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GEP

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**Abstract**

We examine the export behavior of Chinese firms, in particular firms' decision on product quality, in the face of product- and market-specific tariff shocks that arise when importers impose anti-dumping (AD) duties. Exploiting the time-varying trade policy changes from the Global Antidumping Database and transaction-level Chinese customs data between 2000 and 2015, we find that Chinese firms hit by AD duties tend to decrease not only the export flows but also the quality of the targeted products, while no significant effect is found for prices. We show that the results are robust to several sensitivity checks . The estimated impact of quality downgrading continues even after the measure is revoked and it is more pronounced for firms exporting to developing countries. Further results allow us to better understand the underlying mechanism. Specifically, firms exposed to AD duties respond by importing input varieties with lower prices, which contributes to reduce the quality of their products. Back-of-the-envelope calculations show that countries imposing AD measures experience a 5.4% loss in consumer surplus for the targeted products.

**JEL codes**: F13, F14, D22
**Keywords**: antidumping, China, trade, quality, imported inputs

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## 1. Introduction

The landscape of international trade has evolved considerably over the last three decades with the rapid proliferation of temporary barriers to trade, which include anti-dumping (AD) and countervailing duties, as well as safeguard measures. AD measures are particularly important as they are among the most widely used form of trade restriction (Vandenbussche and Zanardi, 2010a; Bown, 2018).[1] In practice, AD measures refer to duties imposed when the imported products of the targeted suppliers are deemed to be *dumped and causing injury to domestic import-competing industries* (WTO Antidumping Agreement, Article 3). While the economic impact of AD on the firms directly protected by such measures has been well documented in the literature, less attention has been paid to the targeted suppliers.[2] In particular, the extent to which such measures affect the quality of the targeted products from the perspective of exporters remains poorly understood. This is a significant omission, as the relationship between AD duties and product quality is far from clear. On the one hand, the imposition of AD duties may encourage targeted exporters to improve product quality in order to remain competitive in the market. On the other hand, the imposition of AD duties on targeted exporters leads to an increase in trade costs and a reduction in demand, which may divert resources away from quality control and this could lead to lower product quality. This ambiguous relationship makes this an interesting issue that warrants detailed empirical investigation. Understanding this relationship is crucial for policymakers and firms involved in international trade, as it can help them make informed decisions about trade protection.

This paper contributes to the literature by examining how the behavior of Chinese firms, in terms of exports, prices, and the quality of their products, changes when faced with AD duties. China is an excellent candidate for studying the impact of trade protection on firm performance. As the fastest growing economy over the last 30 years, China has not only become the world's largest exporter, but has also been the target of a large number of AD measures. Between 1995 and 2022, 766 AD cases were in force against China, accounting for almost 34% of total measures in place worldwide.[3] Given the important role of China in the global economy and the extensive use of AD measures against Chinese products, this study makes a valuable contribution to the literature on trade and firm behavior. The empirical strategy uses information on export values and quantities at the firm-product-destination-year level from Chinese customs data for the manufacturing sector between 2000 and 2015. Based on these data, we follow Bernini and Tomasi (2015) and estimate a proxy for product quality from demand residuals based on a discrete choice model of consumer demand (Berry, 1994; Khandelwal, 2010). Information on all foreign use of AD measures against Chinese products is obtained from the Global Antidumping Database (Bown, 2015).

In order to study the effect of contingent tariffs on Chinese exporters, the paper implements an empirical strategy that controls for the potential endogeneity of the treatment, i.e., the application of AD measures to different products and firms by different countries. Firms and products subject to AD measures may indeed differ in terms of quality and exports prior to the treatment. Alternatively, countries that impose AD measures may differ in terms of income levels and eco-

[1] According to WTO notifications, a total of 4,012 AD measures were imposed worldwide between 1995 and 2020, while during the same period there were only 337 and 191 notifications of countervailing duties and safeguards, respectively.

[2] The dimensions along which the economic impacts have been assessed include firm productivity (Konings and Vandenbussche, 2008; Pierce, 2011), intra-firm input reallocation (Vandenbussche and Viegelahn, 2018), employment (Gallaway et al., 1999), and firm profitability (Blonigen et al., 2004).

[3] Data on the AD measures in force are taken from the WTO's I-TIP database (WTO, 2023).

nomic growth from countries that do not impose AD measures. The empirical strategy is therefore based on a Difference-in-Differences-in-Differences (DDD) approach coupled with a rich battery of fixed effects. The treatment group is defined as firms exporting products to destinations affected by an AD measure in the period 2000-2015. This treatment group is compared with three different control groups. In a first baseline model, we consider the full sample and use as controls all product-destination combinations not subject to AD duties during the same period. In a second case, we reduce the sample and include only products that are subject to AD measures in one market but not in another. In this case, the control group consists of firms exporting treated products to destinations free of trade barriers.[4] Finally, following the approach of Jaravel et al. (2018), we apply a one-to-one exact matching procedure to this second sample, which allows us to obtain a control group of not-target countries that have similar characteristics to the target ones in terms of economic growth and volume of imports from China. This procedure allows us to create a control ("placebo") group with the same level of development and imports as the treatment group and to run a specification where we also account for pre- and post-period trends that are common to both treated and placebo groups.

As a preview of our empirical results, we find evidence consistent with the literature that the foreign use of AD against China leads to a significant reduction in Chinese firms' exports (see Lu et al., 2013; Chandra, 2017; Felbermayr and Sandkamp, 2019; Schiavo et al., 2021, among others).[5] Next, in line with the pattern of results presented in these studies, the paper finds that firms subject to AD duties experience no impact on prices, suggesting that AD duties are fully passed on to importers (Blonigen, 2016).[6] More importantly, the results indicate that Chinese firms exposed to such measures lower the quality of their targeted products. This is novel to the literature as it identifies a new channel through which AD measures can negatively affect the economies of both importing and exporting countries. The trade deterrence and quality attenuation results are robust to several sensitivity checks, including different control groups and different samples based on different sets of importing countries. The findings hold for alternative measures of product quality. The results are robust to a dynamic specification, as in an event study, and we do not find evidence against the parallel trends assumption. Moreover, we assess the robustness of our main results using the "interaction-weighted" estimator proposed by Sun and Abraham (2021), specifically devised for event studies with binary treatment and different treatment timing across cohorts.

In addition, we improve upon the existing literature by considering that some AD measures are revoked at a certain point in time following the mandatory review process, while other AD measures are renewed. We find that AD duties tend to have a hysteresis effect and, even after they are revoked, their negative effect on quality continues. This is a novel finding in the literature on AD.

We further enrich the analysis by assessing whether the AD policies have a disproportionate effect on export behavior in different countries. We observe substantial quality downgrading for

[4]For example, shipments of "warm-water shrimp" were subject to AD measures in the US in 2004, but were free of such trade barriers in the EU.

[5]As AD duties are designed to counter harmful dumping, the trade-restrictive effect is to be expected and has been observed in many countries and regions, such as the US (Prusa, 1997, 2001), the EU (Konings et al., 2001; Sandkamp, 2020), India (Ganguli, 2008) and China (Park, 2009). Other papers document such trade-distorting effects also for the so-called "new users" (i.e., developing countries) (Vandenbussche and Zanardi, 2010b; Egger and Nelson, 2011).

[6]The lack of price response on the part of exporters also means that AD duties may act more like tariffs. See, for example, Amiti et al. (2019) and Fajgelbaum et al. (2020), who find complete pass-through of the US tariffs imposed in 2018.

products exported to developing countries, while export quality adjustment is almost muted for products exported to higher-income countries. In line with the literature on the relationship between quality and the level of development of destination countries (Verhoogen, 2008a; Choi et al., 2009), when exporting to richer destinations, firms may be less likely to reduce quality in response to negative trade shocks in order to maintain their market share. We also provide evidence for the mechanism behind the negative effects of tariffs on product quality. Firms respond to country-specific and discriminatory AD restrictions by importing cheaper intermediate inputs, leading them to produce and export lower quality products (Kugler and Verhoogen, 2012).

Finally, using a simple framework, we provide a quantitative assessment of the loss of consumer surplus in the destination country-product pairs that apply the AD measures that takes into account the negative effects of AD duties on both quantity and quality by using a quality-adjusted output quantity measure. We find that on average consumer surplus decreases by 5.4% for the targeted products. This back-of-the-envelope calculation of consumer surplus provides new insights into the role that contingent protection plays in restricting trade and decreasing welfare.

Our work advances several strands of research. First, our research sheds new light on the recently flourishing literature that seeks to understand the effects of temporary trade barriers on the performance of targeted exporters, and as such also relates to the broader literature on firm behavior and trade policy. In a pioneering work, Lu et al. (2013) document that the use of AD measures by the US against Chinese products has resulted in a sharp decline in Chinese export volumes and that this decline in exports is mainly due to a significant decrease in the number of exporters. Follow-up studies, including Lu et al. (2018), Chandra (2019) and Bao et al. (2021) show that the imposition of AD measures leads to intra-firm adjustments in products and export destinations. Other studies, such as Chandra and Long (2013) and Jabbour et al. (2019), focus on the effect of AD protection on firm productivity. By exploiting within-product and between-firm variations in AD duties, which largely reduces endogeneity concerns, Felbermayr and Sandkamp (2019) identify separate trade effects of EU and US AD duties on Chinese firms, while Crowley et al. (2018) focus on the extensive margin and show that Chinese firms are less likely to enter new foreign markets and more likely to exit established foreign markets when their products are subject to AD measures.[7]

However, little attention has been paid in the above literature to the impact of AD measures on product quality, and even less to the mechanism by which adjustments in product quality may occur. To the best of our knowledge, the only other work that has addressed the issue of the relationship between AD measures and product quality, and is therefore most directly related to ours, is the paper by Meng et al. (2020). In contrast to our results, they find that Chinese firms tend to improve the quality of their exports in the face of AD measures. The difference in results is explained by several dimensions. First and foremost, differently from Meng et al. (2020) who include only product, country-time and firm-time fixed effects in their main specification, we rely on a DDD estimation approach, which includes a much larger set of fixed effects and is thus more robust to the endogeneity criticism that applies to regular difference-in-difference estimation. By including firm-product-destination, firm-destination-year, and firm-product-year fixed effects in the specification, identification relies only on variation over time within a firm exporting the same product to a given destination. Second, we employ a different empirical specification that takes into account both AD investigations and AD duties for the whole period, whereas Meng

[7]Rather than studying the firm behavior, Brambilla et al. (2012) explore the livelihood of catfish producers, i.e., Vietnamese households, in response to the US imposed heavy tariffs on imports of catfish. de Souza and Li (2020) provide a first general equilibrium analysis of the aggregate employment effect of Brazilian AD tariffs that takes into account all related sectors, i.e., the midstream, upstream, and downstream sectors.

et al. (2020) focus only on the first year after the start of the investigation. Third, we use a different methodology to estimate quality, in particular with respect to estimating the elasticities of substitution. Following the methodology developed by Khandelwal (2010), we estimate quality at the firm-product-destination level implementing an instrumental variable approach as in Bernini and Tomasi (2015).

We further contribute to the existing literature on the impact of AD measures in a number of directions. First, we show that the AD measures have a hysteresis effect that continues even after the AD measures have been revoked. Second, we go one step further by making a significant advance in the mechanism at work. Indeed, we find that firms hit by AD duties import cheaper inputs. Not only is this finding consistent with a decline (rather than an improvement) in product quality for firms facing AD duties, but it also highlights the importance of considering all the effects of trade protectionism in order to fully understand its consequences. Finally, we provide a quantitative assessment of the welfare implications of imposing AD measures by calculating the percentage loss in consumer surplus. This allows us to draw a full picture of the consequences of the AD measures that takes into account both the imposing and the targeted countries.

The paper is also relevant to a vibrant literature that examines the role of imported inputs on the quality of output. Influential papers by Kugler and Verhoogen (2012) and Hallak and Sivadasan (2013a) show that the production of high-quality products requires high-quality inputs. We build on these insights by empirically confirming that Chinese firms cannot afford to buy higher-expensive (i.e., higher-quality) inputs and thus cannot maintain the quality of their final goods. These results are in line with other empirical studies including Verhoogen (2008b), Manova and Zhang (2012), Manova and Yu (2017), Caselli (2018), and Tomasi and Zhu (2020), who show the significant role of imported intermediate inputs in improving firms' export quality. None of these papers examine the issue as a consequence of the imposition of AD duties.

The paper makes a contribution to the trade literature focusing on the welfare effects in the countries imposing the AD measures. To the best of our knowledge, only a few of papers have attempted to estimate the welfare loss resulting from AD duties, and none of them have considered the potential impact on quality due to the imposition of these trade-restrictive measures. Using a computable general equilibrium model, early work by Gallaway et al. (1999) estimates that the presence of outstanding AD and countervailing duties represents a collective net economic welfare cost to the US economy of $3 billion.

