# Firms' imports and quality upgrading: evidence from Chinese firms

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**Abstract**

Using transaction-level data for the Chinese manufacturing sector, this paper provides a comprehensive analysis of the causal effect that firms' imports have on quality upgrading. We implement an empirical strategy that delivers quality estimates at the firm-product-destination level. Exploiting this measure and accounting for the endogeneity of imported inputs, this paper shows that sourcing from abroad boosts export quality. Moreover, the analysis indicates that quality improvements are particularly strong when firms purchase inputs from high-income countries. Taken together, these results provide direct evidence that quality upgrading is an important mechanism through which imports favor firms' export performance.

**JEL codes**: F10, F12, F31, F41.
**Keywords**: Export quality upgrading, Firms' imports, Imports from developed countries

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## 1. Introduction

The literature on trade and firm heterogeneity highlights strong complementarity between import and export activities: the majority of exporters are also importers and vice versa, and these firms account for the bulk of a country's total trade.[1] Existing studies provide evidence that sourcing from abroad enhances a firm's ability to enter export markets (the extensive margin) as well as its export value (the intensive margin), suggesting that the connection between imports and exports is causal rather than the result of a simple byproduct of the productivity sorting effect.

While previous analyses mainly examine the effect of firms' imports on export intensive and extensive margins, our work enriches the existing literature by providing evidence of a specific channel through which imports may support exports, i.e., the quality upgrading of the products sold abroad. Our paper tests for this mechanism using Chinese customs data for manufacturing firms between 2001 and 2013. Following Bernini and Tomasi (2015), we rely on an original methodology to obtain a firm-product-destination level measure of revealed export quality from the estimation of a discrete choice model of consumer demand (Berry, 1994; Khandelwal, 2010). Quality is identified at the firm, destination, product, and year levels from the residual variations of market shares once price variations have been controlled. One of the main challenges one encounters when estimating demand functions is the endogeneity of prices, which are likely to be correlated to demand and other shocks. We address this endogeneity problem by applying an instrumental variable approach to identify quality in the spirit of Khandelwal (2010). We also provide an additional measure of quality by using the alternative strategy developed by Khandelwal et al. (2013), who construct quality by calibrating price elasticity with estimates from Broda and Weinstein (2006).

By using these measures, we empirically investigate the impact that a firm's imports have on the quality of its exported products.[2] We adopt an instrumental variable (IV) strategy to control for possible endogeneity bias of our key import variable due to omitted variables, measurement error or reverse causality. We use exchange rate movements and information on firms' lagged import activities to instrument firms' import activities. The empirical analysis confirms the causal effect of the increased use of imports on the export quality of traded products. The estimates from our reduced-form equation indicate that for each 10% increase in imports, the quality of an exported variety to destination $d$ at time $t$ increases by approximately 0.2-0.3%.[3] To gain further insight into the quality upgrading mechanism, we compare the benefits of sourcing from different countries of origin, distinguishing between developed and less-developed countries. Consistent with the idea that firms source mainly high-quality inputs that incorporate advanced knowledge and technologies from advanced countries, we document that imports from high-income countries have the greatest benefits in terms of quality upgrading. We implement various robustness checks considering a different set of instruments, an alternative

[1] Evidence of this pattern has been provided for different countries such as Italy (Castellani et al., 2010; LoTurco and Maggioni, 2015), Belgium (Muuls and Pisu, 2009), Chile (Kasahara and Rodrigue, 2008), Hungary (Altomonte and Bekes, 2009), a group of Eastern European and Central Asian countries (Aristei et al., 2013), and the United States (Bernard et al., 2007).

[2] Because customs data do not contain any information regarding firm-level characteristics such as total inputs and sales revenue, our analysis does not capture the effect of import intensity but rather focuses on the causal effect of increased usage of imported inputs on firms' export outcomes. While this could be a limitation of our empirical work, we believe that it is still important to understand the benefit of sourcing inputs from abroad, regardless their relative importance in a firm's total inputs.

[3] One important caveat of this estimation method is that quality measure cannot be interpreted in absolute value but rather as a position over the quality ladder in a market (Khandelwal, 2010). The estimated coefficient implies that, within the most important destination-product export market for China (i.e., US in the portable digit automatic data processing machine), for a firm with median quality (0.412) an increase in, say, 20% of imports (one standard deviation in the sample) corresponds to a movement along the quality ladder from position 226 to position 215. Given a quality ranking that ranges from the highest value of 1 to the lowest value of 451, this corresponds to a quality ranking upgrading of about 2%.

measure of import activities, sample selection, multiproduct firms, and different subperiods. Our findings continue to hold among these checks.

