likelihood (PPML).[56] The results are reported in Column (5) of Table 1.4. The estimated coefficient of -1.44 is almost identical to the baseline ppml regression excluding zero trade flows (Column 7 of Table 1.6 further down) and very similar to the baseline OLS result (Column 3 of Table 1.2). Within the fixed effects setup, adding zero trade flows hence does not significantly alter the results.

Since China is not only the largest non-market economy, but also the major target of EU AD duties, it is possible that estimated coefficients of the effect of AD duties against NMES countries are driven by China. Another robustness test hence excludes imports from China and re-estimates AD effects for MES and NMES countries. The results, presented in Columns (6) and (7) of Table 1.4 are very similar to the baseline results in Table 1.2. Coefficients are thus not driven by China, which provides further evidence that non-market economy status drives the results, not any unobserved China characteristics.[57]

In Section 1.2 it has been argued that existing studies may suffer from endogeneity bias, resulting in underestimation of the treatment effect. Indeed, baseline estimates provided in Table 1.2 are at the high end of estimates in the literature. However, it is also possible that this paper overestimates the treatment effect. One channel that constitutes a threat to identification of the treatment effect and may cause overestimation is the potential of AD duties to cause a reversal of trade deflection. This would be the case if the imposition of AD duties by EU15 countries before 2004 has lead to increased imports of targeted products into the new member states. The imposition of AD duties in new member states following accession to the EU in 2004 could thus have two effects, firstly the standard trade destruction effect and secondly the reversal of previous trade deflection.

The potential for the reversal of trade deflection can be estimated by testing whether trade deflection has taken place before 2004. Figure 1.4 has already shown that treated products

[56] Since PPML does not permit negative dependent variables, a fixed effects estimation is employed instead of a first differences estimation.

[57] As discussed in Section 1.3, only Belarus and China are subject to EU AD duties in the investigation period. Hence excluding China leaves Belarus as the only other NMES country subject to AD duties in the sample period. Excluding Belarus instead of China from the sample yields estimated coefficients that are also very close to the baseline (not reported). This constitutes further evidence that results are driven by the two countries' NMES.

did not react differently to untreated products before 2004. As an additional robustness check, import quantities and prices of EU accession states are regressed on AD duties imposed by the EU in the pre-accession period 2000 to 2003.[58] The treatment dummy AD_t switches from zero to one in the year in which final AD duties are imposed and remains equal to one until the end of the sample period. AD cases revoked between 2000 and 2003 are excluded from the sample.

Table 1.5: Trade Deflection and post Accession Effects

	(1)	(2)	(3)	(4)
Importer	EU Accession	EU Accession	EU 25	EU 25
Sample	pre 2004	pre 2004	post 2004	post 2004
Dep. var.	$\ln price$	$\ln quantity$	$\ln price$	$\ln quantity$
AD_t	0.0489	-0.2213*		
	(0.0448)	(0.1327)		
AD_t^{EU15}			0.0659**	-0.8647***
			(0.0257)	(0.0910)
$AD_t^{Accession}$			0.0611*	-0.5956***
			(0.0354)	(0.1041)
Obs.	931,883	931,883	2,467,857	2,467,857
R^2	0.8976	0.8897	0.8890	0.9072
Clusters	239248	239248	436888	436888

Note: OLS regression (fixed effects). Regressor: AD Dummy (time variant). Regressions (1) and (2) include exporter-product, exporter-year and product-year fixed effects. Regressions (3) and (4) include exporter-importer-product, exporter-importer-year and importer-product-year fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Sample period pre 2004: Import data 1999 - 2003, AD Duties imposed 2000 - 2003, Sample period post 2004: Import data 2005 - 2009, AD Duties imposed 2006 - 2009

The results of the fixed effects estimation are reported in Columns (1) and (2) of Table 1.5. The coefficient of the time varying AD dummy in Column (1) is insignificant, indicating no effect of EU15 duties on import prices of new member states in the period before the accession. The estimated coefficient for quantity effects is negative and statistically significant at the 10% level (Column 2). Both coefficients provide evidence for the absence of trade deflection of EU imports towards the new member states. They also indicate that there were no anticipation

[58] With trade data from 1999 to 2003, only AD duties imposed from 2000 onwards are considered to ensure the existence of a pre-treatment period for each targeted product.

effects for AD duties imposed in the years before the accession. If exporters had increased prices before the accession to avoid the implementation of AD duties by EU accession states after 2004, one would observe positive price effects. Similarly, if exporters increased exports to new member states before 2004 to sell as many products as possible before the imposition of duties, this would have resulted in a positive coefficient in Column (2). Even though the data does not allow to make a statement on duties implemented before 2000, it does permit the conclusion that EU AD duties imposed between 2000 and 2003 did not cause trade deflection to new member states.

The significantly negative coefficient in Column (2) constitutes an interesting result. It is negative but much smaller in magnitude than the coefficient of -1.3518 in the baseline regression (Column (3) of Table 1.2). It hence should not be interpreted as evidence that the new member states already adopted the EU AD policy before their accession in 2004. If this was the case, the coefficient would be larger in magnitude. In addition, this would have resulted in significant coefficients for the pre-treatment years in Figure 1.4. In fact, the finding is in line with Bown and Crowley (2010), who also find weak evidence for trade chilling effects of exports of targeted countries to third countries. The authors interpret this finding as a political chilling effect. Regarding the European Market, an alternative explanation would be that EU15 countries constitute the primary market for some exporters. When EU15 AD duties drive them out of this market, they cease production and also stop exporting to other countries, including the new member states. The small negative effect could constitute such a spillover effect.

Felbermayr and Sandkamp (2018) show that the effect of AD duties may vary by imposing country. This raises the question of external validity, more precisely whether the results can be transferred to EU15 countries or whether they are specific to EU accession states. To test if the new member countries react differently to the imposition of AD duties than EU15 states, both EU15 and EU accession states' import quantities and prices are regressed on AD duties (nested by EU15 and EU accession states) imposed after the EU enlargement in 2004. The sample period consists of the years 2005 - 2009.[59]

The results are reported in Columns (3) and (4) of Table 1.5. Comparing price effects (Column 3) and quantity effects (Columns 4) for EU15 and EU accession state importers reveals coefficients of very similar size, indicating no systematic difference between the two entities. The price coefficients (column 3) are not statistically significantly different from each other. Both are

[59] Only AD duties imposed from 2006 - 2009 are considered to have a pre-treatment period.

positive and significantly different from zero, while quantity effects in Column (4) are negative and significant. The results are thus in line with the baseline regression, although smaller in magnitude. This provides further evidence for endogeneity leading to underestimation of the treatment effect when not relying on the natural experiment.[60]

Column (1) of Table 1.5 has shown that AD duties imposed by EU15 countries did not affect import prices in EU accession countries before 2004, although import quantities fell slightly (Column 2). These regressions however rely on a different estimation strategy, as each AD case is implemented at a different point in time and thus has its own pre- and post-treatment period. Another robustness test instead replicates the experiment for different samples. First of all, the baseline experiment is carried out for EU15 countries, with the years 2003 and 2005 as pre- and post treatment period respectively.

Table 1.6: The Effect of AD Duties on Imports, Placebo Tests and PPML Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	2004 EU15	2004 EU15	2002	2002	2004	2004	2004	2004
Method	OLS	OLS	OLS	OLS	PPML	PPML	PPML	PPML
Dep. var.	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln price$	$\Delta \ln quantity$	$price$	$price$	$quantity$	$quantity$
AD	0.0082	-0.2810	0.0608	-0.1013	0.7668*		-1.4427***	
	(0.0572)	(0.1854)	(0.0590)	(0.1520)	(0.4105)		(0.3276)	
AD*MES						0.8301*		-1.5243***
						(0.4261)		(0.2939)
AD*NMES						-0.2786		-1.8040***
						(0.3109)		(0.3311)
Observations	267,578	267,578	151,943	151,943	289,996	290,026	289,996	289,996
R^2	0.9384	0.9382	0.9329	0.9266				

Note: OLS regressions (first differences) with country and product fixed effects. PPML regressions with country-product, country-time and product-time fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

The results are summarised in Columns (1) and (2) of Table 1.6. Both price and quantity coefficients are not significantly different from zero. This shows that EU15 import prices and quantities of products targeted by AD in 2003 and 2005 did not change between the two periods. In addition, it demonstrates the absence of variation over time in any unobserved exporting

[60] Even though the sample is similar to the one used for the natural experiment, it is by no means identical, so that results do not constitute sufficient evidence to say without doubt that estimates obtained without the use of the experiment are biased towards zero. Making such a statement would require a comparison of the two methods using the same sample, which is not feasible.

country-product specific variables that correlate with imports and AD duties and may cause omitted variable bias. Similarly the experiment is carried out for accession states, but with an assumed accession year of 2002, using 2001 and 2003 as pre- and post-treatment periods respectively. Results are provided in Columns (3) and (4). As expected, both coefficients are not significantly different from zero.

To show that results are not driven by the the regression method used, the baseline regressions are also carried out using the poisson-pseudo-maximum-likelihood (PPML) estimator. Results are provided in Columns (5) to (8) of Table 1.6. Price effects lose some significance but increase in magnitude by a factor of 3.5. Results continue to be driven by MES countries. Quantity effects remain stable in magnitude and significance.

The sample used in the baseline regression does not include AD cases that were revoked before 2006 to make sure only cases actually in force in 2005 are included in the post-treatment period. When including cases that were revoked in 2004 and 2005 (results reported in Columns (1) - (6) of Table A.4 in the Appendix) estimated coefficients remain significant but become smaller in magnitude. This is not surprising as wrongly assigning treatment to products that are not treated (anymore), leads to an underestimation of the treatment effect.

Since all ten EU accession countries are subject to the same treatment, import values and quantities are aggregated to one single importing entity. As an additional robustness check, the baseline regression is rerun on a sample with ten individual importing countries. The estimation is adjusted by expanding the fixed effects by the importer dimension.[61] This also ensures that bilateral exchange rate fluctuations are controlled for. The results are reported in Columns (7) and (8) of Table A.4 in the Appendix. Coefficients are similar in magnitude and significance to those of the baseline estimation shown in Table 1.2.

1.7 Conclusion

This paper exploits the EU enlargement of 2004 as a natural experiment to estimate treatment effects of AD duties on import prices and quantities. Following their accession to the European Union, the new member states inherited the EU's AD duties. Under the plausible assumptions that the accession countries did not join the EU because of its AD policy and that the EU did

[61] The regression hence includes exporter-importer and importer-product fixed effects. Standard errors are clustered by exporter-importer-product.

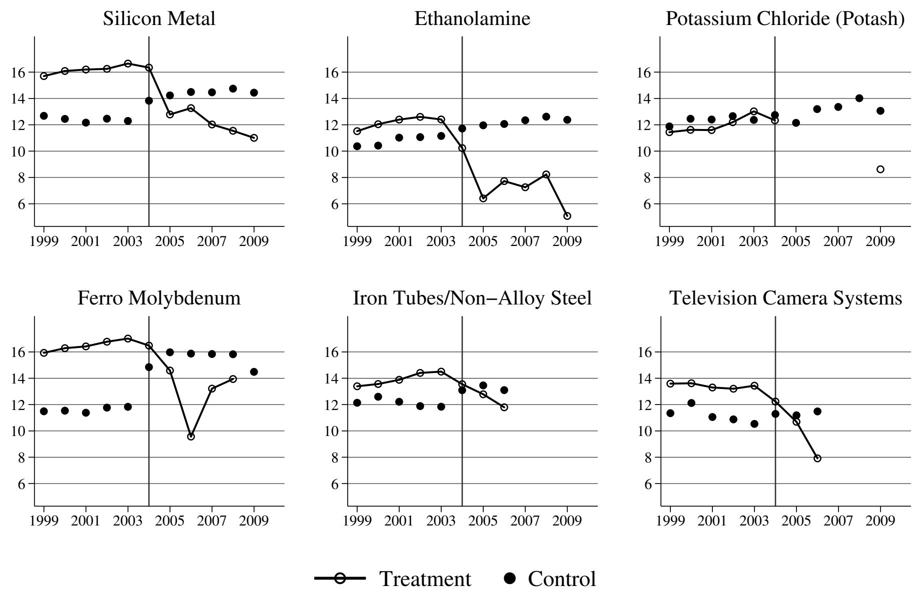
not act on behalf of the new member states before their entry, this implementation can be seen as exogenous. The resulting estimation consequently does not suffer from endogeneity bias due to simultaneity (larger import values increasing the likelihood and size of AD duties) that has not sufficiently been addressed in the existing AD literature. Omitted variable bias by means of unobserved changes in preferences or subsidies is also addressed. The paper's main contribution to the literature consists of the estimation of price effects over time and the demonstration that these (together with quantity effects) differ depending on the AD methodology applied.

The paper provides evidence that AD duties do increase producer prices and reduce import quantities. These effects are larger than suggested by previous studies that estimate treatment effects by relying on their direct implementation. With regard to the recent change in European AD legislation, this paper shows that price effects of AD duties are only present when implemented against countries with market economy status, suggesting that the methodology used does play a role in achieving the set policy objective of "fair" prices. This result aligns seemingly contradicting findings of previous studies by showing that differing estimates of price effects are driven by market economy status of the exporter investigated in the respective sample. Imports from non-market economies fall by more following the imposition of AD duties, which can be explained by the larger average AD duties they receive. The paper also finds evidence for spillover effects, as import prices of products from non-targeted countries also increase. This has strategic implications for the use of AD policy, as the imposition of AD duties against one country may affect prices of imports from other countries, too.

Effects are not driven by a reversal of trade deflection and do not seem to be specific to EU accession states, as their imports react similar to those of EU15 countries when using alternative estimation strategies. Finally, evidence is presented that trade dampening effects of AD duties tend to persist over several years and even beyond their revokement, indicating that exporters find it hard to re-enter a market once AD duties are lifted.

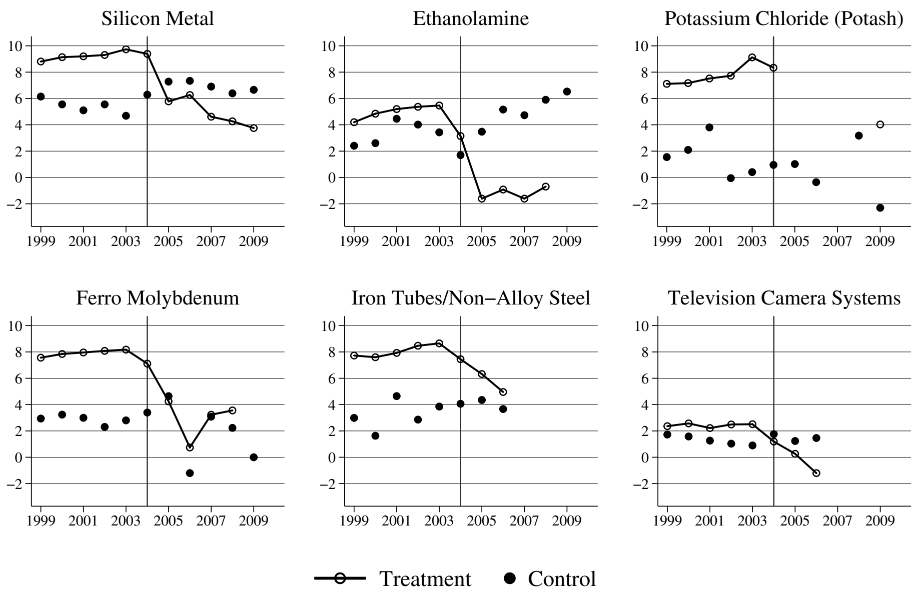
Appendix A.1 Additional Figures

Figure A.1: Average Import Values by Treatment Status



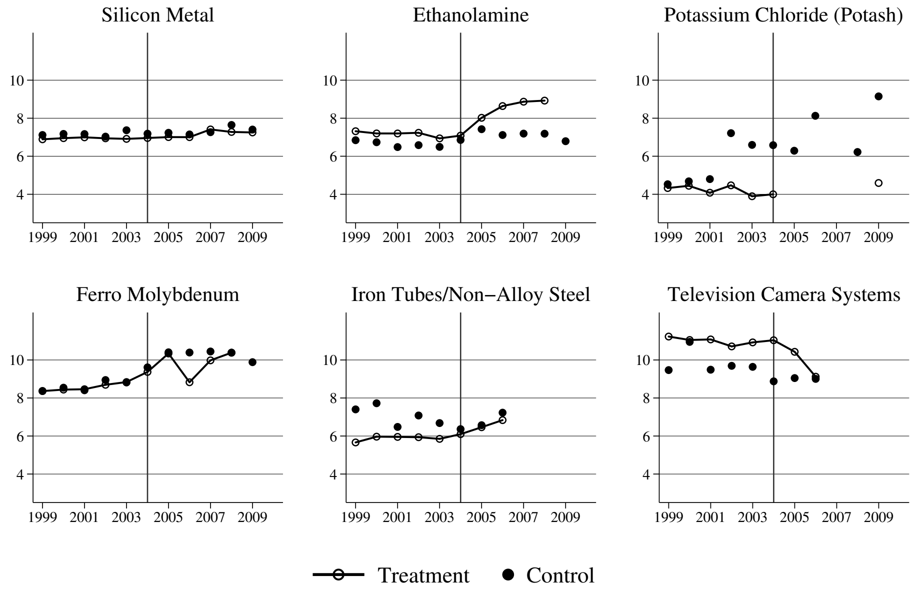
Note: EU accession (beginning of treatment) in May 2004. Ln import value on vertical axis, year on horizontal axis. Missing observations represent non-reported values and can be interpreted as zero trade flows.

Figure A.2: Average Import Quantities by Treatment Status, excluding EU Exporters



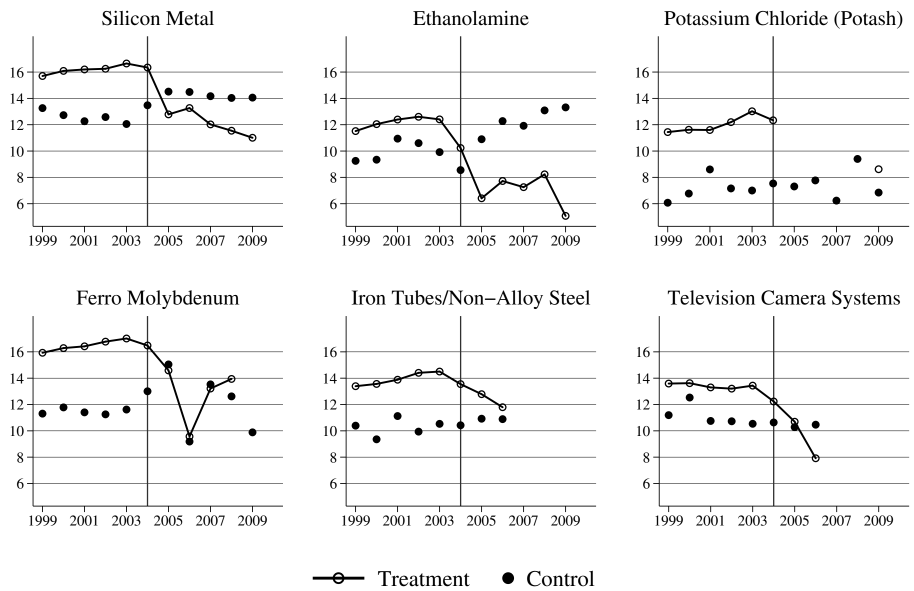
Note: EU accession (beginning of treatment) in May 2004. Ln import quantity on vertical axis, year on horizontal axis. Missing observations represent non-reported quantities and can be interpreted as zero trade flows.

Figure A.3: Average Import Prices by Treatment Status, excluding EU Exporters



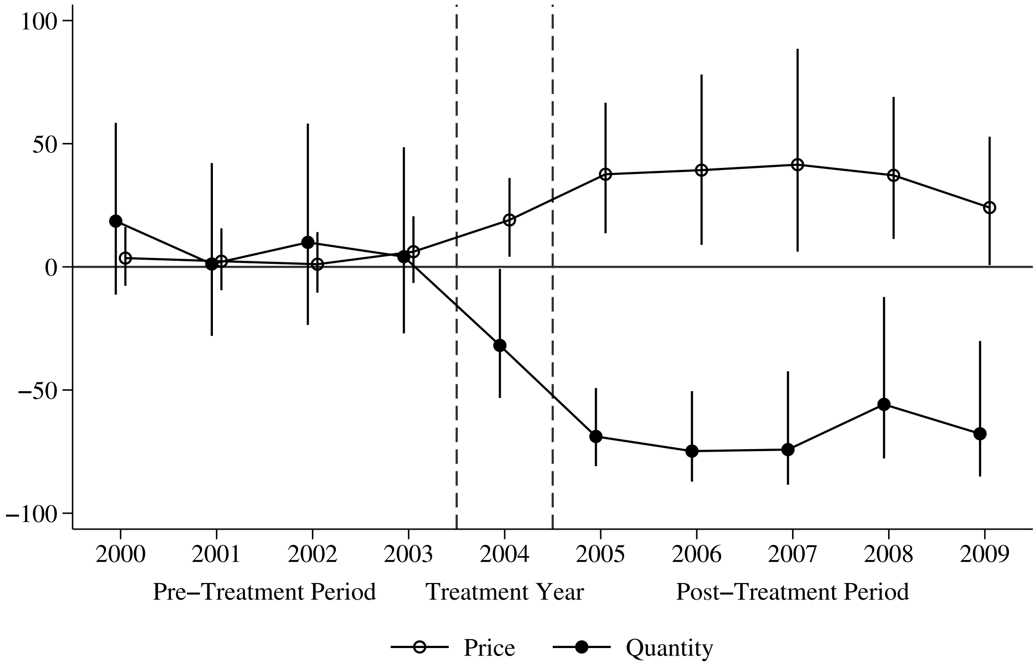
Note: EU accession (beginning of treatment) in May 2004. Ln import price on vertical axis, year on horizontal axis. Missing observations represent non-reported prices and can be interpreted as zero trade flows.

Figure A.4: Average Import Values by Treatment Status, excluding EU Exporters



Note: EU accession (beginning of treatment) in May 2004. Ln import value on vertical axis, year on horizontal axis. Missing observations represent non-reported values and can be interpreted as zero trade flows.

Figure A.5: Effect of AD Duties on Import Prices and Quantities, 2000 - 2009



Note: EU accession (beginning of treatment) in May 2004. Percentage change in import prices and quantities of treated products on vertical axis, year on horizontal axis. The plot shows point estimates with 95% confidence intervals, indicating large and significant price and quantity effects of AD duties since their introduction in 2004.

Appendix A.2 Additional Regressions

Table A.1: The Effect of AD Duties on Import Prices and Quantities, varying Fixed Effects

	(1)	(2)	(3)	(4)
Dep. var.	$\Delta \ln price$	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln quantity$
AD	0.2130**	0.2598***	-1.3071***	-1.1357***
	(0.0887)	(0.0860)	(0.2084)	(0.2107)
R^2	0.0000	0.0312	0.0003	0.0428
Exporter FEs	NO	YES	NO	YES
Product FEs	NO	NO	NO	NO

Note: OLS regression with first differences. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. 144,998 observations.

Table A.2: The Effect of AD Duties on Import Prices and Quantities over Time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	1999 - 2007	1999 - 2007	1999 - 2007	1999 - 2007	1999 - 2008	1999 - 2008	1999 - 2009	1999 - 2009
AD Cases	baseline	baseline	if 2007	if 2007	baseline	baseline	baseline	baseline
Dep. var.	$\ln price$	$\ln quantity$	$\ln price$	$\ln quantity$	$\ln price$	$\ln quantity$	$\ln price$	$\ln quantity$
2000					0.0346	0.1714	0.0351	0.1705
					(0.0586)	(0.1475)	(0.0587)	(0.1480)
2001	-0.0001	-0.0631	0.0669	-0.0991	0.0226	0.0098	0.0228	0.0116
	(0.0567)	(0.1461)	(0.0811)	(0.1990)	(0.0626)	(0.1737)	(0.0625)	(0.1736)
2002	-0.0088	0.0303	-0.0237	0.0898	0.0127	0.0953	0.0108	0.0948
	(0.0563)	(0.1533)	(0.0782)	(0.2146)	(0.0620)	(0.1847)	(0.0619)	(0.1855)
2003	0.0492	-0.0322	-0.0583	0.1285	0.0630	0.0425	0.0598	0.0406
	(0.0574)	(0.1584)	(0.0743)	(0.2132)	(0.0646)	(0.1805)	(0.0649)	(0.1813)
2004	0.1545**	-0.4459***	0.0585	-0.2762	0.1731**	-0.3729*	0.1743**	-0.3838**
	(0.0655)	(0.1725)	(0.0825)	(0.2308)	(0.0683)	(0.1907)	(0.0683)	(0.1917)
2005	0.3035***	-1.2927***	0.3147**	-1.3430***	0.3240***	-1.1848***	0.3192***	-1.1665***
	(0.0955)	(0.2379)	(0.1232)	(0.3055)	(0.0976)	(0.2496)	(0.0977)	(0.2497)
2006	0.3224***	-1.4998***	0.3435**	-1.7155***	0.3344***	-1.3881***	0.3313***	-1.3779***
	(0.1229)	(0.3326)	(0.1735)	(0.4732)	(0.1253)	(0.3459)	(0.1254)	(0.3450)
2007	0.3367**	-1.5096***	0.4105**	-2.0314***	0.3531**	-1.3744***	0.3471**	-1.3535***
	(0.1441)	(0.4007)	(0.2010)	(0.6034)	(0.1464)	(0.4116)	(0.1465)	(0.4094)
2008					0.3187***	-0.8147**	0.3161***	-0.8170**
					(0.1077)	(0.3562)	(0.1065)	(0.3503)
2009							0.2157**	-1.1313***
							(0.1064)	(0.3945)
Obs.	1,716,485	1,716,485	1,716,485	1,716,485	1,930,787	1,930,787	2,127,801	2,127,801
R^2	0.8537	0.8471	0.8537	0.8471	0.8498	0.8435	0.8456	0.8388
Clusters	313891	313891	313891	313891	340108	340108	352556	352556

Note: OLS regressions including exporter-product, exporter-year and product-year fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table A.3: Lagged Effect of revoked AD Cases

	(1)	(2)	(3)	(4)	(5)
Dep. var.	$\ln price$	$\ln quantity$	$\ln price$	$\ln quantity$	$\ln value$
AD_t	0.0261	-0.4073			
	(0.1777)	(0.2990)			
revoked_0			0.0355	0.1138	-0.0809
			(0.1926)	(0.2528)	(0.3125)
revoked_1			-0.0414	0.6594	0.6204**
			(0.2578)	(0.4109)	(0.2999)
revoked_2			-0.0732	0.6729	0.6020
			(0.1778)	(0.4759)	(0.4421)
revoked_3			-0.4085*	0.3889	-0.0555
			(0.2099)	(0.5118)	(0.4187)
Observations	904,290	904,290	904,290	904,290	1,121,074
R^2	0.8781	0.8910	0.8781	0.8910	0.8734
Clusters	239477	239477	239477	239477	292665

Note: OLS regression (fixed effects). Regressor: AD Dummy (time variant, Columns 1 and 2) and revokement. All regressions include exporter-product, exporter-year and product-year fixed effects. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Import data 2005 - 2009, revoked cases 2006 - 2009

Table A.4: The Effect of AD Duties on Imports, further Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	including rev cases	including rev cases	including rev cases	including rev cases	including rev cases	including rev cases	individual countries	individual countries
Dep. var.	$\Delta \ln price$	$\Delta \ln price$	$\Delta \ln quantity$	$\Delta \ln quantity$	$\Delta \ln value$	$\Delta \ln value$	$\Delta \ln price$	$\Delta \ln quantity$
AD	0.1563**		-0.9112***		-0.7549***		0.1680***	-0.9261***
	(0.0639)		(0.1707)		(0.1600)		(0.0620)	(0.1570)
AD*MES		0.1496**		-0.7232***		-0.5735***		
		(0.0709)		(0.1904)		(0.1748)		
AD*NMES		0.1852		-1.7249***		-1.5398***		
		(0.1406)		(0.3192)		(0.3287)		
Obs.	144,998	144,998	144,998	144,998	144,998	144,998	337,822	337,822
R^2	0.9099	0.9099	0.9016	0.9016	0.8922	0.8922	0.9154	0.8946

Note: OLS regression with first differences. Robust standard errors clustered by Exporter-Product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Columns (1) to (6) include cases revoked in 2004 and 2005 and country and product fixed effects. Columns (7) and (8) include importer-product and exporter-importer fixed effects, with standard errors clustered by exporter-importer-product in parenthesis.

2 The Trade Effects of Anti-Dumping Duties: Firm-level Evidence from China*

2.1 Introduction

Trade protection is on the rise again and anti-dumping (AD) duties remain a common instrument in this respect, especially against China. With an average of 60 initiations per year between 2000 and 2014, the country has been the target of a quarter of global AD investigations. Given a rule change with respect to China's treatment in AD investigations in 2017, EU policy makers are demanding to move closer to the US system, which is characterized by significantly higher AD duties compared to the EU - a difference that we put into perspective. Against the background of this reawakened interest in trade protection in general and AD in particular, it is all the more important to obtain unbiased estimates of the effect of AD duties on exports.

This paper uses Chinese customs data to investigate the effects of AD duties on exporters, exploiting differences in duties across different firms exporting the same product with the hope to minimize endogeneity concerns which have afflicted previous work. As a first step, we use simple theory to derive a firm-level gravity equation. This framework imposes some structure which helps uncovering potential sources of endogeneity and motivates the empirical strategy. We argue and demonstrate empirically that existing firm-level estimations which fail to include the appropriate fixed effects are indeed subject to omitted variable bias.

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Focusing on the EU and the US, we find that the effect of AD duties differs strongly between the two. Although trade elasticities cannot be distinguished at conventional levels of statistical significance at the firm-level, extensive margin effects do differ. Overall, the estimated average trade effect of US anti-dumping policies on Chinese exporters is stronger than that of EU policy. Another contribution of the paper is a sectoral comparison of the effects of AD duties. In line with theory, we find that the effect of AD duties differs strongly across sectors, suggesting that average treatment effects hide significant heterogeneity.

Trade dampening effects are stronger for smaller firms, implying a shift in exports from small to large exporters. These reallocation effects may well reduce the protective effects that AD-duties have on firms in the importing countries. Finally, this paper is the first to look at trade deflection following AD at the firm-level. We find that Chinese firms increasingly enter new markets following AD investigations in the EU and the US. In addition, we find evidence for falling average export prices to third countries following US duties, accompanied by an increase in average export quantity.

The causes and consequences of dumping have interested economists for quite some time.[1] Indeed, the effects of AD duties on exporters are the subject of an extensive body of research.[2] Blonigen and Park (2004) have constructed a dynamic pricing model in which the development of export prices and AD duties depends on the exporter's ex ante expectations of AD enforcement. The authors set out conditions under which exporters pass duties on to consumers in excess of 100% so as to reduce duty levels in subsequent periods.[3] Their empirical findings support the model's prediction. A static model constructed by Blonigen and Haynes (1999) predicting pass through rates of up to 200% is confirmed empirically by the same authors, who find AD pass-through rates of 160% (Blonigen and Haynes, 2002).

These findings are in contrast to those of Lu et al. (2013), who empirically examine the effects of US AD duties on Chinese exports and who find no significant effects on producer prices, indicating 100% pass-through. While the authors do not seek to explain this seeming contradiction with the literature, our paper sheds some light on the issue by accounting for China's status as a NME. In addition, the authors do not look at composition effects. While surviving firms may increase or decrease prices, Melitz (2003) suggests exit of firms with high marginal

1 See for example Ethier (1982); Brander and Krugman (1983); Dixit (1988); Gruenspecht (1988); Staiger and Wolak (1992); Clarida (1993); Blonigen and Wilson (2010)
2 Overviews of the AD literature are provided by Blonigen and Prusa (2003a, 2016) and Nelson (2006).
3 The associated welfare loss is examined by Gallaway et al. (1999) and Blonigen and Prusa (2003b).

costs, which would push average prices down. In order to help disentangling these channels, we look at the within firm price variation as well as the change in average prices.