More broadly, the paper addresses the trade phenomenon referred to as the "China syndrome" – the impact of surging Chinese exports on markets around the world. In an influential study, David et al. (2013) estimate that increased import competition from China was responsible for a quarter of US industrial job losses between 1990 and 2007. Subsequent work confirms that increased import competition from goods produced in Chinese factories is associated with worsening local labor market conditions, including lower wages, falling labor force participation rates and higher unemployment (see, for example, Acemoglu et al., 2016; Pierce and Schott, 2016; Balsvik et al., 2015; Autor et al., 2014). However, the academic debate on the China syndrome has often ignored the role of trade policy, with few exceptions (Bown et al., 2021). This paper therefore contributes to this literature by evaluating the consequences of the emergence of Chinese trade from a diametrically opposite perspective. Indeed, we analyze the consequences for firms facing the imposition of AD duties and, by exploring the other side of the coin, we complete the assessment of firm performance in a context of growing trade disputes at the global level.

The remainder of the paper is structured as follows. Section 2 introduces the data we use and the construction of the variables that will be used in our regression analysis. Section 3 outlines the empirical model, comments the results and considers a set of robustness tests of our empirical findings. Section 4 presents a dynamic analysis of the effect of AD duties on Chinese export product quality. Section 5 discusses a possible mechanism behind the downgrading of the product quality, while Section 6 examines the aggregate welfare implications. Section 7 concludes.

## 2. Data, variables and summary statistics

This section describes our primary data sources, the variables used in the empirical analysis, and the procedure that we followed to obtain a revealed measure of export quality at the firm-product-destination level. We then present summary statistics from the combination of firm-level customs data and AD measures for the period 2000-2015.

### *2.1. Chinese Customs data*

Our main source of micro-level data is the census of annual firm-level export and import transactions in China for the period from 2000 to 2015, collected by the Chinese Customs Office. Foreign-trade statistics cover all export and import flows, defined at the firm-product-country level, in both values and quantities.[8] Export (free on board) and import (cost, insurance, and freight included) values are expressed in US dollars. Quantities are recorded in various units of measurement such as kilograms, pieces, meters, liters and carats. We calculate unit values, which are our proxy for prices, as the ratio of values to quantities. Chinese customs data are available at monthly frequency from 2000 and 2006 and at annual frequency from 2007 to 2015. We therefore aggregate the monthly data to annual data in order to obtain a consistent sample over the whole period. Product categories are classified according to the Harmonized System (HS) classification of traded goods, and they are available at the 8-digit level (HS8). We aggregate products from HS8 to HS6 for cross-country comparisons. As some product categories are assigned to different HS6 product codes at different times, in order to harmonize the classification over time, we use concordance tables provided by the UN Statistics Division and reconcile the data with the 1996 version of the HS classification.

We focus on manufacturing exporters only. Following Ahn et al. (2011), we identify the set of intermediary firms by finding the presence of phrases (such as "trading", "exporting", and "importing") in their company names.[9] After removing these firms, we are left with an unbalanced panel of 462,650 exporting firms selling 4,999 different HS6 products to 238 destination markets, for a total of 49,245,295 observations. Statistics on the number of manufacturing traders and their total trade value are reported in Table 1. The number of manufacturing exporters more than quadrupled from 54,719 in 2000 to 230,257 in 2015, with a similar growth pattern on the import side. A large fraction of firms are involved in both trading activities, as shown in column (3). The data also confirm the rapid expansion of China's exports and imports. Total manufacturing exports increased from \$156 billion in 2000 to \$1,661 billion in 2015. A similar pattern is observed for imports.

For the empirical analysis, we implement a number of operations to clean the data. In particular, quantity information is known to be noisy in trade data. To mitigate this problem, we drop transactions with zero or missing quantities (and values). We drop those observations that have year-to-year variations in unit values within each sector that are above the 99th or below the 1st percentile of the sample distribution. As mentioned above, customs statistics from China collect data on quantities in different units and this information may be subject to measurement errors.

[8]To compare the micro-level dataset with the information provided by the UN Comtrade, we aggregate all the transactions and obtain the same amount of exports and imports, as shown in Table A1 in the Appendix.

[9]The identification of intermediary firms left us with a value of total direct exports, between 2000 and 2005, which is exactly the same as the one reported in Table 1 of Ahn et al. (2011).

Table 1: Descriptive statistics: trade value and number of manufacturing traders

| Year | Exporters | Importers | Two-way traders | Exports (billions) | Imports (billions) |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| 2000 | 54,511 | 55,149 | 37,456 | 156.0 | 155.4 |
| 2005 | 114,851 | 92,830 | 61,187 | 551.8 | 465.9 |
| 2010 | 169,144 | 107,671 | 72,746 | 1,161.1 | 973.9 |
| 2015 | 228,862 | 120,898 | 79,697 | 1,661.1 | 1,116.5 |

*Notes*: The table reports the number of manufacturing (direct) traders and the overall trade volume.

The majority of transactions are recorded in either kilograms or pieces. We drop those firms that report quantities in different units within the same product-destination pair over years.[10] After this cleaning, we are left with 433,328 exporting manufacturing firms, accounting for about 80% of total manufacturing exports.

### *2.2. Global Anti-dumping Dataset*

Information on AD activity is provided by the Global Antidumping Database (GAD), a World Bank sponsored initiative that provides details on global AD cases from the early 1980s to 2015 (Bown, 2015). The GAD dataset collects official documentation from national governments on the investigation procedures and outcomes of AD activities in importing countries (so-called *users*) against the countries subject to an AD investigation (so-called *targets*). An AD proceeding typically involves an investigation into the pattern of import volumes and import prices from the countries from which an import-competing domestic industry is accused of dumping. The investigation process usually has two main stages and lasts for about 12-15 months. At the first preliminary stage, countries take provisional measures either by imposing temporary duties or by terminating the investigation. The second, final, stage takes place when the preliminary determination is positive and the country can either impose definitive measures or dismiss the case without imposing sanctions. AD measures may take the form of an *ad valorem* duty (an import tax based on the value of transactions), a specific duty (a tax per quantity unit), or a price undertaking (whereby the targeted exporter agrees to sell its products at a minimum price). AD measures are intended to last as long as injurious dumping continues and they are generally imposed for a period of five/six years, after which they are subject to a mandatory review process and can be renewed for decades. While countries have some leeway in the actual implementation of AD laws, as long as their practices are consistent with a set of basic principles under the WTO Agreement on Antidumping, there is considerable homogeneity across countries in how procedures are carried out.[11]

Information on the AD *cases*, where the term case refers to a specific country and industry involved in an AD proceeding,[12] is collected in the GAD dataset. An AD case may involve just a single tariff line (a single HS8 product), or it may involve dozens of tariff headings. The GAD database provides detailed product-level information for each AD case, including the dates of initiation and conclusion, the outcomes of the investigations, the type of measures applied (e.g., ad valorem duty, specific duty, price undertaking, suspension agreement, etc.), the level of AD

[10]There are also a few cases where firms report a different unit of measurement than the main one used within a given product category. We exclude these observations from our sample.

[11]See Bown (2005) and Blonigen and Prusa (2016) for a detailed description of AD practices.

[12]For example solar glass investigations from the EU against China, or silico-manganese against India.

Table 2: Number of AD measures and affected HS6 products against China

| Country | # of affected HS6 | # of revoked HS6 | # of non-revoked HS6 |
|---|---|---|---|
| Argentina | 135 | 35 | 100 |
| Australia | 33 | 10 | 23 |
| Brazil | 95 | 31 | 64 |
| Canada | 75 | 20 | 55 |
| Colombia | 56 | 29 | 27 |
| European Union | 160 | 60 | 100 |
| India | 196 | 67 | 129 |
| Indonesia | 36 | 15 | 21 |
| Israel | 10 | 10 | 0 |
| Jamaica | 1 | 1 | 0 |
| Japan | 2 | 0 | 2 |
| Malaysia | 17 | 6 | 11 |
| Mexico | 45 | 6 | 39 |
| New Zealand | 5 | 3 | 2 |
| Pakistan | 12 | 8 | 4 |
| Peru | 56 | 37 | 19 |
| Philippines | 1 | 1 | 0 |
| Russia | 33 | 16 | 17 |
| South Africa | 41 | 30 | 11 |
| South Korea | 36 | 20 | 16 |
| Taiwan | 20 | 2 | 18 |
| Thailand | 51 | 2 | 49 |
| Trinidad and Tobago | 7 | 7 | 0 |
| Turkey | 117 | 5 | 112 |
| USA | 219 | 25 | 194 |
| Ukraine | 16 | 12 | 4 |
| Uruguay | 1 | 0 | 1 |
| Venezuela | 15 | 15 | 0 |
| Total | 1491 | 473 | 1018 |

*Notes*: The table reports the number of AD measures and products by imposing country on China between 2000 and 2015, using the Global Antidumping Database (Bown, 2015).

measures and the duration of the measures.[13] Combining firm-level trade data with the GAD dataset requires the aggregation of AD information to the HS6 level, which is the finest level of classification that is common to all countries. As AD duties are often applied at a more disaggregated level, the use of HS6 category means assigning AD treatment to products that are not covered by trade policy. This would lead to the classical attenuation bias in the model coefficients due to noise in the variable, and thus to an underestimation of the treatment effect. However, the fact that these HS6 categories are defined consistently across trading partners means that any measurement error is common to all AD users, reducing concerns about potential bias. The same empirical strategy has been used by Lu et al. (2013), Jabbour et al. (2019), Lu et al. (2018), and Felbermayr and Sandkamp (2019), among others. After aggregating the information provided by the GAD dataset at the HS6 level, we harmonize the classification over time using the UN concordance tables and reconciling the data with the 1996 version of the HS classification.

As explained above, the AD procedure normally consists of an initial investigation phase,

[13]For some countries the GAD dataset also has a spreadsheet presenting a common set of information on foreign firms subject to the AD investigation, and, where available, the foreign-firm specific outcomes (e.g., level of duties imposed).

which may be followed either by termination of the case or by the imposition of a provisional duty (usually in force for six months), after which the final definitive measure is imposed. It is quite rare for a case with a provisional duty to be subsequently terminated without the imposition of a measure. For this reason, in our empirical analysis we define the starting year of AD as the date when the provisional AD measure was imposed. It follows that our dummy $\text{AD}_{pdt}$ identifies the product-country combination subject to AD duty, starting from the year of the provisional countervailing duty.[14] In the case of China, the GAD dataset provides information on 1491 product-country combinations with AD duty imposition between 2000 and 2015.[15,16] As shown in Table 2, these AD cases are imposed by 28 economies, covering 860 different HS6 products. Over the sample period, the top five users account for more than 50% of all AD measures and the share rises to 75% when the focus is extended to the top ten users. Temporary trade restrictions have spread beyond "historical users" such as the US and the EU. There has been a remarkable increase in the use of AD measures in several emerging economies in recent years, and countries such as India, Argentina, Turkey, and Brazil are currently among the top users.[17]

To determine the last year of the AD measure, we use the data on the year of withdrawal provided by the GAD dataset. As shown in columns (2) and (3) of Table 2, of the 1491 treated product-country pairs, about 30% are revoked after about six years from the year the AD measure is imposed. For the remaining 70% of cases, the measure continues after the review process. The empirical analysis further explores this difference in the post-treatment period and distinguishes between the two categories of treated product-country combinations. The dummy $\text{AD}_{pdt}^{NotRevoked}$ identifies the product-country pairs for which the AD duty is renewed: it takes the value of one starting from the year of the provisional countervailing duty until the end of the sample period. The dummy $\text{AD}_{pdt}^{Revoked}$ refers to the product-country combinations for which the AD duty is revoked after the review process: it takes the value of one starting from the year of the provisional countervailing duty for the whole period in which the AD measure is imposed, and changes to zero from the year of withdrawal.

### *2.3. The estimator of export quality*

Trade data at the customs level are used to obtain a measure of export quality at the firm-product-destination level. Such a measure is estimated using the methodology developed by Khandelwal (2010) and applied to firm-level trade data following the strategy implemented by Bernini and Tomasi (2015).[18] The basic intuition of Khandelwal (2010)'s approach is to infer the quality of each exported variety as the part of its market share that is not explained by its price. The quality of each variety can thus be measured as the residual from the estimation of a demand model. That is, the dependent variable, which is the log market share of a variety minus the log

[14]Our dummy excludes the investigation phase. This is mainly because we use annual rather than monthly data, which are not available from 2007 onwards, so we cannot distinguish exactly between the two phases. However, in several AD cases the investigation period ends within the same year as the provisional AD. In Section 3.4 we account for possible anticipatory effects by defining the AD dummy starting from the year of the investigation.

[15]Around 500 product-country pairs were investigated but concluded without measures being imposed. We perform a robustness check in Section 3.4, where we exclude these cases from the sample.

[16]The European Union is considered as a single country in the GAD dataset but, when linking with the Chinese Customs data, we take into account its individual members separately, including the different enlargements.

[17]In analyzing the usage of AD measures from the beginning of the 1980s until 2015, Schiavo et al. (2021) show that China is the primary target of investigations, contributing over 20 percent to European investigations and 14 percent to American investigations.

[18]See also Piveteau and Smagghue (2019) and Gervais (2015) for a similar strategy to estimate quality at the micro level.

market share of an 'outside variety',[19] is regressed on a variety's export price and a set of other variables.