Within the vast literature on firm heterogeneity in international trade, this article relates to the theoretical and empirical studies on the interdependence between importing and exporting activities. Starting from the evidence that a significant part of international transactions comes from imports of intermediate inputs, a relevant line of research has looked at the effect that imports have on firm-level performance and, in particular, on a firm's decision to participate in the export market and its export value. The theoretical literature has highlighted different mechanisms through which imports may affect firms' export outcomes. Exogenous changes in firms' access to foreign inputs may increase export activities *(i)* through a cost-saving mechanism, *(ii)* through productivity effects, and *(iii)* due to a quality upgrading channel.

First, sourcing foreign inputs may increase firms' exports directly through a cost-saving effect, either via common sunk costs or through lower input prices. Because some of the sunk costs to start participating in international markets are common to export and import activities,[4] a firm that purchases inputs from abroad will face lower costs to export than a company with no previous international experience. Moreover, due to the access to cheaper foreign goods, which are more likely to be acquired at lower prices from less-developed countries, a firm's costs of production decrease, and its competitiveness increases (Bas, 2012). By using French data, Bas and Strauss-Kahn (2014) find evidence that imported inputs affect export scope directly through lower input prices and reduced fixed export costs. LoTurco and Maggioni (2015) also show that only imports from less-developed countries significantly affect the export probability of Italian firms, confirming the existence of the cost-saving channel.

Second, importing may influence firms' ability to export not only directly through the costs saving mechanism but also indirectly through higher productivity (and therefore profitability). By enhancing firms' productivity, imports of intermediate goods exert an indirect positive effect on firms' export decisions (Kasahara and Lapham, 2013).[5] The causal nexus from imports to productivity and exports is empirically investigated by Bas and Strauss-Kahn (2014), who use French data to show that importing more varieties positively affects firms' productivity due to complementarity and technology mechanisms. Using detailed data on imports and exports at the firm-product-market level for Slovenian firms, Damijan et al. (2014) confirm that the effect of imported varieties is far more important for firms' productivity and export growth than the cost-saving channel.[6] By further digs into the issue, Navas et al. (2013) provide empirical evidence that importing has a positive effect on a firm's productivity and in turn on its exports, which depends on both the mass of imported intermediate inputs available, as well as on the price of each intermediate. Feng et al. (2016) study the causal effect of firm-level intermediate imports on firm-level export outcomes using a panel of Chinese manufacturing firms. Their results suggest that technology embedded in imported inputs helped Chinese firms to increase their participation in export markets.

The third and last mechanism, which is directly related to our paper, refers to quality upgrading. Recent theoretical works show that producing high-quality products require high-

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[4]Common sunk costs between the two trade activities might result, for instance, from relying on the same distribution network, from sharing the same system to make and receive payments, or from the need to get familiar with local government regulations. Empirically, the evidence provided by Muuls and Pisu (2009); Aristei et al. (2013); Serti and Tomasi (2014); LoTurco and Maggioni (2015) point to the potential existence of these cost complementarities.

[5]Kasahara and Lapham (2013) develop a symmetric country model on the import-productivity-export nexus. In their theoretical framework, the use of foreign intermediates increases a firm's productivity and, because of the existence of fixed costs of importing, only the most productive firms are able to source from abroad. It turns out that productivity gains from importing allow some importers to start exporting.

[6]According to Damijan and Kostevc (2015), there is a clear evidence of sequencing between the two trade activities and innovation (and therefore productivity) with stronger evidence for sequencing proceeds from imports through innovations to exports.

quality inputs (Kugler and Verhoogen, 2012; Hallak and Sivadasan, 2013). Access to a wider range of foreign inputs and to foreign inputs of superior quality than those domestically available enables firms to upgrade their products and to enter the export market.[7] 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.[8] Other empirical studies have shown that trade liberalization episodes, which allow access to higher quality inputs, turn out to be particularly important for the product quality and the export success of firms in developing countries. Using the late-1994 Mexican peso crisis as a source of variation, Verhoogen (2008) shows that Mexican exporters upgrade quality in response to currency depreciation. Bustos (2011) finds that a regional free trade agreement led Argentine firms to upgrade their technologies and quality. Using Chinese transaction data, Bas and Strauss-Kahn (2015) find that input tariff cuts allow firms to access high-quality inputs and consequently to export higher quality products. In the same spirit, Fan et al. (2015) explore the causal link between input tariffs reduction and exported product prices for Chinese firms in the post-WTO accession period. Using data for Colombian firms, Fieler et al. (2018) show that trade liberalization leads firms to upgrade the quality of their products because greater availability of foreign inputs enables them to produce high-quality goods.[9]