Indirect evidence for the effect of duties on export prices is given by Gourlay and Reynolds (2012), who find that US duties paid by Chinese exporters decreased on average by 28.1% following the First Administrative Review. This indicates that Chinese exporters do increase their prices following the imposition of duties. In contrast, Nita and Zanardi (2013) find a small increase in average EU duties paid by Chinese exporters following the First Interim Review, indicating further dumping.

Regarding the effect of AD duties on export volumes, Staiger and Wolak (1994) find that the initiation of an AD investigation in the United States significantly lowers imports. Prusa (1997, 2001) finds that US AD duties reduce exports to the United States by up to 50% (50% - 70% for named countries), while Egger and Nelson (2011) only find small negative effects. Carter and Gunning-Trant (2010) find strong negative effects of AD duties on trade volume in the agricultural sector. Looking at the European Union, Messerlin (1989) finds that AD measures reduce imported quantities by 40%. Effects of comparable magnitude are estimated by Lasagni (2000) as well as by Konings et al. (2001). Baran (2015) finds strong and long lasting negative impacts of final EU AD duties on imports, while withdrawn and rejected cases affect imports only for the duration of provisional measures. Extending the sample of AD imposing countries to so called “new adopters”, Vandenbussche and Zanardi (2010) find trade chilling effects of AD duties on bilateral trade flows. While most studies have focused on either EU or US AD duties, we contribute by examining effects of EU and US AD duties simultaneously, thus permitting a comparison of their effectiveness in reducing import volumes and inducing price adjustments. Beyond that, our data structure allows us to use country-time fixed effects to account for changes in multilateral resistance terms (Baier and Bergstrand, 2007).

For China, Lu et al. (2013) show that while the initiation of an AD case does not have any effect, a one percentage point increase in preliminary (final) US AD duties reduces Chinese exports to the United States by 0.27% (0.6%). These results are driven by the intensive as well as by the extensive margin.[4] However, the authors’ estimates of intensive margin effects may be subject to several biases. We base our estimation on a firm-level gravity equation, exploring an additional identification channel in order to obtain unbiased estimates. Lu et al. (2013) argue that duties cause less productive firms to exit the market, leaving only the productive

[4] Besedeš and Prusa (2013) also find US AD to induce firm exit.

ones behind. In support of that, Jabbour et al. (2016) find that Chinese exporters reduce their exports to the EU following the imposition of EU AD duties. However, they do grow larger and more productive. Our results indicate that exit could also be caused be different duties applied to different firms. Chandra and Long (2013) find evidence that AD duties reduce exporter productivity.

All of these studies look at aggregate effects of duties on prices and export volumes, ignoring potential heterogeneity across individual sectors. In fact, Feenstra (1989) finds very different pass-through rates of tariffs and exchange rates for Japanese cars, trucks and motorcycles in the United States, ranging from 0.6 to unity. The author credits this variation to differences in demand, cost structures, institutions and the degree of competition across industries. For example, Feenstra observed incomplete pass through for trucks as increased competition meant exporters had to reduce f.o.b. prices in order not to lose market share. In contrast, motor cycles exhibited complete pass through as prices were already close to marginal cost, leaving no room to manoeuvre.

If such differences can occur within an individual (transport) industry, it is not unreasonable to expect similar heterogeneity across industries when it comes to AD duties.[5] Vandenbussche and Zanardi (2010) take a first step in this direction in their estimation of the effect of AD duties on exports by successively excluding iron and steel, chemicals, textiles and agricultural goods from their estimation. We extend this research strand by simultaneously estimating AD effects for individual sectors.

Regarding third-country effects of AD policy, Bown and Crowley (2007) find that the imposition of US AD duties on Japanese exports increases the country's exports of affected products to third countries by 5 - 7% (trade deflection). Looking at the Vietnamese footwear industry, Nguyen et al. (2016) find that EU duties on these goods increase Vietnamese exports to the US. Similarly, Baylis and Perloff (2010) find that Mexican exports of tomatoes to Canada increased significantly following the imposition of US AD duties on tomatoes against Mexico.

Evidence is mixed when it comes to China. While Chandra (2016) also finds evidence for trade deflection, Lu et al. (2013) find no such effects. One reason for this difference in findings

[5] Other reasons for variation across industries can be political (larger industries have greater bargaining power when it comes to pushing through AD protection (Baldwin, 1985)), behavioural (firms and industries learn how to best pursue AD (Morck et al., 2001; Blonigen, 2006)), or sectoral interdependence (AD action in one product raises costs for downstream firms so that these also ask for AD protection (Hoekman and Leidy, 1992; Feinberg and Kaplan, 1993)).

could be that Chandra (2016) uses annual data, whereas Lu et al. (2013) use monthly data, so that results might reflect differences in short- and long-run responses. Bown and Crowley (2010) look at the effect of more general EU and US import restrictions against China and find no systematic evidence of increased exports to third countries. In contrast, they find some evidence for reduced exports to third countries. We expand the literature by also studying trade deflection at the firm-level, examining the effect of AD duties on both the number of exporters as well as firm sales to third countries. We also look at export prices to third countries.

The remainder of this paper is structured as follows. After briefly describing the AD mechanisms, Section 2.2 presents the model on which we base our estimation. This is followed by a discussion of our estimation strategy and the data used (Section 2.3). Section 2.4 contains our empirical results, followed by robustness checks in Section 2.5. Section 2.6 concludes.

2.2 Conceptual Framework

2.2.1 Some Remarks on the Institutional Setup

The WTO defines "dumping" as selling a product at a price below its normal value (GATT, 1947; WTO, 1994). For exporters from countries with market economy status (MES),[6] this means that the importer is permitted to impose AD duties whenever export prices (net of transport costs) in the importing country are below the exporting country's domestic market prices or, if price data are not available, production costs (European Union, 2009; United States Government Accountability Office, 2006).[7] Traditionally, AD duties are associated with higher prices, and thus lower export volumes, because firms have an incentive to increase prices in an effort to reduce the gap between export and domestic prices and thus reduce AD duties following reviews in consecutive periods (Feenstra, 2008). This means that the consumer price increases by more than the duty, implying a pass-through rate greater than 100%.

For countries with non-market economy status (NMES), AD duties work more like tariffs. This is because the dumping margin is calculated as the difference of average export prices and production costs and prices in a third country with MES (European Union, 2009; United

[6] These are almost all WTO member states.

[7] Under this definition, a producer is found to dump if she sells a product at the same price at home and abroad, as the export price used to determine the dumping margin excludes transport costs. See Hindley (1988) or Detlof and Fridh (2006) for a more detailed discussion.

States Government Accountability Office, 2006; United States International Trade Commission, 2016).[8] As average export prices, rather than individual company prices are used, firms have no incentive to adjust prices to avoid the duty, unless they have significant market power or unless a few large exporters are able to collude and jointly raise prices to induce a reassessment of dumping margins.

China is a special case since, as of 2017, it is still classified as a NME by both the European Union and the United States.[9] However, the European Union grants individual Chinese exporters market economy treatment (MET) if they can prove that they are active in a market economy environment, in which case individual company export and production prices are used to calculate the dumping margin (Felbermayr et al., 2016). Alternatively, companies may also apply for individual treatment (IT) which means that individual rather than average export prices are used to calculate the dumping margin. If companies fail to qualify for one of these firm-specific treatments, they are subject to a product-wide duty that is the same for all firms exporting a particular product. Similarly, cooperating exporters to the United States may receive individual treatment. In the United States, MET can only be granted to an entire sector, something that has not yet happened. AD duties imposed against MET and IT firms are significantly below those imposed against NMES firms (see Figure 2.1 further down).

2.2.2 Deriving a Firm-level Gravity Equation

In order to guide our estimation strategy and to get a better understanding of potential endogeneity issues involved, we incorporate dumping into what probably is the simplest model of firm heterogeneity. We do not aim to make a theoretical contribution here. Dumping in the legal sense - i.e. exporting a good at a price below “normal value” - is easy to capture in a Melitz (2003) type model. We can then use this framework to identify the determinants of bilateral firm-level exports that need to be controlled for.

The representative consumer in country j gains utility from consuming varieties ω (product-firm combination hf) of different products h imported from country i (China) according to

[8] This is because it is assumed that domestic prices are distorted and thus do not reflect supply and demand, e.g. due to state subsidies. The European Union uses analogue (third-country) prices and costs to construct the normal value (reference price). The Unites States use surrogate (third-country) input prices but estimate production costs using (average) production functions of the exporter. A comparison of different countries’ methodologies is provided by Detlof and Fridh (2006).

[9] The EU abandoned NMES for WTO members in December 2017 (European Parliament, 2017).

the utility function $U_j = \prod_{h=1}^{H} \left(\int_{\Omega_{hj}} q(\omega)^{\frac{\sigma_{hj}-1}{\sigma_{hj}}} d\omega \right)^{\frac{\sigma_{hj}}{\sigma_{hj}-1}\mu_{hj}}$, with Cobb-Douglas preferences across products h such that $\sum_{h=1}^{H} \mu_{hj} = 1$ for each j.[10] The elasticity of substitution between varieties σ_{hj} is allowed to vary by destination country j and product h.

This implies the following firm-level demand equation:

$$q_{hfijt}(\varphi) = \mu_{hj} Y_{jt} \frac{(p_{hfijt}(1 + T_{hfijt}))^{-\sigma_{hj}}}{P_{hjt}^{1-\sigma_{hj}}}, \tag{2.1}$$

where Y_{jt} is the income of consumers in country j at time t, μ_{hj} is the share of Y_{jt} spent on good h, P_{hjt} is the product-specific price index in country j at time t and T_{hfijt} is the ad valorem AD duty imposed by country j on imports from China (i) of product h produced by firm f at time t. The producer price (excluding the AD duty) $p_{hfijt}(\varphi)$ charged by firm f for product h sold to destination country j at time t is

$$p_{hfijt}(\varphi) = \frac{\sigma_{hj}}{\sigma_{hj} - 1} \frac{c_{hfit}\tau_{hijt}}{\varphi_{hfit}}. \tag{2.2}$$

As usual, the price depends on the elasticity of substitution σ_{hj}, iceberg transport costs $\tau_{hijt} \geq 1$ and productivity φ_{hfit}.[11] We view unit production costs c_{hfit} as functions of wages, the cost of capital, the cost of materials, and potentially also of product or firm-specific subsidies. These components vary across different dimensions. Overall, this means that costs of production vary at the product-firm-time dimension. It follows that the export value $x_{hfijt}(\varphi) = p_{hfijt}(\varphi) q_{hfijt}(\varphi)$ is given by

$$\Rightarrow x_{hfijt}(\varphi) = \frac{\mu_{hj} Y_{jt}}{P_{hjt}^{1-\sigma_{hj}}} \left(\frac{\sigma_{hj}}{\sigma_{hj} - 1} \frac{c_{hfit}\tau_{hijt}}{\varphi_{hfit}} \right)^{1-\sigma_{hj}} (1 + T_{hfijt})^{-\sigma_{hj}}, \tag{2.3}$$

which can be log-linearized to yield a firm-level gravity equation:

$$\begin{aligned} \ln(x_{hfijt}(\varphi)) = & \ln(\mu_{hj}) + \ln(Y_{jt}) - \sigma_{hj} \ln(1 + T_{hfijt}) \\ & + (1 - \sigma_{hj}) \left(\ln\left(\frac{\sigma_{hj}}{\sigma_{hj} - 1} \right) + \ln(c_{hfit}) + \ln(\tau_{hijt}) - \ln(\varphi_{ihft}) - \ln(P_{hjt}) \right). \end{aligned} \tag{2.4}$$

10 This set-up borrows from Chaney (2008) with the difference that we do not include a homogeneous good.

11 $\tau_{hiit} = 1$

In order for the model to constitute an appropriate framework for our empirical analysis, dumping needs to be both possible and profitable. In Section B.2.1 in the Appendix, we propose two types of dumping behaviour which can be replicated within the Melitz world: tougher competition in China's export market as reflected by a higher demand elasticity, and the presence of distortions that artificially lower production costs. Both configurations are very relevant in the case of China.

2.2.3 Strategic Price Setting

The above model allows us to make predictions regarding the effects of AD duties on Chinese exporters. From Equations (2.1), (2.2) and (2.3) it can be seen that following the imposition of AD duties, firm export quantity and export value fall, while producer prices remain unchanged. Profits go down, forcing the least profitable firms to exit the market once they are no longer able to recover fixed export costs.

The absence of endogenous markups and of reciprocal dumping may put in doubt the usefulness of the Melitz model for our purposes. However, the literature and our own work do not suggest that Chinese firms adjust their prices. Moreover, as discussed above, the NMES regime does not provide exporting firms with incentives to adjust prices strategically in order to lower duties. Even under the MET and IT regime, there are conditions under which firms do not adjust prices. First, Gourlay and Reynolds (2012) argue that for many firms, applying for an administrative review - or even for MET in the first place - is very costly. If these costs outweigh the increase in profits from adjusting prices and thus receiving a lower duty in the long run, it might be optimal for firms to just take duties as given. Second, asking for a reduction of duties requires exporters to raise producer prices. Since duties respond to such price increases with a lag of several years (duties are recalculated based on past prices), this implies a temporary increase in consumer prices by more than the level of the duty. Depending on the degree of competition in the industry, such price increases - even if only temporary - may not be feasible.

Another popular framework to think about dumping duties is the Melitz and Ottaviano (2008) model in which markups are endogenous and reciprocal dumping occurs. This framework does not give rise to a log-linear firm-level gravity equation and, thus, is not useful to guide our empirical strategy. Nonetheless, it offers an interesting way to rationalize the stability of producer prices in the face of anti-dumping policy. As sketched in Section B.2.2 in the Appendix, uncertainty regarding the AD regime may be key to explain why we (and the literature) do not find producer prices to react to AD duties.

In particular, the model is consistent with the following predictions. First, prices under AD will be higher than prices in the absence of AD. However, it will not be optimal for firms to raise prices to fully eliminate the duty. Second, under uncertainty, prices will be larger than in the absence of AD but lower than under certain AD. Hence, the firm raises prices even before becoming subject to AD.[12] Third, if fixed costs of applying for a review following the imposition of AD are prohibitively high, the firm may not raise prices at all. The increase in prices following the AD duty will thus be smaller than expected because firms will already have raised prices and because they will never raise prices sufficiently to fully eliminate the duty. If some firms don't adjust prices at all due to the associated fixed costs, it is not unreasonable to observe no significant change in average prices empirically.

2.3 Estimation Strategy, Identification and Data

2.3.1 Firm-level Gravity

Following the firm-level gravity equation (2.4), our baseline specification is

$$\ln Y_{jhft} = \sum_{c}^{N_c} \beta_c \ln(1 + Duty^c_{jhft}) + \nu_{jhf} + \nu_{jht} + \nu_{hft} + \epsilon_{jhft}, \quad (2.5)$$

with $c \in \{EU, US, other\}$, where $\ln Y_{jhft}$ is the natural logarithm of export value, price or quantity at the destination country-product-firm-time level, and $Duty^c_{hfjt}$ is the AD duty (value added). As we want to know whether the effects of AD duties vary by duty imposing countries, we nest AD duties by imposing countries.[13] ν_{jhf}, ν_{jht} and ν_{hft} are country-product-firm, country-product-time and product-firm-time fixed effects,[14] respectively and ϵ_{jhft} is an error term.

[12] Blonigen and Park (2004) argue that firms typically act under uncertainty as the imposition of AD duties also depends on factors exogenous to the exporter such as the industry structure and the strength of lobbies in the importing country. Sandkamp (2018) shows that export prices of non-targeted exporters increase following the imposition of AD duties against exporters in other countries. In the context of this model, this could constitute probability updating of firms' regarding AD duties.

[13] Nesting is chosen over the alternative of running separate regressions for each country and product group in order to allow for better comparability of estimated coefficients and enable testing for equality.

[14] To implement all three-dimensional fixed effects simultaneously, we use the STATA command "reghdfe" provided by Correia (2016).

The fixed effects are motivated by the firm-level gravity equation (2.4), which informs us about potential sources of omitted variable bias. In the model, AD duties imposed against China vary by product, firm, destination country and time. Hence all explanatory variables varying across the same dimensions should be examined closely. In particular, we can divide the variables on the right hand side of the equation into demand side and supply side variables. Demand side variables are μ_{hj}, Y_{jt} and P_{hjt}. It is reasonable to assume that these may vary with the AD duty T_{hfijt} as higher imports - which may or may not be caused by dumping - may increase the probability of an AD duty being implemented as well as its size. Bown and Crowley (2013) show that the likelihood of AD duties increases with the size of imports.

Not accounting for demand side effects may thus lead to an underestimation of the true treatment effect. To see this, consider a standard difference-in-differences approach as employed by Lu et al. (2013), in which the change in exports of the treatment group is compared to the change in exports of the control group. This methodology relies heavily on the common trends assumption. If products subject to AD are characterized by larger underlying growth rates than the control group, it is possible that export growth of these treated products is lower than it would be without the AD duty but still higher than that of the control group. The estimated treatment effect would be smaller than the true treatment effect.

Lu et al. (2013) approach this problem by using a synthetic control group. Instead of using the entire population of exports as the control group, the authors use only exports of HS6 products that are in the same HS4 product group as the treated goods subject to AD duties.[15] They thus examine how treated exports react to AD duties relative to similar products. While this should reduce the bias, we show further down that it is by no means eliminated.

Instead of using a synthetic control group, our data structure allows us to control for demand side variables directly using country-product-time fixed effects, which completely eliminates the bias. This is possible because of the different AD duties faced by MET (IT) and NMES exporters. It means that different firms exporting the same product to the same country receive different duties, allowing the exploitation of within product across firm variation to estimate the treatment effect. If all firms exporting the same product received the same duty, it would

[15] The authors also construct an artificial control group using matching. However, the estimated coefficients are very similar.

be impossible to control for time varying factors specific to country-product combinations.[16] Country-product-time fixed effects also take into account time-varying multilateral resistance terms (Feenstra, 2008) which is necessary since the sample includes several destination countries.

Beyond our fixed effects specification it is essential to control for firm-specific AD duties. Figure 2.1 below illustrates that MET (IT) duties are significantly lower than NMES duties. Incorrectly assigning the higher product wide duty to firms that in reality receive lower duties due to MET (IT) would lead to attenuation bias and thus an underestimation of the treatment effect. Given the non-negligible market share of these firms (Figure B.2 in the Appendix), distortions caused by not controlling for MET (IT) duties may be significant.

Regarding the supply side, costs c_{hfit} including potential product or even firm-specific subsidies and productivity φ_{ihft} can be controlled for using product-firm-time fixed effects. All other explanatory variables vary at a higher level of aggregation and are thus also controlled for. Given China's transition from cheap manufacturing goods to more advanced products, product-firm-time fixed effects also enable us to control for product-specific time trends.

A final source of bias needs to be discussed. In their firm-level estimation, Lu et al. (2013) only control for product and time fixed effects (the country dimension is redundant since they only use Chinese exports to the US). While this approach constitutes the desired difference-in-differences specification at the product-level, it does not represent a time invariant dummy identifying the treatment group at the firm-level. Instead, the product fixed effect captures several firms receiving differential treatment. The result is a biased estimator of the duty coefficient. This is because firms receiving product-specific treatment are subject to larger AD duties (Figures 2.1 and B.1 in the Appendix) and have, on average, lower export volumes than firms subject to individual firm-specific AD duties (Figure B.3 in the Appendix). The AD duty may thus simply identify firms that were smaller to begin with rather than a causal effect, resulting in an overestimation of the intensive margin effect of AD duties on firm exports. A proper difference-in-differences estimation hence also requires country-product-firm fixed effects. The estimated coefficient of the AD duty tells us how a given firm changes its exports of a particular product to a particular country, if this product becomes subject to AD duties.

[16] As we only have information on firm-specific duties for the EU and the US, we can only estimate treatment effects for these two economies. In other specifications we are less restrictive to allow treatment effects of AD duties imposed by other countries to be estimated.

Finally, Equation 2.4 also suggests that different products react differently to AD duties as σ_{hj} can be product-specific.[17] We therefore also nest AD duties by sector.[18] Here it is particularly important to control for country-specific product-time trends, as otherwise there is a risk that our treatment variables simply capture sector-specific trends. The corresponding estimation specification is

$$lnY_{jhft} = \sum_{c}^{N_c} \sum_{sector=1}^{N_{sector}} \beta_c \ln(1 + Duty_{jhft}^{c,sector}) + \nu_{jhf} + \nu_{jht} + \nu_{hft} + \epsilon_{jhft}, \qquad (2.6)$$

where $c \in \{EU, US, other\}$.

2.3.2 Data and stylised Facts

We use annual export data at the firm-product-destination-country (HS8 digit) level for the years 2000 – 2009, provided by the Chinese customs office. From this dataset we use exports to 193 countries, 22 of which impose AD duties against China.[19] Information on bilateral AD duties comes from the World Bank's Global Anti-Dumping Database (Bown, 2015), from which we extract information for 330 AD cases against China, including 51 US AD cases as well as 43 EU cases. These are only cases that received a final AD duty.[20] AD duties can be at the HS6, HS8 or HS10 (US only) digit level.

As products are comparable only at the HS6 digit level (Lu et al., 2013; Bown and Crowley, 2016), we match the two datasets at this level of aggregation. At this level of aggregation,

[17] Beyond the Melitz model, in the Melitz and Ottaviano (2008) framework, Bagwell and Lee (2015) show that individual exporter responses to tariffs depend on several parameters, including the distribution of marginal cost, transport cost, firm-specific marginal costs, degree of product differentiation between varieties and entry costs. As these parameters differ across industries (Cebeci and Fernandes, 2012; Bremus et al., 2013; Spearot, 2013), AD duty elasticities are very likely to vary across different industries within a country, as well as across firms and duty imposing countries.

[18] A list of sectors is provided in Table B.1 in the Appendix.

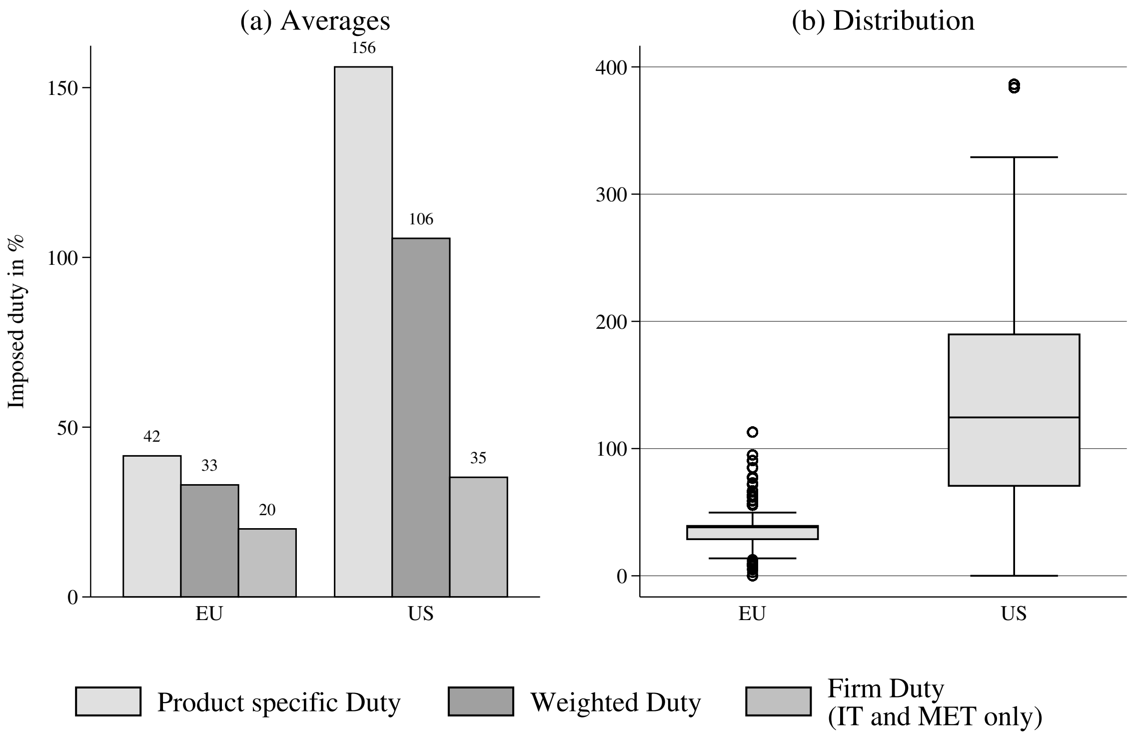
[19] These are Argentina, Australia, Brazil, Canada, Columbia, the EU, Indonesia, India, Israel, Jamaica, Japan, Korea, Mexico, New Zealand, Pakistan, Peru, Thailand, Trinidad and Tobago, Turkey, Taiwan, the US and South Africa.

[20] EU AD investigations against China may also result in the imposition of alternative trade barriers such as negotiated price undertakings (Bown and Crowley, 2016; Crowley and Song, 2015). The share of such cases in EU AD proceedings against all exporters has however decreased from 41% in 1981 - 2001 to 21% in 2002 - 2012 (Steinbach, 2014). Regarding imports from China, only 9% of investigations resulted in the impositions of price undertakings between 2002 and 2012. These are excluded from the sample.

there are 523/129/91 treated HS6 products subject to global/US/EU AD duties.[21] Tables B.1, B.2 and B.3 in the Appendix provide summary statistics.

The firm-level analysis requires information on firm-specific AD duties. We merge firm-specific duties with exports using firm names. As the export dataset has firm names in Chinese characters, whereas firm names in the AD dataset are in English, some information is lost in the translation process. Overall, we have successfully matched 69% (711) of Chinese firms subject to US AD duties and 84% (192) of Chinese firms subject to EU AD duties.

Figure 2.1: AD Duty Rate against China in the EU and the US



Note: Panel (a): “Product-specific Duty” is the unweighted mean of country-wide duty levels over all affected HS6 products; “Weighted Duty” is the mean of firm-specific duty levels weighted by export value in USD; “Firm Duty (IT and MET only)” is the unweighted mean of firm-specific duties over all firm-product combinations receiving individual or market economy treatment; Panel (b): Boxplots show the distribution of ad valorem AD duties across all Chinese exporters to the EU and the US.

[21] If products are treated at the HS8 product-level but we only observe trade flows at the HS6 level, we might underestimate the true treatment effect due to aggregation bias. Lu et al. (2013) show that aggregation bias is not problematic in this context. Nevertheless, we address this potential problem in Section 2.4 by relying on firm-level duties which are less prone to aggregation bias.

Panel (a) of Figure 2.1 summarizes average AD duty rates imposed against China by the EU and the US. It illustrates the difference in average AD duty levels between the US (156%) and the EU (42%). One reason for this difference is the so called lesser duty rule applied by the EU which means that the AD duty is equal either to the dumping margin or to the injury margin of domestic companies, whichever is lower. Since the injury margin is often below the dumping margin, this practice results in lower duties. Hence, it is worth investigating the role played by this difference in duty rates when it comes to their effect on Chinese exporters.

However, this difference is only so extreme for product-specific duties (imposed against firms with NMES). Average duties against firms receiving IT or MET are closer together (35% US and 20% EU).[22] It is thus worth looking at the effectively applied duty rate, i.e. the mean duty across all exporting firms, weighted by their export value in USD. This is also considerably below the simple product duty mean. The difference is more pronounced for the US because there are more firms receiving some form of individual treatment per AD case in the US (3 firms per treated HS6 product) than in the EU (1). Consequently, average applied AD duties, weighted by export values, are only 106% for the US and 33% for the EU. This is also reflected in the distribution of duties across firms (Panel (b) of Figure 2.1). The median duty is 38% for the EU and 124% for the US.

2.4 Results

2.4.1 Endogeneity of AD Duties

In Sections 2.2 and 2.3, we stressed the importance of applying the correct fixed effects specification in order to address several sources of omitted variable bias. We now show that not doing so indeed biases the estimated coefficients. In order to do this, we start by replicating the results estimated by Lu et al. (2013).[23] The authors investigate monthly exports from China to the US in the years 2000 - 2006 to estimate effects of the different stages of an AD investigation. These are the initiation of the case (a dummy indicating whether an investigation has been launched), a preliminary duty (temporary pending the final result of the investigation) that is the same for all firms exporting the affected product and a final duty

[22] Our data does not allows us to differentiate between MET and IT.
[23] Note that their sample differs from our preferred sample. To ensure replicability of their results, we use the sample investigated by Lu et al. (2013) in this subsection and switch to our preferred sample in the next subsection.

that may be firm or product-specific. The authors limit the control group to only include HS6 products that are in the same HS4 product category as products subject to AD duties.[24] Finally, the authors estimate semi-elasticities, regressing the log of exports on the duty rate.[25]

Table 2.1: The Effect of AD Duties on Firm Export Value

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Importers	US only	US only	US only	US only	US only	US only	US only	all countries	all countries
Products	HS4 control	HS4 control	HS4 control	HS4 control	HS4 control	HS4 control	HS4 control	all products	all products
Initiation	0.0025	-0.0950***	-0.0061		-0.0341				
	(0.0268)	(0.0348)	(0.0251)		(0.0369)				
Preliminary	-0.0008***	-0.0013***	-0.0000		-0.0006***				
AD Duty	(0.0002)	(0.0002)	(0.0002)		(0.0002)				
Final	-0.0026***	-0.0027***	-0.0003*	-0.0118***	-0.0014***	-0.0023***	-0.0026***	-0.0017***	-0.0435**
AD Duty	(0.0002)	(0.0003)	(0.0002)	(0.0008)	(0.0003)	(0.0005)	(0.0007)	(0.0005)	(0.0181)
Observations	707,100	406,718	406,718	406,718	406,718	406,718	406,718	28,558,296	28,145,387
R^2	0.1734	0.1405	0.6952	0.1617	0.5452	0.7071	0.8150	0.8339	0.8347
Product FEs	YES	YES	NO	NO	YES	NO	NO	NO	NO
Time FEs	YES	YES	YES	NO	NO	NO	NO	NO	NO
Prod.-Firm FEs	NO	NO	YES	NO	NO	YES	YES	YES	YES
Prod.-Time FEs	NO	NO	NO	YES	NO	YES	YES	YES	YES
Firm-Time FEs	NO	NO	NO	NO	YES	NO	YES	YES	YES
Clusters	127,658	41,725	41,725	41,725	41,725	41,725	41,725	3,656,326	3,618,802

Note: Dependent Variable: ln firm export value in USD. AD Variables: Initiation (dummy) preliminary and final AD duty rate in percent; Surviving firms only. (8) and (9): EU and other countries' duties controlled for but not reported. (9): Product-specific duties excluded. Robust standard errors clustered by (Country-)Product-Firm in parenthesis, Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs in (8) and (9). *** p<0.01, ** p<0.05, * p<0.1.

Column (1) of Table 2.1 replicates the firm-level estimation results by Lu et al. (2013). It reports results from regressing firm export values in USD on the three AD variables as well as product and firm fixed effects. The initiation coefficient is not significantly different from zero, indicating that launching an AD investigation does not affect export value. The estimated coefficient of preliminary (final) duties is significantly negative, indicating that a one percentage point

[24] They also construct an alternative control group using matching. However, the estimated coefficients are very similar.

[25] In line with our model, our preferred specification estimates elasticities. However, for better comparison with the results of Lu et al. (2013), we stick to semi-elasticities for now.

increase in preliminary (final) AD duties reduces firm-level exports of the affected product by 0.08% (0.26%). All coefficients are comparable to Lu et al. (2013).[26]

As discussed in Sections 2.2 and 2.3, we suspect this estimation to be subject to two main biases. As our preferred fixed effects estimation is more restrictive, it reduces the sample size as some observations get kicked out. In order to ensure that our results are not driven by differences in sample composition, we start by running the Lu et al. (2013) specification on our restricted sample. The results are presented in Column (2) of Table 2.1. While the initiation coefficient now becomes negative and significant, coefficients for preliminary and final duties remain similar in magnitude.

The next step is to perform a correct difference-in-differences estimation, replacing product fixed effects with product-firm fixed effects to take into account unobserved product-firm characteristics. This allows for a causal interpretation of the coefficients as the AD variable now identifies how a given firm changes exports of a particular product if this product is subject to AD duties. There is no “selection” in the sense that AD duties identify firms with smaller export values as was the case in Specifications (1) and (2).