Following Bernini and Tomasi (2015), we estimate the following specification of the demand model

$$\begin{aligned} \ln(s_{fpdt}) - \ln(s_{p2dt}) &= \alpha p_{fpdt} + \sigma_{ns}\ln(ns_{fpdt}) + \delta_{dt} + \delta_{fp} + \epsilon_{fpdt}, \\ \Rightarrow \qquad Quality_{fpdt} &= \delta_{dt} + \delta_{fp} + \epsilon_{fpdt} \end{aligned} \tag{1}$$

where $f$, $p$, $d$, and $t$ are subscripts that identify the firm, HS6 product, destination, and year, respectively. $\ln(s_{fpdt})$ represents the market share of an exported variety $fp$ in destination $d$ in year $t$, and $\ln(s_{p2dt})$ represents the market share of the 'outside variety' within the product category $p2$, which is defined at the HS2 level. The variable $p_{fpdt}$ represents the price of the exported variety, and $\ln(ns_{fpdt})$ represents the 'nest share' of the variety $fp$. The nest share is the market share of the variety over a more disaggregated product category than the one used to construct the market share on the left-hand side of the model. This variable enables a product market to be segmented into subclasses of closer substitute varieties. A proxy for quality, $Quality_{fpdt}$, can be obtained as a linear combination of the demand parameters on price and nest market share.

To estimate equation (1), we first need to build the empirical counterpart of these variables. The proxy for the market share, $s_{fpdt}$, is defined as

$$s_{fpdt} = \frac{q_{fpdt}}{MKT_{p2dt}} = \frac{q_{fpdt}}{\frac{\sum_{f\in p2dt} q_{fpdt}}{ShChina_{p2dt}}},$$

where $q_{fpdt}$ is the quantity exported by firm $f$ of HS6 product $p$ to destination $d$ in year $t$, divided by a proxy for the destination market size in $p2$ in year $t$ ($MKT_{p2dt}$). The expression $MKT_{p2dt}$ is defined as the total export quantity across all Chinese firms to destination $d$ within product category $p2$ in year $t$, divided by the Chinese import share in that market, computed as

$$ShChina_{p2dt} = \frac{M^{China}_{p2dt}}{M^{Tot}_{p2dt}}.$$

This variable measures the relative importance of the Chinese import quantity ($M^{China}_{p2dt}$) over the total imports ($M^{Tot}_{p2dt}$) in that product-class $p2$, in destination $d$ in year $t$. To compute the latter variable, we rely on the information included in the BACI dataset containing product-year-level information on imports and exports for a large set of countries.[20]

The empirical counterpart of the outside variety market share, $s_{p2dt}$, is defined as the ratio of the total quantity of non-Chinese imports ($M^{NoChina}_{p2dt}$) over the total imports in the same $p2d$ in year $t$

$$s_{p2dt} = 1 - ShChina_{p2dt} = \frac{M^{NoChina}_{p2dt}}{M^{Tot}_{p2dt}}.$$

[19] Indeed, Berry (1994) shows that under the assumption that each consumer makes a discrete choice among different varieties, market shares result from the aggregation across consumers of their individual probability of choosing one variety over the others. By subtracting the log market share of the 'outside variety' from the log market share of each variety, one can obtain the normalized market shares mirroring the relative probability that a consumer in a given market chooses one unit of variety $i$ over another variety.

[20] The BACI dataset reconciles trade declarations from importers and exporters as they appear in the COMTRADE database (Gaulier and Zignago, 2010).

Table 3: Quality estimation results: export side

| | Mean | Median | 1st Quart. | 3rd Quart | Sd. |
|---|---|---|---|---|---|
| FE price coefficient ($\alpha$) | -0.004 | -0.00003 | -0.0005 | -0.000 | 0.014 |
| IV price coefficient ($\alpha$) | -0.050 | -0.001 | -0.018 | -0.000 | 0.126 |
| FE nest shares coefficient ($\sigma_{ns}$) | 0.778 | 0.798 | 0.739 | 0.838 | 0.071 |
| IV nest shares coefficient ($\sigma_{ns}$) | 0.682 | 0.777 | 0.447 | 0.908 | 0.273 |
| $Quality_{fpdt}$ | -0.000 | 0.115 | -1.355 | 1.411 | 3.263 |

*Notes*: The table reports the estimates of equation (1) obtained from regressions at the HS2 level. The measure of quality is estimated for 36,226,068 observations.

As far as the right-hand side of equation (1) is concerned, the empirical counterpart of the export price is given by the unit value, defined as the ratio between export values and export quantities, at the firm, HS6, destination, and year level. The empirical counterpart of the 'nest share' ($\ln ns_{fpdt}$) is defined as

$$ns_{fpdt} = \frac{q_{fpdt}}{MKT_{pdt}} = \frac{q_{fpdt}}{\frac{\sum_{f \in pdt} q_{fpdt}}{ShChina_{p2dt}}},$$

where the numerator is the quantity exported by firm $f$ in the product-class $p$ to destination $d$ at time $t$, and the denominator $MKT_{pdt}$ is the destination market size constructed as before but at a finer level of disaggregation.

Equation (1) is run separately for each HS2 product category to allow for changes in the demand parameters across product classes. To control for shocks in demand that are common across the varieties exported to the same destination, we include a set of destination-time fixed effects ($\delta_{dt}$), and to remove the firm-product specific component from the error term, we include a set of firm-HS6 product fixed effects ($\delta_{fp}$). Once we obtain consistent estimates of the demand parameters $\hat{\alpha}$ and $\hat{\sigma}_{ns}$, we can obtain the estimator of quality, $Quality_{fpdt}$.

The estimates of $\alpha$ and $\sigma_{ns}$ in equation (1) are generally upward biased because $Quality_{fpdt}$ in the error term correlates positively with the price $p_{fpdt}$ (Nevo, 2000). Similarly, greater quality determines higher demand within subgroups of substitute varieties; hence, it correlates positively with the nest share $\ln(ns)_{fpdt}$. To address endogeneity in prices and nest shares we estimate equation (1) by Two Stage Least Squares (2SLS) with four instruments. The first instrument is the median price computed across all Chinese firms exporting the same product $p$ to country $d$ in year $t$. Arguably, variations in the product-destination specific median price over time and across markets capture common demand and supply shocks affecting all Chinese companies exporting a particular product. Because the dependent variable is a normalized market share and common demand and supply shocks do not affect individual companies' market shares, this instrument is orthogonal with respect to the component of the error that is specific to individual varieties and that represents the main source of endogeneity in export prices. The second instrument, computed using the BACI dataset, is the average price of an HS6 product across all other countries (excluding China) operating in the same $dt$ pair. The third instrument is given by the number of different HS6 product categories exported by the same firm to $d$ in year $t$. The fourth instrument is the number of Chinese firms operating in each product-destination-year triplet.

Estimation results are summarized in Table 3, which reports the estimates of the coefficients $\alpha$ and $\sigma_{ns}$, both for the simple fixed effect model and the instrumental variable approach. The estimate of quality is obtained for approximately 36 million observations. As expected, the distribution of the estimates for the price elasticity, $\alpha$, from the IV models has a lower mean and median than the one obtained from the FE models. This evidence suggests that by instrumenting

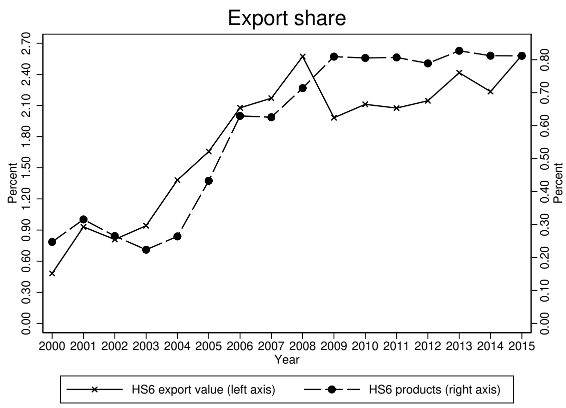


Figure 1: Export share (left axis) and product-destination pairs share (right axis) affected by AD measures. Source: Authors' calculation using GAD and Chinese Customs data.

unit values and nest shares, we correct the upward bias due to their correlation with the unobserved time-variant component of quality. In addition, estimates of the substitution parameter $\sigma_{ns}$ fall in the plausible range $[0 - 1)$. The IV estimates of the demand parameters are used to obtain the measure of quality, $Quality_{fpdt}$. The range of values obtained for the quality measure is consistent with the ones reported by Bernini and Tomasi (2015).

*2.4. Preliminary evidence*

To set the stage for our analysis, we start by documenting the aggregate effects of AD measures on Chinese exports. We first provide a broad picture of the trends in AD activity over the last decades, looking at both the number of products and the share of China's exports that are subject to AD duties. The first indicator is a count metric, calculated as the number of product-country pairs imposing AD measures, divided by the total number of product-country pairs importing from China. Figure 1 (right axis) reports the evolution of this share over time: the percentage of product-destination pairs subject to AD measures has grown from 0.25% in 2000 to 0.82% in 2015. To capture more precisely the breadth of trade affected by AD measures, we compute a value metric, which consists of the fraction of overall China's exports subject to AD duties. The evolution looks even more remarkable when one accounts for the value of exports hit by AD measures (left axis of Figure 1). AD had a little impact in early 2000 but the share of affected exports has risen to almost 3% in 2015.[21] These results confirm the existing aggregate evidence for earlier periods (Prusa, 2011; Vandenbussche and Viegelahn, 2011): they all show that Chinese exports are increasingly targeted by AD measures.

Next, we examine the characteristics of the products subject to AD measures to see whether certain types of goods are more likely to be subject to AD duties. The left-hand panel of Figure 2 illustrates that the share of Chinese exports of intermediate and consumer goods subject to AD measures significantly increased significantly after 2004.[22] In the years following the 2008 financial crisis, AD measures have increasingly focused on intermediate goods, with consumer products playing a lesser role. Moreover, the right-hand panel of Figure 2 shows that the use of

[21]Most countries had AD protection in place against China before 2000. As our trade data starts in 2000, there is an underlying stock of products affected by AD measures that we do not capture. As a result, both the number of HS6 products targeted and the value of trade affected shown here are the lower bound of the actual impact.

[22]To classify the type of products we use the Broad Economic Categories (BEC) classification.

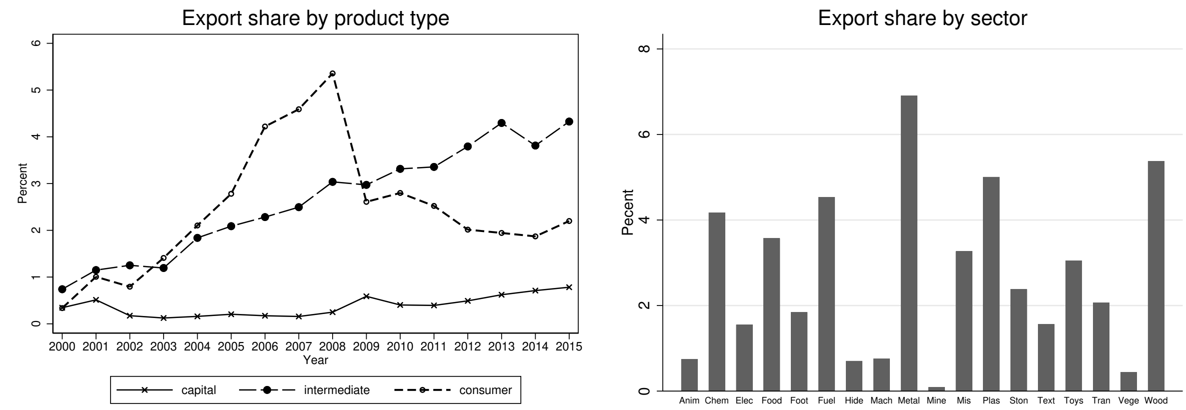


Figure 2: Export share by type of good (left panel) and by sector (right panel) affected by AD measures. Source: Authors' calculation using GAD and Chinese Customs data.

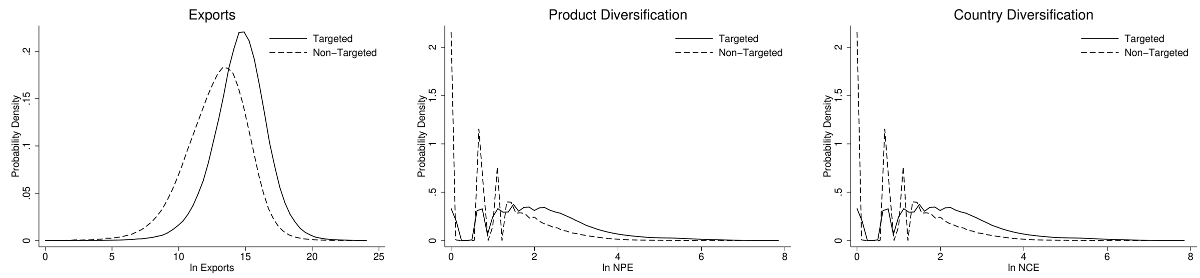


Figure 3: Empirical density of firms' exports (left), number of products exported (middle), and number of countries served (right). Source: Authors' calculation using GAD and Chinese Customs data.

AD measures varies a great deal across different sectors.[23] Metal, wood, plastic and chemicals display the highest shares, indicating that some industries are indeed more likely to be subject to AD measures.