Our paper provides insights into this recent literature on quality heterogeneity and trade by testing for the causal effect of firm-level import activities on the quality upgrading. Because the quality of exported goods is generally unobserved in trade datasets, existing empirical analyses focus on a specific sector for which quality information is available (Crozet et al., 2012) or draw inferences about product quality from information about prices (Manova and Zhang, 2012; Manova and Yu, 2017). We therefore improve upon existing analyses by estimating the quality from the demand side rather than using export prices and by identifying a causal link between the use of foreign inputs and this revealed measure of quality. Moreover, by using panel data covering the period 2001-2013, we enlarge the time-horizon of previous studies on Chinese firms that usually restrict the analysis to the period 2000-2007, following WTO entry.

The remainder of this paper is organized as follows. Section 2 describes the data we use and the construction of the variables that will be used in the regressions. Section 3 outlines the empirical models, describes the results and considers a set of robustness tests of our empirical findings. Section 4 concludes.

## 2. Data and Variables

This section describes our main data sources, the variables used in the empirical analysis and the procedure we follow to obtain a revealed measure of export quality at the firm-product-destination level.

### *2.1. Data description*

The empirical analysis is based on the Chinese customs data on imports and exports, which consist of all cross-border transactions performed by the universe of Chinese firms during the period 2001-2013. The transaction data come from the Chinese Customs Trade Statistics (CCTS), compiled by the General Administration of Customs in China. For all export (import)

[7] Of course, other characteristics such as access to skilled labor and management practices are important for firms' product quality and export performance. See Verhoogen (2008) and Bloom et al. (2018) for a discussion on the topic.

[8] Extending the analysis on Chinese multiproduct 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.

[9] At a more aggregate level, using product data on exports to the United States from different countries, Amiti and Khandelwal (2013) show that import competition, measured through the level of import tariffs, has positive effects on quality upgrading.

flows defined at the firm-product-destination (origin) level, we observe both annual values and quantities, together with information regarding the customs regime (e.g., processing trade or ordinary trade). Product categories are classified according to the Harmonized System classification of traded goods, and they are available at the 8-digit level and then aggregated at the 6-digit level (HS6). Because some product categories are assigned different HS6 product codes at different points in time, we use concordance tables provided by the UN Comtrade to harmonize the classifications to the 1996 version. The database includes the country of origin of imports as well as the destination of exports. For both export and import transactions, we drop all observations with no country information or country reporting the People's Republic of China. Overall customs data include approximately 5,000 HS6-digit products that are exported (imported) to (from) 237 countries. By exploiting the information on the company name, we exclude the intermediary firms as defined by Ahn et al. (2011) and Fan et al. (2015) from our sample.[10] After excluding these firms, we end up with an unbalanced panel of 509,412 firms (or 55 million firm-product-destination observations over the sample period), including both exporters and importers. Column 1 of Table 1 presents the number of exporters and importers for three different years, 2003, 2007 and 2013.

Following previous analyses (Fan et al., 2015; Bai et al., 2017; Feng et al., 2016), we further restrict our sample by considering only ordinary Chinese manufacturing exporters and importers, i.e., those that are not part of the processing regime that allows firms to import intermediates tariff free. This choice is motivated by the fact that processing trade is very different from ordinary trade, not only for tariff exemptions but also for additional policy preferences applied to firms engaged in processing trade and for the stark underlying differences in the production decisions underpinning the two customs regimes.[11]

Imports under ordinary trade include all types of goods (intermediate, capital and consumer goods). While in the econometric analysis we mainly focus on a firm's total imports, as a robustness check we also consider a reduced sample that includes only imports of intermediate inputs. To identify these intermediate inputs, we exploit the available information on product categories, and we single out those HS6 products falling into the intermediate input category according to the Broad Economic Categories Revision 4 (BEC) classification.[12] The BEC classification has been widely used in the literature of international trade to identify intermediate inputs (Amiti et al., 2014; Brandt et al., 2017; Feng et al., 2016). These intermediate inputs account for approximately 80% of total ordinary imports on average over the period under analysis.