The results are reported in Column (3). The first thing to note is the much larger R^2 statistic (0.7) compared to Specification (2) (0.14). This confirms that - unsurprisingly - a lot of variation in firm export sales is explained by firm characteristics. All three AD coefficients are much smaller in magnitude than those presented in Column (2). While the initiation and preliminary AD duty coefficients turn insignificant, the final duty coefficient remains significant but is only one ninth the size of the estimated coefficient in Specification (2). This result shows that the specification performed by Lu et al. (2013) indeed suffers from omitted variable bias, leading to an overestimation of the treatment effect.

Following our model, we suspect another bias stemming from the omission of demand-side variables. To address this, we control for product-time fixed effects in Specification (4). Coefficients for initiation and preliminary duties cannot be estimated as these variables do not vary across firms exporting the same product. Comparing the estimated coefficient of final duties with the estimate by Lu et al. (2013) in Column (2) shows that controlling for

[26] The initiation coefficient in Lu et al. (2013) is negative but insignificant. The coefficient for preliminary duties is identical. The coefficient for final duties is slightly less negative. However, we would not expect a perfect match for the final duty coefficient as this depends on the successfully merged firm-specific duties which most likely will not be the same. The coefficients are however in the same order of magnitude.

product-time fixed effects increases the magnitude of the coefficient by a factor of four. This is again evidence for an omitted variable bias in Specification (2), this time resulting in an underestimation of the true treatment effect.

Our model also suggests the use of product-firm-time fixed effects. As the sample used by Lu et al. (2013) only includes one destination country, using product-firm-time fixed effects would eliminate all variation in AD duties and exports. However, it is possible to control for firm-time fixed effects, which we do in Specification (5). Relative to Column (2) coefficients halve in size. Once we have seen the effects of adding the three different fixed effects separately, Column (7) shows regression results of controlling for all three simultaneously.[27]

Having demonstrated the importance of controlling for the three sets of fixed effects using the Lu et al. (2013) sample, we can introduce the destination country (henceforth country) dimension and increase product scope. Rather than just using Chinese exports to the US, we now include exports to all countries in our dataset. We also include all traded HS6 products. We then perform a regression similar to the one in Specification (7) with a few important adjustments. Since we now have a country dimension, our panel variable is the country-product-firm combination. As suggested in Sections 2.2 and 2.3, we now control for country-product-firm, country-product-time, and product-firm-time fixed effects. Note that while the country dimension was redundant in Specification (1) to (7), and country-product-firm and country-product-time fixed effects are merely the equivalent to product-firm and product-time fixed effects with a single country pair, the additional dimension allows us to control for product-firm-time, rather than just firm-time fixed effects. The regression results are reported in Column (8). While smaller in magnitude, the final duty coefficient is not significantly different from that in Column (7).

A final problem is measurement error. As described in Section 2.3, AD duties can be product or firm-specific. While product-specific duties can be assigned via HS code, firm-specific duties are more difficult to assign without identifiers, leading to matching rates of less than 100%. If a firm receives a (low) firm-specific duty but is not matched in the data set, it is incorrectly assigned a (high) product-specific duty. The estimated coefficient suffers from attenuation bias and constitutes an underestimation of the true treatment effect. In order to eliminate this bias, we hence exclude all firm-product combinations that received product-specific

[27] Comparing Columns (6) and (7) shows that once product-firm and product-time fixed effects are controlled for, adding firm-time fixed effects does not change the AD coefficients. However, it does increase the R^2.

treatment.[28] The estimation results are presented in Column (9). As may be expected, the coefficient increases dramatically in size.

2.4.2 Baseline Results

We now move to our baseline specification (estimating elasticities rather than semi elasticities) using annual exports for the years 2000 - 2009.[29] We switch from monthly to annual data for two reasons. First of all, transactions for the years 2007 - 2009 are only availably at an annual level. Since a lot of AD investigations were launched in this period (especially in the EU), this provides a lot of additional variation for identification of the treatment effect. Second, most firms do not export every month, so that they are only observed infrequently. Aggregating up to the annual level provides a more balanced panel. The disadvantage of using annual data is that we cannot differentiate between initiation, preliminary and final duties anymore, since all three stages typically take place within one year. Given that our estimation strategy precludes the estimation of treatment effects for initiation and preliminary duties anyway, forgoing the monthly dimension does not affect our ability to estimate a treatment effect.

Table 2.2 presents our baseline results estimated using Equation (2.5). Column (1) shows that Chinese firm exports fall following the imposition of AD duties. In particular, a one percent EU (US) AD duty increase is associated with a 7.5% (4.8%) fall in exports.[30] Within the model, this correlation can be interpreted to be causal. Despite the difference in magnitude, EU and US coefficients are not statistically different from each other, indicating that exports to the EU do not react more sensitively to the imposition of AD duties than exports to the US.

The second column of Table 2.2 presents price effects. In line with the optimal pricing rule in Equation (2.2), we find no effect of AD duties on producer prices. This indicates 100 % pass-through, meaning that AD duties are fully passed on to consumers. The final column in Table 2.2 presents quantity effects. It can be seen that these are very similar in magnitude to value effects, indicating that adjustments in firm export values are primarily driven by adjustments in quantity rather than adjustments in prices. Given that the coefficients in Columns (1) and

[28] This procedure also tackles aggregation bias. Some AD duties are assigned at a more disaggregated level than HS6, so that a treated HS6 product may actually include untreated HS8 products. This problem is reduced when focusing on duties that are specific to product-firm combinations.

[29] The regressor is thus $\ln\left(1+\frac{Duty\ rate\ in\ \%}{100}\right)$.

[30] Given that these elasticities are estimated using within product across firm variation, it is not surprising that they are larger than if estimated at a more aggregated level. The results are broadly in line with the literature on trade elasticities (Caliendo and Parro, 2014).

(3) are both estimates of the price elasticity of demand, it is not surprising to see them being not significantly different from each other.

Table 2.2: Firm-level Estimation - Elasticities - Firm-specific Duties only

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU	-7.5353***	-0.3997	-7.1355***
	(1.5936)	(0.3246)	(1.6494)
AD Duty US	-4.7992***	-0.0628	-4.7364***
	(1.5762)	(0.2734)	(1.5368)
EU = US (p value)	0.2207	0.4224	0.2851
R^2	0.8413	0.9586	0.8787

Note: AD Variable: $\ln$ (1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms and firms exporting before treatment only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 17,995,095 observations, 5,381,311 clusters

2.4.3 The Role of Firm Size

In Section 2.3 we have already shown that small firms are more likely to receive product-level - and thus larger - AD duties than large ones. Now we are also interested if firms of different size react differently to the imposition of AD duties. For each destination country and year, we therefore rank firm-product combinations by export value and divide them into three categories of equal size (small, medium and large). These are then interacted with AD duties.

Columns 1 and 3 of Table 2.3 show that the effect of AD duties on export value and quantity declines with firm size, indicating that large firms react less sensitively to AD duties than small firms. The difference between the coefficients for the individual size clusters is statistically significant. Price effects reported in Column (2) are insignificant for all size clusters except for large firms exporting to the EU. Here the coefficient is significantly negative, indicating that these firms absorb parts of the AD duty.

Against the background of the correlation between firm size and productivity observed in the literature, this implies that given the same AD duties, productive firms' exports decline by less than those of less productive firms. Taken together with the aforementioned negative correlation of firm size and AD duties, AD action may intensify competition as productive exporters expand relative to less productive ones.

Table 2.3: Duty interacted with Firm Size

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU x small	-14.7694***	-0.2613	-14.5080***
	(2.0719)	(0.5658)	(2.0844)
AD Duty EU x medium	-11.2412***	0.0450	-11.2861***
	(1.7196)	(0.3850)	(1.7827)
AD Duty EU x large	-5.3170***	-0.5967*	-4.7203***
	(1.5223)	(0.3239)	(1.5445)
AD Duty US x small	-12.1460***	-0.1615	-11.9845***
	(2.7361)	(0.4834)	(2.7199)
AD Duty US x medium	-7.5355***	0.0557	-7.5912***
	(2.0890)	(0.2627)	(2.0661)
AD Duty US x large	-3.5262*	-0.0690	-3.4572*
	(1.9722)	(0.2744)	(1.9440)
R^2	0.8408	0.9586	0.8783

Note: AD Variable: $\ln$ (1 + AD Duty Rate/100) interacted with firm size clusters. Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms and firms exporting before treatment only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 18,060,430 observations, 5,396,449 clusters.

2.4.4 Decomposition: Extensive versus Intensive Margin

Next we want to see how results at the firm-level extend to the product-level. The change in total exports at the product-level X_{jht} can be decomposed into a change in the number of exporters exporting a particular product to a particular country n_{jht} (extensive margin) as well as a change in the average firm export value (intensive margin) which in turn can be decomposed in the change in average export prices $\bar{p}_{jht}$ and quantities $\bar{q}_{jht}$:

$$\ln X_{jht} = ln\, n_{jht} + ln\, \bar{p}_{jht} + ln\, \bar{q}_{jht}.$$

As both dependent variable and AD duties now only vary across country, product and time, we have to adjust our estimation strategy. Since we can no longer use firm-specific AD duties, we need to use one single AD duty per affected HS6 product. One possibility is to use the product-specific duty. This may however lead to attenuation bias as the product-level exports would incorporate exports of firms receiving low duties. As these will be larger than they would be if these firms had received the higher product wide duty, incorrectly associating high export - low duty firms with the high duty through aggregation would underestimate the treatment effect.

An alternative which we will use henceforth is to calculate an average AD duty over all firms exporting a given product at a point in time, weighted by the firm's export value.[31] We also have to adjust our fixed effects as the firm dimension disappears. We hence use country-product (the panel identifier), country-time and product-time fixed effects. It can be seen directly that the country dimension allows us to control for product-time fixed effects, something that is not possible when restricting the sample to a single country pair. Nevertheless, there may still be omitted variable bias following the omission of country-product-time specific demand side control. We hence do the next best thing and use country-HS4-time fixed effects to at least account for country-specific product group trends. They also provide a proxy for time varying transport costs of certain kinds of goods as well as the strength of lobbying groups in a particular industry in the destination country.

Table 2.4 presents regression results for each of the components. Column (1) shows that a one percent increase in EU (US) AD duties is associated with a 1.4% (1%) reduction in Chinese exports of the affected product. Not surprisingly, the elasticities estimated across HS6 products are smaller than those estimated within HS6 products as the degree of competition declines. Column (2) provides the estimated coefficients of a regression of the log of the number of exporters on AD duties. Coefficients for the EU and the US are both negative

[31] A potential problem with this approach is an automatic adjustment of the duty downwards as high duty firms reduce exports or exit the market and low duty firms expand. In a robustness check, we thus also use product wide duty rather than a weighted average. As expected, the estimated coefficients are slightly smaller in magnitude but remain similar.

and statistically significant, indicating that AD duties drive out exporters. However, the EU coefficient is significantly larger in magnitude than the one for the US, indicating that exporters react more sensitively to EU duties. Column (3) looks at the effect of AD duties on average firm export prices. EU and US coefficients are both not statistically different from zero. Finally, Column (4) shows the effects of AD duties on average firm export quantity. Both EU and US coefficients are negative and significant, confirming that aggregate results are driven by changes in average export quantity rather than by changes in average export prices.

Table 2.4: Decomposition: Extensive versus Intensive Margin

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-1.4391***	-0.8409***	0.0844	-0.6826**
	(0.3771)	(0.1306)	(0.1594)	(0.3197)
Duty US	-1.0051***	-0.3792***	0.0319	-0.6578***
	(0.1695)	(0.0525)	(0.0600)	(0.1583)
Duty other	-0.3764***	-0.1771***	0.0311	-0.2304***
	(0.0964)	(0.0485)	(0.0445)	(0.0850)
EU = US (p value)	0.2940	0.0010	0.7578	0.9447
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: $\ln$ (1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 Observations; 293,660 clusters.

2.4.5 The overall Effect of AD Duties

The elasticities presented in Table 2.4 show how sensitive Chinese exports react to the imposition of AD duties. They fail to show the overall impact, as this also depends on the magnitude of the AD duties which was shown to differ dramatically between the US and the EU. We thus also regress export values, prices and quantities on dummies that indicate if a duty is in place against a particular product at a certain point in time. The estimated coefficient captures both the elasticities as well as the magnitude of the duty.

The estimation results are provided in Table 2.5. Estimated effects of AD duties on export value (1), the number of exporters (2) as well as mean export quantity (4) remain significantly negative. However, once the magnitude of the AD duties is taken into account, EU and US duty coefficients switch places. As can be seen in Columns (1), and (4), US coefficients are now significantly larger in magnitude than EU coefficients, indicating that once the size of the duty is taken into account, US duties have a stronger trade dampening effect than EU duties. The coefficients in Column (1) can be interpreted in the way that on average the imposition of EU (US) AD duties tends to reduce exports of affected products by $100 * (e^{\beta} - 1)\% = 41\%$ (62%). Hence while the larger average US AD duties mean that the US is overall more effective in reducing Chinese imports than the EU, the larger EU elasticity as well as the greater number of firms receiving individual treatment in the US mean that the difference is not as big as may be inferred from only looking at the difference in product-level duty rates (Figure 2.1 above). Price effects in Column (3) remain insignificant for the EU and the US, while they turn positive and significant for other countries.

Table 2.5: Decomposition: Extensive versus Intensive Margin, overall Effect

Dependent Variable	(1) ln value	(2) ln no. firms	(3) ln mean price	(4) ln mean quantity
Duty Dummy EU	-0.5196***	-0.2970***	0.0112	-0.2338**
	(0.1333)	(0.0483)	(0.0473)	(0.1168)
Duty Dummy US	-0.9574***	-0.3560***	0.0352	-0.6366***
	(0.1555)	(0.0489)	(0.0528)	(0.1452)
Duty Dummy other	-0.4899***	-0.2413***	0.0692**	-0.3178***
	(0.0788)	(0.0322)	(0.0286)	(0.0694)
EU = US (p value)	0.0327	0.3908	0.7349	0.0305
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

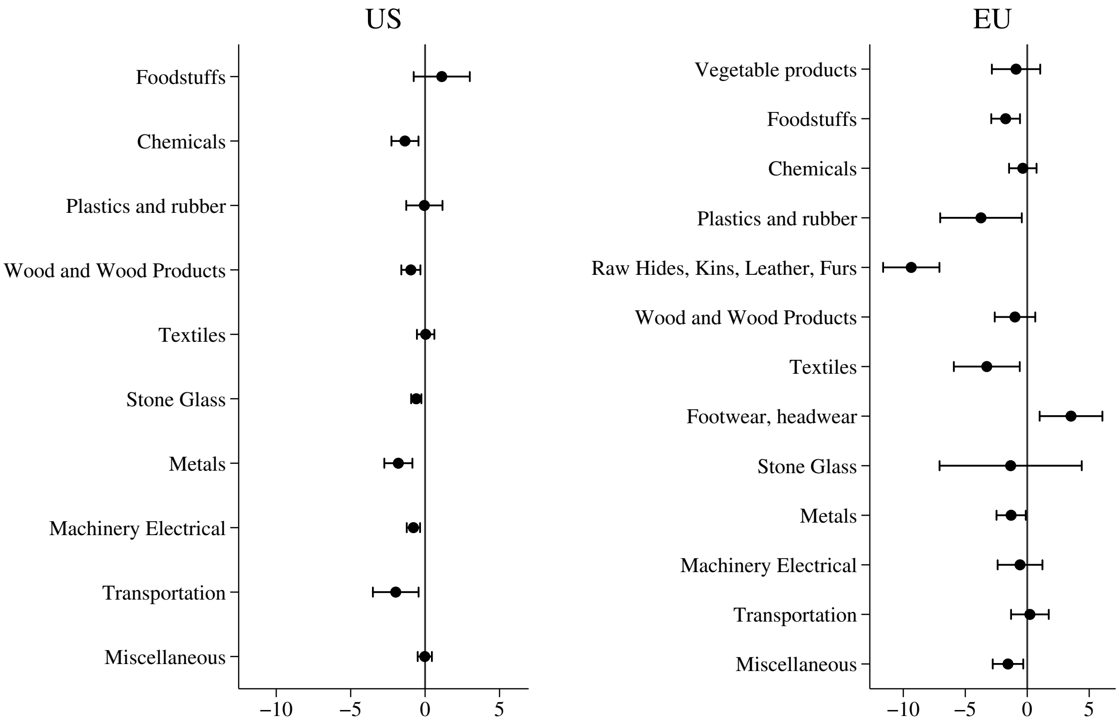
2.4.6 Trade Effects by Sector

It was suggested that exports in different sectors may react quite differently to AD duties. Following Equation (2.6), AD duties are nested by sector to obtain sector-specific coefficients. Figure 2.2 summarizes the regression results for US and EU duties at the product-level.[32] The

[32] For a full list of affected sectors see Table B.1 in the Appendix.

figure reveals that aggregate elasticities hide significant heterogeneity across sectors. The results for the EU in the right panel of Figure 2.2 show that EU imports react very differently to AD duties compared to US imports.[33]

Figure 2.2: The Effect of AD Duties on Export Value, nested by Sector

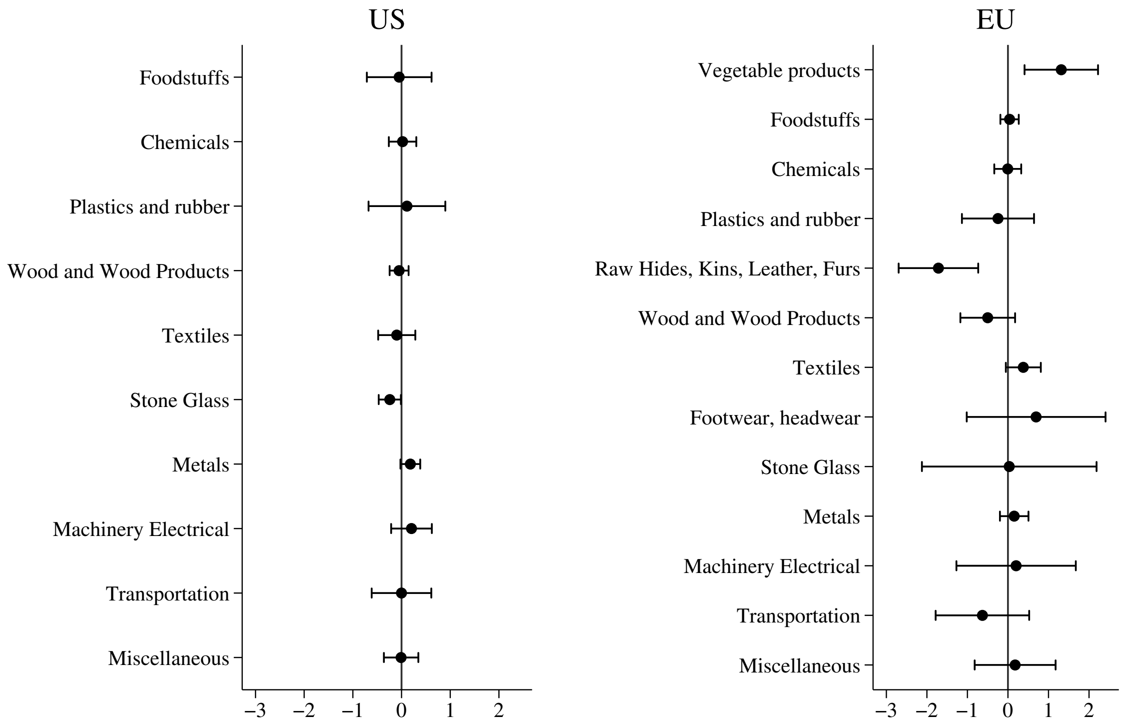


Note: Regression of $\ln$ exports on $\ln$ (1 + Trade weighted AD Duty Rate/100), Country-Product, Country-HS4-Time and Product-Time FEs. Robust standard errors clustered by Country-Product. 293,660 clusters. 1,765,887 observations. Vertical line corresponds to zero. Sorted by sector classification.

Figure 2.3 shows that price effects are absent in most sectors. However, average prices rise following EU AD duties in the footwear sector and fall in the metals sector. The findings suggest that Chinese exporters react differently to duties in different sectors. One possible explanation for the positive coefficients observed in some sectors could be that these sectors either have a lot of firms receiving MET or that they are dominated by a few large exporters that are able to collude and jointly increase prices in order to reduce AD duties in subsequent periods.

[33] The positive coefficient for EU Footwear and headwear products is driven by entry.

Figure 2.3: The Effect of AD Duties on average Export Price, nested by Sector



Note: Regression of $\ln$ average export price on $\ln$ (1 + Trade weighted AD Duty Rate/100), Country-Product, Country-HS4-Time and Product-Time FEs. Robust standard errors clustered by Country-Product. 293,660 clusters. 1,765,887 observations. Vertical line corresponds to zero. Sorted by sector classification.

2.4.7 Trade Deflection

In order to investigate the effect of a country's AD duties on Chinese exports to other countries (trade deflection), we regress Chinese export values, prices and quantities to countries other than the EU and the US on duties imposed by the EU and the US, while still controlling for the importing country's own duties.[34] As before, we restrict our sample to firms surviving the treatment, i.e. exporting to at least one country following the introduction of the AD duty.

Table 2.6 presents the results. The estimated value and quantity effects of EU (US) AD duties on exports to the EU (US) are similar in magnitude to those presented in Table 2.2. However, we do observe a significantly negative price coefficient for EU duties, indicating that Chinese firms reduce export prices to the EU following the imposition of EU AD duties. Looking at the effects of EU and US AD duties on firm-level exports to third countries, we do not find

[34] Exports to the US are also regressed on EU duties and vice versa.

significant effects, indicating that firms do not adjust their exports to third countries following the imposition of AD duties in the EU or the US.

Table 2.6: The Effect of AD Duties on Firm Exports to third Countries

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
Duty EU	-7.2399***	-0.6991**	-6.5408***
	(1.7201)	(0.3452)	(1.7752)
Duty US	-4.9281***	-0.1941	-4.7340***
	(1.7262)	(0.2965)	(1.6899)
Duty EU 3rd	0.2902	-0.2152	0.5054
	(0.5387)	(0.1373)	(0.5593)
Duty US 3rd	-0.0839	0.0353	-0.1192
	(0.1307)	(0.0392)	(0.1298)
EU 3rd = US 3rd (p)	0.4998	0.0793	0.2766
R^2	0.8411	0.9597	0.8791

Note: AD Variable: $\ln$ (1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms and firms exporting before treatment only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 16,737,202 observations, 4,957,495 clusters clusters

We also examine trade deflection at the product-level, differentiating between extensive and intensive margin. As in Table 2.4, the dependent variable is regressed on $\ln$ (1 + Trade weighted AD Duty Rate/100). Given the way the variables "Duty EU 3rd" and "Duty US 3rd" are constructed, we however have to adjust our fixed effects specification. If a US AD duty is in place at a particular point in time against a particular product, the variable "Duty US" takes on the ln duty rate for exports to the US and zero to all other countries. At the same time, the Variable "Duty US 3rd" takes on the ln duty rate for exports to all other countries and zero for exports to the US. Consequently, given an AD duty is in force at a particular point in time for a particular product, the two variables "Duty US" and "Duty US 3rd" are perfectly collinear at the product-time dimension. Consequently, we cannot control for product-time fixed effects anymore as this would lead to one of the two variables dropping out. For the same reason, we move from using country-HS4-time fixed effects towards using country-sector-time fixed effects.

Table 2.7 reports the results. Estimated coefficients for the direct effects of EU and US AD duties are similar to those provided in Table 2.4. One notable difference is the significantly positive coefficient of the EU duty in Column (3), indicating that average export prices to the EU rise following the imposition of EU AD duties. Combined with the negative EU coefficient in Column (2) of Table 2.6, this indicates that while surviving firms reduce export prices, AD duties may drive low price firms out of the market which may be expected if these receive higher duties.

Table 2.7: The Effect of AD Duties on Exports to third Countries - Decomposition

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-1.2524***	-0.6632***	0.2977**	-0.8869***
	(0.3460)	(0.1729)	(0.1507)	(0.3244)
Duty US	-0.8164***	-0.2060***	-0.0301	-0.5804***
	(0.1912)	(0.0721)	(0.0531)	(0.1639)
Duty other	-0.5762***	-0.2609***	0.0303	-0.3456***
	(0.0911)	(0.0561)	(0.0405)	(0.0698)
Duty EU 3rd	0.1461***	0.1199***	0.1208***	-0.0946**
	(0.0447)	(0.0219)	(0.0219)	(0.0384)
Duty US 3rd	0.2114***	0.1704***	-0.0947***	0.1357***
	(0.0166)	(0.0077)	(0.0089)	(0.0155)
EU 3rd = US 3rd (p)	0.1799	0.0326	0.0000	0.0000
R^2	0.8012	0.8815	0.9151	0.8439

Note: AD Variable: $\ln$ (1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product and Country-Sector-Time FEs. 2,101,917 observations; 351,684 clusters.

Regarding third country effects, Column (1) shows that higher EU and US duties increase Chinese exports to other countries. This is evidence of trade deflection and in line with findings by Chandra (2016), who finds evidence of trade deflection with regard to US trade barriers against Chinese exporters. The extensive margin effects are reported in Column (2). They give evidence that firms tend to start exporting to new markets following the imposition of EU and US AD duties. This suggests that the decision of market entry is not independent across markets but may depend on capacity. Effects of US duties on average firm prices and export quantities to third countries are as expected. Average export prices to third countries fall (Column 3) along with rising average export quantities to third countries following the imposition of US AD duties (Column 4). This may indicate increased dumping activity to third countries, although we fail to find evidence for this at the firm-level.

For the EU, mean price and quantity coefficients have the opposite signs. It is, however, unclear whether firms exposed to EU duties increase prices and hence experience falling demand in third countries to avoid investigations in those countries. Since we do not find evidence for this at the firm-level, a selection effect is more likely, meaning that high price firms with lower sales enter new markets, thus driving average prices up and average export quantity down.

2.4.8 The EU Enlargement 2004 - A Natural Experiment

As demonstrated above, using an elaborated fixed effects strategy reduces omitted variable bias at the firm-level. Nevertheless, the risk of endogeneity due to reverse causality (large exports increasing the probability of receiving AD duties or their level) may not be completely eliminated, especially at the product-level. In this subsection, we hence propose a strategy based on Sandkamp (2018) to ensure exogeneity of the AD treatment also at the product-level. Namely, we use the enlargement of the European Union in 2004 as a natural experiment. When the ten accession countries joined the EU,[35] they also adopted the EU's tariffs and AD duties. Under the plausible assumption that these countries did not join the EU because of its AD policy, the treatment can be seen as exogenous from the perspective of the new member states.

Using a sub-sample of product-level exports to the ten EU accession countries for the years 2003 and 2005 (symmetric around the accession), we hence conduct a difference-in-differences estimation (Equation 2.7). $\ln$ exports are regressed on a time dummy (zero in 2003 and one in 2005), an AD dummy identifying the treatment group which is equal to one if the product is subject to AD duties by the EU in 2003 and 2005 and zero otherwise and a treatment dummy which is an interaction of the time and the AD dummy. The latter identifies the treatment effect. The treated products were hence not subject to AD duties in the ten accession countries

[35] Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

in 2003 but became subject to AD duties in 2004 (and still were in 2005) simply because the countries joined the EU (cases initiated since 2004 are ignored).

$$lnY_{jht} = \beta_1 AD_h + \beta_2 Time_t + \beta_3 (AD_h \, x \, Time_t) + \epsilon_{jht} \quad (2.7)$$

The regression results are presented in Table 2.8 below. Column (1) shows results for the basic diff-in-diff estimation described in Equation 2.7 above. The coefficients for Time and AD are positive and statistically significant. The first indicates that exports on average increase over time. The second shows that the average value of products exported to EU accession states that are subject to AD duties in the EU is above the average value of those products not subject to AD duties in the EU. The interaction term ("AD Duty") is negative and statistically significant, indicating that exports of treated products to EU accession states fell following the imposition of AD duties (relative to products not subject to AD duties). Qualitatively this result is in line with the coefficients estimated in Column (1) of Table 2.5 above. Quantitatively, the coefficient estimated in the experiment is larger in magnitude.

Table 2.8: The Effect of AD Duties on Exports to EU Accession Countries

Dependent variable: ln value	(1)	(2)	(3)	(4)	(5)
AD Duty (dummy)	-0.9368**	-1.0420***	-1.0234***	-1.5769***	-1.4991**
	(0.3945)	(0.3756)	(0.3705)	(0.4594)	(0.6356)
Time	0.2955***	0.6475***			
	(0.0212)	(0.0187)			
AD	1.5398***				
	(0.3149)				
Observations	29,182	21,670	21,670	21,440	17,676
R^2	0.0041	0.8320	0.8351	0.8684	0.9058
Country-Product FEs	NO	YES	YES	YES	YES
Country-Time FEs	NO	NO	YES	YES	N/A
HS4-Time FEs	NO	NO	NO	YES	N/A
Country-HS4-Time FEs	NO	NO	NO	NO	YES
Clusters	18347	10835	10835	10720	8838

Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1.

The remaining columns of Table 2.8 show regression results for specifications using different sets of fixed effects, similar to those used in the previous specifications. Controlling for country-product fixed effects (Column (2)) increases magnitude and significance of the treatment coefficient. While controlling for country-time fixed effects does not significantly alter the estimated coefficient (Column 3), adding HS4-time fixed effects - either separately in Column (4) or interacted with country fixed effects in Column (5) - increases its magnitude.

Overall, the experiment provides further evidence that AD duties significantly reduce exports. The magnitude of the estimated coefficient under the most restrictive fixed effects specification is three times larger than those estimated in Table 2.5. It is however not clear if this is driven by the estimation strategy or the very specific sample (Eastern Europe).

2.5 Robustness Checks

2.5.1 Firm-level Regressions

In this section we perform several robustness checks. Detailed regression results are reported in Section B.3 of the Appendix. We have shown in Table 2.1 Columns (8) and (9) that including firm-product combinations with wrongly assigned product-specific duties leads to attenuation bias. To see if this bias is also present in our preferred sample, we perform our baseline specification, now including product-specific duties. The results are reported in the first panel of Table 2.9 below. As can be seen in Columns (1) and (3), the estimated price elasticities of demand fall dramatically in magnitude relative to the coefficients reported in Table 2.2. The bias is stronger for the US than for the EU. This is in line with the difference in successfully matched firm-specific duties between the EU (84%) and the US (69%). Given that more US firm-product combinations are wrongly assigned a higher product-specific duty, it is not surprising to see a larger bias for the US coefficient.

Table 2.9: Robustness Checks

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
(I) Including product specific duties			
AD Duty EU	-2.3292***	0.2052	-2.5344***
	(0.6617)	(0.1474)	(0.6486)
AD Duty US	-0.4212**	-0.0040	-0.4172***
	(0.1692)	(0.0312)	(0.1619)
(II) Excluding products receiving product treatment only			
AD Duty EU	-2.3829***	0.2000	-2.5830***
	(0.6644)	(0.1497)	(0.6499)
AD Duty US	-0.4124**	-0.0047	-0.4077**
	(0.1691)	(0.0312)	(0.1617)
(III) Firms entering post treatment			
AD Duty EU	-7.5175***	-0.3994	-7.1181***
	(1.5916)	(0.3244)	(1.6472)
AD Duty US	-4.8946***	-0.0526	-4.8419***
	(1.5668)	(0.2740)	(1.5305)
(IV) Excluding intermediaries			
AD Duty EU	-7.0956***	-0.4530	-6.6426***
	(1.7704)	(0.3621)	(1.8373)
AD Duty US	-5.1766***	0.1731	-5.3497***
	(1.9601)	(0.2577)	(1.9165)
(V) Excluding producers			
AD Duty EU	-6.1620***	-0.3942	-5.7677***
	(1.6294)	(0.3096)	(1.6749)
AD Duty US	-5.4369***	-0.1148	-5.3221***
	(1.8265)	(0.3321)	(1.7989)

Note: For detailed tables please refer to Section B.3 in the Appendix.

An alternative explanation for the difference in coefficients when including product-specific duties could be sample selection. Some products do not receive firm-specific treatment.