Turning our attention to a firm-level analysis, it appears that treated firms differ from non-treated firms in a number of important ways.[24] For both treated and non-treated firms, Figure 3 presents the empirical density of firms' exports, product and country diversification. Firms exposed to AD measures are on average larger and more diversified compared to untreated exporters, as they tend to have higher levels of exports, to export more HS6 products and to serve more destinations.

## 3. Empirical Specification and Results

### *3.1. Empirical model*

The empirical analysis aims to study the impact of AD duties on targeted firms in terms of export performance in general, and product quality in particular. To do so, we employ a difference-in-differences-in-differences (DDD) estimation strategy to exploit all sources of variation (Gruber, 1994). This approach exploits a triple difference and aims to address possible concerns associated

[23]The association between HS chapters and sectors is reported in Table A2 in the Appendix.

[24]A firm is considered as "treated" whenever one of its exported HS6 products is subject to a foreign AD measure.

with a more classical difference-in-differences (DD) specification, which would be prone to either selection bias or the presence of confounding factors. Indeed, many empirical analyses, employ a DD strategy that compares, within firms, products subject to AD duties in a given country with products exported to the same destination but immune from the administered protection, before and after the policy measure is imposed. In this case, there may be a selection problem if the products subject to AD measures are different from the control group; in other words, the common trend assumption may not hold. To address such concerns, an alternative DD specification would compare the exports of a product to a country imposing AD duties with those to destinations where the same product is not subject to any restrictions. While this approach would dispel concerns about a possible selection bias, it opens the door to other unaddressed confounding factors due to country-specific drivers other than AD duties. A triple difference, inherent in a DDD strategy, allows us to exploit all sources of variation. Within each firm, the export performance of Chinese goods before and after the imposition of AD duties is compared with the performance of the same product shipped to destinations where no duties are imposed, and with different products (not subject to AD measures) exported to the same country that adopts administered protection. Specifically, we estimate the following empirical specification

$$\ln \mathrm{ExportPerf}_{\mathrm{fpdt}} = \beta_0 + \beta_1 \mathrm{AD}_{\mathrm{pdt}} + \gamma_{\mathrm{fpd}} + \gamma_{\mathrm{fdt}} + \gamma_{\mathrm{fpt}} + \varepsilon_{\mathrm{fpdt}}, \quad (2)$$

where $\mathrm{ExportPerf}_{\mathrm{fpdt}}$ measures the export performance of firm $f$ exporting product $p$ to destination $d$ in year $t$. We consider three measures of export performance: export value, unit value, and estimated product quality at the firm-product-destination-year level. Our main variable of interest is the dummy $\mathrm{AD}_{\mathrm{pdt}}$, which takes the value of one if the product $p$ exported to destination $d$ is subject to AD measures at time $t$, and zero otherwise. As noted above, we define the AD starting point as the year in which the preliminary AD measure is imposed. This dummy remains equal to one until the measure is revoked.

In this triple difference specification, we include fixed effects at the firm-product-destination level ($\gamma_{fpd}$), at the firm-destination-year level ($\gamma_{fdt}$), and at the firm-product-year level ($\gamma_{fpt}$). These three sets of fixed effects help to control for potential sources of omitted variable bias. In particular, as discussed by Felbermayr and Sandkamp (2019), this highly demanding specification allows us to account for both demand and supply side effects which may bias the coefficient of interest.

On the demand side, factors such as the level of imports, consumer preferences, GDP, GDP per capita, exchange rate movements or trade policies unrelated to AD measures are likely to be correlated with trends in export prices, quantity, and quality, as well as with the imposition of AD measures. For example, the model proposed by Bagwell and Staiger (1990) predicts that increases in import tariffs are more likely when import volumes increase, and empirical evidence from Bown and Crowley (2013) shows that a one standard deviation increase in bilateral imports increases the likelihood of an AD tariff by 35%. Neglecting the impact of demand-side effects can lead to an underestimation of the treatment effect. If demand for the products affected by the antidumping measures is higher than for the control group, the estimated negative treatment effect would be positively biased and therefore smaller than the true treatment effect. These demand-side effects are controlled for directly by using both firm-product-destination fixed effects ($\gamma_{fpd}$) and firm-destination-year fixed effects ($\gamma_{fdt}$). The firm-product-destination fixed effects capture the average export performance for each firm-product-destination triplet, including a firm's experience and reputation in the destination market, existing distribution channels and supply chains. This allows us to use the variation over time to estimate the treatment effect. In addition, the firm-destination-year fixed effects ($\gamma_{fdt}$) are designed to control for any time-varying and invariant confounding factors that may vary by destination, thus capturing demand-side factors such as changes in local demand and consumer preferences, as well as changes in the competitive environment (Head and Mayer, 2014).

On the supply side, firm- or firm-product-specific factors such as productivity, technology, marketing and organizational strategy, changes in the production process and marginal costs could also affect our results. These factors are likely to be time-varying due to rapid advances in areas such as high-tech manufacturing and commercial applications by Chinese firms. They can be accounted for by including firm-product-year fixed effects ($\gamma_{fpt}$), which control for any time-varying and invariant product characteristics that may occur at the firm level. By including this set of fixed effects, the $\mathrm{AD_{pdt}}$ dummy variable is able to exploit the variation of the same product exported by the same firm at time $t$ across destinations. By combining all these fixed effects, we can reduce omitted variable bias and improve the precision of the estimates by saturating all possible sources of variation unrelated to trade policy.

Our identification strategy holds under the assumption that, conditional on firm-product-destination, firm-destination-year and firm-product-year fixed effects, the within product-destination variation in the AD measure is orthogonal to all other determinants of the export performance dynamics. As in any observational study, a potential threat to our identification strategy is the possible correlation between the error term and the main variable of interest, generated by reverse causality. Since AD duties are typically imposed at the product level, this source of bias is less problematic when using firm-level data, as it is less likely that the export behavior of individual Chinese firms can systematically influence the imposition of AD duties. Another potential threat to our identification strategy is related to measurement error. Although an AD measure is imposed on all firms exporting a product to that destination, the form of the applied measures - e.g. specific duties or price undertakings, instead of ad valorem duties - as well as the intensity of the measures themselves can vary considerably across firms (Chandra and Long, 2013; Chandra, 2017, 2019; Felbermayr and Sandkamp, 2019). As discussed by Felbermayr and Sandkamp (2019), exporters in Market Economy Status (MES) countries are more likely to be subject to individual, firm-specific duties than firms in Non-Market Economy Status (NMES) countries, such as China, where firms are typically subject to a - typically higher - country-wide duty that is the same for all exporting firms. Firms in NMES can only be granted individual duties if they can demonstrate that they qualify for individual treatment, for example by showing that they operate in a market economy environment or by using individual export prices rather than average export prices to calculate the dumping margin. It follows that using product- rather than company-level information would increase the likelihood of assigning a higher product-specific duty to firms that qualify for individual treatments. This would lead to the classical "attenuation bias" of the estimated coefficient of AD towards zero, representing an underestimation of the true treatment effect. As discussed by Felbermayr and Sandkamp (2019), the attenuation bias is likely to be a problem when using tariff rates to estimate the elasticities. However, unlike Felbermayr and Sandkamp (2019), who use tariff rates and exploit within product-country-time variation across firms to estimate the treatment effect, we employ a dummy variable to mitigate this measurement problem.

Since our main variable of interest varies at the product-country level over time, to cope with potential heteroscedasticity and serial autocorrelation, we cluster standard errors at the product-destination pair level.

### *3.2. Selecting the treated and the control groups*

As discussed in the previous section, we employ a DDD estimation strategy to identify the possible effect of AD measures on firms' export behavior. This strategy involves comparing the outcome variables of the group that is exposed to the duty, which is called the treatment group, and the group that is not exposed to the treatment, known as the control group. As far as the treated group is concerned, we restrict our sample to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the implementation of the AD measure.[25]

For the control group, we select three different samples. In our baseline model, we estimate equation (2) using the full sample, which includes all products and destinations. The treated group consists of surviving transactions of products subject to AD duties in one of the 28 destinations that imposed such measures against China between 2000 and 2015, while the control group includes all other HS6 product-destination pairs. However, this empirical strategy faces a fundamental challenge: the counterfactual for the treated product, i.e., the outcome of the AD treatment in the post-treatment period relative to the effect of no treatment for the same observation, is unobservable. To be valid, our estimation strategy requires that the average change in outcomes would have been the same for both the treated and control groups in the absence of treatment. Specifically, it requires that the relative outcome of treated and untreated products in the destination where the AD duty is imposed follows the same trend as the relative outcome of treated and untreated products in the "control" destination where no AD measure is imposed. However, this assumption may be too restrictive if the distribution of certain observable characteristics that are thought to affect the outcome dynamics is uneven between the treated and control groups. In addition, the inclusion of all products and destinations in the analysis may be problematic, as AD measures tend to be concentrated on specific products and countries, which may differ from other markets and products.

To address the challenges posed by our baseline model, we implement a limited sample approach to estimating equation (2). This approach only includes products that are subject to AD measures in at least one country, but not subject to AD tariffs in other destinations. This means that each product in the sample is both subject to AD measures and not subject to AD measures, depending on the destination market. For example, shipments of "warm-water shrimp" (HS 030613) from China were subject to AD measures in the USA in 2004 but were not restricted in the EU. This allows us to control for common factors that may affect such goods and reduces the risk of selection bias. We refer to this approach as *Control 1*.[26]

One problem with using all the other destinations where the product has not been subject to AD duties as the control group, as in *Control 1*, is that it may not be a very good match to the country that has imposed the measure. Macroeconomic conditions, such as the level of development and the overall volume of imports, are important factors that need to be considered when comparing different destinations. To test the robustness of our results, we construct a second alternative control group from the sample of observations belonging to *Control 1* using a coarsened exact matching (CEM) algorithm, recently implemented by Jaravel et al. (2018). We construct a "placebo treatment group" by applying a one-to-one exact matching procedure using the CEM algorithm described by Iacus et al. (2011). This involves coarsening each variable so that indistinguishable values are combined into meaningful groups, creating a set of strata with the same coarsened values of the covariate, and applying the exact matching algorithm to the

[25]This strategy has been applied also by Felbermayr and Sandkamp (2019). Table A3 in the Appendix replicates the analysis by using all firms, that is, also those that appear only before or after the treatment.

[26]It is important to note that focusing solely on the impact of AD measures in a single country on targeted firms, as in the case of previous studies, such as Lu et al. (2013), may limit our ability to compare products subject to AD measures in a single destination with the same product exported without restrictions to other destinations. Therefore, our approach allows for a more comprehensive analysis of the impact of AD measures on different products in different destinations.

coarsened data to determine matches.[27] We use two continuous variables, GDP growth rate and total import volume from China, to find exact matches in the sub-sample of destinations where the same product has not received any administered protection. This gives us a control group with the same level of development and the same level of imports. We denote the final sample as *Control 2*.

As explained by Jaravel et al. (2018), the standard difference-in-difference setting raises some concerns that year and other set of fixed effects may not fully account for, such as trends in trade patterns that are common to both treated and placebo product groups. It is important to note that the exact matching process results in a scenario where the placebo products inherit the counterfactual year of treatment associated with their corresponding treated products. This allows us to run a specification where we also account for pre- and post-period trends that are common to both treated and placebo groups. The specification can be written as follows

$$\ln \text{ExportPerf}_{\text{fpdt}} = \beta_0 + \beta_1 \text{AD}_{\text{pdt}} + \beta_2 \text{Post}^{\text{All}}_{\text{pdt}} + \gamma_{\text{fpd}} + \gamma_{\text{fdt}} + \gamma_{\text{fpt}} + \varepsilon_{\text{fpdt}}, \quad (3)$$

where, differently from equation 2, we add a variable $\text{Post}^{All}_{pdt}$, that is a dummy turning to 1 after the treatment year for both the treated and the corresponding control group, and zero in the pre-treatment period. Under our identification assumption, $\beta_1$ gives the average causal effect of AD duties for the treated group, while $\beta_2$ shows the effect of possible patterns that are common to both treated and placebo groups.

### *3.3. Baseline results*

We begin our empirical analysis by estimating equation (2) on the full sample, including the surviving transactions for the treated group and firms exporting to all other unaffected product-destination pairs for the control group. The results of the estimations are reported in the first three columns of Table 4, which shows the effects on exports, price, and quality, respectively.[28] Our findings are consistent with existing literature, which shows that AD measures lead to a significant reduction in Chinese exports (see Konings and Vandenbussche, 2008; Lu et al., 2013; Felbermayr and Sandkamp, 2019; Chandra and Long, 2013, among others). Specifically, AD duties are estimated to reduce exports by around 7.9%, confirming the dampening effect of AD on Chinese exports.

The second column of Table 4 reports the effect of AD measures on export prices. Our result indicates that Chinese firms do not adjust their prices following the imposition of AD duties. This finding is consistent with Lu et al. (2013) and Felbermayr and Sandkamp (2019), who also find no significant price effect for Chinese exporters. The lack of price response may imply that AD duties are fully passed on to importers, acting in a similar way to tariffs (Amiti et al., 2019; Fajgelbaum et al., 2020).[29] However, as shown by Cole and Eckel (2018), whether consumers bear the full burden depends on the level of competition in the retail sector. Indeed, retailers, who face competition across various products, might absorb some of the duties by reducing mark-ups on the affected items, thereby preventing complete pass-through to consumers.[30]

[27] To run the exact matching technique, we use the stata command *cem*, developed by Blackwell et al. (2009).