Excluding these might affect estimated coefficients. As a further robustness check, we thus perform once again our baseline regressions, excluding products that only receive product-specific AD duties. Firms that receive product-specific duties but export products that are also subject to firm-specific duties remain in the sample. The results are summarized in the second panel of Table 2.9. It can be seen that coefficients are very similar to those reported in the first panel, indicating that the jump in coefficients does not stem from a selected sample, but instead from eliminating firms wrongly associated with product-specific treatment.[36]

As we are interested in the intensive margin effects, we have dropped firms exiting or entering post treatment. However, Lu et al. (2013) only drop firms exiting following the treatment. We hence perform a further robustness test by keeping firms that only entered the market following the imposition of AD duties as well as those that left the market. The results are reported in the third panel of Table 2.9. Relative to our baseline results, coefficients remain similar.

In our baseline regressions, we include exports from producers as well as from trade intermediaries. In a robustness check, we perform the firm-level regression excluding all trade intermediaries (fourth panel in Table 2.9). Coefficients remain robust. If we only look at exports by intermediaries (fifth panel),[37] the EU coefficient slightly decreases in magnitude while the US coefficient slightly increases, so that the two move closer together.

2.5.2 Product-level Regressions

Moore and Zanardi (2009, 2011) find evidence of a correlation between the use of anti-dumping and trade liberalization in general. Consequently, if AD duties correlate with tariffs, this could contribute to omitted variable bias. In our baseline firm-level regression, tariffs are controlled for through country-product-time fixed effects. This is however not the case at the product-level. In another robustness check,[38] we thus perform the product-level regression controlling for MFN tariff rates. Coefficients remain robust, with the exception of the EU AD duty coefficient for average export quantity, which turns insignificant. MFN tariff coefficients are insignificant throughout. This is however not surprising given our fixed effects specification and the limited

[36] Given the use of country-product-time fixed effects, products not subject to firm-specific duties do not provide any remaining variation to identify the treatment effect.
[37] In the customs data set, some firms are labeled as intermediaries while others are labeled as producers. Firms for which this information is missing are included in both the fourth and the fifth panel.
[38] Detailed tables are reported in Section B.3 in the Appendix.

within country variation of MFN tariffs across time. In addition to using the weighted AD duty, we also estimate trade deflection effects using dummy regressions. Results remain qualitatively similar.

In the product-level regression (Table 2.4), we include country-HS4-time fixed effects. Doing this reduces the number of observations as any treated product requires an untreated product in the same country-HS4-time dimension to be included. We hence run a more relaxed specification with country-time rather than country-HS4-time fixed effects. Coefficients for value, number of firms and mean quantity remain robust. However, average price effects become positive and significant. This can be driven either by exit of low price firms following the imposition of high AD duties or by surviving firms raising prices. The latter is however not observed in the firm-level regressions. One possible explanation would be that all firms in an industry start raising prices following the imposition of AD duties against a particular product. Given such spillover effects, one would not observe positive price effects when controlling for industry time trends using country-HS4-time fixed effects. However, the coefficients could also be driven by unobserved country and industry-specific time trends, which is why controlling for country-HS4-time fixed effects remains our preferred specification. The same robustness test is carried our for trade deflection at the product-level. Performing dummy regressions yields qualitatively similar results.

Using weighted average AD duties for the product-level regression might give rise to endogeneity concerns. This is because firms receiving high AD duties reduce their exports, such that their AD duties receive smaller weights in subsequent periods. To address this issue, we perform the product-level regression using product-specific duties rather than a weighted average including both product and firm-specific duties. As predicted, coefficients are smaller in magnitude as firms receiving low firm-specific duties are implicitly assigned higher product-specific duties due to aggregation from firm to product-level. Nevertheless, coefficients remain similar in magnitude and significance.[39]

2.5.3 Results by Sector

Beyond sectoral effects of AD duties on export value and average export prices, we also examine effects on the number of exporters as well as average export quantity. Detailed

[39] Coefficients for other countries are identical as weighted averages could only be calculated for the EU and the US.

regressions results (weighted duty as well as dummies) for the key sectors chemicals, metals and machinery are reported in the Appendix, which also provides further summary graphs, illustrating the heterogeneity across sectors.

2.6 Conclusions

AD duties remain a common trade defence instrument, the use of which having increased over the past decade. Given their role and controversies around them, it is essential that the effects of AD dumping duties on trade are correctly measured. We take a step into this direction by basing our estimation on a theoretical model, incorporating firm heterogeneity that informs us about potential sources of omitted variable bias. Using Chinese customs data on firm-level transactions, we find that existing firm-level estimations indeed suffer from two main biases that work in opposite directions.

Exploiting within product across firm variation in exports and AD duties, we identify separate treatment effects of EU and US AD duties. We find that AD duties do reduce firm export value but do not affect producer prices, so that AD duties are completely passed through to consumers. However, effects differ between the EU and the US as the number of exporters reacts more sensitively to EU duties, meaning that higher duties are required in the US to achieve the same overall effect. In addition, only comparing product-level duties overstates the difference in applied duty levels between the EU and the US. When considering the use of firm-specific duties - which is more common in the US than in the EU - and weighing duties by export volume of the affected firms, it becomes clear that the difference in effectively applied duties is smaller than commonly stated. When considering both elasticities as well as duty levels, exports to the US fall by more than exports to the EU following the imposition of AD duties. Nevertheless, the difference is smaller than implied by the difference in product-specific duties. EU duties also significantly impact firm export values, meaning that there is no need for the EU to move closer to the US system in order to protect its domestic market.

Beyond a fall in firm-level exports, falling exports at the product-level are driven by firm exit as well as a fall in average firm export quantity. Interpreted through the lens of our model and combined with the finding that small firms are affected more strongly by the imposition of duties, this implies that AD duties force out the least efficient exporters, thus increasing the overall competitiveness of Chinese exporters. All results vary significantly across sectors, indicating that a one size fits all AD policy may lead to very different effects in different sectors.

Finally, we find evidence for trade deflection at the firm-level. At the product-level, exports to third countries increase following the imposition of AD duties in the EU and the US. For both economies, this is driven by the extensive margin, as firms enter new markets following the imposition of EU or US AD duties. In addition, average export prices to third countries fall following US AD duties, implying that firms dump products to third countries. This is accompanied by an increase in average export quantities. For the EU, mean prices actually rise and average quantity falls, indicating that the composition effect (high price producers with low sales entering new markets as they are driven out of the EU) dominates. This illustrates the deep interdependence of global markets which has to be taken into account when designing new trade policies.

Appendix B.1 Summary Statistics

Table B.1: Distribution of global AD Cases across Sectors

	Exports (m)	Total (m)	Ratio	N hs6	N hs6 d	Cases	Revenue (m)	Ratio
Animals	17	6,522	0.00	238	1	1	26	0.00
Vegetables	19	8,609	0.00	350	2	2	7	0.00
Foodstuffs	77	11,158	0.01	204	7	8	109	0.01
Mineral Products	359	18,666	0.02	158	2	3	593	0.03
Chemicals	658	32,931	0.02	856	77	75	543	0.02
Plastics rubber	863	22,516	0.04	227	41	33	664	0.03
Raw Hides Skins	1	13,445	0.00	105	1	1	0	0.00
Wood	350	12,507	0.03	298	44	18	412	0.03
Textiles	647	108,271	0.01	900	88	34	302	0.00
Footwear headwear	514	22,438	0.02	55	19	3	107	0.00
Stone Glass	222	17,304	0.01	219	26	17	150	0.01
Metals	2,073	60,535	0.03	613	126	81	937	0.02
Machinery Electrical	1,500	314,018	0.00	875	56	40	1,017	0.00
Transportations	312	32,135	0.01	137	7	7	855	0.03
Miscellaneous	2,612	71,046	0.04	409	35	30	2,166	0.03
Service	.	1,309	.	3	.	.	0	0.00
Total	10,224	753,413	0.01	5652	532	330	7,889	0.01

Note: The table reports the average annual export value of HS6 products affected by AD, the average annual total export value, the share of export value affected by AD, the total number of HS6 products in the sample, the number of treated HS6 products, the number of AD cases, the AD revenue as well as the average annual revenue in percent of total exports.

Table B.2: Distribution of US AD Cases across Sectors

	Exports (m)	Total (m)	Ratio	N hs6	N hs6 d	Cases	Revenue (m)	Ratio
Animals	17	964	0.02	126	1	1	26	0.03
Vegetables	.	474	.	276	.	.	0	0.00
Foodstuffs	51	1,464	0.03	178	2	1	94	0.06
Mineral Products	266	1,364	0.20	142	1	1	535	0.39
Chemicals	198	4,388	0.05	806	16	13	361	0.08
Plastics rubber	456	5,891	0.08	226	11	4	424	0.07
Raw Hides Skins	.	3,245	.	75	.	.	0	0.00
Wood	197	2,958	0.07	278	22	5	361	0.12
Textiles	61	13,917	0.00	869	3	3	26	0.00
Footwear headwear	.	8,045	.	55	.	.	0	0.00
Stone Glass	92	2,840	0.03	208	2	2	118	0.04
Metals	900	10,446	0.09	594	47	15	563	0.05
Machinery Electrical	893	65,436	0.01	862	13	6	644	0.01
Transportations	246	5,450	0.05	119	2	1	828	0.15
Miscellaneous	2,309	21,101	0.11	405	9	6	2,022	0.10
Service	.	75	.	2	.	.	0	0.00
Total	5,685	148,058	0.04	5222	129	51	6,004	0.04

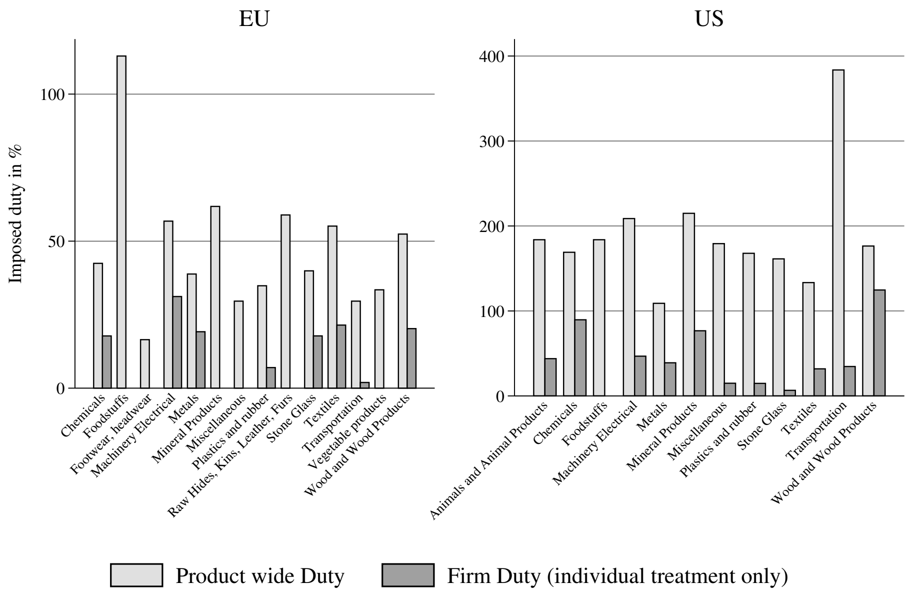
Note: The table reports the average annual export value of HS6 products affected by AD, the average annual total export value, the share of export value affected by AD, the total number of HS6 products in the sample, the number of treated HS6 products, the number of AD cases, the AD revenue as well as the average annual revenue in percent of total exports.

Table B.3: Distribution of EU AD Cases across Sectors

	Exports (m)	Total (m)	Ratio	N hs6	N hs6 d	Cases	Revenue (m)	Ratio
Animals	.	1,188	.	130	.	.	0	0.00
Vegetables	16	1,028	0.02	296	1	1	5	0.01
Foodstuffs	8	1,180	0.01	185	1	1	10	0.01
Mineral Products	92	1,791	0.05	143	1	1	57	0.03
Chemicals	168	6,207	0.03	819	16	13	60	0.01
Plastics rubber	313	3,674	0.09	227	5	4	80	0.02
Raw Hides Skins	1	3,049	0.00	96	1	1	0	0.00
Wood	109	2,269	0.05	285	2	2	43	0.02
Textiles	230	17,161	0.01	891	6	2	110	0.01
Footwear headwear	369	3,875	0.10	55	7	1	61	0.02
Stone Glass	42	3,031	0.01	214	5	1	15	0.01
Metals	1,042	10,846	0.10	595	35	14	315	0.03
Machinery Electrical	381	64,916	0.01	863	8	5	168	0.00
Transportations	33	7,031	0.00	121	2	1	9	0.00
Miscellaneous	254	14,750	0.02	400	1	1	75	0.01
Service	.	26	.	2	.	.	0	0.00
Total	3,058	142,021	0.02	5323	91	43	1,009	0.01

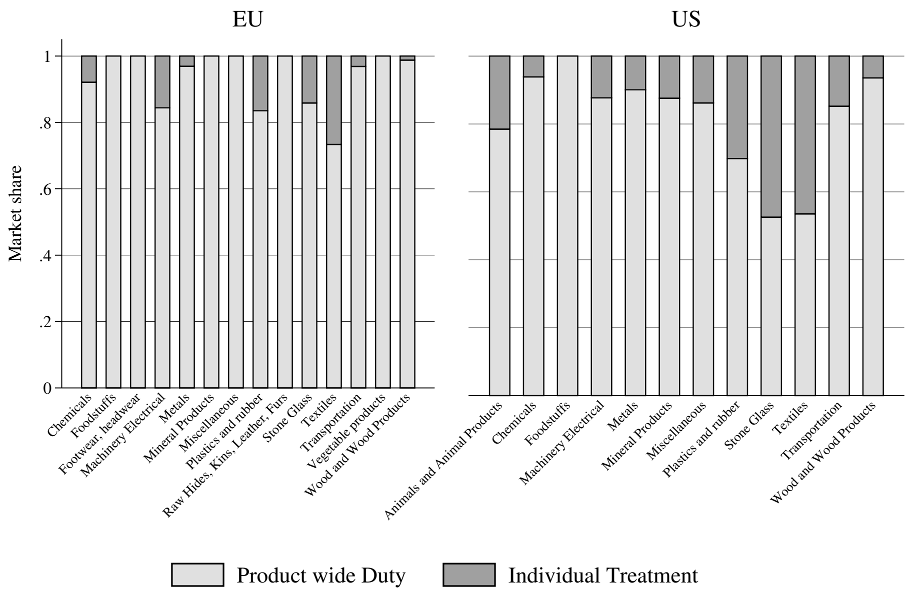
Note: The table reports the average annual export value of HS6 products affected by AD, the average annual total export value, the share of export value affected by AD, the total number of HS6 products in the sample, the number of treated HS6 products, the number of AD cases, the AD revenue as well as the average annual revenue in percent of total exports.

Figure B.1: Average EU and US AD Duties by Treatment Status and Sector



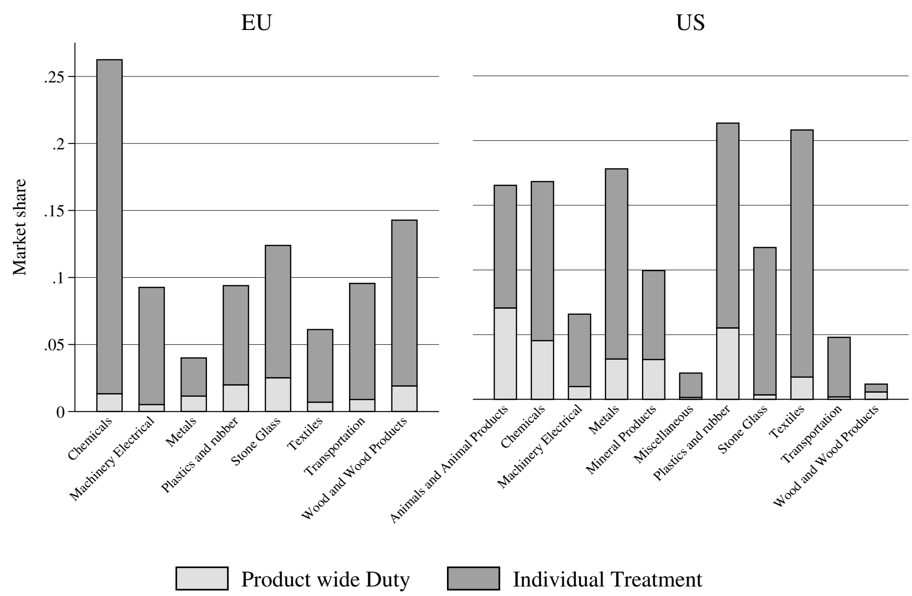
Note: Sector on the horizontal axis. Product and firm-specific duties are simple averages. Within each case and HS6 product, the firm-specific duty is below the product wide duty.

Figure B.2: Total Export Market Share of Firms by Treatment Status and Sector



Note: Sector on the horizontal axis. Treated products only. Export market share over entire period. Data for export market share at the firm-level comes from the Chinese customs office.

Figure B.3: Average Export Market Share of Firms by Treatment Status and Sector



Note: Sector on the horizontal axis. Treated products only. Export market share over entire period. Data for export market share at the firm-level comes from the Chinese customs office.

Appendix B.2 Details on Conceptual Frameworks

B.2.1 Modeling Dumping in a Melitz Model

This section shows how certain pricing decisions of firms that are consistent with the WTO's definition of dumping can be modelled within a Melitz framework. The aim of this section is not to make predictions regarding the effects of AD on firms but rather to illustrate that the resulting firm-level gravity equation is also applicable in the context of anti-dumping so that it can offer guidance for the empirical strategy.

Type 1: Classic Dumping

In line with the WTO definition, we define type 1 dumping as charging an export price below the domestic price. In the model, this can happen for two reasons:

1. Pricing to market

$$\sigma_{hj} > \sigma_{hi} \Rightarrow \frac{p_{hfijt}(\varphi)}{\tau_{hijt}} < p_{hfiit}(\varphi) \;\; since \; \frac{\partial p_{hfijt}}{\partial \sigma_{hi}} < 0.$$

Following the optimal pricing condition in Equation (2.2) of Section 2.2 of the paper, a profit maximising firm will charge an export price (adjusted for transport costs) below the domestic price whenever the elasticity of substitution is higher in the foreign market than in the domestic market. In the context of the Melitz model, this elasticity is taken as exogenously given.

2. Indirect export subsidies such as reduced fuel taxes

$$\tau_{hijt}^{distorted} < \tau_{hijt}^{true} \Rightarrow \frac{p_{hfijt}(\varphi, \tau_{hijt}^{distorted})}{\tau_{hijt}^{true}} < p_{hfiit}(\varphi).$$

Transport costs are distorted through subsidies such that they are below the “fair” transport cost used by the importer’s authorities to calculate the dumping margin. Consequently, the export price adjusted by “fair” transport costs is below the domestic price. From a legal perspective, this constitutes dumping, even if the export price adjusted by the distorted transport cost is not lower than the domestic price.

Type 2: Production distortions

$$c_{hfit}^{distorted} < c_{hfit}^{true} \; but \; \frac{p_{hfijt}(\varphi)}{\tau_{hijt}} = p_{hfiit}(\varphi).$$

In this case production costs c are distorted due to distorted cost of capital r (state finance), distorted cost of material m (energy subsidies) or direct subsidies s. In this case the exporter dumps both at home and abroad. Adjusted export price and domestic price are both below the undistorted production cost and dumping cannot be identified any longer by comparing the two. Such a case justifies the use of third country prices to identify dumping. However, when using third country prices, “dumping” can also result form exporters having higher productivity φ than the third country firms used to construct the comparison price (normal value). In this case productivity differences are impossible to disentangle from unfair competition.

Both types of dumping are thus possible in the model. To investigate if dumping can be profitable, let us consider a two stage game. At stage one, firms set prices $p^* = arg\, max\, E(\pi)$. At stage two, AD duties are imposed with probability ρ_{hj}(Dumping, Injury, Causality, Lobbying,...) with $0 < \rho < 1$ exogenous from the perspective of the firm.[1] This probability varies by destination country and industry. Given an AD investigation is launched, dumping is detected if

$$\frac{p^x_{hfijt}}{\tau_{hijt}} < p^n_{hfijt} \ in \ which \ case \ (T_{hfijt}+1) = \frac{p^n_{hfijt}}{p^x_{hfijt}/\tau_{hijt}},$$

where p^n_{hfijt} is normal value and $\frac{p^x_{hfijt}}{\tau_{hijt}}$ is the net export price used by the investigators to calculate the dumping margin.[2] Given AD action, the exporter faces three possible treatments:

1 MET with probability α_j: $p^x_{hfijt} = p_{hfijt}(\varphi)$ = the firms own export price and $p^n_{hfijt} = p_{hfiit}(\varphi)$ = the firms own domestic price,

2 IT with probability β_j: $p^x_{hfijt} = p_{hfijt}(\varphi)$ = the firms own export price and $p^n_{hfijt} = p_{hkkt}$ = domestic price in a third country k which has MES,

3 NMES with probability γ_j: $p^x_{hfijt} = \bar{p}_{hijt}$ = the average export price across all Chinese exporters selling product h to country j and $p^n_{hfijt} = p_{hkkt}$ = price in third country k.

$\alpha_j + \beta_j + \gamma_j = 1$. Once the duty is implemented, firms sell at consumer prices $p^*_{hfijt}(1+T_{hfijt})$. At stage one, the expected duty given AD duties are imposed is:

$$E(T_{hfijt}+1)|AD = \alpha_j \frac{p_{hfiit}(\varphi)}{p_{hfijt}(\varphi)/\tau_{hijt}} + \beta_j \frac{p_{hkkt}}{p_{hfijt}(\varphi)/\tau_{hijt}} + \gamma_j \frac{p_{hkkt}}{\bar{p}_{hijt}/\tau_{hijt}}.$$

Under NMES, the firm has no incentive to adjust its export price as it cannot influence the calculated dumping margin. While this is not true for MET and IT firms, we nevertheless assume price adjustments are not possible in stage two. This is realistic for several reasons. First of all, applying for a reassessment of dumping margins is a very costly and timely process so that for most firms (especially those receiving lower MET duties) it is simply not worth the effort. Second, in order to get AD duties reduced, firms first have to raise consumer prices which means that consumer prices including the AD duties would be even higher until the

[1] Of course the probability of an AD investigation is not completely exogenous but is probably decreasing with the firm's export price (Ruhl, 2014). However, especially for a country with non-market economy status, the probability of an AD investigation depends on many other things such as export prices across all exporters and strength of the industry in the importing country which are exogenous from the point of view of the individual exporter.

[2] The export price used by the authorities p^x_{hfijt} does not necessarily equal the true export price p_{hfijt}.

reassessment is completed, further reducing demand. Firms would need deep pockets to survive that.

Hence, firms set prices under uncertainty at stage one. A firm will never set a price below the monopoly price $p^m_{hfijt}(\varphi)$ and never one higher than $p^a_{hfijt} = p_{hkkt}\tau_{hijt}$ which would completely avoid the duty in case the firm receives IT.[3] Hence, the firm chooses a price $p^*_{hfijt}(\varphi)$ for which $p^m_{hfijt}(\varphi) \leqslant p^*_{hfijt}(\varphi) \leqslant p^a_{hfijt}$ to maximise expected profits:[4]

$$\begin{aligned} &E\pi(p^*(\varphi), 1 + T_{hfijt}) = \\ &(1-\rho_{hj})\pi(p^*(\varphi), 1) \\ &+ \rho_{hj}\left(\alpha_j \pi(p^*(\varphi), \frac{p_{hfiit}(\varphi)}{p^*(\varphi)\tau_{hijt}}) + \beta_j \pi(p^*(\varphi), \frac{p_{hkkt}}{p^*(\varphi)/\tau_{hijt}}) + \gamma_j \pi(p^*(\varphi), \frac{p_{hkkt}}{\bar{p}_{hijt}/\tau_{hijt}})\right). \end{aligned} \tag{B.1}$$

Let us first look at TYPE 2 dumping. Under this type of dumping, if the firm gets MET, it pays no AD duty as $\frac{p_{hfijt}(\varphi)}{\tau_{hijt}} = p_{hfiit}(\varphi)$ and dumping cannot be identified. If it gets IT, it can influence the duty by increasing its export price (net of transport cost) up to a maximum of the constructed price to reduce or eliminate the duty. If the firm receives NMET, there is nothing it can do to affect the size of the duty. It can be seen that charging the monopoly price is preferred to charging the high price in three out of four possible states (no investigation, MET and NMET). In the case of IT, the firm is better of if it had chosen the high price. Given uncertainty around the AD investigation and that the firm maximises expected profits, there are values for ρ_{hj}, α_j, β_j and γ_j for which charging a price p^* below p_{hkkt} is the optimal strategy.

Under TYPE 1, MET firms will pay a duty which is however lower than that paid by IT or NMES firms assuming its domestic price is below the constructed normal value. Charging $p^m_{hfijt}(\varphi)$ is the better strategy in case no AD investigation is launched and in case the firm receives NMES. With IT, setting a high price in stage one is preferable. With MET it is unclear as $\frac{p^a_{hfijt}}{\tau_{hijt}} = p_{hkkt}$ may be larger than $p^m_{hfijt}(\varphi)$ inclusive of the MET duty. Once again dumping is the profit maximising strategy for certain values of ρ_{hj}, α_j, β_j and γ_j. Given uncertainty, the firm will set a price p^*_{hfijt} which is somewhere between $p^m_{hfijt}(\varphi)$ and p^a_{hfijt} and hence constitutes dumping under at least one regime. To sum up, given uncertainty around the AD investigation - dumping is not only possible but also a firm's preferred pricing strategy in the model given certain perceived parameter values of ρ_{hj}, α_j, β_j and γ_j.

[3] In reality, there is also uncertainty around p_{hkkt}.
[4] The indices for p^* are omitted in the equation for better legibility. They should read p^*_{hfijt}.

B.2.2 Anti-Dumping in Melitz-Ottaviano

In this section, we sketch a simple Melitz-Ottaviano type model which incorporates AD duties in order to get a better understanding of their effects on exporters. Following Melitz and Ottaviano (2008), consumers in country j consuming product h maximise the quadratic utility function

$$U^j = q_0^j + \alpha \int_{h\epsilon\Omega} q_h^j di - \frac{1}{2}\gamma \int_{h\epsilon\Omega} (q_h^j)^2 di - \frac{1}{2}\eta \left(\int_{h\epsilon\Omega} q_h^j dh \right)^2, \tag{B.2}$$

with $q_0^j$and q_h^j representing consumption of the numeraire good and each variety h. α and η are positive demand parameters indexing the degree of substitutability between the numeraire and differentiated varieties. γ is a positive demand parameter representing the degree of product differentiation between varieties. Consumer maximisation yields the following demand function for individual varieties:

$$q_h^j = \frac{1}{\gamma}(p_{max}^j - p_h^j), \tag{B.3}$$

where p_{max}^j is the cut-off price. Given demand, an exporting firm f in country i sets (consumer) export prices p_{hfij} to maximise export profits π_{hfij} subject to AD duties T^{hfij} set by the importing country j:

$$\pi_{hfij} = \left(\frac{p_{hfij}}{1 + T_{hfij}} - \tau_{hij} c_{hfi} \right) \frac{L_j}{\gamma} \left(p_{max}^j - p_{hfij} \right), \tag{B.4}$$

where τ_{hij} is the iceberg transport cost, c_{hfi} the firm's marginal cost and L_j the size of the destination country. The duty T^{hfij} depends on the export price p_{xhfij}:

$$1 + T_{fhij} = \frac{p_{fhij}^n}{p_{fhij}/\tau_{hij}} = p_{fhij}^{-1} p_{hfij}^n \tau_{hij}, \tag{B.5}$$

where p^n is "normal value". In the case of China, this is either the price charged domestically (in the case of Market Economy Treatment) or a reference price in a third country (Individual Treatment or Non-Market Economy Treatment).

Reference Case - Pricing in the absence of AD duties:

In the absence of AD duties, firms set export prices to maximise the following profit function as in Melitz and Ottaviano (2008):

$$\pi_{hfij} = (p_{hfij} - \tau_{hij}c_{hfi})\,\frac{L_j}{\gamma}\,\left(p^j_{max} - p_{hfij}\right), \tag{B.6}$$

$$\Rightarrow p^{NAD}_{hfij} = \frac{1}{2}(p^j_{max} + c_{hfi}\tau_{hij}), \tag{B.7}$$

where p^{NAD}_{hfij} is the optimal price in the absence of AD. From Equation (B.7), it can be seen that the price charged depends on the degree of competition in the destination market modelled by p^j_{max}. In this model, dumping takes place if $p^{NAD}_{hfij} < p^{NAD}_{hfii}$ which is the case whenever $p^j_{max} < p^i_{max}$. Of course the model can also accommodate the legal definition of dumping, i.e. $p_{hfij} < p^n_{hfij}$, which is the "normal value". We now examine two possible states of AD.

State 1 - Pricing under AD uncertainty:

In state 1, there is uncertainty surrounding the AD process. The firm does not know whether it will become subject to AD duties when setting prices. AD duties are realised with probability ρ_{hj}. The firm sets a price $p_{fhij}$to maximise expected profits:

$$\begin{aligned} E\pi_{fhij}(p_{fhij}, T(p_{fhij}), \rho_{hj}) =& (1-\rho_{hj})[(p_{fhij} - \tau_{hij}c_{fhi})\frac{L_j}{\gamma_{hj}}(p_{max_{hj}} - p_{fhij})] \\ &+ \rho_{hj}[(p_{fhij}(p_{fhij}(p^n_{fhij})^{-1}\tau^{-1}_{hij}) - \tau_{hij}c_{fhi})\frac{L_j}{\gamma_{hj}}(p_{max_{hj}} - p_{fhij})]. \end{aligned} \tag{B.8}$$

Differentiating yields:[5]

$$\begin{aligned} \frac{\partial \pi}{\partial p} =& (1-\rho)\frac{L}{\gamma}[(p_{max} - p) - (p - \tau c)] \\ &+ \rho\frac{L}{\gamma}[2pp_n^{-1}\tau^{-1}(p_{max} - p) - (p^2 p_n^{-1}\tau^{-1} - \tau c)] = 0, \end{aligned} \tag{B.9}$$

[5] The indices are omitted from now on for better legibility.

$$
\begin{aligned}
&\Rightarrow (1-\rho)p_{max} - 2(1-\rho)p + (1-\rho)\tau c + 2\rho p p_n^{-1}\tau^{-1}p_{max} - 2\rho p^2 p_n^{-1}\tau^{-1} - \rho p^2 p_n^{-1}\tau^{-1} + \rho\tau c = 0,\\
&\Rightarrow (1-\rho)p_{max} + 2p[\rho p_n^{-1}\tau^{-1}p_{max} - (1-\rho)] + (1-\rho)\tau c + \rho\tau c - 3\rho p^2 p_n^{-1}\tau^{-1} = 0,\\
&\Rightarrow 3\rho p^2 p_n^{-1}\tau^{-1} - 2p[\rho p_n^{-1}\tau^{-1}p_{max} - (1-\rho)] = (1-\rho)p_{max} + \tau c,\\
&\Rightarrow (3\rho p_n^{-1}\tau^{-1})p^2 - 2[\rho p_n^{-1}\tau^{-1}p_{max} - (1-\rho)]p - [(1-\rho)p_{max} + \tau c] = 0,
\end{aligned}
$$

So that the optimal export price under uncertain AD is

$$
p_1^* = \frac{2[\rho p_n^{-1}\tau^{-1}p_{max} - (1-\rho)] \pm \sqrt{4[\rho p_n^{-1}\tau^{-1}p_{max} - (1-\rho)]^2 + 12\rho p_n^{-1}\tau^{-1}[(1-\rho)p_{max} + \tau c]}}{6\rho p_n^{-1}\tau^{-1}}. \tag{B.10}
$$

Differentiating with respect to ρ yields

$$
\begin{aligned}
\frac{\partial p_1^*}{\partial \rho} &= f(p_{max,}p_n, \tau, c, \rho), \qquad \text{(B.11)}\\
\Rightarrow \frac{\partial p_1^*}{\partial \rho} &= \frac{p_{max}}{3\rho} + \frac{p_n\tau}{3\rho}\\
&+ \frac{2\rho p_{max}^2 - 2p_n^2\tau^2 + 3cp_n\tau^2 + 2\rho p_n{}^2\tau^2 + p_n p_{max}\tau - 2\rho p_n p_{max}\tau}{3\rho(2(\rho^2 p_n^2\tau^2 - \rho^2 p_n p_{max}\tau + \rho^2 p_{max}^2 - 2\rho p_n^2\tau^2 + \rho p_n p_{max}\tau + 3c\rho p_n\tau^2 + p_n^2\tau^2)^{(1/2)})}\\
&- \frac{(\rho^2 p_n^2\tau^2 - \rho^2 p_n p_{max}\tau + \rho^2 p_{max}^2 - 2\rho p_n^2\tau^2 + \rho p_n p_{max}\tau + 3c\rho p_n\tau^2 + p_n^2\tau^2)^{(1/2)}}{3\rho^2}\\
&+ \frac{\rho p_{max} - p_n\tau + \rho p_n\tau}{\rho^2}.
\end{aligned}
$$

It will be shown further down that there exist values for the parameters so that p_1^* is increasing in ρ. Hence, the firm increases prices if it expects AD duties to be implemented.

State 2 - Certain AD duties:

In state 2, prices and AD duties are set simultaneously.[6] The firm knows that AD duties are calculated according to Equation (B.5) and sets prices accordingly. The two states can also be

[6] This is a simplification. As discussed in Section 2.2 of the paper, AD duties in period t are a function of prices in period $t-1$. This dynamic relationship is ignored for simplicity.

seen as a sequential game. The firm operates under state 1 until duties are realised. Once this is the case, the firm can either stick to its pricing decision or pay a fixed cost F to apply for a review and face the decision problem of state 2. The profit equation in state 2 is

$$\pi_2 = \left(\frac{p_2}{1+T_2} - \tau c\right)\frac{L}{\gamma}\left(p^j_{max} - p_2\right), \tag{B.12}$$
$$\Rightarrow \pi_2 = \left(p_2(p_2 p_n^{-1}\tau^{-1}) - \tau c\right)\frac{L}{\gamma}\left(p^j_{max} - p_2\right).$$

Differentiating yields

$$\frac{\partial \pi_2}{\partial p_2} = c\tau - \frac{p_2^2}{p_n\tau} - \frac{2p_2(p_2 - p_{max})}{p_n\tau} = 0,$$
$$p_2^* = \frac{p_{max}}{3} + \frac{(p_{max}^2 + 3cp_n\tau^2)^{1/2}}{3}. \tag{B.13}$$

Calibration:

In order to make predications on firms dumping behaviour, we now calibrate the model by setting plausible values for parameters. The aim of this exercise is not to show that certain results must hold but instead that our empirical results regarding price setting by firms are consistent with the model. The parameter values must fulfil several conditions. First, a firm will never set a price p below the profit maximising price in the absence of dumping. Second, assuming $p^n > p^{NAD}$ which is required for dumping to take place, firms will never set a price above the normal value. Consequently, $p^{NAD} = \frac{1}{2}(p_{max} + \tau c) \leq p \leq p^n$. In addition, it is realistic to assume $p^n < p_{max}$. For simplicity, we take $\tau = 1$. Given the above conditions, we set $p_{max} = 4$, $p^n = 3.5$ and $c = 2$.

We can now derive the following results: From Equations B.7 and B.13 we see that the consumer price in the absence of AD $p^{NAD} = 3$ is smaller than under certain AD $p_2^* = 3.36$ which is in turn smaller than the price necessary to eliminate the duty ($p^n = 3.5$). Hence, in a Melitz-Ottaviano world, firms will absorb part of the duty in order to avoid losing too much demand. If $(1+T)$ was exogenous (as is the case for NMES) and set such that $1 + T = \frac{p^n\tau}{p^{NAD}} = 1.167$, this would imply a consumer price of $p^T = \frac{1}{2}(p_{max} + c\tau(1+T)) = 3.167$ which is smaller than under the endogenous AD duty. This is not surprising since the endogenous duty provides the firm with an incentive to raise prices, as the duty will fall in response.

Under uncertainty and assuming $\rho = 0.5$, firms would set $p_1^* = 3.2263$, which is between p^{NAD} and p_2^*. In addition, for the parameters set above, $\frac{\partial p_1^*}{\partial \rho} > 0$ so that p_1^* is strictly increasing in ρ for all $0 < \rho < 1$. Firms hence set higher prices when they think AD is more likely.

Finally, as in the Melitz world, firms will only adjust prices if $\pi_2(p_2^*) - F > \pi_2(p_1^*)$. If the costs of applying for a review are sufficiently high, the costs from doing so might outweigh the benefits of raising prices and lowering the duty.

CONCLUSION:

The model implies that there exist plausible parameter values such that:

1. Prices under AD will be higher than prices in the absence of AD. However, it will never be optimal for firms to raise prices to fully eliminate the duty.
2. Under uncertainty, prices will be larger than in the absence of AD but lower than under certain AD. Hence, the firm raises prices even before becoming subject to AD.
3. If fixed costs of applying for a review following the imposition of AD are prohibitively high, the firm may not raise prices at all.

Taken together, these three mechanisms provide an explanation for the empirical observation that on average firms do not change prices following the imposition of AD duties. The model also provides additional motivation for our empirical strategy as export prices depend on p_{max} and c_{hfi}. These reflect demand and supply side variables and should be taken into account by using product-destination-time and firm-product-time fixed effects respectively.

Appendix B.3 Detailed Robustness Checks

Table B.4: Firm-level: Elasticities, including Product-specific Duties

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU	-2.3292***	0.2052	-2.5344***
	(0.6617)	(0.1474)	(0.6486)
AD Duty US	-0.4212**	-0.0040	-0.4172***
	(0.1692)	(0.0312)	(0.1619)
EU = US (p value)	0.0052	0.1647	0.0015
R^2	0.8410	0.9584	0.8783

Note: AD Variable: $\ln$(1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms and firms exporting before treatment only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 18,187,189 observations, 5,419,324 clusters.

Table B.5: Firm-level: Excluding Products receiving Product Treatment only

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU	-2.3829***	0.2000	-2.5830***
	(0.6644)	(0.1497)	(0.6499)
AD Duty US	-0.4124**	-0.0047	-0.4077**
	(0.1691)	(0.0312)	(0.1617)
EU = US (p value)	0.0040	0.1805	0.0012
R^2	0.8406	0.9585	0.8781

Note: AD Variable: $\ln$(1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms and firms exporting before treatment only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 18,156,972 observations, 5,415,5574 clusters.

Table B.6: Firm-level: Including Firms entering and exiting post Treatment

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU	-7.5175***	-0.3994	-7.1181***
	(1.5916)	(0.3244)	(1.6472)
AD Duty US	-4.8946***	-0.0526	-4.8419***
	(1.5668)	(0.2740)	(1.5305)
EU = US (p value)	0.2387	0.4095	0.3092
R^2	0.8413	0.9586	0.8787

Note: AD Variable: $\ln$(1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 17,995,219 observations, approx. 5,381,000 clusters.

Table B.7: Firm-level: Excluding Intermediaries

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU	-7.0956***	-0.4530	-6.6426***
	(1.7704)	(0.3621)	(1.8373)
AD Duty US	-5.1766***	0.1731	-5.3497***
	(1.9601)	(0.2577)	(1.9165)
EU = US (p value)	0.4677	0.1591	0.6264
R^2	0.8514	0.9623	0.8868

Note: AD Variable: $\ln$(1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 13,118,639 observations, 4,077,722 clusters.

Table B.8: Firm-level: Excluding Producers

	(1)	(2)	(3)
Dependent Variable	ln value	ln price	ln quantity
AD Duty EU	-6.1620***	-0.3942	-5.7677***
	(1.6294)	(0.3096)	(1.6749)
AD Duty US	-5.4369***	-0.1148	-5.3221***
	(1.8265)	(0.3321)	(1.7989)
EU = US (p value)	0.7664	0.5374	0.8557
R^2	0.8464	0.9589	0.8822

Note: AD Variable: $\ln$(1 + AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6)-Firm in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Surviving firms only. Country-Product-Firm, Country-Product-Time and Product-Firm-Time FEs. 15,790,108 observations, 4,931,772 clusters.

Table B.9: Product-level: Decomposition - MFN Tariffs - Weighted Duties

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-1.1602***	-0.7590***	0.1032	-0.5044
	(0.3753)	(0.1335)	(0.1620)	(0.3204)
Duty US	-1.0431***	-0.3815***	0.0231	-0.6848***
	(0.1815)	(0.0540)	(0.0677)	(0.1676)
Duty other	-0.3308***	-0.1558***	0.0254	-0.2005**
	(0.0946)	(0.0476)	(0.0443)	(0.0828)
MFN Tariff	0.0135	-0.0468	0.0251	0.0352
	(0.0856)	(0.0346)	(0.0443)	(0.0788)
EU = US (p value)	0.7790	0.0086	0.6479	0.6169
R^2	0.8938	0.9507	0.9513	0.9098

Note: AD Variable: $\ln$(1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-hs4-Time and Product-Time FEs. 1,297,588 observations; 208,595 clusters.

Table B.10: Product-level: Trade Deflection - Decomposition - Dummies

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-0.4981***	-0.2885***	0.1191***	-0.3287***
	(0.1223)	(0.0565)	(0.0448)	(0.1139)
Duty US	-0.8245***	-0.1998***	-0.0423	-0.5825***
	(0.1775)	(0.0669)	(0.0549)	(0.1547)
Duty other	-0.7024***	-0.3370***	0.0702***	-0.4355***
	(0.0730)	(0.0387)	(0.0265)	(0.0569)
Duty EU 3rd	-0.0034	-0.0090	0.0599***	-0.0543***
	(0.0165)	(0.0082)	(0.0072)	(0.0140)
Duty US 3rd	0.2354***	0.1778***	-0.1241***	0.1818***
	(0.0154)	(0.0072)	(0.0082)	(0.0145)
EU 3rd = US 3rd (p)	0.0000	0.0000	0.0000	0.0000
R^2	0.8013	0.8815	0.9151	0.8439

Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product and Country-Sector-Time FEs. 2,101,917 observations; 351,684 clusters.

Table B.11: Product-level: Decomposition - Weighted Duties - simple FEs

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-1.6787***	-0.9768***	0.2076*	-0.9095***
	(0.3247)	(0.1135)	(0.1221)	(0.3012)
Duty US	-1.1103***	-0.4602***	0.0995**	-0.7497***
	(0.1591)	(0.0515)	(0.0436)	(0.1424)
Duty other	-0.5965***	-0.2746***	0.0752**	-0.3972***
	(0.0983)	(0.0471)	(0.0325)	(0.0742)
EU = US (p value)	0.1158	0.0000	0.4043	0.6311
R^2	0.8222	0.9089	0.9241	0.8569

Note: AD Variable: $\ln$(1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-Time and Product-Time FEs. 2,102,174 observations; 351,745 clusters.

Table B.12: Product-level: Trade Deflection - Decomposition - Weighted Duty - simple FEs

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-1.3274***	-0.7342***	0.3077**	-0.9009***
	(0.3515)	(0.1844)	(0.1518)	(0.3208)
Duty US	-0.8739***	-0.2605***	-0.0030	-0.6103***
	(0.1912)	(0.0700)	(0.0515)	(0.1629)
Duty other	-0.6016***	-0.2666***	0.0409	-0.3760***
	(0.0944)	(0.0579)	(0.0402)	(0.0704)
Duty EU 3rd	0.1259***	0.1060***	0.1200***	-0.1001***
	(0.0452)	(0.0223)	(0.0218)	(0.0385)
Duty US 3rd	0.2218***	0.1750***	-0.0937***	0.1405***
	(0.0167)	(0.0078)	(0.0089)	(0.0156)
EU 3rd = US 3rd (p value)	0.0510	0.0040	0.0000	0.0000
R^2	0.7965	0.8775	0.9138	0.8410

Note: AD Variable: $\ln$(1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product Country-Time and Sector-Time FEs. 2,102,083 observations; 352,152 clusters.

Table B.13: Product-level: Decomposition - Dummies - simple FEs

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-0.6235***	-0.3571***	0.0638*	-0.3303***
	(0.1139)	(0.0392)	(0.0339)	(0.1051)
Duty US	-1.1379***	-0.4549***	0.1043***	-0.7874***
	(0.1477)	(0.0497)	(0.0375)	(0.1271)
Duty other	-0.7410***	-0.3369***	0.1110***	-0.5152***
	(0.0684)	(0.0316)	(0.0219)	(0.0530)
EU = US (p value)	0.0058	0.1221	0.4229	0.0055
R^2	0.8222	0.9089	0.9241	0.8569

Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-Time and Product-Time FEs. 2,102,174 observations; 351,745 clusters.

Table B.14: Product-level: Trade Deflection - Decomposition - Dummies - simple FEs

Dependent Variable	(1) ln value	(2) ln no. firms	(3) ln mean price	(4) ln mean quantity
Duty EU	-0.5343***	-0.3232***	0.1248***	-0.3359***
	(0.1197)	(0.0590)	(0.0445)	(0.1107)
Duty US	-0.8733***	-0.2508***	-0.0164	-0.6060***
	(0.1784)	(0.0670)	(0.0537)	(0.1545)
Duty other	-0.7043***	-0.3393***	0.0793***	-0.4443***
	(0.0737)	(0.0390)	(0.0258)	(0.0564)
Duty EU 3rd	-0.0121	-0.0141*	0.0593***	-0.0573***
	(0.0167)	(0.0084)	(0.0072)	(0.0141)
Duty US 3rd	0.2425***	0.1810***	-0.1230***	0.1845***
	(0.0156)	(0.0073)	(0.0083)	(0.0146)
EU 3rd = US 3rd (p)	0.0000	0.0000	0.0000	0.0000
R^2	0.7965	0.8776	0.9138	0.8410

Note: AD Variable: AD Dummy. Other countries' own duties controlled for but not reported. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-Time and Sector-Time FEs. 2,104,083 observations; 352,152 clusters.

Table B.15: Product-level: Decomposition - Product-specific Duties

Dependent Variable	(1) ln value	(2) ln no. firms	(3) ln mean price	(4) ln mean quantity
Duty EU	-1.3606***	-0.8282***	0.0642	-0.5967**
	(0.3537)	(0.1260)	(0.1449)	(0.3040)
Duty US	-0.9266***	-0.3692***	0.0195	-0.5769***
	(0.1577)	(0.0489)	(0.0577)	(0.1481)
Duty other	-0.3764***	-0.1771***	0.0311	-0.2303***
	(0.0964)	(0.0485)	(0.0445)	(0.0851)
EU = US (p value)	0.2625	0.0007	0.7741	0.9533
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: $\ln$(1 + Product-specific AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-hs4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Table B.16: Product-level: Decomposition - Chemicals - Weighted Duties

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-0.3592	-0.7928**	-0.0055	0.4391
	(0.5656)	(0.3152)	(0.1696)	(0.6061)
Duty US	-1.3511***	-0.5289***	0.0210	-0.8432**
	(0.4632)	(0.1021)	(0.1439)	(0.3739)
Duty other	-0.5008	-0.3837**	0.0298	-0.1469
	(0.3928)	(0.1514)	(0.1299)	(0.3669)
EU = US (p value)	0.1736	0.4223	0.9053	0.0694
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: $\ln$(1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Table B.17: Product-level: Decomposition - Chemicals - Dummies

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-0.1517	-0.2921***	-0.0346	0.1750
	(0.2386)	(0.1007)	(0.0671)	(0.2349)
Duty US	-1.4835***	-0.5426***	0.0007	-0.9416***
	(0.4500)	(0.0984)	(0.1478)	(0.3641)
Duty other	-0.2974*	-0.1665**	0.0758	-0.2066
	(0.1551)	(0.0703)	(0.0699)	(0.1709)
EU = US (p value)	0.0088	0.0720	0.8274	0.0095
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Table B.18: Product-level: Decomposition - Metals - Weighted Duties

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-1.3002**	-0.5388**	0.1537	-0.9151
	(0.6025)	(0.2353)	(0.1795)	(0.5987)
Duty US	-1.7958***	-0.5932***	0.1807*	-1.3834***
	(0.4811)	(0.1660)	(0.1038)	(0.4355)
Duty other	-0.6097**	-0.2424***	0.0531	-0.4203*
	(0.2587)	(0.0876)	(0.0804)	(0.2381)
EU = US (p value)	0.5195	0.8500	0.8959	0.5258
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: $\ln$(1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Table B.19: Product-level: Decomposition - Metals - Dummies

	(1)	(2)	(3)	(4)
Dependent Variable	ln value	ln no. firms	ln mean price	ln mean quantity
Duty EU	-0.5297**	-0.2367***	0.0291	-0.3220*
	(0.2187)	(0.0863)	(0.0600)	(0.1936)
Duty US	-1.2103***	-0.4012***	0.1368*	-0.9458***
	(0.3677)	(0.1304)	(0.0774)	(0.3208)
Duty other	-0.8861***	-0.3760***	0.0611	-0.5712***
	(0.1736)	(0.0640)	(0.0581)	(0.1593)
EU = US (p value)	0.1114	0.2922	0.2707	0.0951
R^2	0.8860	0.9454	0.9500	0.9074

Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Table B.20: Product-level: Decomposition - Machinery - Weighted Duties

Dependent Variable	(1) ln value	(2) ln no. firms	(3) ln mean price	(4) ln mean quantity
Duty EU	-0.5811	-0.7756***	0.2012	-0.0067
	(0.9222)	(0.2519)	(0.7513)	(0.4562)
Duty US	-0.7839***	-0.1726**	0.2041	-0.8153**
	(0.2282)	(0.0761)	(0.2130)	(0.3637)
Duty other	-0.4185**	-0.1105	0.1871**	-0.4951***
	(0.1983)	(0.0909)	(0.0878)	(0.1839)
EU = US (p value)	0.8309	0.0220	0.9970	0.1655
R^2	0.8860	0.9454	0.9500	0.9074

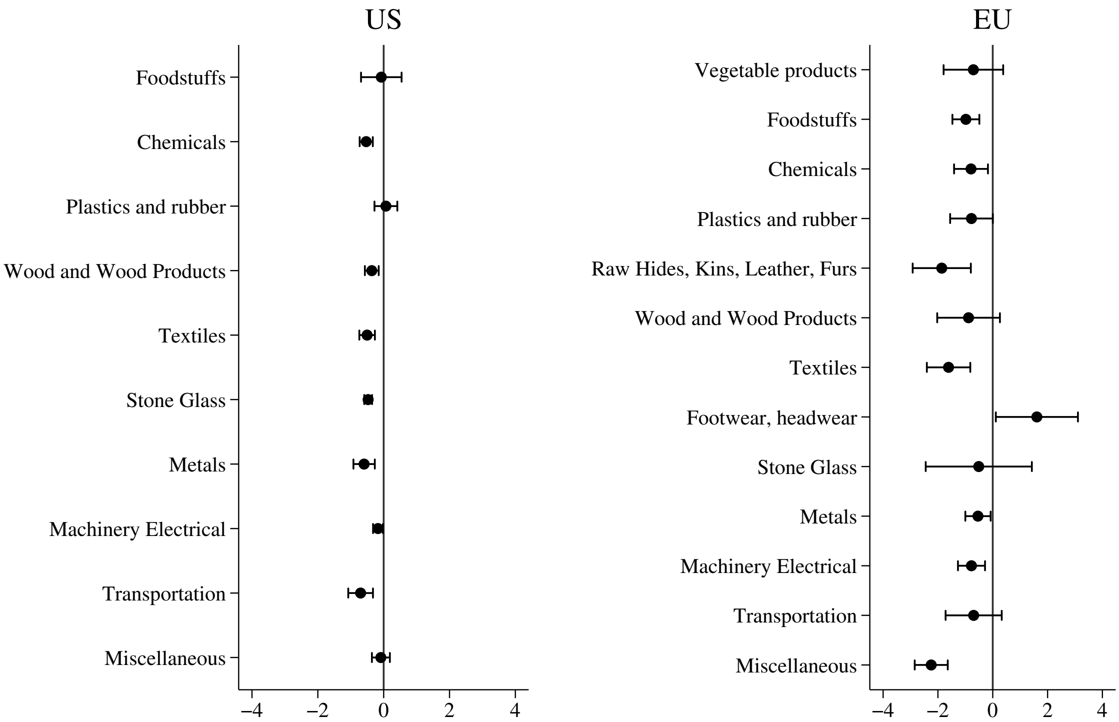
Note: AD Variable: $\ln$(1 + Trade weighted AD Duty Rate/100). Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Table B.21: Product-level: Decomposition - Machinery - Dummies

Dependent Variable	(1) ln value	(2) ln no. firms	(3) ln mean price	(4) ln mean quantity
Duty EU	-0.2908	-0.3098***	0.0039	0.0151
	(0.3202)	(0.1131)	(0.2593)	(0.1962)
Duty US	-0.7930***	-0.2231***	0.1474	-0.7173**
	(0.2198)	(0.0817)	(0.1886)	(0.3243)
Duty other	-0.6139***	-0.2426***	0.1170	-0.4883***
	(0.1819)	(0.0649)	(0.0879)	(0.1630)
EU = US (p value)	0.1955	0.5348	0.6541	0.0531
R^2	0.8860	0.9454	0.9500	0.9074

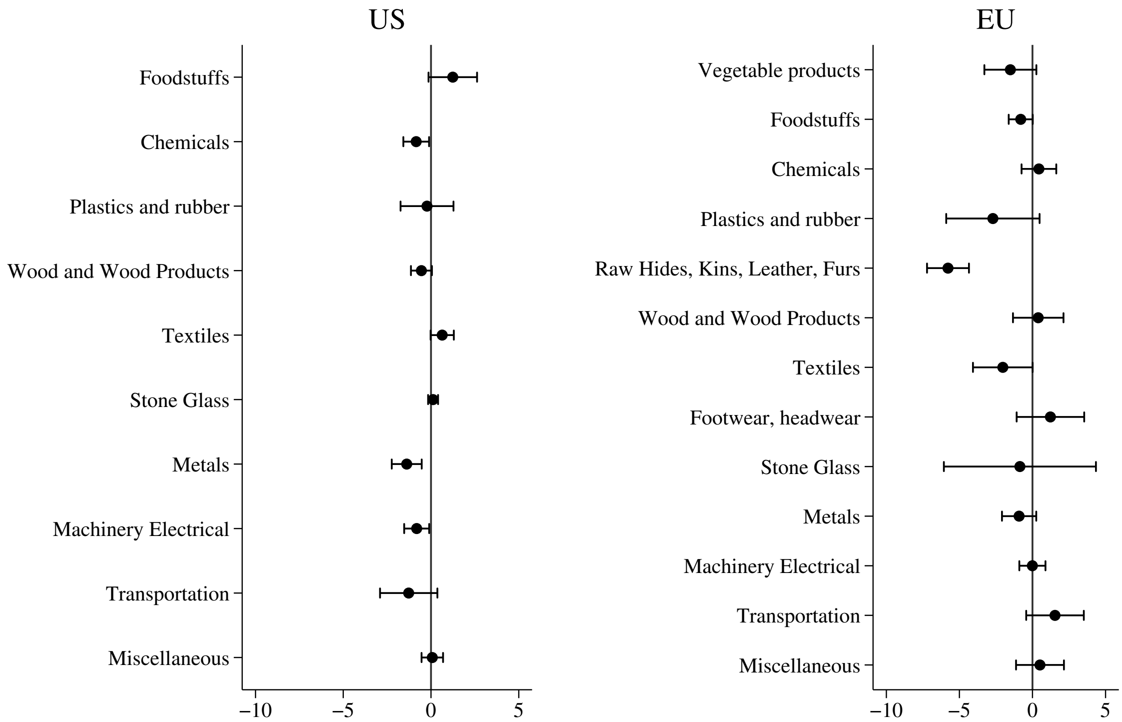
Note: AD Variable: AD Dummy. Robust standard errors clustered by Country-Product(HS6) in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. Country-Product, Country-HS4-Time and Product-Time FEs. 1,765,887 observations; 293,660 clusters.

Figure B.4: The Effect of AD Duties on the Number of Exporters, nested by Sector



Note: Regression of $\ln$ (no. of exporters) on $\ln(1 +$ Trade weighted AD Duty Rate/100), Country-Product, Country-HS4-Time and Product-Time FEs. Robust standard errors clustered by Country-Product. 293,660 clusters. 1,765,887 observations. Vertical line corresponds to zero. Sorted by sector classification.

Figure B.5: The Effect of AD Duties on average Export Quantity, nested by Sector



Note: Regression of $\ln$ (average export quantity) on $\ln(1$ + Trade weighted AD Duty Rate/100), Country-Product, Country-HS4-Time and Product-Time FEs. Robust standard errors clustered by Country-Product. 293,660 clusters. 1,765,887 observations. Vertical line corresponds to zero. Sorted by sector classification.

3 Trade Protection and the Role of Non-Tariff Barriers*

3.1 Introduction

Applied tariffs have declined steadily over the past two decades, having decreased from an average level of 9.7% in 2000 to less than 6.5% in 2015.[1] Nevertheless, the International Monetary Fund warns that protectionism is increasing and poses a threat to global economic growth (International Monetary Fund, 2017). In particular, governments increasingly resort to non-tariff barriers (NTBs),[2] with around 300 of such measures implemented in 2014 alone. In addition, NTBs play an increasing role in the design of trade agreements (Felbermayr, 2016; Felbermayr et al., 2017), so that understanding their effects should be a key concern for policy makers.

Considering a broad range of government measures that lead to a discriminatory treatment of foreign competitors relative to domestic firms as a non-tariff barrier, this paper exploits the recently updated Global Trade Alert (GTA) database, that collects information about protectionist instruments.[3] We empirically quantify how bilateral trade flows change on average if at least one non-tariff barrier is implemented. By estimating a structural gravity equation at the CPC[4] three-digit product level for 152 country pairs for the period 2010 to 2015, we find that bilateral import values of a particular product fall by 6% to 12% if at least one NTB is implemented by the importing country. Additionally, our estimations account for trade defence instruments (TDIs) such as anti-dumping duties. This enables us to compare the trade dampening effects of NTBs and TDIs, showing that they are on average of similar size.

* This chapter is based on joint work with Luisa Kinzius and Erdal Yalcin. It is based on the Master Thesis entitled “Trade Protection and the Role of Non-Tariff Barriers”, 2017 by Luisa Kinzius and the ifo study “Hidden Protectionism: Non-tariff Barriers and Implications for International Trade”, ifo Forschungsberichte 91, 2017 on behalf of the Bertelsmann Foundation by Gabriel Felbermayr, Luisa Kinzius and Erdal Yalcin. We are grateful to Gabriel Felbermayr, Yoto Yotov, Thomas Zylkin as well as two anonymous referees for helpful comments and suggestions.

[1] Tariff data used in this paper is accessible via the World Integrated Trade Solution database provided by the World Bank.

[2] See for example studies by Datt et al. (2011), Kee et al. (2013) or Evenett (2014).

[3] The Global Trade Alert (GTA) database was launched in 2009 following the global financial crisis. The following analysis is based on the recent update published in July 2017.

[4] Central Product Classification.

As non-tariff barriers can be very diverse, we distinguish four groups of NTBs: (1) import controls, (2) state aid and subsidy measures, (3) public procurement and localisation policies and (4) other non-tariff barriers, which include sanitary and phytosanitary standards (SPS), technical barriers to trade (TBT) and capital controls. While we provide strong evidence that import controls reduce trade on average by 4% to 11%, the effect of the remaining NTBs is less pronounced.

Methodologically, our analysis contributes to the ongoing discussion on how to correctly identify the effect of NTBs that affect all trading partners equally. Most of the NTBs identified in the GTA database are so-called behind-the-border (BTB) measures. This means they are not targeted against specific trading partners but affect all trading partners equally. As soon as one accounts for importer-product-time fixed effects in a gravity equation, all variation within the BTB policy variable is absorbed. Hence, the effect of BTB measures on trade cannot be identified in a gravity equation with directional fixed effects. We apply a two-step estimation procedure following Head and Ries (2008) to identify the effect of BTB measures on trade and illustrate that such measures significantly reduce market access.

Our analysis relates to several strands of the trade literature. Regarding studies that examine how the overall level of non-tariff barriers affects trade, Kee et al. (2009) construct an overall restrictiveness index for over 70 developed and developing countries. The authors estimate ad valorem tariff equivalents to facilitate a direct comparison between the restrictiveness of non-tariff barriers and tariffs. They find that on average, non-tariff barriers contribute almost as much to trade restrictions as tariffs. According to Niu et al. (2017), even though tariffs have generally fallen between 1997 and 2015, the increase in the use of NTBs has meant that the overall protection level for countries and products has not decreased. Hoekman and Nicita (2011) find that on average trade decreases more strongly if non-tariff barriers are implemented rather than tariffs. More specifically, trade decreases on average by 1.7% if the level of non-tariff barriers increases by 10%. Similar ad valorem tariff equivalents are calculated by Bouët et al. (2008) and Bratt (2017). We contribute to this recent literature by estimating trade effects using a dataset which incorporates a broad variety of different NTBs, comparing trade dampening effects to those of traditional TDIs.

With regard to the studies examining the effects of specific types of non-tariff barriers, a large strand of literature investigates the effects of technical barriers to trade as well as sanitary and phytosanitary standards on trade.[5] Crivelli and Gröschl (2016) use a gravity model in order to investigate the intensive as well as extensive margin effects of SPS on agricultural and food trade. They find that SPS reduce the probability of exporting to a protected market but increase exports of incumbents, indicating that they serve as a barrier to market entry. Beestermöller et al. (2017) look at food safety border inspections, examining how the risk of rejection at European borders on safety grounds affects Chinese agri-food exporters. The authors find that inspections affect both entry to and exit from the European market as well as the value of incumbent exports.

Ghodsi et al. (2017) study different types of non-tariff barriers. Covering the period from 1995 to 2014, the authors estimate average trade reducing effects that vary between 5% to 30% depending on the type of non-tariff barrier. They conclude that the trade reducing effects of non-tariff barriers can be similar to those of traditional trade defence instruments. However, 82% of non-tariff barriers investigated are SPS or TBT measures.[6] Non-tariff barriers such as subsidies, state aid or public procurement measures are not included as their database is limited to direct trade policies.[7] Furthermore, the authors are unable to distinguish whether non-tariff measures are likely to have a trade liberalising or a protectionist impact, a distinction we are able to make with our data. This paper adds to the literature by comparing the protectionist impact of several different types of non-tariff barriers beyond those used in previous studies.

Non-tariff barriers can be measured directly or indirectly (Chen and Novy, 2012). If non-tariff barriers are directly measured, information about the actual incidence of a non-tariff barrier is used to construct counts, coverage or frequency ratios. This allows to distinguish different types of non-tariff barriers (Henn and McDonald, 2014; Ghodsi et al., 2017). The indirect approach exploits information from market anomalies, such as price gaps or unexpectedly large or small trade flows to estimate the effects of non-tariff barriers (Andriamananjara et al., 2004; Bradford, 2003; Ferrantino, 2006). However, the identification of a single type of non-tariff barrier is not feasible (Ederington and Ruta, 2016). Since we aim to disentangle different trade effects for varying types of non-tariff barriers, we use the direct approach.

[5] A comprehensive overview of studies that focus on specific non-tariff measures is provided by Ederington and Ruta (2016).
[6] In this analysis less than 1% of all measures have been SPS or TBT measures.
[7] Ghodsi et al. (2017) use the WTO's I-TIP database.

The greatest disadvantage of using the direct measurement approach is that data on non-tariff barriers is still relatively scarce.[8] We use the recently updated GTA database, which collects protectionist policies that were implemented worldwide since 2009. Most studies that use data on non-tariff barriers from the GTA database either focus on determinants of protectionism (Georgiadis and Graeb, 2016) or restrict their study to a specific protectionist measure or region (Shingal, 2009; Evenett, 2014).

To the best of our knowledge, Henn and McDonald (2014) are the only ones who use the GTA database to assess the impact of different types of non-tariff barriers on bilateral trade. The authors find that border controls (defined as non-tariff and tariff measures) reduce trade by about 8%. We build on their analysis by relying on an updated version of the database which allows us to extend their estimation strategy substantially.[9] Specifically, we cover a broader period of time and more countries (six years from 2010 to 2015 for 152 countries compared to three years (2008 - 2010) for G20 countries). Our analysis thus overcomes the potential caveat of Henn and McDonald (2014), who look at trade flows that were still largely affected by the world economic crisis.