[28] As shown in Table A3 in the Appendix, the results are qualitatively and quantitatively very similar when all transactions are used, including those that appear either only before or only after the treatment.

[29] Both Amiti et al. (2019) and Fajgelbaum et al. (2020) report minimal impacts on the prices of imports subject to tariffs, suggesting that a significant portion of the tariffs was promptly passed on to importers and consumers.

[30] Regarding the impact of AD duties on prices, the studies by Blonigen and Haynes (2002) and Blonigen and Park (2004) demonstrate that exporters may, theoretically, pass on these duties to consumers in excess of 100%. The fact that we do not find a more than 100% pass-through could be explained by China's NMES. In market

Table 4: The effect of AD measures on Chinese firms

| Dep. Var (log) | $Exports_{fpdt}$ | $UV_{fpdt}$ | $Quality_{fpdt}$ | $Exports_{fpdt}$ | $UV_{fpdt}$ | $Quality_{fpdt}$ | $Exports_{fpdt}$ | $UV_{fpdt}$ | $Quality_{fpdt}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | *Full sample* | | | *Control 1* | | | *Control 2* | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $AD_{pdt}$ | -0.079*** | 0.002 | -0.082*** | -0.092*** | 0.006 | -0.101*** | -0.081*** | 0.0001 | -0.114*** |
| | (0.019) | (0.006) | (0.022) | (0.021) | (0.007) | (0.025) | (0.029) | (0.010) | (0.032) |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 11,407,879 | 11,407,879 | 11,407,883 | 2,973,223 | 2,973,223 | 2,973,223 | 1,331,130 | 1,331,130 | 1,331,130 |
| adj. $R^2$ | 0.761 | 0.948 | 0.825 | 0.732 | 0.921 | 0.734 | 0.707 | 0.911 | 0.698 |
| # Cluster | 210,818 | 210,818 | 210,818 | 56,267 | 56,267 | 56,267 | 21,340 | 21,340 | 21,340 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. *Full sample* includes all the other triplets. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In columns (7)-(9) the dummy $Post^{All}_{pdt}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

While the first two columns of Table 4 confirm previous findings, our study goes further by examining other channels through which AD duties may affect export behavior. While Chinese firms do not adjust their export prices in response to AD duties, they may change the quality of the exported products to compensate for the increase in variable costs due to the imposition of AD restrictions. Column (3) shows that AD measures are associated with a substantial decrease in product quality. The estimated semi-elasticity of quality is 0.082. By comparing the quality of the same product in the same destination market and exported by the same firm before and after the imposition of the AD duty, we are able to control for many potential sources of spurious correlation, such as country-, product-, or firm-specific factors that might affect quality. Across specifications, the large $R^2$ across outcome variables indicates the use of a battery of fixed effects helps to explain a significant amount of variation in firm export performance.

To address potential self-selection bias, as discussed in the previous section, we consider two different control groups and report the results of our DDD empirical model using both *Control group 1* (columns 4-6) and the exact matched counterfactual, *Control group 2* (columns 7-9) in Table 4. In both specifications, the coefficient of interest on AD exhibits the same sign as in the baseline model, reaffirming the robustness of our results. We also find that the estimated coefficients on export value are similar in magnitude to those reported in column (1) when the "control" group encompasses a broader classification of unaffected firm-product-destination triplets. We observe a negative effect on export value of about 8-9%, while the point estimates for the price are small and not significantly different from zero, suggesting that the bulk of the AD effect on trade flows is represented by a change in quantity. In addition, we find that the negative effect on product quality is even larger (about 10%) when these two samples are used, implying that AD duties may cause negative externalities that are not necessarily related to prices. The AD policy measure has additional detrimental effects beyond those that were previously assessed in the literature.

economies, exporters may raise ex-factory prices to manipulate the calculated AD duty margin, but this is less likely in NMES countries, where the domestic price is irrelevant for computing the dumping measure. Rather, AD-imposing countries use costs from an alternative "surrogate" country to determine the margin. Chinese firms therefore have limited incentives to manipulate domestic prices.

As a robustness check, we encompass other two strategies in the construction of the control groups. First, similarly to Lu et al. (2013) and Meng et al. (2020), we select as control group all the unaffected products within the HS4 product category to which the affected products belong (referred to as *Control 3*). Second, following the matching method employed by Blonigen and Park (2004); Konings and Vandenbussche (2008), and Pierce (2011), we construct a matched group within the affected HS4 product category (referred to as *Control 4*). Specifically, we estimate a probability of the product subject to AD duties via a logistic model. The variables used to predict the likelihood of being subject to AD duties are import penetration from China, the average import price, the GDP growth rate, and the real exchange rate. After calculating the probability of protection using the fitted values from the logistic regression, the control group is limited to the affected HS4 product category that were in the top 50th percentile in terms of their predicted probability of facing the protection. As reported in Table A4 in the Appendix, the results preserve strong statistical significance with these different control groups.

Taken together, these results suggest that the control groups used in our analysis are appropriate counterfactuals, and that the potential selection effects at work are not too severe. The significant negative effect on product quality, combined with the null effect on price, underlines the importance of controlling for the potential unintended consequences of AD duties on firm behavior and trade flows.

### *3.4. The AD effect on quality: robustness checks*

In this section, we examine the robustness of the DDD estimation results for our main outcome variable, i.e., the quality of exported products. We perform a series of exercises to test the robustness to the adoption of similar measures of export quality, a different specification, and a change in the sample composition.

We conduct two sensitivity tests to check the robustness of our results regarding the impact of AD measures on product quality. Specifically, we measure product quality using the methodology proposed by Amiti and Khandelwal (2013), who calibrates a CES demand system with price elasticity estimates from Broda and Weinstein (2006). This alternative approach allows us to obtain product quality as the residual from a regression of $\ln q_{fpdt} + \eta \ln p_{fpdt}$ on $\theta_p + \theta_{dt} + v_{fpdt}$, where $\eta$ is the elasticity of substitution. We employ two different measures for the elasticity of substitution. First, we use the sector-specific (3-digit) elasticity of substitution from Broda and Weinstein (2006), and then we check the robustness of our results using a constant elasticity of substitution of five. The main differences between this measure and the one developed above and based on Khandelwal (2010) and Bernini and Tomasi (2015) are, firstly, that the former does not depend on the strategy used to estimate the parameter of the demand equation and, secondly, that the dependent variable of the demand equation is not a market share but rather the export quantity of a variety adjusted for its price.

Our results, presented in Table 5, confirm the robustness of our findings regarding the negative impact of AD measures on product quality. The coefficients remain similar and statistically significant, indicating that the quality of exported products declines significantly when they are subject to AD duties, regardless of the methodology used to measure product quality. These results provide additional confidence in the robustness of our findings.

Despite the very demanding specification of our baseline model, i.e., equation (2), which accounts for several set of fixed effects, other time-varying product-destination factors could bias the estimates of our parameter of interest. Unlike Felbermayr and Sandkamp (2019), who exploit the within-country-product-time across firm variation to identify the treatment effect, we cannot include $\gamma_{pdt}$ fixed effects because this variation is required to estimate the effect of AD duties. In order to mitigate the omitted variable bias due to time-varying product-destination characteristics,

Table 5: The effect of AD measures on quality using alternative quality measures approach

| Dep. Var (log) | $Quality_{fpdt}$ | | | | | |
|---|---|---|---|---|---|---|
| | Broda and Weinstein (2006) elasticity | | | Constant elasticity | | |
| | *Full Sample* | *Control 1* | *Control 2* | *Full Sample* | *Control 1* | *Control 2* |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $AD_{pdt}$ | -0.134*** | -0.085** | -0.080* | -0.074*** | -0.074** | -0.081* |
| | (0.042) | (0.035) | (0.044) | (0.026) | (0.032) | (0.043) |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 10,195,643 | 2,739,126 | 1,242,809 | 11,407,879 | 2,973,223 | 1,331,130 |
| adj. $R^2$ | 0.868 | 0.895 | 0.903 | 0.787 | 0.733 | 0.707 |
| # Cluster | 192,025 | 54,061 | 20,555 | 210,818 | 56,267 | 21,340 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In columns (1)-(3), quality is computed using the elasticity of substitution estimated by Broda and Weinstein (2006), while in columns (4)-(6) is constant and equals to 5. In Columns 3 and 6 the dummy $Post^{All}_{pdt}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

we perform a robustness check by including other controls. We introduce time-varying product-destination proxies for the level of demand and the level of concentration in the exporting country, using import data for each product-destination pair from the BACI dataset. Specifically, demand is computed as $\text{Demand}_{pdt} = \sum_{c \in \mathcal{C}_{pdt}} \text{IMP}_{pcdt}$ where $\text{IMP}_{pcd,t}$ is the total imports of product $p$ by destination $d$ in year $t$. Here $\mathcal{C}_{pd}$ is the set of countries, excluding China, exporting product $p$ to destination $d$. Similarly, concentration is given by $\text{HHI}_{pdt} = \sum_{c \in \mathcal{C}_{pdt}} \left( \frac{\text{IMP}_{pcdt}}{\text{Demand}_{pdt}} \right)^2$. Given the positive correlation between the use of AD protection and trade liberalization (Moore and Zanardi, 2011), we control for the most-favored-nation (MFN) applied tariff at the HS6 level imposed against China by each destination country.[31] The results are reported in the first three columns of Table 6, for the *Full sample*, *Control 1* and *Control 2*, respectively. The negative coefficient of the AD duty on export quality is robust to the inclusion of these additional control variables. While our main focus is on the relationship between trade policy and export quality, our regressions provide further insight into the determinants of export quality. Time-varying product-destination characteristics, such as the degree of concentration and aggregate demand, are related to export performance. In line with Hallak and Schott (2011) and Khandelwal (2010), we find that export quality increases with foreign demand and with the level of market competition.

Up to this point in our analysis, we have defined the starting point of an AD case as the year in which the provisional AD measure was imposed. However, as explained in Section 2.2, a critical point in an AD case is the initiation (investigation) phase, which is the period during which the importing country tries to determine whether imported goods are being sold at a price below that in the producing country. This period typically lasts between six and nine months. Although in several AD cases the investigation period ends within the same year as the provisional AD, a possible concern with our definition is that potential anticipatory effects during this investigation period, before the preliminary and final AD decisions, are not properly taken into account, thus

[31] Data for the MFN tariffs are taken from the World Integrated Trade Solution (WITS) dataset.

Table 6: The effect of AD measures on Chinese firms: robustness check

| Dep. Var (log) | $Quality_{fpdt}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Full sample* | *Control 1* | *Control 2* | *Full sample* | *Control 1* | *Control 2* | *Full sample* | *Control 1* | *Control 2* |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $AD_{pdt}$ | -0.088*** | -0.106*** | -0.118*** | -0.056*** | -0.073*** | -0.090*** | -0.060*** | -0.097*** | -0.114*** |
| | (0.023) | (0.027) | (0.034) | (0.021) | (0.025) | (0.031) | (0.022) | (0.026) | (0.033) |
| $Tariff_{pdt}$ | 0.001 | 0.003 | 0.009 | | | | | | |
| | (0.001) | (0.002) | (0.008) | | | | | | |
| $\ln Concentration_{pdt}$ | -0.018*** | -0.029*** | -0.037*** | | | | | | |
| | (0.004) | (0.007) | (0.012) | | | | | | |
| $\ln Demand_{pdt}$ | 0.024*** | 0.021*** | 0.032*** | | | | | | |
| | (0.003) | (0.006) | (0.011) | | | | | | |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 10,113,902 | 2,565,012 | 1,190,246 | 11,834,784 | 2,973,223 | 1,331,130 | 11,584,268 | 2,858,446 | 1,279,495 |
| adj. $R^2$ | 0.823 | 0.739 | 0.706 | 0.825 | 0.734 | 0.698 | 0.819 | 0.729 | 0.700 |
| # Cluster | 187,656 | 49,774 | 19,625 | 210,818 | 56,267 | 21,340 | 210,932 | 55,371 | 21,077 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that export an HS6 products to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. In columns (1)-(3), we include the (ln) level of foreign demand ($\ln Demand_{pdt}$), the (ln) level of concentration ($\ln Concentration_{pdt}$), and the product duty in the destination country $d$. In columns (4)-(6), we define $AD_{pdt}$ takes the value of one since the year when the investigation was initiated in the first six month of the year, while coded AD case investigation that was initiated in the last six month of the year as belonging to the subsequent year. In columns (7)-(9), we exclude the product-destination pairs investigated but concluded without measure being imposed. *Full sample* includes all the other triplets. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In columns (3), (6), and (9) the dummy $Post^{All}_{pdt}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

threatening identification. Indeed, it has been shown in Staiger et al. (1994) that there can be significant changes in firms' export behavior during the investigation phase due to the uncertainty it brings to their business.[32] To account for these possible anticipatory effects, we modify the indicator variable $AD_{pdt}$ to take a value of one in the year in which the investigation takes place. As we do not have monthly data, we cannot identify exactly when the case was initiated. Following Bao et al. (2021), we code AD cases started in the first six months of the year as belonging to that year, whereas AD cases started in the last six months of the year as belonging to the following year. As shown in columns (4)-(6) of Table 6, our results are qualitatively very similar when we specify our AD indicator variables to account for the investigation phase.[33] Finally, we run a robustness check in which we exclude those product-country combinations that were investigated but concluded without measures being imposed. The results, shown in columns (7)-(9) of Table 6, do not change. Alternatively, we redefine our $AD_{pdt}$ dummy to take a value of one in the year in which the investigation takes place for all product-destination combinations that have been subject to an initiation phase, regardless of whether the AD duty has been imposed or not.[34] The results for this robustness check, not shown but available upon request, are also consistent with the previous findings.