In addition, it is reasonable to assume that trade flows do not immediately react to newly implemented trade barriers. Therefore, having the possibility to analyse yearly and not monthly trade flows as done by Henn and McDonald (2014) might capture the impact of non-tariff barriers on trade more accurately. The information on the types of products targeted by each measure is now available at the CPC three-digit level instead of the CPC two-digit level.[10]

A further strand of related literature is concerned with effects of BTB measures on trade. Their estimation is problematic as BTB measures do not vary by exporter and hence, they are absorbed in a gravity setting by importer-product-time fixed effects. Henn and McDonald (2014) address this problem by constructing dyads and tetrads of trade flows, which represent changes in imports relative to a reference importer and exporter. They argue that variation among exporters would be preserved particularly in cases where the reference exporter is not affected by protectionism in a certain import market, while most other exporters are subject to such protectionism. However, the problem is exactly that all exporters are equally affected

[8] See Section 3.3 for details on different databases used.
[9] Section 3.2 provides details on the estimation strategy.
[10] Data is also available at the HS six-digit product level. However, the affected HS six-digit product code is systematically missing for a subset of observations. See Section 3.3 for details.

by BTB measures. Hence, there cannot be this one reference exporter that is less affected in a certain import market.

Three alternative solutions have been suggested in the recent related literature: First, instead of including the full set of fixed effects into the regression, one could use proxies to account for multilateral resistance (Baier and Bergstrand, 2009). However, Yotov et al. (2016) do not recommend relying on remoteness indices, as they cannot account for all multilateral resistances and therefore still lead to biased estimates.

A second solution is to extend international trade data with intra-national trade data. This is done by Heid et al. (2015) to identify the effect of non-discriminatory trade policies on trade. By adding intra-national trade, BTB measures become bilateral by definition and thus can be identified. The major issue here is that intra-national trade data is not yet available for all years and all countries considered in this analysis. The databases available to construct intra-national trade (i.e. databases that include bilateral trade and production data) do only cover data until 2004 (the World Bank's Trade Production and Protection database) or 2006 (CEPII's TradeProd database).

The third alternative suggested by Head and Mayer (2014), Egger and Nigai (2015) and Yotov et al. (2016) is to estimate the effect of BTB measures in two steps. In the first step the gravity equation is estimated with the full set of fixed effects. In the second step the predicted importer-product-time fixed effects from the first stage are regressed on importer-specific determinants to assess their impact on the importer's market access.[11] Head and Mayer's derivation neglects the time dimension, as the model is assumed to hold in all time periods. In addition, the two-step estimator is only derived at the importer-exporter dimension. We extend Head and Mayer (2014)'s model to the product level. In doing so, we are close to Anderson and Yotov (2016), who also use a two-step procedure, regressing estimates of importer-exporter-product fixed effects on standard gravity variables.

The remainder of the paper is structured as follows. Section 3.2 presents the empirical strategy, emphasizing the identification of the effect of behind-the-border measures using a two-step

[11] Eaton and Kortum (2002) apply the two-step procedure as they are interested in the determinants of exporters' competitiveness. They use exporter fixed effects derived from a gravity equation and show that technology and human capital are important exporter-specific determinants. Head and Ries (2008) adopt Eaton and Kortum's approach to assess country-specific determinants of foreign direct investments. In a very recent approach Agnosteva et al. (2017) use the two-step procedure to estimate systematic unobserved trade barriers based on standard gravity variables and predict pair-fixed effects from a first stage gravity estimation.

estimation procedure. An overview of the data used is given in Section 3.3. Section 3.4 presents the main findings, followed by some robustness checks. Section 3.5 concludes.

3.2 Estimation Strategy

We estimate a structural gravity equation based on Yotov et al. (2016) and extend it to the product level as proposed by Larch and Wanner (2017). Modelling the gravity equation explicitly with tariffs allows the estimates to be interpreted as trade elasticities. This enables a direct comparison of the trade effect caused by non-tariff barriers and by tariffs. For each trade policy parameter tariff equivalents can be estimated (Yotov et al., 2016).

Extending the gravity model to the product level avoids potential underestimation of the effects of non-tariff barriers. Non-tariff barriers are mostly targeted at specific products and do not target all imported or exported goods. The sectoral gravity equation captures all intersectoral linkages (Yotov et al., 2016) so that it accounts for substitution effects across different goods. The gravity equation derived by Larch and Wanner (2017) is given by

$$X_{ij}^k = \frac{Y_i^k \gamma_j^k Y_j}{Y^W} \left(\frac{t_{ij}^k}{\pi_i^k P_j^k} \right)^{(1-\sigma^k)} (\tau_{ij}^k)^{-\sigma^k}, \tag{3.1}$$

where X_{ij}^k are exports of product k from country i to country j. The equation can be decomposed into two terms that determine trade flows: The size effect and the trade costs effect. $\frac{Y_i^k \gamma_j^k Y_j}{Y^W}$ represents the size of the respective economies. It includes production value of product k in country i Y_i^k, the fraction of country j's expenditure spent on good k γ_j^k, country j's expenditure Y_j and global expenditure Y^W. The size effect determines the level of trade if there are no trade costs. It can be interpreted as follows: Firstly, without any trade costs large producers will export more to all destinations. Secondly, bigger or richer markets will import more from all origins. And thirdly, bilateral trade flows will be larger, the more similar two countries are in size.

The remaining term ($\left(\frac{t_{ij}^k}{\pi_i^k P_j^k} \right)^{(1-\sigma^k)} (\tau_{ij}^k)^{-\sigma^k}$) reflects the effect of trade costs on bilateral trade flows. t_{ij}^k contains all bilateral trade costs at the product level, which are assumed to be symmetric. These are factors like distance, a common language or a shared border, but also NTBs. P_j^k is defined as the inward multilateral resistance. It reflects importer j's market access, which depends on economic size and bilateral trade costs. π_i^k is defined as the outward multilateral resistance and reflects exporter i's market access. Similar to the inward multilateral resistance, outward multilateral resistance also depends on domestic production and bilateral trade costs. It is assumed that both, inward and outward multilateral resistance terms are product specific. Finally, τ_{ij}^k are product specific trade costs induced by tariffs. All trade costs are assumed to have negative effects on trade. σ^k is the elasticity of substitution between varieties of good k (assumed > 1).[12]

3.2.1 Identification of the Trade Effects of Non-Tariff Barriers

To empirically identify the effects of non-tariff barriers, we exploit the fact that for each implemented non-tariff barrier, the GTA database contains the following information: Trading partners that are most likely affected, products that are affected (at CPC three-digit product level) and the date of implementation of any measure. We use this information to construct a dummy variable which equals one if at least one non-tariff barrier is implemented between a destination country j and an origin country i that affects a product k at time t. Similar, a count variable is constructed, which counts how many non-tariff barriers are implemented between a country pair that affect product k at time t. For a more detailed analysis we split non-tariff barriers into four groups: (1) import controls, (2) state aid and subsidy measures, (3) public procurement and localisation policies and (4) other non-tariff barriers, which include SPS, TBT and capital controls. We estimate how imports change in response to non-tariff barriers from 2010 to 2015 using the following equation:

$$X_{ijkt} = \quad (3.2)$$
$$exp[\beta_1 NTB_{ijkt-1} + \beta_2 TD_{ijkt-1} + \sigma ln(1 + t_{ijkt-1}) + \beta_3 FTA_{ijt} + \lambda_{ikt} + \gamma_{jkt} + \theta_{ijk}]\epsilon_{ijkt},$$

where X_{ijkt} are bilateral trade flows in thousand USD from country i to country j at product level k and time t. NTB_{ijkt-1} identifies non-tariff barriers imposed by the importing country j against exporting country i and either consists of a dummy or count variable.[13] TD_{ijkt-1} does the same for trade defence instruments. Tariffs are included in logarithmic form ($ln(1+t_{ijkt-1})$), so that σ provides a direct estimate of the trade elasticity of tariffs. Henn and McDonald (2014) estimate a gravity equation, which does not explicitly model tariffs. This has the disadvantage

[12] For more detailed information on the individual components of the gravity equation the reader is referred to Yotov et al. (2016) and Larch and Wanner (2017).

[13] We use the year of implementation as the starting period and the year of removal as the end period. If the policy was still in place at the beginning of 2015, we set the end date to 2014, the last year covered in our dataset. Only measures that last for at least one year are included.

that one cannot compare the impact of non-tariff barriers on trade with trade elasticities from tariff estimates received directly from within the model. To be able to make this comparison, we estimate a structural gravity equation that includes tariffs. FTA_{ijt} is a dummy controlling for the existence of a free trade agreement between two countries. λ_{ikt}, γ_{jkt} and θ_{ijk} are exporter-product-time, importer-product-time and exporter-importer-product fixed effects respectively. ϵ_{ijkt} is the stochastic error term.

All trade policy variables are lagged by one year for two reasons: Firstly, non-tariff barriers and trade defence instruments are often implemented in reaction to an unexpected or rapid increase in imports. As we use annual trade data, our analysis cannot control for the exact date of implementation of each policy. Therefore, without lagging, the estimates might be biased towards zero, leading to an underestimation of the potentially negative treatment effect. Secondly, as argued by Ghodsi et al. (2017), it is reasonable to assume that intermediate goods do not react immediately to changes in trade costs. Using lags ensures that we account for changes in trade, which do not follow immediately, but only after some time of adaptation.

One major concern when estimating the gravity equation is to consistently account for multilateral resistance terms. We do so by including importer-product-time and exporter-product-time fixed effects (Feenstra, 2015; Head and Mayer, 2014; Yotov et al., 2016). Country-pair-product fixed effects are included in order to absorb all time invariant bilateral trade costs at the product level such as distance, a shared border or specific industry linkages. By controlling for all trade costs that vary across the same dimensions as non-tariff barriers, we can identify their causal effect on trade.[14] Given this identification, the estimated coefficient of the protectionist dummy can be interpreted as the average change in bilateral yearly-imports at the product level caused by the implementation of at least one protectionist policy by the importer. If counts of protectionist policies are used, this interpretation changes to the average change in imports following the implementation of one additional protectionist policy.

Regarding the estimation method used it is important to address zero and missing trade flows correctly. The gravity model does not explain the occurrence of zero trade flows. It assumes that trade flows are positive. However, in the trade data one observes several missing and zero trade flows. A missing trade flow can occur either because two countries do not trade with each other or because trade is not correctly reported and thus missing. The problem of

[14] Our data structure also allows us to include importer-exporter-time fixed effects. Unfortunately, the ppml workhorse estimator employed does not accommodate this additional dimension. Importer-exporter-time fixed effects can however be included in OLS estimations and we do so in Section 3.4.2.

missing trade flows increases with the level of detail of the trade data. The more products are distinguished, the more likely it is that countries do not trade certain specific goods with each other.

If an OLS estimator is used, missing or zero trade flows are dropped from the estimation and are thus ignored. The Poisson pseudo maximum likelihood (PPML) estimator constitutes an alternative method which treats all missing trade flows as zeros and assumes that these are statistical zeros, i.e. that the zeros occur randomly (Head and Mayer, 2014). As Santos Silva and Tenreyro (2006) show, applying the PPML estimator has the additional advantage that it accounts for heteroscedasticity in trade data.[15] PPML is hence our preferred estimation method. It is estimated in Stata using the command "ppml_panel_sg" by Larch et al. (2017). OLS estimates are provided for comparison and are generated using the command "reghdfe" by Correia (2014).[16]

3.2.2 Identification of the Trade Effects of behind-the-Border Measures

The bilateral structure in the dataset is constructed.[17] Identifying which trading partners are likely to be affected from a non-tariff barrier based on past trade flows might cause substantial endogeneity. In addition, most of the non-tariff barriers identified in the GTA database are typical behind-the-border measures. This means that they are not targeted against specific trading partners, but affect all trading partners equally. As soon as one accounts for importer-product-time fixed effects in the gravity equation, all variation within the behind-the-border policy variable is absorbed by the fixed effects.

We follow the two-step procedure suggested by Head and Mayer (2014), Egger and Nigai (2015) and Yotov et al. (2016) to correctly identify the effect of behind-the-border measures on trade, extending Head and Mayer's model to the product level. In the first stage, the gravity equation is estimated as before with the full set of fixed effects, but without a dummy identifying non-tariff barriers. All non-tariff barriers are treated as behind-the-border measures and are thus

[15] Another solution to the problem of zero trade flows would be to estimate a Heckman selection model, which is a two-step model. It first estimates the likelihood that two economies trade with each other at a product line (extensive margin). Then it assesses the impact of trade policies in a second step conditional on the fact that two economies trade with each other. Alternatively, Tobit models could be estimated, which assume that trade flows are not randomly missing (Head and Mayer, 2014). However, these models are biased if trade costs are heteroscedastic.

[16] Please also see Correia (2016). For the OLS estimation Equation 3.2 is log-linearised, so that it takes an additive form.

[17] See Section 3.3 below.

absorbed by the importer-product-time fixed effects. Trade defence instruments and tariffs, which vary across all four dimensions, remain in the estimation equation. The first stage is estimated using the PPML estimator and takes the following form:

$$X_{ijkt} = exp\left[\beta_1 TD_{ijkt-1} + \sigma ln(1 + t_{ijkt-1}) + \beta_2 FTA_{ijt} + \lambda_{ikt} + \gamma_{jkt} + \theta_{ijk}\right] \epsilon_{ijkt}. \quad (3.3)$$

In the second stage the predicted importer-product-time fixed effects from the first stage are regressed on behind-the-border measures to assess their impact on the importer's market access. We hence assess how importer-specific trade costs on average change, if at least one behind-the-border measure is implemented. The second stage is a linear estimation. The importer-product-time fixed effect can be split into unobserved and observed country-product-time specific determinants ($\gamma_{jkt} = \alpha_{jkt} + \beta BTB_{jkt}$). In this study behind-the-border-measures are the observed determinants (BTB_{jkt}).

As noted by Yotov et al. (2016), directional fixed effects do not only absorb all multilateral resistances, but also all economic size terms, like production and expenditures. Importer-fixed effects for example also control for differences across countries in the expenditure of domestic consumers. Therefore, we have to eliminate as many confounding factors as possible to capture a pure trade cost effect. We do so by including importer-product, importer-time and product-time fixed effects. Importer-time fixed effects control for differences in economic size, which is an important determinant of importers' market access. The product-time fixed effects absorb changes in productivity which are product specific and vary over time. For example, this could be a new production technology that is adopted across all countries. Finally, importer-product fixed effects control for time invariant importer-product characteristics.

As Head and Mayer (2014) note, the importer-product-time fixed effects from the first stage are estimated with error (denoted as ν_{jkt}). This error is included in the error term of the second stage estimation. As the importer-product-time fixed effects are estimated with varying precision, the error term of the second stage can be heteroscedastic (Head and Mayer, 2014). Therefore, we choose to estimate bootstrapped standard errors to get consistent estimates.[18] This gives the following second stage estimation equation:

$$ln\widehat{\gamma_{jkt}} = \beta BTB_{jkt} + \eta_{jt} + \kappa_{kt} + \zeta_{jk} + (\psi_{jkt} + \nu_{jkt}). \quad (3.4)$$

[18] This is in line with Agnosteva et al. (2017) who also used the OLS estimator with bootstrapped standard errors. Head and Ries (2008) used weighted-least squares to account for heteroscedasticity in the error term, while Eaton and Kortum (2002) used the OLS estimator without adjusting for heteroscedasticity.

3.3 Data

3.3.1 The GTA Database

All data on non-tariff barriers and trade defence instruments comes from the GTA database. It collects all national policies that are imposed unilaterally and likely to change the treatment of domestic commercial interest relative to foreign commercial interests. International commercial flows are defined as trade in goods and services, as well as labour migration and foreign direct investments. We only focus on policies that affect trade in goods. The GTA database collects protectionist policies that were implemented worldwide since 2009, covering non-tariff barriers imposed by 152 countries.[19] In July 2017, a comprehensive update of the database was released. It covers an outstanding range of non-tariff barriers, which makes a detailed and up-to-date assessment of implemented non-tariff barriers possible.

In our estimation, we rely on measures that were implemented between January 2009 and December 2014.[20] Products are identified according to the CPC product classification scheme at three digit level (version 2.1) and the HS six-digit product level. Since information about affected products at HS six-digit level is incomplete, we estimate the trade impact at CPC three digit product level (177 product categories) to avoid any sample selection bias caused by omitting observations with missing information.[21]

The dataset covers both measures that are likely to harm and likely to benefit trade in goods. As we are interested in the role of non-tariff barriers as protectionist instruments, only protectionist measures are included in the analysis. We further restrict our study to "inward" measures, focusing on trade barriers that are likely to restrict imports into the implementing country.[22] The database distinguishes 44 different protectionist measures that can affect trade in goods. These could either be standard trade policies such as tariff increases and trade defence instruments or non-tariff barriers. For each policy intervention, the GTA database provides information on a) which trading partners are likely to be affected, b) which products are targeted and c) the date of implementation. Typical examples of non-tariff barriers included

[19] A full list of countries is provided in Tables C.4 and C.5 in the Appendix.
[20] Note that we use lagged dummies of non-tariff barriers.
[21] If an official policy document states that a measure is targeted at the agricultural sector and no more detailed information on which types of products are affected could be gained, no affected products at the HS six-digit were identified. However, information about affected products at the CPC three-digit level is complete.
[22] The large majority of non-tariff barriers are inward measures. In a robustness check we control for outward measures, which are implemented by the exporting country.

in the database are state aid measures, changes in public procurement rules, trading quotas, licensing requirements or trade finance instruments.

The GTA database offers several advantages over alternative data sources.[23] First, in contrast to data collection efforts of the WTO, UNCTAD, ITC and the World Bank, GTA data does not rely on official government notifications. Instead the GTA researchers systematically monitor government's websites and other official sources to depict all policy changes that potentially affect trade. This renders under-reporting of the actual degree of protectionism less likely. The set of policies covered is not predefined. Therefore, it can be expected that the GTA database covers a broader range of policies than other sources.

Second, the database clearly distinguishes between discriminatory and non-discriminatory non-tariff barriers. The TRAINS database, which is one of the largest databases on non-tariff measures, does not make this distinction. In the TRAINS database this leads to multiple entries of SPS and TBT measures, which are not necessarily protectionist, but could also be trade enhancing. In contrast, each policy intervention that is included in the GTA database has to pass a six-step evaluation process. During this process it is evaluated whether the policy discriminates against foreign exporters to the benefit of domestic producers.[24]

Third, the definition of non-tariff barriers according to the GTA is not restricted to merely trade policies. The TRAINS database, as well as I-TIP restrict their collection of non-tariff measures to explicit trade policies. According to I-TIP, non-tariff measures are "defined as the measures subject to monitoring through notification under GATT-WTO agreements. Measures that are not subject to monitoring are not considered".[25] As a consequence, these databases do not include state aid or bailout measures. However, especially this kind of hidden protectionism might play an increasingly important role for developed economies, as WTO regulations have reduced the scope to use standard trade policies to restrict trade. Lastly, the GTA database is superior to the Non-Tariff-Measure business surveys, which are published by the ITC. These surveys provide very detailed information on how specific non-tariff measures affect busi-

[23] Data on non-tariff barriers is still relatively scarce. Most often, researchers rely on data from the TRAINS database, which is collectively published by the WTO, UNCTAD, ITC and the World Bank. It contains information about implemented non-tariff barriers at detailed HS six-digit product level, classified according to the UN MAST classification of non-tariff barriers. Another common source is the I-TIP database provided by the WTO in cooperation with UNCTAD. It also collects trade policies classified according to the UN MAST classification.
[24] See Evenett and Fritz (2017) for details.
[25] http://i-tip.wto.org/goods/Default.aspx. For a comprehensive list of measures subject to notification, see: https://www.wto.org/english/docs_e/legal_e/33-dnotf_e.htm, last accessed: 25. September 2017.

nesses. However, they are only conducted country-wide and are therefore not suitable for a cross-country comparison.

One of the greatest drawbacks of the GTA database, however, is that it only contains information on non-tariff barriers from 2009 onwards, so that no comparison with pre-crisis levels of protectionism is possible. In addition, its data collection method strongly relies on the transparency of governments publishing their policies online. For example this problem: Saudi-Arabia was listed as the least protectionist country among the G20 economies in 2015. Only after its state development fund made information about all loans and financial grants given to domestic companies publicly available, it jumped to the seventh rank in 2016 (Evenett and Fritz, 2016). Similarly, governments differ in how they announce policies. As noted by the GTA initiative, the US government tends to announce each policy separately, while European governments tend to announce policies in bundles.

Furthermore, it is important to keep in mind that the GTA database only provides indicators of whether a certain measure is implemented or not. Indicators of non-tariff barriers do not reflect the degree of protectionism. The introduction of a protective non-tariff barrier is treated equivalently to a less protective barrier. Nevertheless, only measures which are likely to impose a significant relative change on the treatment of domestic relative to foreign agents pass the six-step evaluation process and are included in the database.

We group the 31 intervention types listed in the GTA database into four groups of non-tariff barriers: (1) import controls, (2) state aid and subsidy measures, (3) public procurement and localisation requirements and (4) other non-tariff barriers, which include SPS measures, TBT and capital controls. We also use the GTA database to identify the existence of trade defence instruments including anti-dumping, anti-subsidy, safeguard and anti-circumvention policies. One potential problem for the estimation strategy is that TDIs are often implemented at a more disaggregated (HS6 or HS8 digit) level than the one observed in the data. If not all HS6 products within a CPC three digit product classification are treated, this results in an underestimation of the treatment effect. This has to be kept in mind when comparing estimated coefficients of trade effects of NTBs and TDIs. Nevertheless, the coefficients do show the overall impact of trade policy instruments on trade flows at the CPC three digit level.

A detailed overview of the types of non-tariff barriers included in this study is provided in Table C.1 in the Appendix. For each implemented trade barrier the database includes the date of implementation and the date of removal for any measure. About 20% of the measures implemented after 2009 have been removed before the end of 2015. For each non-tariff barrier that is implemented by a country, information is available about which trading partner(s) will most likely be affected by the respective measures based on past trade flows.[26] This bilateralisation of unilateral policies may trigger a potential endogeneity bias. We address this concern by applying the two-step estimation, eliminating the bilateral structure of non-tariff barriers and treating all measures as if they affect all trading partners equally. The constructed bilateral structure of non-trade barriers means that they may vary even among EU member states so that each member state is included separately, even though trade policy is set at the supranational level.

3.3.2 Other Data Sources

Data on applied tariffs at HS six-digit product level originates from TRAINS and the WTO's Integrated Database. As it is incomplete we use interpolated tariffs to cover all product lines. The MFN tariff is used as the applied tariff if there is neither a preferential trade agreement between two countries nor a tariff according to the Generalized System of Preferences. In all other cases, the preferential tariff is used as the applied tariff. Like imports, tariffs are aggregated to the CPC three-digit product classification by calculating simple averages and trade weighted averages.[27] We use simple averages across all specifications and provide estimation results using weighted tariff averages as robustness checks. An indicator of whether a free trade agreement is in place is retrieved from CEPII, which builds on free trade agreements notified to the WTO.

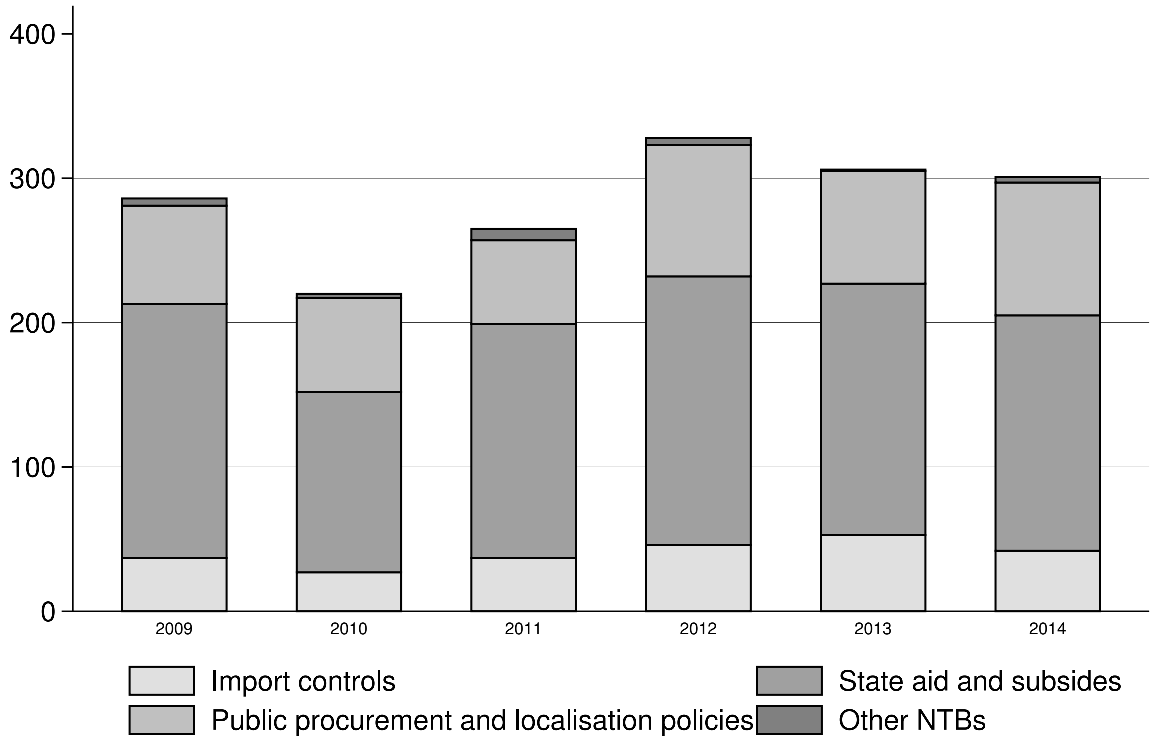
Data on bilateral imports is retrieved from BACI, which reports trade flows at the HS6 digit product level using the HS-92 classification. Trade flows are aggregated to the CPC three-digit product classification to fit the data on non-tariff barriers. Since all policy variables (non-tariff barriers, trade defence instruments and tariffs) are lagged by one year, we use imports from 2010 to 2015 and merge those with trade policy data from 2009 to 2014.

[26] For trade in goods a country is identified as being affected, if in the year prior to the implementation of the policy, exports of the respective product to the implementing country exceeded one million US-Dollars.
[27] Both aggregation methods have their disadvantages: The problem with trade-weighted averages is that extremely high tariffs with nearly no trade contribute to the weighted average in the same way as zero-tariffs with high volumes of trade. The problem of using the simple averages of tariffs is that tariffs of products with a small import share and a large import share have the same weight.

3.3.3 Development of Non-Tariff Barriers

Figure 3.1 plots the amount of newly implemented non-tariff barriers for each year. The number of NTBs implemented remains relatively stable over the sample period, averaging around 280 per year.[28] State aid and subsidy measures constitute the largest share of NTBs, followed by public procurement and localisation policies. Discriminatory SPS and TBT measures (included in "other NTBs") make up for only a very small group of non-tariff barriers.[29]

Figure 3.1: Number of newly implemented NTBs by Type (2009-2014)



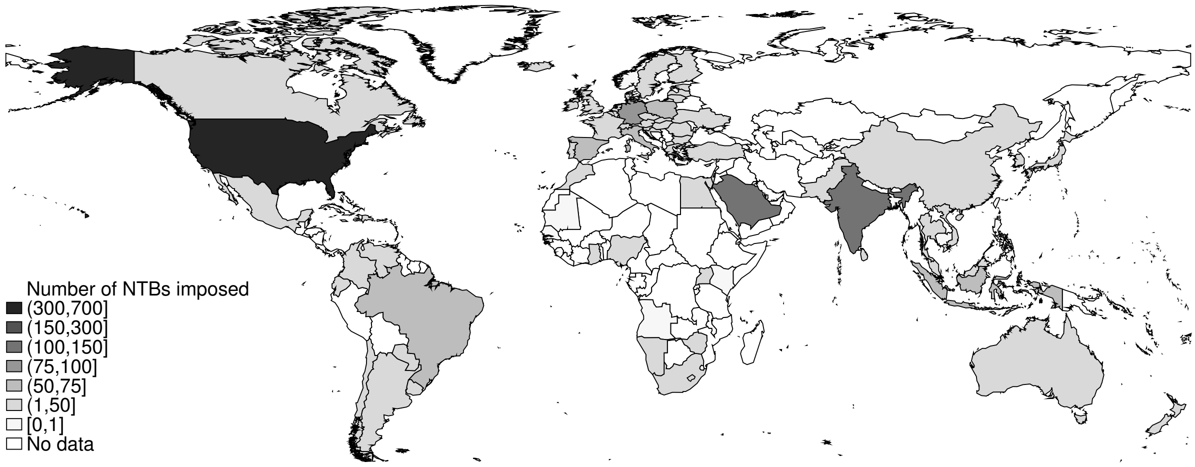
Source: Data from Global Trade Alert Database

The world map in Figure 3.2 shows the number of newly implemented non-tariff barriers by country between 2009 and 2014. It is eye-catching that the United States implemented by far the most non-tariff barriers (662). Saudi-Arabia and India, as the second and third largest users,

[28] In contrast to that, usage of trade defence instruments declined over the period of analysis. While 204 trade defence instruments were implemented in 2009, this number dropped to 140 in 2014. Among the different types of trade defence instruments, anti-dumping is by far the most often applied instrument.
[29] This stands in contrast to other data on non-tariff barriers. For example, in the I-TIP database, SPS and TBT measures are by far the most often recorded non-tariff barriers. This shows the importance of distinguishing between discriminatory and non-discriminatory NTBs.

only implemented 130 and 128 NTBs respectively. Germany and Brazil follow with 76 and 71 implemented measures.[30] Each implemented non-tariff barrier on average targets imports of 24 products and affects 40 countries. Products of electrical energy, domestic appliances and parts thereof as well as products of iron and steel are most often targeted.

Figure 3.2: Number of newly implemented NTBs by imposing Country (2009-2014)



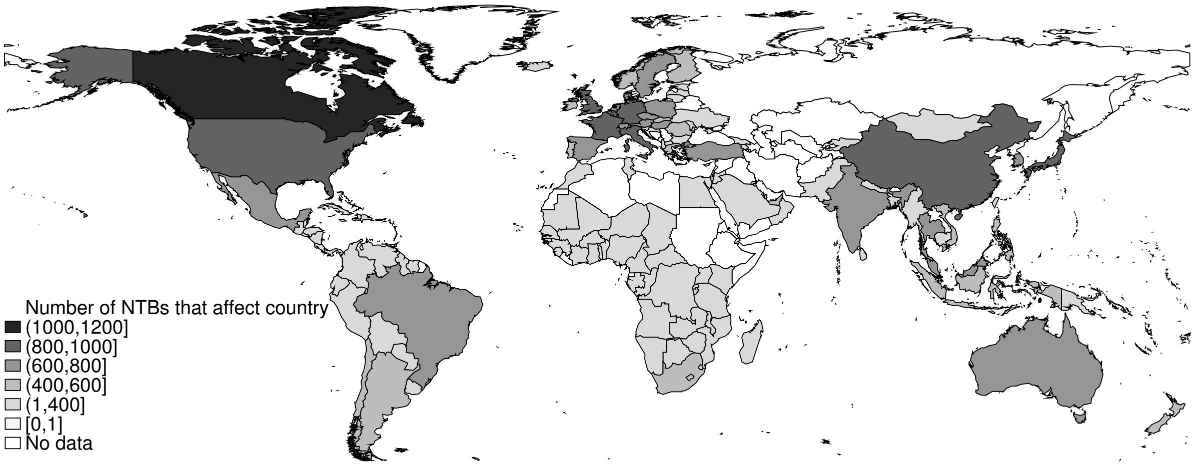
Source: Data from Global Trade Alert Database

The world map in Figure 3.3 shows how often exporters from each country were likely to be affected by a non-tariff barrier imposed by another country between 2009 and 2014. Canada, Germany and China are the three economies that were most often likely to be affected by an implemented non-tariff barrier. Accumulated, Canadian exporters were affected by 1,101, German exporters by 989 and Chinese exporters by 948 non-tariff barriers between 2009 and 2014.[31] In the majority of cases import flows are only distorted by one non-tariff barrier. There are a few outliers, where certain country-product pairs are affected by more than 10 non-tariff barriers simultaneously. Overall, 2.6% of all importer-exporter-product-time combinations in the sample faced at least one non-tariff barrier (Table C.2 in the Appendix). Trade defence instruments, including anti-dumping, countervailing duties and safeguards, were implemented in 0.3% of all observations.

[30] Most of the implemented non-tariff barriers from the United States are concentrated in the group of public procurement and localisation policies. They account for about 50% of all implemented measures worldwide. Similar, the United States is responsible for close to 40% of all state aid and subsidies measures. To a certain degree this extreme outlier might be driven by the fact that the US government tends to announce each policy separately, while for example European governments tend to announce policies in bundles. We provide a robustness check, excluding the United States from the estimation sample. Results are not driven by this outlier (see Tables 3.4 and C.3 in the Appendix).

[31] Tables C.4 and C.5 in the Appendix provide a list with the number of times a country implemented non-tariff barriers and the number of times it has been affected by a non-tariff barrier.

Figure 3.3: Number of newly implemented NTBs by Target Country (2009-2014)



Source: Data from Global Trade Alert Database

3.4 Estimation Results

3.4.1 Gravity Estimation Results

Baseline estimation results are reported in Table 3.1. Columns (1) and (2) present results using the OLS estimator. According to the most general specification in Column (1), imports decrease on average by 11.9% following the implementation of at least one non-tariff barrier.[32] This effect is significant at the 1% level. Trade defence instruments have a similarly large effect on bilateral trade flows. On average, imports of a particular product from a targeted country fall by 10.8% if at least one trade defence instrument is implemented against this product. The two coefficients are not significantly different from each other, indicating that non-tariff barriers have on average the same trade dampening effects as traditional trade defence instruments.

Tariffs also have a significantly negative effect on imports. The estimated coefficient of 0.176 means that a one percent increase in tariffs reduces the import value by 0.18%.[33] The existence of free trade agreements has a significant trade enhancing effect with a reported coefficient

[32] Percentage change = $(e^{\beta_{NTB}} - 1) * 100$.

[33] This estimate is very low and can be explained by the aggregation method (simple average) which gives every tariff the same weight, disregarding the trade volume of the related product. Using a weighted average yields a significantly larger estimated coefficient, while those of the other variables remain unchanged (see Section 3.4.2).

of 0.015 (statistically significant at the 5% level), meaning that the implementation of a free trade agreement on average increases bilateral trade at the product level by 1.5%.

Table 3.1: Estimation Results using OLS and PPML with Dummies of NTBs

	(1)	(2)	(3)	(4)
Estimation Method	OLS	OLS	PPML	PPML
Dependent Variable	ln imports	ln imports	imports	imports
ln (1 + tariff)	-0.176***	-0.175***	-0.414**	-0.414**
	(0.0596)	(0.0596)	(0.179)	(0.179)
Trade defence instruments	-0.114***	-0.111***	-0.053***	-0.053***
	(0.0175)	(0.0175)	(0.018)	(0.018)
Non-tariff barriers	-0.127***		-0.067***	
	(0.00761)		(0.026)	
Import controls		-0.117***		-0.042**
		(0.0129)		(0.021)
State aid and subsidies		-0.0558***		-0.066
		(0.0105)		(0.043)
Public procurement/localisation policies		-0.183***		-0.075***
		(0.0142)		(0.019)
Other NTBs (SPS, TBT, capital controls)		-0.108***		-0.026
		(0.0248)		(0.045)
FTA dummy	0.0153**	0.0154**	0.062***	0.062***
	(0.00648)	(0.00648)	(0.017)	(0.017)
Observations	4,405,016	4,405,016	6,810,966	6,810,966
R-squared	0.913	0.913		

Note: All estimations include importer-product-time, exporter-product-time and country-pair-product fixed effects. Standard errors are clustered at country-pair-product level. Variables for non-tariff barriers, trade defence instruments and tariffs are lagged by one year. Except for tariffs all explanatory variables enter the regression as dummies. Imports in thousand USD. *** p<0.01, ** p<0.05, * p<0.1.

Column (2) of Table 3.1 shows effects for the four disaggregated measures for non-tariff barriers using OLS. Estimated coefficients are negative and statistically significant for all types of non-tariff barriers. Public procurement and localisation policies (-0.183) have the strongest negative impact on bilateral imports. On average, bilateral imports of a particular product decrease by 17%, following the implementation of at least one public procurement or localisation policy. In contrast, state aid and subsidies (-0.0558) have the smallest negative impact on imports (-5%). Direct import controls and other NTBs (SPS, TBT and capital controls) reduce trade by 11% and 10% respectively.

Columns (3) and (4) of Table 3.1 show estimation results using the PPML estimator. While the effect of tariffs on trade increases compared to the OLS estimates (from 0.176 to 0.414), the estimated coefficients of TDIs and NTBs reported in Column (3) decrease in size by about one-half compared to the OLS estimates. According to the PPML estimation results, bilateral imports on average decrease by 6.5% if at least one non-tariff barrier is implemented. For trade defence instruments, the estimated coefficient decreases from -0.114 in the OLS estimation to -0.053 in the PPML estimation, predicting a average decrease in imports of 5% if at least one trade defence instrument is implemented. Both coefficients remain significant at the 1% level and are not significantly different from each other.[34]

Looking at the disaggregate measures of non-tariff barriers (Column 4), it is evident that only public procurement and localisation policies as well as import controls significantly affect imports, with reported coefficients of -0.075 and -0.042, respectively. State aid, subsidies and other non-tariff barriers do not significantly affect trade flows.

Estimation results using counts instead of dummies are provided in Table 3.2. Qualitatively, the results are similar to those provided in Table 3.1. Column (1) of Table 3.2 shows that tariffs, trade defence instruments as well as non-tariff barriers all reduce imports. However, the coefficients for TDIs and NTBs are now significantly different from each other, indicating that each individual trade defence instrument reduces trade eight times more than a non-tariff barrier. This is also true, albeit to a lesser extent, in the PPML estimation (Column (3) of Table 3.2). However, as shown in Table C.2 in the Appendix, NTBs (113,725 cases) were applied about nine times as often as TDIs (12,432), so that the aggregated effect is similar.

The results change when looking at the individual groups of non-tariff barriers (Column (2) of Table 3.2). The estimated coefficients for import controls and other NTBs are both about twice as large as the one for trade defence instruments (the difference is significant at the 5% level), while the coefficient for state aid is of very similar size. The small aggregate effect is driven primarily by the small and insignificant coefficient of public procurement. Interestingly, while the estimates of TDIs and Import controls both halve when estimated using PPML rather than OLS (Column 4), the estimate for state aid doubles in magnitude.

[34] The smaller coefficients might be explained by the fact that one adds a substantial amount of zero trade flows to the reference group, if the PPML estimator is applied (Anderson and Yotov (2016)). Applying the PPML estimator using the OLS sample that excludes missing trade flows however also yields smaller estimated coefficients (results reported in Column 6 of Table C.3 in the Appendix.) Therefore, the different PPML results might also be explained by the fact that the PPML estimator corrects for heteroscedasticity.

Table 3.2: Estimation Results using OLS and PPML with Counts of NTBs

	(1)	(2)	(3)	(4)
Estimation Method	OLS	OLS	PPML	PPML
Dependent Variable	ln imports	ln imports	Imports	Imports
ln (1 + tariff)	-0.174***	-0.173***	-0.415**	-0.494***
	(0.0596)	(0.0596)	(0.179)	(0.179)
Trade defence instruments	-0.0439***	-0.0411***	-0.019***	-0.019***
	(0.00957)	(0.00956)	(0.004)	(0.004)
Non-tariff barriers	-0.00519***		-0.005*	
	(0.00131)		(0.003)	
Import controls		-0.0715***		-0.037**
		(0.00862)		(0.015)
State aid and subsidies		-0.0489***		-0.076*
		(0.00789)		(0.039)
Public procurement/localisation policies		-0.00149		0.001
		(0.00134)		(0.001)
Other NTBs (SPS, TBT, capital controls)		-0.104***		-0.025
		(0.0245)		(0.044)
FTA dummy	0.0153**	0.0153**	0.063***	0.063***
	(0.00648)	(0.00648)	(0.017)	(0.017)
Observations	4,405,016	4,405,016	6,810,966	6,810,966
R-squared	0.913	0.913		

Note: All estimations include importer-product-time, exporter-product-time and country-pair-product fixed effects. Standard errors are clustered at country-pair-product level. All variables for non-tariff barriers, trade defence instruments and tariffs are lagged by one year. Except for tariffs all explanatory variables enter the regression as counts. Imports in thousand USD. *** p<0.01, ** p<0.05, * p<0.1.

3.4.2 Robustness of the Baseline Results

Since our variables of interest vary across the importer-exporter-product-time dimension, it is also possible to include importer-exporter-time fixed effects to further reduce omitted variable bias. We abstain from doing so in the baseline regression because our workhorse ppml estimator does not easily accommodate this additional dimension. However, it is possible to include importer-exporter-time fixed effects in the OLS estimation and we do so in a robustness check.

Estimates of the dummy regressions are reported in Columns (1) and (2) of Table 3.3 below. Compared to the same Columns in Table 3.1, it can be seen that the estimated coefficient of NTBs in Column (1) remains almost unchanged. The same is true for the estimates of the different types of NTBs reported in Column (2). The tariff coefficient becomes smaller and insignificant. This is not surprising since the country-pair-time dimension constitutes a main source of variation for this variable. The estimated trade dampening effect of TDIs also becomes smaller but remains strongly significant. Columns (3) and (4) of Table 3.3 report results using counts. As with the dummy regressions, coefficients for NTBs are robust relative to the Baseline, while those for TDIs become smaller in magnitude and tariff effects turn insignificant.

Table 3.3: Robustness Checks: OLS with full Fixed Effects

Trade Policy Variable	(1) Dummies	(2) Dummies	(3) Counts	(4) Counts
ln(1+tariff)	-0.0144	-0.0135	-0.0153	-0.0140
	(0.0765)	(0.0765)	(0.0765)	(0.0765)
Trade defence instruments	-0.0792***	-0.0777***	-0.0225**	-0.0202**
	(0.0180)	(0.0180)	(0.0098)	(0.0098)
Non-tariff barriers	-0.1251***		-0.0054***	
	(0.0081)		(0.0014)	
Import controls		-0.1116***		-0.0825***
		(0.0134)		(0.0092)
State aid and subsidies		-0.0590***		-0.0454***
		(0.0111)		(0.0083)
Public procurement/localisation policies		-0.1689***		-0.0017
		(0.0152)		(0.0014)
Other NTBs (SPS, TBT, capital controls)		-0.1867***		-0.1799***
		(0.0303)		(0.0299)
Observations	4,393,589	4,393,589	4,393,589	4,393,589
R^2	0.9164	0.9164	0.9164	0.9164

Note: OLS regression with ln(imports in thousand USD) as dependent variable. All estimations include importer-product-time, exporter-product-time exporter-importer-time and and country-pair-product fixed effects. Standard errors are clustered at country-pair-product level. All variables for non-tariff barriers, trade defence instruments and tariffs are lagged by one year. *** p<0.01, ** p<0.05, * p<0.1.

To test whether results depend on the aggregation method for tariffs from the HS six-digit to the CPC three-digit product level, a robustness check carries out the baseline regressions with tariff rates weighted by trade value. The results for the OLS estimation are reported in Columns (1) and (2) of Table 3.4.[35] Estimated coefficients for non-tariff barriers and trade defence instruments do not change if trade-weighted averages of tariffs instead of simple

[35] Results for the PPML estimation are reported in Column (1) of Table C.3 in the Appendix. Unless indicated otherwise, only results for aggregated NTBs are shown.

averages are used. However, as expected, the estimated trade elasticity increases substantially if weighted averages of tariffs are used.

Table 3.4: Robustness Checks: Baseline using OLS

	(1) Weighted tariffs	(2) Weighted tariffs	(3) Exporter NTBs	(4) Exporter NTBs	(5) w/o USA	(6) w/o USA	(7) Placebo	(8) Placebo
ln (1 + tariff)	-10.30**	-10.23**	-0.177***	-0.175***	-0.173***	-0.172***	0.00362	0.00215
	(4.226)	(4.225)	(0.0596)	(0.0596)	(0.0598)	(0.0598)	(0.0482)	(0.0482)
TDI	-0.114***	-0.111***	-0.111***	-0.111***	-0.113***	-0.110***	0.0471***	0.0467***
	(0.0175)	(0.0175)	(0.0175)	(0.0175)	(0.0183)	(0.0183)	(0.0156)	(0.0156)
Non-tariff barriers	-0.127***		-0.126***		-0.126***		0.151***	
	(0.00761)		(0.00761)		(0.00790)		(0.00702)	
Import controls		-0.117***		-0.117***		-0.118***		0.106***
		(0.0129)		(0.0129)		(0.0131)		(0.0107)
State aid / subsidies		-0.0559***		-0.0558***		-0.0490***		0.0978***
		(0.0105)		(0.0105)		(0.0109)		(0.00916)
Public proc./loc. pol.		-0.183***		-0.183***		-0.200***		0.147***
		(0.0142)		(0.0142)		(0.0164)		(0.0141)
Other NTBs		-0.108***		-0.108***		-0.108***		0.135***
		(0.0248)		(0.0248)		(0.0247)		(0.0258)
Exporter NTB			-0.197***	-0.196***				
			(0.0234)	(0.0234)				
FTA Dummy	0.0158**	0.0159**	0.0152**	0.0154**	0.0159**	0.0160**	0.0172***	0.0171***
	(0.00648)	(0.00648)	(0.00648)	(0.00648)	(0.00655)	(0.00655)	(0.00648)	(0.00648)
Observations	4,405,016	4,405,016	4,405,016	4,405,016	4,323,498	4,323,498	4,405,016	4,405,016
R-squared	0.913	0.913	0.913	0.913	0.911	0.911	0.913	0.913

Note: OLS regression with ln(imports in thousand USD) as dependent variable. All estimations include importer-product-time, exporter-product-time and country-pair-product fixed effects. Standard errors are clustered at country-pair-product level. All variables of non-tariff barriers, trade defence instruments and tariffs are lagged by one year. Except for tariffs all explanatory variables enter the regression as dummies.*** p<0.01, ** p<0.05, * p<0.1.

Second, non-tariff barriers imposed by the exporting country might affect both its exports as well as the importing country's decision to impose non-tariff barriers. To avoid any omitted variable bias that may result from this relationship, we use an additional dummy to control for the existence of non-tariff barriers imposed by the exporter, targeting exports to the importing country. The results are provided in Columns (3) and (4) of Table 3.4.[36] Non-tariff barriers imposed by the exporter significantly reduce imports into the importing country. However, they do not seem to simultaneously affect any other estimates. The estimated coefficients of non-tariff barriers implemented by the importing country remain robust to including this additional control variable.

Third, the United States are responsible for more than half of global public procurement and localisation policies. To ensure that our results are not driven by the US, we thus run our baseline estimation excluding the United States. Regression results are reported in Columns

[36] PPML results in Column (2) of Table C.3 in the Appendix.

(5) and (6) of Table 3.4. All coefficients remain robust, indicating that the US is not driving the results.[37]

Fourth, we conduct a placebo test, regressing bilateral imports on future changes in non-tariff barriers, using two-year leads.[38] The placebo test yields positive and significant coefficients for the non-tariff barrier variables (Columns (7) and (8) of Table 3.4).[39] This is reasonable, as it underlines the argument that non-tariff barriers are implemented in response to increasing imports. It also shows that the estimated baseline coefficients are likely to be biased towards zero, hence constituting a lower bound of the true treatment effect.

With regard to the PPML estimation, we perform an additional robustness check, excluding all missing trade flows from the sample (rather than treating them as zeros). The results are reported in Column (6) of Table C.3 in the Appendix. The estimated coefficients are very similar in magnitude and significance to the Baseline results reported in Column (3) of Table 3.1.

3.4.3 Two-Step Estimation Results

The constructed bilateral structure of non-tariff barriers based on past trade flows might lead to substantial endogeneity that biases the estimation results. In addition, the constructed bilateral structure might especially bias estimation results for those non-tariff barriers that classify as behind-the-border measures and affect all exporters equally. We address this issue by applying a two-step estimation procedure. In the first step, We estimate a standard gravity equation which omits any non-tariff barriers. In the second step, we regress the predicted importer-product-time fixed effects from the first stage on importer-product specific non-tariff barriers to assess their contribution to importer-specific trade costs.

[37] Using the PPML estimator, the estimated coefficient for the aggregate measure of non-tariff barriers decreases by about one half to -0.0288 (Column (3) of Table C.3 in the Appendix). The effect remains significant at the 10% level. Looking at the four decomposed non-tariff barriers (Column 4) however shows that the change in the aggregate coefficient is driven exclusively by State aid and subsidies, which was already insignificant in the baseline regression. The estimated coefficients for the other disaggregated measures remain similar to the baseline results in both size and significance. Public procurement and localisation policies as well as import controls remain the drivers behind the negative effect of non-tariff barriers on trade.

[38] For the last two years, 2014 and 2015, we used data on non-tariff barriers from 2009 and 2010 respectively, as no future data was available.

[39] PPML results are reported in Column (5) of Table C.3 in the Appendix.

Results for the first stage are shown in Column (1) of Table 3.5. The coefficients for tariffs, trade defence instruments and free trade agreements all remain similar to the baseline results in magnitude and significance.[40]

Table 3.5: 2 Stage Estimation Results

	1st stage	2nd stage			
	(1)	(2)	(3)	(4)	(5)
ln (1+tariff)	-0.4147**				
	(0.1788)				
Trade defence instruments	-0.0549***				
	(0.0178)				
FTA dummy	0.0616***				
	(0.0173)				
Behind-the-border measures		-0.0232**	-0.0232**		
		(0.0112)	(0.0101)		
BTB: Import controls				-0.0299*	-0.0299**
				(0.0159)	(0.0137)
BTB: Subsidies / state aid				0.0063	0.0063
				(0.0140)	(0.0134)
BTB: Puplic proc. / loc. pol.				-0.0184	-0.0184
				(0.0234)	(0.0191)
BTB: Others				0.0357	0.0357
				(0.0627)	(0.0654)
R^2	0.9899	0.9495	0.9495	0.9495	0.9495
Standard errors	cluster: ijk	cluster: jk	bootstrapped	cluster: jk	bootstrapped

Note: Dependent variable: Import value in thousand USD (1st Stage) and importer-product-time fixed effects (2nd stage). The 1st stage ppml estimation includes importer-product-time, exporter-product-time and country-pair-product fixed effects. Standard errors are clustered at country-pair-product level. The 2nd stage OLS estimations include importer-time, product-time and importer-product fixed effects. Standard errors are either clustered at country-product level or bootstrapped. All explanatory variables except for the FTA dummy are lagged by one year. Except for tariffs all explanatory variables enter the regression as dummies. *** p<0.01, ** p<0.05, * p<0.1.

In the second stage, importer-product-time fixed effects are regressed on a dummy indicating the existence of at least one non-tariff barrier, controlling for importer-product, importer-time and product-time fixed effects. We assume that any implemented non-tariff barrier affects all

[40] Importer-product-time fixed effects are predicted using the gen(M) option of the ppml_panel_sg command from stata. The gen(M) option produces exponentiated importer-product-time fixed effects (Larch et al., 2017). Therefore, we use the logarithm of the predicted fixed effects in the second stage as the dependent variable. Taking the logarithm excludes all fixed effects that are zero. This is not problematic since fixed effects of the value zero do only occur, if an importer did not import any goods of a respective product at time t. After taking the logarithm, the predicted fixed effects vary between -22.9 and 15.53. The average predicted fixed effect is -0.97. 147,667 non-zero fixed effects are predicted.

exporters equally and therefore we refer to it as behind-the-border barrier.[41] The estimated coefficient can be interpreted as the average change in importer market access caused by at least one implemented non-tariff barrier. Due to the potential heterogeneity contained in the error term from the predicted fixed effects from the first stage we report standard errors once clustered at the importer-product level and once bootstrapped.[42]

Results of the second stage regression are reported in Table 3.5. Importer-product market access on average decreases by 2.3% following the implementation of at least one behind-the-border measure (Columns 2 and 3). This effect is significant at the 5% level regardless of whether standard errors are clustered at importer-product level or bootstrapped. Looking at the disaggregated measures of non-tariff barriers (Columns 4 and 5) it becomes clear that the aggregate effect is driven by import controls. While these findings confirm the baseline result that NTBs in general and import controls in particular negatively affect trade, they do not offer evidence that all types of non-tariff barriers are effective in reducing imports.

3.5 Conclusion

Our empirical analysis provides evidence that non-tariff barriers significantly decrease the level of trade. For the period from 2010 to 2015, our baseline results show that non-tariff barriers implemented by a country reduce imports of affected products from targeted exporters by 6% to 12%, depending on the estimation method used. While an individual NTB does not reduce trade as much as a traditional trade defence instrument, taking into account the number of implemented non-tariff barriers, their effect on trade is comparable to that of traditional TDIs such as anti-dumping, countervailing duties or safeguards.

When looking at individual NTBs, it is demonstrated that import controls significantly reduce imports across all specifications. Specifically, the implementation of one additional import control reduces trade by 4% to 7%, so that imports fall on average by 4% to 11% if at least one import control is implemented. Public procurement and localisation policies have an even

[41] By making this assumption the constructed bilateral structure of the GTA dataset becomes irrelevant. The sample size naturally is much smaller than in the first stage, as the exporter-dimension is dropped. In total 147,667 observations are included.

[42] If the bootstrapping method is used, the estimation is repeated 100 times for different draws from the estimation sample. Each time a sample of the same size of the estimation sample is drawn. Observations can be included more than once in the drawn sample. Bootstrapping ensures that standard errors are estimated consistently.

larger average effect (7% to 17%), although evidence is less robust when it comes to marginal effects of one additional such policy. State aid and subsidies as well as other non-tariff barriers (SPS, TBT and capital controls) also reduce imports by up to 5% and 10% respectively, even though their effect is less robust to changes in the estimation method. Overall the results illustrate the importance of exploiting new data on non-tariff barriers as they reveal the significant protectionist impact of non-standard trade policies.

Methodologically, this study applies a two-step estimation procedure to identify trade effects caused by behind-the-border measures. The two-step estimation confirms that non-standard trade policies are important determinants of the trade costs faced by the importer. Implementing at least one behind-the-border measure that discriminates all exporters equally on average reduces market access of the importer by 2%.

The results imply that the WTO should follow recent developments in bilateral trade agreements. More precisely, it should shift its focus towards multilateral agreements that aim at limiting the use of non-tariff barriers to avoid the increase in hidden protectionism that might otherwise result in lower levels of trade and thus welfare.

Appendix C.1 Additional Tables

Table C.1: Overview of Types of Non-Tariff Barriers and Trade Defence Instruments

Non-tariff barriers	
(1) Import controls	**(3) Public procurement and localisation policy**
Import ban	Public procurement access
Import incentive	Public procurement localisation
Import licensing requirement	Public procurement preference margin
Import monitoring	Local operations
Import quota	Local sourcing
Import tariff quota	Localisation incentive
Import-related non-tariff measure, nes	
Internal taxation of imports	**(4) Other non-tariff barriers**
Trade balancing measure	Competitive depreciation
Trade payment measure	Price stabilisation
	Instrument unclear
(2) State aid and subsidies	Sanitary and phytosanitary measure
Bailout (capital injection or equity participation)	Technical barrier to trade
Financial assistance in foreign market	
Financial grant	
In-kind grant	
Interest payment subsidy	**Types of trade defence instruments**
Loan guarantee	**Trade defence instruments**
Production subsidy	Anti-circumvention
State aid, nes	Anti-dumping
State loan	Anti-subsidy
Tax or social insurance relief	Safeguard

Source: Data from Global Trade Alert Database

Table C.2: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Imports in thousand USD	19725.189	317480.117	1	97142264	4,405,016
Tariff (simple average, in percent)	6.28	20.066	0	2314.286	4,405,016

		Count	Percent
Trade defence instruments	0	4,392,584	99.7
	1	12,432	0.3
Non-tariff barriers	0	4,291,291	97.4
	1	113,725	2.6
Import controls	0	4,368,891	99.2
	1	36,125	0.8
State aid & subsidies	0	4,365,324	99.1
	1	39,692	0.9
Public procurement & localisation policies	0	4,367,799	99.2
	1	37,217	0.8
Other NTBs (SPS, TBT, capital controls)	0	4,390,576	99.7
	1	14,440	0.3

Source: Data from Global Trade Alert Database

Table C.3: Robustness Checks: Baseline using PPML

	(1) Weighted tariffs	(2) Exporter NTBs	(3) w/o USA	(4) w/o USA	(5) Placebo	(6) w/o missing trade
ln (1 + tariff)	-28.37**	-0.413**	-0.433**	-0.434**	-0.311*	-0.405**
	(12.76)	(0.179)	(0.182)	(0.182)	(0.175)	(0.176)
Trade defence instruments	-0.0532***	-0.0529***	-0.0498**	-0.0476**	0.0319**	-0.0539***
	(0.0178)	(0.0178)	(0.0229)	(0.0229)	(0.0128)	(0.0178)
Non-tariff barriers	-0.0672***	-0.0672***	-0.0288*		0.0515***	-0.0547**
	(0.0259)	(0.0259)	(0.0165)		(0.0129)	(0.0256)
Import controls				-0.0480**		
				(0.0218)		
State aid and subsidies				-0.000202		
				(0.0240)		
Public procurement/localisation policies				-0.0823***		
				(0.0230)		
Other NTBs (SPS, TBT, capital controls)				-0.0277		
				(0.0436)		
Non-tariff barriers by impl. by exporter		-0.0563**				
		(0.0253)				
FTA Dummy	0.0626***	0.0617***	0.0728***	0.0731***	0.0666***	0.0578***
	(0.0173)	(0.0173)	(0.0170)	(0.0170)	(0.0173)	(0.0159)
Observations	6,810,966	6,810,966	6,703,950	6,703,950	6,810,966	4,660,786

Note: PPML regression with imports in thousand USD as dependent variable. All estimations include importer-product-time, exporter-product-time and country-pair-product fixed effects. Standard errors are clustered at country-pair-product level. All variables of non-tariff barriers, trade defence instruments and tariffs are lagged by one year. Except for tariffs all explanatory variables enter the regression as dummies. *** p<0.01, ** p<0.05, * p<0.1.

Table C.4: NTBs by Country (2009 - 2014)

Country	Number of implemented NTB's	Number of times country is affected by NTB	Country	Number of implemented NTB's	Number of times country is affected by NTB
Afghanistan	0	0	Korea (DPR)	0	0
Albania	0	159	Congo (DR)	0	17
Algeria	0	0	Ecuador	9	125
American Samoa	0	0	Egypt	6	387
Andorra	0	0	El Salvador	0	40
Angola	1	22	Equatorial Guinea	0	0
Anguilla	0	0	Eritrea	0	0
Antigua and Barbuda	0	7	Estonia	21	318
Argentina	38	467	Ethiopia	0	0
Armenia	1	8	Fiji	0	14
Aruba	0	0	Finland	25	584
Australia	3	661	France	48	938
Austria	32	742	French Polynesia	0	0
Azerbaijan	0	0	Gabon	0	13
Bahamas	0	0	Gambia	1	4
Bahrain	0	212	Georgia	0	235
Bangladesh	1	138	Germany	76	989
Barbados	0	13	Ghana	3	34
Belarus	0	0	Greece	31	427
Belgium	34	823	Grenada	0	2
Belize	0	13	Guam	0	0
Benin	0	11	Guatemala	0	234
Bermuda	0	0	Guinea	0	7
Bhutan	0	0	Guinea-Bissau	0	2
Bolivia	0	34	Guyana	0	16
Bosnia and Herzegovina	0	0	Haiti	0	12
Botswana	0	17	Honduras	0	43
Brazil	71	674	Hong Kong	1	602
Brunei Darussalam	0	10	Hungary	23	608
Bulgaria	26	338	Iceland	2	143
Burkina Faso	0	10	India	128	683
Burundi	0	4	Indonesia	63	548
Cambodia	1	76	Iran	0	0
Cameroon	0	28	Iraq	0	0
Canada	17	1101	Ireland	32	581
Cape Verde	0	4	Israel	2	519
Cayman Islands	0	0	Italy	54	927
Central African Republic	0	3	Ivory Coast	0	30
Chad	0	7	Jamaica	0	25
Chile	2	431	Japan	29	802
China	42	948	Jordan	0	64
Taiwan, Province of China	0	47	Kazakhstan	0	0
Colombia	13	321	Kenya	1	42
Comoros	0	0	Kiribati	0	0
Congo	0	19	Kuwait	1	68
Costa Rica	0	297	Kyrgyzstan	1	6
Croatia	11	247	Laos	0	0
Cuba	0	26	Latvia	23	301
Cyprus	20	136	Lebanon	0	0
Czech Republic	28	634	Lesotho	0	10
Denmark	35	678	Liberia	0	0
Djibouti	0	1	Libya	0	0
Dominica	0	6	Liechtenstein	0	12
Dominican Republic	2	288	Lithuania	21	218

Table C.5: NTBs by Country (2009 - 2014), continued

Country	Number of implemented NTB's	Number of times country is affected by NTB	Country	Number of implemented NTB's	Number of times country is affected by NTB
Luxembourg	11	435	Saint Lucia	0	5
Macao	0	1	Saint Pierre and Miquelon	0	0
Macedonia	2	175	Saint Vincent and the Grenadines	0	3
Madagascar	0	32	Samoa	0	0
Malawi	0	10	San Marino	0	0
Malaysia	6	601	Sao Tome and Principe	0	0
Maldives	0	6	Saudi Arabia	130	349
Mali	0	7	Senegal	1	30
Malta	9	119	Serbia	0	0
Marshall Islands	0	0	Seychelles	0	0
Mauritania	1	11	Sierra Leone	0	8
Mauritius	0	31	Singapore	0	605
Mayotte	0	0	Slovakia	22	480
Mexico	8	632	Slovenia	30	393
Micronesia	0	0	Solomon Islands	0	7
Mongolia	0	8	Somalia	0	0
Montenegro	0	0	South Africa	16	526
Montserrat	0	0	South Sudan	0	0
Morocco	3	138	Spain	52	768
Mozambique	0	97	Sri Lanka	6	101
Myanmar	0	43	Palestine, State of	0	0
Namibia	4	26	Suriname	0	55
Nauru	0	0	Swaziland	0	42
Nepal	0	30	Sweden	28	784
Netherlands	34	765	Switzerland	2	724
Netherlands Antilles	0	0	Syrian Arab Republic	0	0
New Caledonia	0	0	Tajikistan	0	0
New Zealand	2	452	Tanzania, United Republic of	0	31
Nicaragua	0	37	Thailand	3	690
Niger	0	3	Timor-Leste	0	0
Nigeria	12	86	Togo	1	22
Niue	0	0	Tokelau	0	0
Norway	1	521	Tonga	0	1
Oman	0	280	Trinidad and Tobago	0	253
Pakistan	13	297	Tunisia	0	171
Palau	0	0	Turkey	7	644
Panama	1	114	Turkmenistan	0	0
Papua New Guinea	0	25	Turks and Caicos Islands	0	0
Paraguay	5	39	Tuvalu	0	0
Peru	0	170	Uganda	2	19
Philippines	1	480	Ukraine	17	395
Pitcairn	0	0	United Arab Emirates	0	511
Poland	60	626	United Kingdom	39	915
Portugal	31	553	United States of America	662	833
Qatar	0	78	Uruguay	2	159
Korea (Republic of)	10	746	Uzbekistan	0	0
Moldova (Republic of)	0	24	Vanuatu	0	0
Sudan	0	0	Venezuela	14	299
Romania	24	523	Vietnam	13	494
Russian Federation	0	0	Western Sahara	0	0
Rwanda	0	4	Yemen	0	0
Saint Helena	0	0	Zambia	0	52
Saint Kitts and Nevis	0	2	Zimbabwe	3	205

4 Where has the Rum gone? Firms' Choice of Transport Mode under the Threat of Maritime Piracy*

4.1 Introduction

With 180 incidents in 2017 which lead to 166 crew members being taken hostage or kidnapped and three killed, maritime piracy remains a real threat to international merchant shipping (ICC IMB, 2018).[1] Beyond the risk faced by the crew, piracy increases the cost carried by shipping companies, including higher wage premia, a rise in insurance payments due to a lower expected value of a shipment (since it may be damaged or sunk with a higher probability), ransom payments, as well as the actual cost of protecting the ship through military escorts, armed guards, electric fencing, razor wire, water cannons, non-lethal laser or acoustic devices (Towergate Insurance, 2018; Gilpin, 2009). Increased fuel and time cost of altering routes can also be substantial. For example, routing around the Strait of Malacca - one of the world's busiest sea lanes and frequently prone to pirate attacks - would mean a detour of about 1,000 nautical miles (Berg et al., 2006). Estimates for the direct costs of piracy due to such measures range from 7 billion USD to 12 billion USD in 2010 (Bowden et al., 2010).[2]

This paper combines Chinese firm-level customs data with data on maritime piracy to investigate how exporting firms respond to such piracy induced costs. They cannot be modelled as iceberg transport costs because they are transport mode specific - goods shipped by air are not subject to pirate attacks - and accrue per journey, as one military escort or security staff is required per ship, no matter whether the latter runs at full capacity. The paper shows that pirate activity on a certain trade route induces firms to change transportation mode, shipping

* This chapter is based on joint work with Shuyao Yang. We would like to thank our supervisor Gabriel Felbermayr for his support throughout this project. We are also grateful to participants of the ifo Center for International Economics Internal Seminar for their helpful comments and suggestions.