[32]It should be noted, however, that using monthly data for China, Lu et al. (2018) did not find any significant effect exerted by the initiation of the investigation, in contrast to Staiger et al. (1994).

[33]We also run a regression in which we include the $AD_{pdt}$ dummy, defined using the provisional measure as the starting year, together with a dummy $AD^{Invest}_{pdt}$, which takes the value of one in the year in which the investigation process was initiated. Results do not change with this alternative specification.

[34]We recall from Section 2.2 that around 500 product-country pairs were investigated but concluded without measures being imposed.

Table 7: The effect of AD measures on product quality: different fixed effects

| Dep. Var (log) | $Quality_{pdt}$ | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| | Panel A: *full sample* | | | | |
| $AD_{pdt}$ | 0.379*** | 0.395*** | 0.409*** | 0.325*** | -0.119*** |
| | (0.044) | (0.046) | (0.047) | (0.043) | (0.020) |
| FE | f,p,d,t | p,ft,dt | pt,ft,dt | fpt,dt | fpt,fpd,dt |
| $N$ | 35,285,161 | 34,946,751 | 34,944,417 | 29,331,902 | 18,572,527 |
| adj. $R^2$ | 0.356 | 0.360 | 0.370 | 0.644 | 0.861 |
| | Panel B: *Control 1* | | | | |
| $AD_{pdt}$ | 0.268*** | 0.293*** | 0.303*** | 0.238*** | -0.126*** |
| | (0.047) | (0.050) | (0.052) | (0.046) | (0.019) |
| FE | f,p,d,t | p, ft,dt | pt,ft,dt | fpt,dt | fpt,fpd,dt |
| $N$ | 12,629,772 | 12,340,552 | 12,340,440 | 10,871,710 | 7,022,703 |
| adj. $R^2$ | 0.391 | 0.381 | 0.390 | 0.605 | 0.843 |
| | Panel C: *Control 2* | | | | |
| $AD_{pdt}$ | 0.166*** | 0.208*** | 0.209*** | 0.157*** | -0.126*** |
| | (0.051) | (0.056) | (0.059) | (0.054) | (0.022) |
| FE | f,p,d,t | p, ft,dt | pt,ft,dt | fpt,dt | fpt,fpd,dt |
| $N$ | 7,111,503 | 6,825,573 | 6,825,205 | 5,778,816 | 3,889,664 |
| adj. $R^2$ | 0.349 | 0.331 | 0.339 | 0.592 | 0.831 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. The *Full sample* includes all other unaffected triplets. *Control 1* comprises the group of treated HS6 products exported to non-treated destinations, while *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In Panel C, the dummy $Post^{All}_{pdt}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

In Section 3, we have highlighted the importance of applying the correct set of fixed effects to reduce the endogeneity concerns due to omitted variable bias. As a final step, we empirically demonstrate the importance of doing so and how different models can affect the estimated coefficients. Table 7 reports the estimation results on product quality where we introduce progressively more stringent fixed effects. In column (1), we report the estimated coefficient from a specification that includes firm, country, product, and year fixed effects. These fixed effects control for time-invariant characteristics that vary across firms (e.g. ownership, industry, labor skill composition, etc), destination markets (e.g. income level of destination market, trade cost from China, distribution costs, etc), or product categories (degree of product differentiation, degree of technological sophistication, comparative advantage, etc). In column (2), in line with the main specification in Meng et al. (2020), we augment the firm and destination fixed effects with firm-year and destination-year fixed effects which take into account supply-side factors such as firm productivity shock and destination-specific time-varying heterogeneity, such as business cycle fluctuations. In column (3), we further expand the product fixed effects with product-year fixed effect to capture all unobservable time varying factors at the product-level, such as demand shocks for a specific product or common shocks affecting production. In column (4), we report the results from a specification that includes firm-product-year and destination-year fixed effects, which capture possible idiosyncratic time-varying firm-product attributes that may be correlated with the evolution of product quality. In column (5), we also include firm-product-destination fixed effects to control for unobservable time-invariant differences across firm-product-destination triplets that may influence trends in product quality. Notably, we observe a significantly larger $R^2$ statistic (0.8) when including firm-product-destination fixed effects (column (5)) compared to specifications in columns (1) to (4). In addition, failing to account for unobserved time-invariant characteristics that are idiosyncratic to the transaction can lead to severe omitted variable bias that works in opposite directions, resulting in a change in the sign of the coefficient that turns out to be positive in columns (1) to (4). This finding underscores the importance of applying the correct fixed effects specification to estimate the impact of AD measures on export behavior.

## 4. Dynamic model and revoked effects

The DDD model captures the average post-treatment effect of the trade policy. To examine the timing of the effects, we apply a panel event study model, which also allows us to test for pre-trends. Although we have argued that the control groups allow us to take into account self-selection bias, we still need to rule out the possibility that higher quality products (or exports) were also those that were subject to the trade policy in the first place. In this case, we would still observe an ex-post effect, but the causal relationship would be questionable. The dynamic model exploits the panel structure of the dataset by including a full set of leads and lags around the year of the imposition of AD measures for AD targeted product-destination pairs. Lags and leads are thus binary variables indicating that the given state was a given number of periods away from the event of interest in the given time period. The predictive effects associated with these leads and lags are denoted by $\{\phi_k^{Treat}\}_{k=-7}^{7}$, where $k$ refers to the time relative to the imposition of AD measures.[35] Formally, we estimate the following model

$$Quality_{fpdt} = \phi_0 + \sum_{k=-7, k\neq -1}^{7} \phi_k^{Treat} AD_{pdk} + \gamma_{fpd} + \gamma_{fdt} + \gamma_{fpt} + \varepsilon_{fpdt}, \quad (4)$$

[35] We consider seven leads and lags because there are few observations when the time window is extended and therefore the coefficients are imprecisely estimated.

Table 8: The dynamic effect of AD measures on quality

| Dep. Var (log) | $Quality_{fpdt}$ | | |
|---|---|---|---|
| | *Full Sample* | *Control 1* | *Control 2* |
| | (1) | (2) | (3) |
| $AD_{pdk=-7}$ | 0.056 | 0.122* | 0.106 |
| | (0.057) | (0.068) | (0.093) |
| $AD_{pdk=-6}$ | 0.019 | 0.075 | 0.084 |
| | (0.044) | (0.052) | (0.073) |
| $AD_{pdk=-5}$ | -0.056 | -0.027 | 0.009 |
| | (0.036) | (0.042) | (0.058) |
| $AD_{pdk=-4}$ | -0.001 | 0.032 | 0.019 |
| | (0.033) | (0.042) | (0.049) |
| $AD_{pdk=-3}$ | 0.001 | -0.010 | -0.002 |
| | (0.027) | (0.032) | (0.046) |
| $AD_{pdk=-2}$ | 0.010 | -0.002 | -0.006 |
| | (0.022) | (0.025) | (0.032) |
| $AD_{pdk=0}$ | -0.048** | -0.063** | -0.108*** |
| | (0.023) | (0.026) | (0.031) |
| $AD_{pdk=1}$ | -0.116*** | -0.131*** | -0.137*** |
| | (0.027) | (0.032) | (0.038) |
| $AD_{pdk=2}$ | -0.085*** | -0.107*** | -0.145*** |
| | (0.031) | (0.037) | (0.045) |
| $AD_{pdk=3}$ | -0.076** | -0.072* | -0.096** |
| | (0.033) | (0.038) | (0.043) |
| $AD_{pdk=4}$ | -0.086** | -0.088** | -0.124** |
| | (0.037) | (0.043) | (0.048) |
| $AD_{pdk=5}$ | -0.094** | -0.111** | -0.097** |
| | (0.041) | (0.056) | (0.045) |
| $AD_{pdk=6}$ | -0.050 | -0.026 | -0.040 |
| | (0.051) | (0.061) | (0.059) |
| $AD_{pdk=7}$ | -0.083* | -0.109* | -0.083* |
| | (0.050) | (0.056) | (0.044) |
| $\gamma_{fpd}$ | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes |
| $N$ | 11,407,883 | 2,973,223 | 1,301,193 |
| adj. $R^2$ | 0.825 | 0.734 | 0.705 |
| # Cluster | 210,818 | 56,267 | 20,696 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In column (3), the dummies $Post^{All}_{pdk}$ are included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

where the set of dummy variables $AD_{pdk}$ represents relative periods with respect to the event of the AD imposition. The first lag, $k = -1$, is omitted to capture the baseline difference between groups where the AD policy does not occur. Lags and leads capture the difference between treated and control groups relative to the prevailing difference in the omitted base period. The full set of event lags allows for the inspection of parallel trends in the pre-treatment period. Table 8 shows the results of the standard event study model, using the three samples. Looking at column (1), we see that the estimated effects of the AD measures for the years before the event are not statistically significant, supporting the conclusion that the policy events were not correlated with pre-existing underlying trends. Looking at the post-trade policy coefficients, the quality of exported products is negatively affected by the imposition of the AD duties, and the effect seems to be permanent and with a similar impact over time. The results at years 6 and 7 are still negative, although barely statistically significant. The lower statistical significance could simply be related to the sample composition, as there are few firms that appear several years after the AD measure. A similar pattern is also observed when we restrict our sample to *Control 1* for the counterfactual

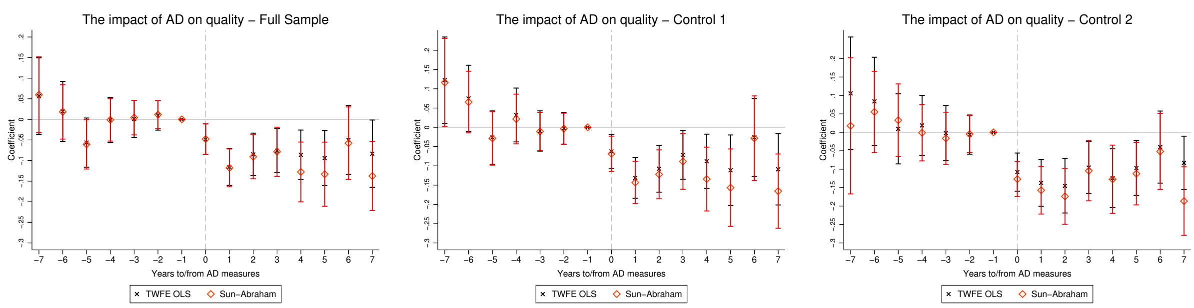


Figure 4: Dynamic Causal Effects of AD measures on firms' quality

comparison, as can be seen from column (2) of Table 8.

We run a similar specification using the exact matching for *Control 2*. By construction, the use of a one-to-one exact matching procedure ensures that the placebo group shared a "counterfactual" year of AD duty imposition with the corresponding treated group. This allows us to incorporate a set of leads and lags around the AD measures that were common to both groups ($Post^{All}_{pdk}$), in addition to the set of leads and lags around the year of AD duty imposition for the AD targeted product-destination combinations ($AD_{pdk}$). Following the approach of Jaravel et al. (2018), we estimated the following equation

$$\ln \mathrm{Quality}_{\mathrm{fpdt}} = \phi_0 + \sum_{\mathrm{k}=-7,\mathrm{k}\neq -1}^{7} \phi_{\mathrm{k}}^{\mathrm{Treat}} \mathrm{AD}_{\mathrm{pdk}} + \sum_{\mathrm{k}=-7,\mathrm{k}\neq -1}^{7} \phi_{\mathrm{k}}^{\mathrm{All}} \mathrm{Post}_{\mathrm{pdk}}^{\mathrm{All}} + \gamma_{\mathrm{fpd}} + \gamma_{\mathrm{fdt}} + \gamma_{\mathrm{fpt}} + \varepsilon_{\mathrm{fpdt}}, \quad (5)$$

with $\{\phi_k^{Treat}\}_{k=-7}^{7}$ denote the causal effect of AD duty on the outcome of interest, while $\{\phi_k^{All}\}_{k=-7}^{7}$ are the predictive effects common to both the real treated group and the placebo one. Results from specification (5) using *Control 2* as the counterfactual comparison are presented in column (3) of Table 8. As in the previous analysis, the first lag (equal to one in the year preceding the imposition of the AD measures) is normalized to zero, and the inference is relative to this lag. The estimated coefficients for the years preceding the imposition of AD measures are not significantly different from zero. In contrast, when a product exported by a firm is hit by AD duties, the negative effect on quality is statistically significant in every year except 6 years after the initial imposition of AD measures.