1 The reasons for piracy are manifold and include traffic along particular trade routes, economic conditions (Percy and Shortland, 2009; Cariou and Wolff, 2011), inadequate government action against piracy (Hastings, 2009; Chalk, 2008), geographic position, weak judicial systems and political instability (Murphy, 2007). For an overview, definitions and historical context the reader is referred to Mejia et al. (2012).

2 Indirect costs of piracy range from threatening the participation of neighbouring states in maritime trade, tourism and fishery (Mbekeani and Ncube, 2011) to an increase in corruption and thus weakening of the legitimacy of governments and even potentially environmental disasters as pirates attack oil tankers or ships carrying toxic chemicals (Chalk, 2008).

some of their goods by plane rather than by ship. The remaining average shipments per firm however become larger and average producer prices fall, indicating that exporters absorb parts of the costs. Despite these compensating activities, overall exports from China decline on routes affected by piracy.

The paper relates to two strands of literature. The first strand concerns the determinants of firms' choice of transportation mode and has already attracted significant research attention. At the macro level, Hummels (2007) discusses how declining transport costs such as the spread of containerization have contributed to an increase in international trade. Correspondingly, this paper shows that an increase in transportation costs on specific ocean routes due to pirate activity reduces bilateral trade flows along the affected routes.

Harrigan (2010) develops a Ricardian model to investigate the interaction between trade, transport cost and the choice of transport mode and tests its predictions using US import data. Beyond the finding that goods with high unit values are more likely to be shipped by air, the author demonstrates that countries more distant from the destination market have a comparative advantage in lightweight goods. Related to that, Hummels and Schaur (2013) model a firm's choice between air and ocean transportation, showing that more time sensitive goods are more likely to be shipped by air. Ge et al. (2014) use Chinese customs data to investigate the choice of transport mode at the firm-level, finding that high productivity firms are more likely to ship goods by air, indicating that they specialise in time sensitive high value products.

Part of the cost of piracy comes from additional shipping time due to re-routing of vessels to avoid areas with pirate activity. For example, a round voyage of a container ship from Singapore to Rotterdam takes on average 33 days if travelling via the Suez Canal and 42 days if travelling around the Cape of Good Hope (Bendall, 2010). Such an increase in shipping time constitutes one explanation for the decision of exporting firms to switch from ocean to air transport.

This paper also relates to the work of Kropf and Sauré (2014). The authors construct and empirically test a model of the relationship between fixed costs per shipment and a firm's choice regarding the size and frequency of shipments. In line with their results, this paper finds that a piracy induced increase in fixed costs per shipment reduces shipment frequency and increases shipment size.[3] An alternative channel through which pirate activity may affect trade and the choice of shipment mode is through uncertainty. Békés et al. (2017) show that firms tend to send less frequent but larger shipments to more uncertain markets. Piracy increases uncertainty by increasing the probability of losing a ship at sea. In line with Békés et al. (2017), it is hence not surprising to see exporters responding to piracy by reducing the number of shipments while increasing their size.

The second strand of literature this paper relates to concerns the effects of piracy on trade in general and firms' choice of transport mode in particular. A good overview is provided by Endler et al. (2012), who also show that most studies are either descriptive or focus on a particular region. For example, Bendall (2010) specifically calculates the costs of re-routing ships from the Suez Canal to the Cape of Good Hope using a model of shipping costs. Using OECD data on maritime transport costs, Bensassi and Martínez-Zarzoso (2013) estimate the effects of piracy on transport cost. The authors find that the hijacking of one additional ship between Europe and Asia increases transport costs between the two continents by 1.2%. However, the authors do not discuss the implications of such increases in costs on prices and the choice of transport mode. This paper shows how piracy affects producer prices, the choice of shipment mode as well as the size of shipments.

Fu et al. (2010) construct a model of the container liner shipping market in order to investigate the impact of piracy on trade volumes. The authors find that Somali pirates have reduced traffic between Europe and the Far East through the Suez Canal by about 30%. As only some of this traffic is rerouted via the Cape of Good Hope, the annual loss is estimated to be around 30 billion USD. Bensassi and Martínez-Zarzoso (2012) estimate a gravity model, finding that 10 additional vessels being hijacked reduce exports by 11%. Both studies focus on trade between Europe and Asia. This paper extends the scope by considering the universe of Chinese exports to all destination countries to empirically investigate the effects of piracy on trade. Moreover, it separately investigates effects on ocean and air trade.

[3] The term "shipment size" in this paper refers to the size of the transaction reported in the customs data. It is not the same as the amount of goods carried by a ship. Costs for military escorts or higher wages for the crew increase the cost of a ship's journey. If these additional costs are divided across containers, the costs of shipping an additional container increases from the perspective of the exporter, thus providing her with an incentive to use its entire capacity.

The remainder of this paper is structured as follows. Section 4.2 presents the data used, while Section 4.3 discusses the empirical strategy. Section 4.4 presents the results, followed by robustness checks in Section 4.5. Section 4.6 concludes.

4.2 Data

To investigate the impact of piracy on trade and the choice of transport mode, this paper uses Chinese customs data, which provides information on monthly export transactions at the firm-product(8 digit)-destination-country level for the period 2000 to 2006. Crucially, for every transaction it also reports the main transport mode employed. While value in USD and quantity are reported directly, unit values are imputed by dividing value by quantity. Since export values are reported free on board, unit values can be interpreted as producer prices.

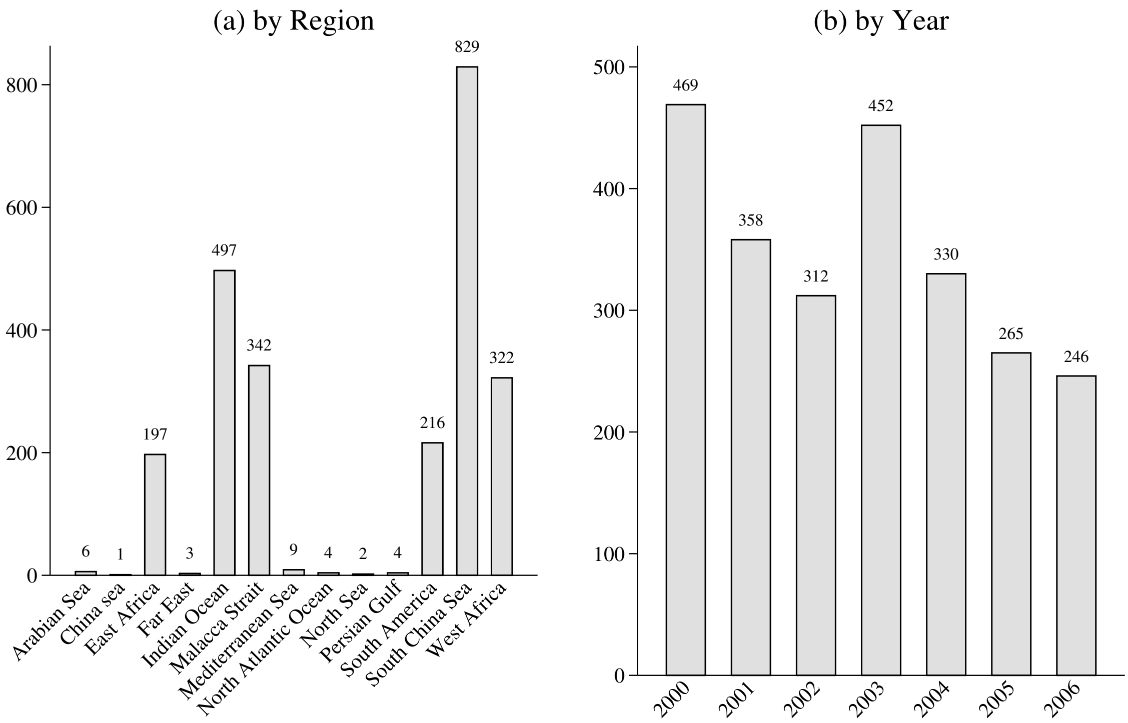
Overall, the Chinese customs data differentiates between six different modes of transport of which we use "sea and river" and "air". We abstain from using "rail" and "road" for two reasons. First, transportation by land is restricted primarily to Asia. Second, it may also be subject to armed robberies that may or may not correlate with pirate activity. For the final two modes "mail" and "other", it is not clear how they are transported, which is why they are excluded from the analysis.

Data on piracy is taken from the International Maritime Organisation which provides monthly reports on piracy incidents (allegedly committed and attempted attacks) in 13 different geographical areas. Panel (a) of Figure 4.1 shows the total number of pirate incidents between 2000 and 2006 by region. With only one observed case in the China Sea and 497 in the Indian Ocean, the figure indicates substantial cross sectional variation.

The three regions most affected by piracy in the period under investigation are the South China Sea with an average of 118 incidents per year, the Indian Ocean (71 incidents per annum) and the Strait of Malacca (49 incidents per annum). Piracy along the Coast of Somalia (East Africa, 29 incidents per year) is not among the top three affected regions, as pirate activity there only increased dramatically in 2008 and 2009. We choose not to extend our analysis to these years for two reasons. First, export data for the years 2007 to 2009 are available only at the annual level. However, aggregating to the annual level would substantially reduce variation over time. In addition, it is possible that the financial crisis affected different trade routes differently, which could bias our estimated treatment effect.

The number of pirate incidents by year is reported in Panel (b) of Figure 4.1. It indicates a declining trend which is however interrupted by sudden increases. A more detailed breakdown of pirate incidents by region and year is provided by Figure D.1 in the Appendix. It shows that while piracy declined in some regions such as the South China Sea, it actually increased in others such as East Africa. Since not all piracy incidents are reported (Berg et al., 2006; Murphy, 2007), all numbers constitute a lower bound for piracy activity.

Figure 4.1: The Number of Piracy Incidents by Region and Year

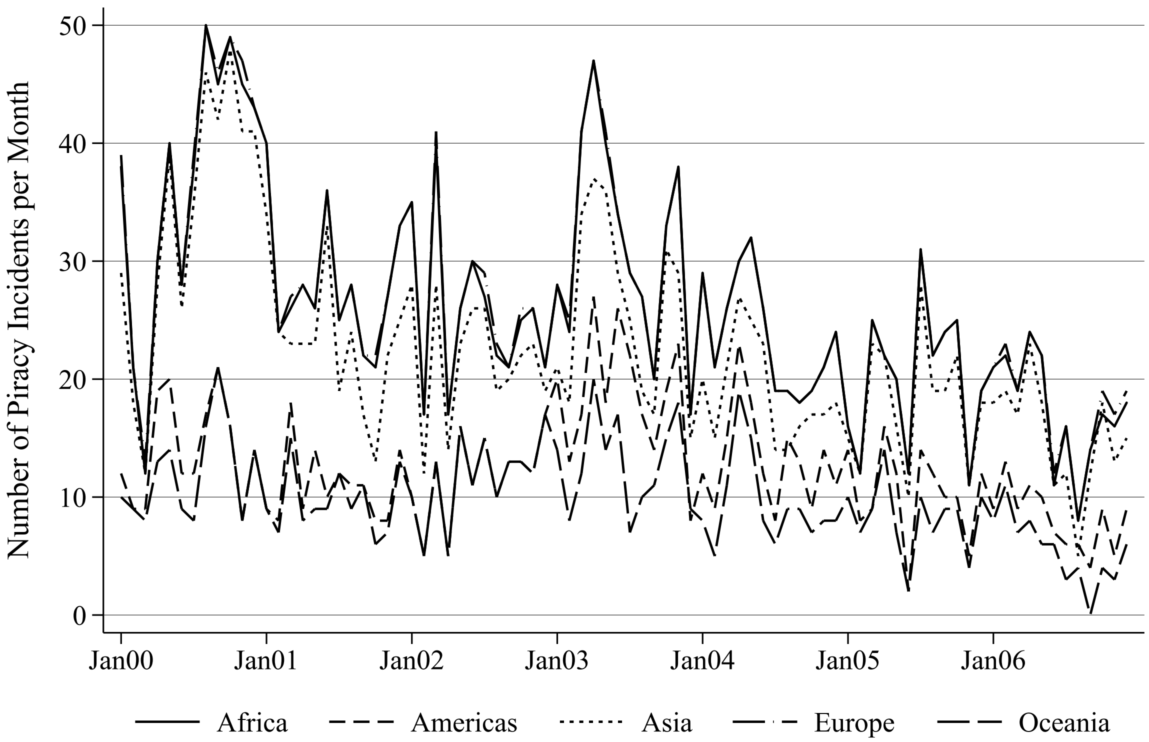


Note: Panel (a) shows the total number of piracy incidents from 2000 - 2006 by region. Panel (b) shows the total number of piracy incidents over all regions by year. *Source:* Data from International Maritime Organisation.

Matching the Chinese customs data with the piracy data is a challenge because the former does only report the destination country, not the exact route taken. For example, goods can be shipped from China to France either through the Suez Canal or by going around Africa along the Cape of Good Hope. The choice of route depends on several factors, including distance, weather conditions, duties, whether or not the ship calls at certain ports for loading and unloading of additional freight and of course the risk of piracy. It is thus not evident which route a ship takes.

This paper applies a conservative approach, considering all possible ocean routes between China and the continent to which the destination country belongs. The number of piracy cases on the route between China and the destination continent is taken to be the sum of all piracy incidents in all areas covered by the possible ocean routes. Information on the exact matching between areas affected by piracy and destination continent is provided in Table D.1 in the Appendix. Even though this reduces the cross sectional variation in piracy incidents to five continents, Figure 4.2 nevertheless shows that there remains significant variation both across continents and over time. The average number of piracy incidents per month between 2000 and 2006 was 26 along all routes to Africa, 12 for America, 22 for Asia, 26 for Europe and 10 for Oceania.

Figure 4.2: The Number of Piracy Incidents over Time by Destination Continent



Note: The graph shows the total number of reported piracy incidents per month, covering all possible routes from China to each of the five destination continents. *Source:* Data from International Maritime Organisation.

There are two obvious drawbacks to this approach. First, it is possible that all or most piracy incidents are observed at a route which is not the preferred route anyway. In this case, the choice of shipment mode should be independent of the piracy incidents, leading to an underestimation of the treatment effect. The results presented in this paper should thus be seen as a lower bound of the effect and a first step towards estimating the impact of piracy on trade and the choice of transport mode.

Second, it is impossible to observe a switch in shipping routes, which also constitutes a plausible response to piracy. A switch from one route to another due to increased pirate activity along the first one would not be picked up by the regressions, as the variation takes place at a more disaggregated level than the one observed in the data. However, a switch from one ocean route to another ocean route would affect neither air travel nor the overall value of goods shipped by ocean. While the effect of piracy on the choice of ocean routes is an interesting research question in itself, the fact that it cannot be observed in the data should not lead to an underestimation of the treatment effect when evaluating the effect of piracy on overall trade as well as the choice of transport mode. However, this is only true as long as diversion to different routes does not increase demand for shipping services and thus transport costs along that alternative route, thus affecting the amount of goods shipped.

4.3 Estimation Strategy

The effect of piracy on the choice of transport mode is estimated as follows:

$$Y_{cpft} = \beta_1 Piracy_{tc} + \beta_2 ln\, p_{cpft} + \nu_{cpf} + \nu_{pft} + \epsilon_{cpft}, \tag{4.1}$$

where Y_{cpft} is a dummy (henceforth "ocean dummy") that equals one if a shipment to country c from firm f of good p at time t is carried out by ship and zero otherwise. In an alternative specification, Y_{cpft} is the natural logarithm of the size of the transaction. Since we are using monthly data, a time-unit equals a particular month in a particular year. $Piracy_{tc}$ is the number of piracy incidents on the route to country c at time t, $\ln p_{cpft}$ is the natural logarithm of the unit value of the transaction, ν_{cpf} and ν_{pft} are destination country-product-firm and product-firm-time fixed effects respectively and ϵ_{cpft} is an error term.

Using the natural logarithm of transaction size as dependent variable and controlling for country-product-firm fixed effects ensures that the piracy coefficient β_1 identifies how the average quantity of product p shipped by firm f to country c changes with every additional piracy incident along a route connecting China to destination country c. Using the ocean dummy as dependent variable, β_1 informs about the effect of piracy on the choice of shipment mode.

Country-product-firm fixed effects also control for all unobserved time invariant variables that may correlate with both the dependent variable and the number of piracy incidents, thus ruling out one possible source of omitted variable bias. In particular, some routes are more likely to experience piracy than others. One reason for this could be geography - natural harbours provide a good basis for piracy operations. Another is the popularity of the route as those with a lot of traffic might either attract piracy (greater likelihood of capturing a ship) or deter it (ships in distress may quickly call for help). However, while popular routes with large trade values may or may not cause increased piracy activity, this relationship is less likely to hold at the firm-transaction-level. Average shipment size and value (per container) should not affect piracy on the route. Nevertheless, any remaining correlation is controlled for by using country-product-firm fixed effects.

Global economic conditions might constitute another source of omitted variable bias. In particular, a strong global economy might be associated with an increase in shipping activity as well as a decline in pirate activity under the assumption that the latter is correlated with economic hardship. Similarly, seasonality might play a role as seasonal weather conditions simultaneously affect shipping and piracy activity. Both factors can be controlled for by using product-firm-time fixed effects, which also account for unobserved product-firm specific time trends.

Since we are also interested in the effect of piracy on total trade, we regress total export quantity at the product-country-time-level (thus aggregating over all firms) on the number of piracy incidents according to the following equation:

$$\ln Y_{cpt} = \beta_1 Piracy_{(t-3)c} + \nu_{cp} + \nu_{cy} + \nu_{cm} + \nu_{pt} + \epsilon_{cpt}, \tag{4.2}$$

where $\ln Y_{cpt}$ is the natural logarithm of total quantity shipped of product p to country c at time t. Since such an estimation may be subject to simultaneity as more popular trade routes are more likely to attract piracy, the number of piracy incidents $Piracy_{tc}$ is lagged by three months. This might only pose a partial solution if trade per route is correlated over time. We therefore also use country-product fixed effects to account for all time invariant factors as well as country-year fixed effects. Seasonality is controlled for using country-month fixed effects and product-time fixed effects control for global as well as product specific time trends.[4] Hence, the estimated coefficient β_1 tells us how total exports of a particular product p to a particular country c change at a point in time t if the number of piracy incidents has changed three months ago.

4.4 Results

4.4.1 Firm-level Regressions

The baseline results of the firm-level regressions are reported in Table 4.1. The first column shows results from regressing the ocean dummy, which identifies whether a transaction has been carried out by ship as opposed to air, on the number of piracy incidents as well as controls. The coefficient of $\ln price$ is negative and significant at the 1% level, indicating that a one percent increase in unit values is a associated with a reduction in the likelihood of the transaction being carried out by sea by 4.5%. Qualitatively, this result is in line with the finding of Harrigan (2010).

Table 4.1: The Effect of Piracy on the Choice of Transport Mode

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Ocean Dummy	ln quantity All	ln quantity Ocean	ln quantity Air	ln price All	ln price Ocean	ln price Air
Piracy cases	-0.0002***	0.0007***	0.0014***	-0.0001	-0.0002*	-0.0002*	-0.0001
	(0.0000)	(0.0003)	(0.0003)	(0.0009)	(0.0001)	(0.0001)	(0.0004)
ln price	-0.0453***	-0.6740***	-0.6851***	-0.5159***			
	(0.0008)	(0.0041)	(0.0039)	(0.0079)			
Observations	10,650,883	10,614,099	8,127,057	1,437,225	10,650,883	8,136,755	1,461,519
R^2	0.5799	0.8025	0.8597	0.8592	0.9585	0.9673	0.9558
Clusters	978225	975291	820381	152990	978225	821182	155136

Note: OLS regressions with country-product-firm and product-firm-time fixed effects. Robust standard errors clustered by country-product-firm in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

[4] "Month" in this context means January - December, whereas "time" is a year-month combination, e.g. January 2000.

The negative piracy coefficient of -0.0002 is significant at the 1% level and indicates that one additional pirate incident on a particular route reduces the probability that a given firm ships a given product to a particular country by ship by 0.02%. This result provides evidence that increased pirate activity induces firms to reduce the number of transactions carried out by ship relative to those by plane.

Column 2 of Table 4.1 presents the effects of piracy on average shipment size across both ocean and air shipments. The statistically significant coefficient of 0.0007 means that the average quantity shipped increases by 0.07% for each pirate incident on a route. This coefficient is twice as large when only looking at goods shipped by sea (Column 3), while it turns insignificant when only considering air shipments (Column 4). Together with results in Column 1, this implies that piracy induces firms to reduce the number of shipments by sea relative to air and to increase the size of the remaining shipments. As stated in Section 4.1, one explanation for this observation is the fact that the additional costs of piracy accrue per journey and are thus not ad-valorem. In order to minimise costs per ton shipped, ships have an increased incentive to run at full capacity. If they charge more per container, firms have an increased incentive to fill them, thus explaining increased average shipment size.

Column 5 of Table 4.1 shows regression results from regressing $\ln price$ on the number of pirate incidents. The coefficient of -0.0002 is significant at the 10% level and indicates that average unit values per shipment fall in the presence of piracy on a given route. This observation may also be explained through the costs associated with piracy. Depending on the elasticity of demand, the increase in transport costs will only partially be passed through to consumers, so that exporters reduce producer prices. As shown by Column (6), this effect is driven by goods shipped by sea. There is no evidence for a change in unit values of goods shipped by air (Column 7).

4.4.2 Product-level Regressions

Table 4.2 presents regression results at the product-level. The significantly negative coefficient of -0.0009 reported in Column (1) means that one additional case of piracy along a particular route is associated with a 0.1% fall in exports to all countries on that route. Looking at Column (2), it can be seen that this aggregate trade effect is driven by a reduction in ocean trade. While ocean trade declines by 0.1%, the respective coefficient for air trade (Column (3)) is, while identical in magnitude, not significantly different from zero. Looking at Figure 4.2, that means that in an average month with 26 piracy cases along the route to Europe, trade is around 2.3% lower than in the absence of piracy.

Table 4.2: The Effect of Piracy on Chinese Exports

	(1)	(2)	(3)
Dependent Variable	ln quantity Aggregate	ln quantity Ocean	ln quantity Air
Piracy cases (lagged)	-0.0009**	-0.0011***	-0.0011
	(0.0004)	(0.0003)	(0.0008)
Observations	4,896,465	3,770,565	1,019,446
R^2	0.6346	0.8071	0.7852
Clusters	211881	194934	70184

Note: OLS regressions with piracy cases lagged by 3 months, country-product, country-year, country-month and product-time fixed effects. Robust standard errors clustered by country-product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

4.5 Robustness Checks

In our baseline regression, we use Chinese export data to investigate effects of piracy on firms' choice of transport mode. In a robustness check, we run the same regressions using import data. The results are summarized in Table 4.3 below. The significantly negative coefficient of piracy in Column (1) reveals that Chinese importers also react to piracy by switching to air transportation. The coefficient is twice as large as its equivalent in Table 4.1, suggesting that importers may react more sensitively than exporters. The coefficient of $\ln price$ is similar to the baseline.

However, Column (2) of Table 4.3 does not provide evidence for increased shipment size following an increase in pirate activity. This is true for both, trade carried out by ocean (Column (3)) and air (Column (4)). Finally, Column (5) indicates no effect of piracy on prices. This result is, however, not directly comparable to the baseline because import values - and thus imputed unit values - are reported at cost insurance freight. They can be interpreted as consumer prices and provide evidence that producers do not pass on the piracy induced increase in transportation cost to consumers. The result is hence in line with falling producer prices indicated by Column (5) of Table 4.1. Interestingly, the price coefficient for ocean shipments (Column 6) is significantly negative while that for air shipments (Column 7) remains insignificant. There is no evidence that piracy negatively affects import quantity at the product-level (Table D.2 in the Appendix).

Table 4.3: The Effect of Piracy on the Choice of Transport Mode, Imports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Ocean Dummy	ln quantity All	ln quantity Ocean	ln quantity Air	ln price All	ln price Ocean	ln price Air
Piracy cases	-0.0004***	-0.0009	-0.0015	-0.0004	-0.0006	-0.0009**	-0.0006
	(0.0001)	(0.0007)	(0.0010)	(0.0009)	(0.0004)	(0.0005)	(0.0006)
ln price	-0.0455***	-0.6441***	-0.6439***	-0.5265***			
	(0.0007)	(0.0037)	(0.0073)	(0.0048)			
Observations	7,155,017	6,854,297	2,959,643	2,385,407	7,155,017	3,020,738	2,565,631
R^2	0.6206	0.8560	0.9010	0.8618	0.9210	0.9515	0.9190
Clusters	548448	529845	283530	205965	548448	288199	220062

Note: OLS regressions with country-product-firm and product-firm-time fixed effects. Robust standard errors clustered by country-product-firm in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Product-firm-time fixed effects are used in the baseline to control - among other things - for seasonal variation. However, when it comes to the choice of transport mode, weather conditions can be very different across different routes at the same point in time. As an additional robustness check, we hence perform the firm-level regression, controlling for country-month fixed effects. The results are reported in Table D.3 in the Appendix. All coefficients remain similar to the baseline results in both magnitude and significance. The only exception are the estimated effects of piracy on prices presented in Columns (5) and (6) of Table D.3, which turn insignificant.

4.6 Conclusion

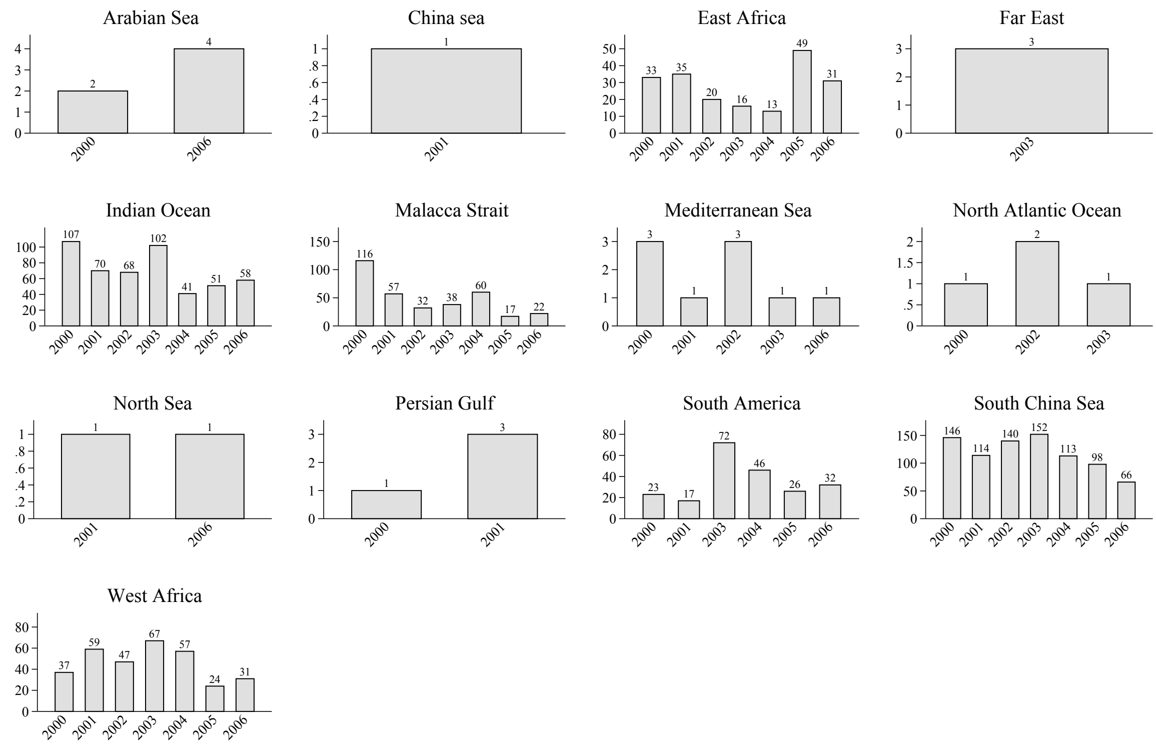
This paper combines Chinese customs data with detailed information on pirate activity to investigate the effects of piracy on firms' choice of transport mode as well as aggregate trade flows. After briefly illustrating that piracy can be modelled as an increase in fixed costs per shipment, it was shown that, in line with the literature, an increase in piracy along a trade route induces exporters to switch from ocean to air transport, while the remaining ocean shipments become larger. This is accompanied by a fall in average producer prices, which can be explained by the fact that a piracy induced increase in transport costs is not fully passed on to consumers.

Aggregating over all firms exporting a particular product to a particular country, it was shown that, despite the aforementioned reactions of exporters, overall trade declines along routes affected by piracy. More specifically, 26 piracy incidents per month on a particular route (the average number for Europe) reduce exports on average by 2.3%. Given the sources of measurement error due to data availability discussed in Section 4.2, this estimate is likely to constitute a lower bound of the true treatment effect.

Overall, the results thus show that piracy does have a small but significant dampening impact on trade. Beyond obvious humanitarian reasons, this constitutes an additional motive for governments to act. Moreover, the switch from ocean to air travel along routes affected by piracy may have second order effects for other industries that have not yet been considered.

Appendix D.1 Additional Figures and Tables

Figure D.1: The Number of Piracy Incidents over Time by Region



Note: The graph reports the total number of piracy incidents from 2000 - 2006 by region. *Source:* Data from International Maritime Organisation.

Table D.1: Matching of Regions to Continents

Continent	Region	Continent	Region	Continent	Region
Africa	East Africa China Sea South China Sea Malacca Strait Far East Indian Ocean West Africa	Europe	China Sea South China Sea Malacca Strait Far East Indian Ocean Arabian Sea Mediterranean Sea West Africa North Atlantic Ocean North Sea East Africa	Asia	China Sea South China Sea Malacca Strait Far East Indian Ocean Arabian Sea Persian Gulf East Africa
Americas	China Sea South China Sea South America	Oceania	China Sea South China Sea Far East		

Note: Authors' own allocation

Table D.2: The Effect of Piracy on Chinese Imports

	(1)	(2)	(3)
Dependent Variable	ln quantity Aggregate	ln quantity Ocean	ln quantity Air
Piracy cases (lagged)	0.0004 (0.0006)	0.0001 (0.0008)	0.0014 (0.0008)
Observations	2,814,960	1,599,758	1,104,302
R^2	0.7210	0.8622	0.7807
Clusters	88113	67523	54258

Note: OLS regressions with piracy cases lagged by 3 months, country-product, country-year, country-month and product-time fixed effects. Robust standard errors clustered by country-product in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table D.3: The Effect of Piracy on the Choice of Transport Mode, Seasonality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Ocean Dummy	ln quantity All	ln quantity Ocean	ln quantity Air	ln price All	ln price Ocean	ln price Air
Piracy cases	-0.0002***	0.0006**	0.0013***	-0.0001	-0.0002	-0.0001	-0.0001
	(0.0000)	(0.0003)	(0.0003)	(0.0010)	(0.0001)	(0.0001)	(0.0004)
ln price	-0.0453***	-0.6738***	-0.6849***	-0.5159***			
	(0.0008)	(0.0041)	(0.0039)	(0.0079)			
Observations	10,650,819	10,614,035	8,126,992	1,436,978	10,650,819	8,136,690	1,461,273
R^2	0.5800	0.8026	0.8598	0.8594	0.9586	0.9673	0.9559
Clusters	978206	975272	820360	152924	978206	821161	155072

Note: OLS regressions with country-product-firm, product-firm-time and country-month fixed effects. Robust standard errors clustered by country-product-firm in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

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