The implementation of a standard event study model does not properly take into account the heterogeneous staggered nature of the AD policy, i.e., the fact that the treatment AD measure is imposed at different points in time. Indeed, recent advances in econometric theory (de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2021; Callaway and Sant'Anna, 2021; Athey and Imbens, 2022; Borusyak et al., 2022) have argued that standard DD regression estimates with staggered treatment timing may not provide valid estimates of the causal effect of interest to researchers. Staggered adoptions do not pose a problem for estimating the average treatment effect if the effects are homogeneous over time periods (Baker et al., 2022) (i.e., no dynamic changes in the effects of treatment). When this is not the case, and a research design combines staggered timing of treatment effects with heterogeneity of treatment effects, the resulting staggered DD estimates are likely to be biased. According to recent research, these biases are not eliminated by implementing an event study estimator. In particular, Sun and Abraham (2021) have shown that when dealing with staggered treatment timing and treatment effect heterogeneity, the estimates of dynamic effects for a particular relative time period based on two-way fixed effects (TWFE) are influenced by the causal effects of other relative time

Table 9: The effect of AD measures on Chinese firms: revoked vs. not-revoked

| Dep. Var (log) | $Quality_{fpdt}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Full Sample* | | | *Control 1* | | | *Control 2* | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $AD_{pdt}$ | -0.104*** | | | -0.122*** | | | -0.146*** | | |
| | (0.026) | | | (0.030) | | | (0.039) | | |
| $AD_{pdt}^{NeverRevoked}$ | | -0.102*** | | | -0.123*** | | | -0.142*** | |
| | | (0.022) | | | (0.026) | | | (0.034) | |
| $AD_{pdt}^{NotRevoked}$ | | | -0.100*** | | | -0.121*** | | | -0.139*** |
| | | | (0.022) | | | (0.026) | | | (0.034) |
| $AD_{pdt}^{Revoked}$ | | | -0.168*** | | | -0.188*** | | | -0.195*** |
| | | | (0.053) | | | (0.061) | | | (0.070) |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 11,356,642 | 11,407,883 | 11,407,883 | 2,933,845 | 2,973,223 | 2,973,223 | 1,299,288 | 1,331,130 | 1,331,130 |
| adj. $R^2$ | 0.825 | 0.825 | 0.825 | 0.733 | 0.734 | 0.734 | 0.695 | 0.698 | 0.698 |
| # Cluster | 210,118 | 210,818 | 210,818 | 55,645 | 56,267 | 56,267 | 20,820 | 21,340 | 21,340 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. Columns (1)-(4)- (7) exclude the AD product-destination combinations for which the AD duty has been withdrawn. Columns (2)-(5)-(8) include the never reversed dummy variable $AD_{pdt}^{NeverRevoked}$ equals one for all the years after the AD was imposed. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In columns (7)-(9) the dummy $Post_{pdt}^{All}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

periods present in the estimation sample, affecting the accuracy of the estimates.[36] In light of these recent advances in the literature, we assess the robustness of our main results using the "interaction-weighted" estimator proposed by Sun and Abraham (2021), specifically devised for event studies with binary treatment and different treatment timing across cohorts.[37] As shown in Figure 4, the results based on the Sun and Abraham (2021) estimator closely mirror those of the TWFE model in terms of direction of the effects, significance and magnitude.

When analyzing the impact of AD measures over time, it is crucial to consider that within the treated group, there are product-country combinations where the AD duty is renewed following the mandatory review process, while in others, the duty is revoked. In other words, some treatments can be reversed at a certain point in time. However, the effects of AD measures after they have been revoked have never been studied previously in the literature on AD. In our setting with a dichotomous treatment variable, this translates to a dummy switching 'on' and 'off' over time within the subset of the treated group.[38] This allows us to model the periods when treatment is withdrawn and to investigate whether the effects fade after the end of the AD duty. One might expect that once the dumping policy is over, firms will return to producing higher quality products. At the same time, however, there might be a hysteresis effect such that companies cannot return to pre-dumping quality standards.

[36]The reason is that the TWFE estimate is a weighted average of many 2-by-2 DD treatment effects, where some of the weights can be negative or incorrect because of contamination from other periods.

[37]To run the Sun and Abraham (2021) estimator, we use the stata command *eventstudyinteract*, using the never-treated units as the comparison group.

[38]In the GAD database, there are only 37 country-product pairs where the dummy switches from 'on' to 'off' and back to 'on' during the period studied. Our results are robust to the removal of these country-product pairs and are available upon request.

As a first step, we run equation (2) by removing those observations for which the AD duty is withdrawn after a certain period of time, leaving only those product-destination pairs that, once subject to AD, remain so until the end of the period. Columns (1), (4) and (7) of Table 9 show that the effect on quality is still negative and slightly larger that the coefficients obtained in Table 4. In columns (2), (5) and (8), we create a never reversed dummy variable $\text{AD}_{pdt}^{NeverRevoked}$, which takes the value of one for all years after the AD was imposed. Thus, we effectively create a dummy that implies that a country-product pair is still treated even after the AD measure has been revoked. The effects on quality are still negative and larger than those in the baseline results. Finally, we distinguish the treated group into product-country combinations for which the AD duty is renewed ($\text{AD}_{pdt}^{NotRevoked}$), and combinations for which the AD duty is reversed ($\text{AD}_{pdt}^{Revoked}$). Columns (3), (6) and (9) report the estimates of the two AD policy dummies: both coefficients are negative and statistically significant, but the coefficient on country-product combinations where the AD duty is revoked is larger, although not in a statistically significant way. This suggests the existence of long-term negative effects of the AD policy, persisting even after the termination of the measure.

## 5. Heterogeneous effects and mechanisms

In this section, we examine the heterogeneity of the treatment effect based on the characteristics of destination countries. Additionally, we conduct an analysis to explore the potential mechanisms and channels underlying the observed robust pattern of quality downgrading at the firm level.

To assess whether the AD policies have a disproportionate effect on export behavior in different areas, we first examine the interaction between the AD dummy and country characteristics. It is reasonable to expect that exporters will tend to offer higher-quality versions of their products in richer countries, as consumers in these markets typically have a lower marginal utility of income and are more willing to pay for quality. In such markets, exporters may face stiffer competition and selling higher-quality goods may lead to higher profits. This positive correlation between quality and the level of development of destination countries is consistent with the theoretical predictions made by Verhoogen (2008a) and Fajgelbaum et al. (2011) and with the empirical analyses of (Hallak, 2006), Choi et al. (2009), Tomasi and Zhu (2020) and Ciani (2021). For example, a Chinese shoemaker might use expensive upper and sole materials to produce a high-quality pair of shoes for export to the US or the EU, while using cheaper materials to produce shoes intended for export to developing countries where consumers are less concerned about quality. When quality rises faster than marginal cost, higher-quality firms tend to capture a larger market share. Therefore, when exporting to richer destinations, firms may be less likely to reduce quality in response to negative trade shocks in order to maintain their market share.

Building on this idea, we run a set of regressions that include an interaction between the treatment status and two dummies representing the US and the EU, as shown in columns (1), (3) and (5) of Table 10. Our findings suggest that while the AD protection continues to have a negative impact for all other countries (the excluded category), the overall effect of quality is negligible for either the US or the EU. Specifically, we observe that export quality decreases by more than 20% in other destinations, while it remains almost unchanged in the US or the EU. We also perform robustness checks by interacting the AD dummy with an indicator variable for developed countries in columns (2), (4) and (6) of Table 10. Our tests confirm a significant heterogeneity in the impact of AD measures on product quality, indicating that it depends on the income level of the export destinations. Notably, we observe substantial quality downgrading for products exported to developing countries, while export quality adjustment is almost muted for

Table 10: The effect of AD measures on quality: differences across countries

| Dep. Var (log) | $Quality_{fpdt}$ | | | | | |
|---|---|---|---|---|---|---|
| | *Full Sample* | | *Control 1* | | *Control 2* | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $AD_{pdt}$ | -0.226*** | -0.252*** | -0.251*** | -0.285*** | -0.270*** | -0.309*** |
| | (0.020) | (0.044) | (0.039) | (0.050) | (0.045) | (0.056) |
| $\times D^{US}{}_d$ | 0.122*** | | 0.193*** | | 0.214*** | |
| | (0.028) | | (0.065) | | (0.073) | |
| $\times D^{EU}{}_d$ | 0.231*** | | 0.203*** | | 0.186*** | |
| | (0.025) | | (0.053) | | (0.064) | |
| $\times \text{Developed}_d$ | | 0.205*** | | 0.221*** | | 0.223*** |
| | | (0.049) | | (0.056) | | (0.063) |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 11,407,883 | 11,407,883 | 2,973,223 | 2,973,223 | 1,331,130 | 1,331,130 |
| adj. $R^2$ | 0.857 | 0.825 | 0.734 | 0.734 | 0.698 | 0.698 |
| # Cluster | 210,818 | 210,818 | 56,267 | 56,267 | 21,340 | 21,340 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS6 product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In columns (5)-(6) the dummy $Post^{All}_{pdt}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

products exported to higher-income countries. Our results hold when alternative control groups are considered, reinforcing their robustness.

Having identified the robust phenomenon of quality downgrading as a result of AD measures and its heterogeneous effects across destinations, we take this line of research further by investigating the driving force behind the decline in product quality. Firms' import activity is one of the possible mechanisms through which AD measures affect the quality of exported products. Since the imposition of the AD treatment corresponds to an increase in trade costs, Chinese exporters facing a rise in export costs may respond by importing lower quality inputs, which in turn could affect the quality of the exported products. Indeed, there is an extensive literature on the interdependence between importing and exporting activities. Recent theoretical works show that producing high-quality products require high-quality inputs (Kugler and Verhoogen, 2012; Hallak and Sivadasan, 2013b). Access to a wider range of foreign inputs and to foreign inputs of superior quality than those domestically available enables firms to upgrade the quality of their products. Empirical evidence on the connection between import activities and export quality has been provided by Manova and Zhang (2012), who find that Chinese firms charging higher export prices import more expensive inputs and those offering a wider range of export prices pay a wider range of input prices and source inputs from more countries.[39]

To test the import mechanism, we estimate the following equation

$$\ln \text{UV}_{fpot} = \zeta_0 + \zeta_1 \text{AD}_{ft} + \tau_{fpo} + \tau_{pot} + \nu_{fpot} \tag{6}$$

[39]Extending the analysis on Chinese multi-product firms, Manova and Yu (2017) provide empirical evidence supporting the idea that firms use inputs of varying quality in order to manufacture products of varying quality.

Table 11: Mechanisms: the effect of AD on firm import prices

| Dep. Var (log) | | $UV_{fpot}$ | |
|---|---|---|---|
| | *Full sample* | *Control 1* | *Control 2* |
| | (1) | (2) | (3) |
| $AD_{ft}$ | -0.020*** | -0.020*** | -0.021*** |
| | (0.004) | (0.004) | (0.004) |
| $\tau_{fpo}$ | Yes | Yes | Yes |
| $\tau_{pot}$ | Yes | Yes | Yes |
| $N$ | 16,999,833 | 12,767,931 | 11,567,883 |
| adj. $R^2$ | 0.915 | 0.913 | 0.911 |

*Notes*: The treatment group refers to surviving transactions, i.e., firms that export products to destinations subject to AD duty both before and after the AD measure. The variable $AD_{ft}$ is a dummy variable that takes a value of one if a firm faced an AD shock at time $t$ and zero otherwise. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

where the subscripts $f$, $p$, $o$, and $t$ in equation (6) denote firm, product, import source country, and year, respectively. Our primary explanatory variable is $AD_{ft}$, a dummy variable that is set to one if firm $f$ encountered an AD duty in year $t$ for any of its destination country-product pair. The parameter of interest, $\zeta_1$, captures the effect of AD duties on firms' import unit value, $UV_{fpot}$. A negative estimate of $\zeta_1$ suggests that firms facing AD duties respond by importing input varieties with lower prices.[40]

The model integrates two sets of fixed effects. The first set, represented by $\tau_{fpo}$, encompasses firm-product-origin fixed effects, which account for unobserved factors specific to each combination of firms, products, and origin countries. Such factors include differences in production technology, managerial abilities, brand reputation, and institutional environments. The second set, denoted by $\tau_{pot}$, refers to product-origin-time fixed effects. These control for temporal variations in the supply and demand of the imported product $p$. These factors encapsulate the impacts of technological advancements in China for product $p$, alterations in industry policies in China for that product, and changes in consumer preferences over time. We cluster the standard errors at the firm level.

The results for the estimation of equation (6) are reported in columns 1-3 of Table 11. We find that when a firm faces an AD duty, it imports cheaper inputs.[41] We thus interpret these findings as preliminary evidence in support of the idea that firms react to the rising of export costs due to AD measures by importing inputs at lower prices and, as a consequence, selling goods of lower quality.

## 6. Welfare Implications

Next, we provide a back-of-the-envelope quantitative assessment of the short-term welfare implications for consumers in the countries imposing AD measures on specific products. This quantitative exercise solely focuses on computing changes in consumer surplus for those specific products subject to AD measures.

[40]We estimate equation (6) using only two-way traders, i.e., firms engaged in both import and export activities. We exclude firms that are solely importers, as they are not affected by AD measures and only exporters.

[41]These results are robust to use of a specification at a more aggregate level, using as dependent variable the average price of products imported by a firm $f$ from country $o$. The additional results are available upon request.

To accurately compute consumer surplus when dealing with vertically differentiated products, it is essential to consider that using output quantities alone is insufficient. First, output quantities are not directly comparable across product varieties, even within the same category, when products are vertically differentiated (Melitz, 2000; Caselli et al., 2023). Second, adopting such an approach would lead to an underestimation of the overall effects of AD measures on consumer surplus since AD measures negatively impact both quantity and quality as demonstrated above.

Thus, following Melitz (2000) and Caselli et al. (2023), we adjust the quantities of each product variety based on their respective quality levels in the following way: $\ln \tilde{q}_{fpdt} = \ln q_{fpdt} + Quality_{fpdt}$, where $\tilde{q}_{fpdt}$ represents quality-adjusted quantity. It should be noted that this measure of quality-adjusted output quantity can be derived from a demand function where the representative consumer has CES preferences in terms of both the quality and quantity of the products offered by firms (Melitz, 2000; Caselli et al., 2023). Such utility function is consistent with the discrete choice model used in Section 2.3 to estimate quality as shown by Anderson et al. (1987).

Once quality-adjusted output quantity is calculated, we can compute consumer surplus ($CS_{pdt}$) in country $d$ for HS6 product $p$ in the year of the AD imposition ($t = 0$) based on the following standard formula of the consumer surplus

$$CS_{pdt} = \frac{1}{2} \cdot \eta \cdot (\ln \tilde{q}_{pdt})^2, \tag{7}$$

where $\eta$ is the elasticity of substitution and $\tilde{q}_{pdt} = \sum_f \tilde{q}_{fpdt}$. As we are interested in the percentage change over time in consumer surplus, we do not require an estimate of $\eta$. Indeed, we can write the percentage change in consumer surplus as

$$\Delta CS_{pdt} = \frac{CS_{pdt} - CS_{pdt-1}}{CS_{pdt-1}} = \left( \frac{\ln \tilde{q}_{pdt}}{\ln \tilde{q}_{pdt-1}} \right)^2 - 1. \tag{8}$$

To compute $\Delta CS_{pdt}$ in equation 8, we only keep destination country-HS6 product pairs that impose an AD duty in any given year. In addition, we only keep data for the first year in which the AD duty is imposed and the year before and only product varieties present in both years. This is to ensure that changes in the sample composition have no impact on the results.

The results show that consumers in the average market (i.e., destination country-HS6 product pair) lose approximately 5.4% of consumer surplus per year due to the imposition of AD measures. This is a relatively large estimate given the high growth of Chinese exports over our sample period, which occurred despite all the contingent protection measures against Chinese firms. Our result complements early estimates of the welfare loss for the US only due to the active AD and countervailing duties by Gallaway et al. (1999). Using a computable general equilibrium model, they estimate that the presence of outstanding AD and countervailing duties represents a collective net economic welfare cost to the US economy of $3 billion, however they do not take into account decreases in quality due to the imposition of these trade-restrictive measures.

## 7. Conclusion

In this paper, we combine information from the Global Antidumping Database with firm-level customs data for the universe of Chinese exporters from 2000 to 2015 to uncover the adjustments for exporters that were hit with AD barriers in given markets. Specifically, we consider the impact of restrictive AD measures on individual firms' export decisions, i.e., how much to export, pricing behavior, and the quality of their export products. We obtain a firm-product-destination level measure of revealed export quality that overcomes many potential sources of spurious correlation that have afflicted previous work. The rich battery of fixed effects allows us to generally control for potential sources of omitted variable bias. As a result, we can be confident that the results we estimate are directly tied to AD measures.

Consistent with prior research, we find that the use of contingent duties in one market leads to a significant reduction in export flows by firms serving that market. Moreover, we find that trade-restrictive AD measures have little-to-no impact on prices, indicating that duties are passed through to importers entirely and Chinese firms are price takers in these market. More importantly, the negative impact on trade flows is transmitted through the product quality dimension. We show that the results are robust to a battery of robustness checks and that the negative effects on quality continue even after the AD measures are revoked, thus highlighting a hysteresis effect of contingent protection. We further investigate the driving force behind the declining quality and find that reduced export revenues prevent Chinese firms from purchasing more expensive and higher-quality foreign-made inputs, leading to lower-quality exports. Finally, we calculate that AD measures decreased consumer surplus for the targeted products in the imposing countries by 5.4%. Our study highlights that the distortions in product quality, in addition to the trade flows subject to AD measures, should be taken into account when calculating losses on exporters and importers. We therefore contribute to the literature by exploring the quality channel through which AD shocks impact exporters, in addition to the well-documented effect on constraining trade flows.

Given the increasing use of AD, in particular towards China, our estimates of these microeconomic impacts provide valuable insights into the evaluation of AD policies. The finding of export quality downgrading highlights the negative role that AD trade shocks have on exporters and, as a result, on consumers and downstream users in protected countries. This result has implications for the effect of trade policies and the design of AD measures.

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## Appendix

Table A1: Chinese Customs data vs UN Comtrade data

| | Chinese Customs data | | | UN Comtrade data | |
|---|---|---|---|---|---|
| Year | Num. of firms | Num. of HS6 | Tot. Value | Num. of HS6 | Tot. Value |
| | | | *Panel A: Export* | | |
| 2000 | 62,771 | 4,971 | 249,235.1 | 4,946 | 248,689.0 |
| 2001 | 68,487 | 4,947 | 267,061.4 | 4,945 | 265,524.3 |
| 2002 | 78,612 | 5,039 | 325,631.7 | 5,037 | 324,950.3 |
| 2003 | 95,688 | 5,040 | 438,472.6 | 5,033 | 437,271.0 |
| 2004 | 120,590 | 5,017 | 593,647.2 | 5,010 | 592,217.4 |
| 2005 | 144,030 | 5,034 | 756,719.1 | 5,029 | 760,348.7 |
| 2006 | 171,205 | 5,031 | 968,512.6 | 5,028 | 966,623.6 |
| 2007 | 193,567 | 4,842 | 1,220,060 | 4,841 | 1,220,059.7 |
| 2008 | 206,452 | 4,787 | 1,430,570.5 | 4,786 | 1,430,693.1 |
| 2009 | 216,221 | 4,788 | 1,201,611.8 | 4,787 | 1,201,646.8 |
| 2010 | 234,367 | 4,787 | 1,577,373.5 | 4,786 | 1,577,763.8 |
| 2011 | 254,618 | 4,782 | 1,898,493.9 | 4,781 | 1,898,388.4 |
| 2012 | 268,666 | 4,869 | 2,043,614.2 | 4,872 | 2,047,366.6 |
| 2013 | 282,436 | 4,871 | 2,209,004.0 | 4,870 | 2,207,279.1 |
| 2014 | 298,493 | 4,884 | 2,342,522.2 | 4,882 | 2,340,026.0 |
| 2015 | 312,484 | 4,964 | 2,274,577.7 | 4,886 | 2,272,961.5 |
| | | | *Panel B: Import* | | |
| 2000 | 62,793 | 5,015 | 225,091.2 | 4,996 | 223,370.6 |
| 2001 | 67,588 | 4,986 | 243,900.4 | 4,984 | 241,877.2 |
| 2002 | 77,303 | 5,056 | 295,155.1 | 5,049 | 293,607.1 |
| 2003 | 87,934 | 5,029 | 413,095.6 | 5,027 | 411,494.4 |
| 2004 | 102,242 | 5,035 | 560,811.2 | 5,032 | 559,700.7 |
| 2005 | 113,454 | 5,043 | 657,143.8 | 5,041 | 657,948.1 |
| 2006 | 121,835 | 5,051 | 788,342.4 | 5,053 | 789,431.6 |
| 2007 | 133,500 | 4,858 | 956,115.4 | 4,858 | 956,115.5 |
| 2008 | 137,973 | 4,846 | 1,132,398.0 | 4,846 | 1,132,562.2 |
| 2009 | 138,267 | 4,831 | 1,005,923.9 | 4,834 | 1,005,555.2 |
| 2010 | 147,897 | 4,826 | 1,395,330.5 | 4,826 | 1,396,001.6 |
| 2011 | 157,289 | 4,842 | 1,743,484.9 | 4,843 | 1,743,394.8 |
| 2012 | 159,671 | 4,902 | 1,746,990.8 | 4,909 | 1,749,430.2 |
| 2013 | 168,118 | 4,902 | 1,949,987.5 | 4,901 | 1,845,256.8 |
| 2014 | 171,879 | 4,921 | 1,960,624.9 | 4,920 | 1,876,471.1 |
| 2015 | 176,830 | 4,996 | 1,683,680.4 | 4,917 | 1,672,429.0 |

*Notes*: Total value in million USD.

Table A2: Industry definitions and classifications

| Sector | | HS chapters |
|---|---|---|
| Anim | Live animals and animal products | 01-05 |
| Chem | Chemicals | 28-38 |
| Elec | Electronics and electrical machinery | 85 |
| Food | Animal or vegetable oils and fats, prepared foodstuffs, beverages, tobacco | 16-24 |
| Foot | Footwear | 64-67 |
| Fuel | Fuel | 27 |
| Hide | Hides, skins | 41-43 |
| Mach | Machinery | 84 |
| Metal | Metals | 72-83 |
| Mine | Mineral products | 25-26 |
| Mis | Miscellaneous | 90-94, 96-99 |
| Plas | Plastic, rubber | 39-40 |
| Ston | Stone, glass | 68-71 |
| Text | Textiles, clothing | 50-63 |
| Toys | Toys and sports equipment | 95 |
| Tran | Transportation equipment | 86-89 |
| Vege | Vegetable products | 06-15 |
| Wood | Wood | 44-49 |

Table A3: The effect of AD measures on Chinese firms: all firms

| Dep. Var (log) | $Exports_{fpdt}$ | $UV_{fpdt}$ | $Quality_{fpdt}$ | $Exports_{fpdt}$ | $UV_{fpdt}$ | $Quality_{fpdt}$ | $Exports_{fpdt}$ | $UV_{fpdt}$ | $Quality_{fpdt}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | *Full sample* | | | *Control 1* | | | *Control 2* | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $AD_{pdt}$ | -0.065*** | 0.001 | -0.062*** | -0.073*** | 0.003 | -0.083*** | -0.057*** | -0.006 | -0.078*** |
| | (0.015) | (0.005) | (0.021) | (0.017) | (0.006) | (0.022) | (0.021) | (0.007) | (0.029) |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 11,834,780 | 11,834,780 | 11,834,784 | 3,316,297 | 3,316,297 | 3,316,297 | 1,596,486 | 1,596,486 | 1,596,486 |
| adj. $R^2$ | 0.761 | 0.947 | 0.819 | 0.735 | 0.920 | 0.731 | 0.712 | 0.908 | 0.702 |
| # Cluster | 212,494 | 212,494 | 212,494 | 57,832 | 57,832 | 57,832 | 22,652 | 22,652 | 22,652 |

*Notes*: Treatment groups are the firm-product-country triplets exporting products to destinations subjected to antidumping duty. The dummy $AD_{pdt}$ that takes value 1 if product $p$ exported to destination $d$ is subject to AD measures at time t and 0 otherwise. *Full sample* includes all the other triplets. *Control 1* includes the group of treated HS6 products exported to non-treated destinations. *Control 2* is constructed using a matching procedure that combines each treated HS6 product-destination to the same HS6 exported to a similar non-treated country. In Columns 7-9 the dummy $Post^{All}_{pdt}$ is included but not shown. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).

Table A4: The effect of AD measures on Chinese firms: alternative control groups

| Dep. Var (log) | $Exports_{pdt}$ | $UV_{pdt}$ | $Quality_{pdt}$ | $Exports_{pdt}$ | $UV_{pdt}$ | $Quality_{pdt}$ |
|---|---|---|---|---|---|---|
| | | *Control 3* | | | *Control 4* | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $AD_{pdt}$ | -0.091*** | 0.004 | -0.104*** | -0.084*** | 0.005 | -0.085*** |
| | (0.019) | (0.006) | (0.023) | (0.022) | (0.007) | (0.026) |
| $\gamma_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fpt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\gamma_{fdt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 6,124,235 | 6,124,235 | 6,124,239 | 3,023,185 | 3,023,185 | 3,023,189 |
| adj. $R^2$ | 0.760 | 0.944 | 0.797 | 0.747 | 0.927 | 0.743 |
| # Cluster | 118,168 | 118,168 | 118,168 | 48,439 | 48,439 | 48,439 |

*Notes*: The treatment group refers to surviving transactions, i.e., a firm that exports an HS product to a destination subject to AD duty both before and after the AD measure. The dummy $AD_{pdt}$ that takes value one if product $p$ exported to destination $d$ is subject to AD measures in year $t$ and zero otherwise. *Control 3* encompasses all unaffected products within the same HS4 product category where the affected products belong to. *Control 4* is limited to the affected HS4 product category that were in the top 50th percentile in terms of their predicted probability of imposing protection. Robust standard errors clustered at the product-destination level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***: p<1%; **: p<5%; *: p<10%).