Transaction-level data are used to obtain some of the variables that will be used in the empirical analysis. Panel A of Table 2 presents the name, definition and the source of micro-level variables. Using customs data we create the unit values $uvx_{fpdt}$ of the exported varieties as the ratio of export values to export quantities, where the subscripts $f$, $p$, $d$ and $t$, respectively, identify firms, HS6 product classes, destinations and years. We drop all observations with zero or missing quantity or value. Moreover, because unit values are noisy proxies for export prices, we drop all observations for which year-to-year variations in unit values are

[10] Similar to Ahn et al. (2011) and Fan et al. (2015), we identify trade intermediaries by finding the presence of phrases (such as "trading", "exporting", and "importing") in their company names.

[11] See Feenstra and Hanson (2005) and Feng et al. (2016) for details.

[12] Although the BEC classification has been revised five times since its first issue in 1971, its overall structure and coverage has remained mainly unchanged since. In our analysis, we use the BEC Revision 4 for which there is a correspondence table with the Harmonized System classification (https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp). Revision 5 differs from the earlier version because, among other things, it adds services as a new product dimension and it differentiates intermediates that are generic i.e., consumed across a wide range of industries, from those that are specified, i.e., typically consumed only in certain industries. Due to these significant changes a direct conversion from the fourth revision of the BEC to its fifth revision is not possible. For further details, see the Manual for BEC Rev.5 available at https://unstats.un.org/unsd/statcom/47th-session/documents/BG-2016-11-Manual-of-the-Fifth-Revision-of-the-BEC-E.pdf.

Table 1: Descriptive statistics: number of firms by trade status

| | Year | Original Customs data | Estimated sample Two-way traders |
|---|---|---|---|
| # Exporters | 2003 | 79,717 | 25,250 |
| | 2007 | 141,249 | 42,510 |
| | 2013 | 195,298 | 66,545 |
| # Importers | 2003 | 64,275 | 25,250 |
| | 2007 | 102,861 | 42,510 |
| | 2013 | 113,344 | 66,545 |

*Note*: Table reports, for three different years, the number of manufacturing exporters, importers, and two-way traders in the Customs Data (column 1), and in the estimated sample with two-way traders (column 2). In the main sample we keep two-way traders and ordinary trade, and we drop extreme values for the unit values.

Table 2: Variables name and definition

| Concept | Variable | Data source |
|---|---|---|
| PANEL A - Micro-level variables | | |
| Imports | $Imports_{ft}$ | Customs data |
| Imports from dev. countries | $Imports_{ft}^{DC}$ | Customs data |
| Imports from less-dev. countries | $Imports_{ft}^{LDC}$ | Customs data |
| Import diversification | $\#ImportedProducts_{ft}$ | Customs data |
| Import diversification from dev. countries | $\#ImportedProducts_{ft}^{DC}$ | Customs data |
| Import diversification from less-dev. countries | $\#ImportedProducts_{ft}^{LDC}$ | Customs data |
| Export diversification | $\#ExportedProducts_{ft}$ | Customs data |
| Export price | $uvx_{fpdt}$ | Customs data |
| Ownership | $Private_{ft}$ | Customs data |
| PANEL B - Macro-level variables | | |
| Destination Income | $Gdp_{dt}$ | World Bank |
| Destination Size | $Pop_{dt}$ | World Bank |
| Export Demand | $Demand_{pdt}$ | Baci-Comtrade |
| Export Concentration | $Concentration_{pdt}$ | Baci-Comtrade |
| Real Exchange Rate | $RER_{dt}$ | IMF |
| Tariff | $Tariff_{dt}$ | WITS |

*Note*: Table reports the name and the source of the variables used in the empirical analysis.

above the 99th or below the 1st percentiles of the sample distribution. Starting from the firm identifier in the customs data, we also create firm-level time-varying measures of import value ($Imports_{ft}$), import diversification proxied by the number of products imported by a firm ($\#ImportedProducts_{ft}$), and export diversification proxied by the number of products exported by a firm ($\#ExportedProducts_{ft}$). By exploiting the disaggregated nature of our dataset, which reports information by country of origin for import activities, we differentiate firms' total import value and diversification from developed and less-developed countries: $Imports_{ft}^{DC}$, $Imports_{ft}^{LDC}$, $\#ImportedProducts_{ft}^{DC}$, and $\#ImportedProducts_{ft}^{LDC}$.[13] Moreover, by exploiting the company information, we can detect a firm's organizational form, distinguishing between private and state-owned (SOE) firms ($Private_{ft}$).

In addition to firm-level data, we complement the analysis with macro-level information at the country and product level, reported in panel B of Table 2. We consider some standard gravity-type variables that can be correlated with firms' export quality, such as the level of income and the size of the destination market, proxied by $Gdp_{dt}$ and $Pop_{dt}$, respectively. Both data are taken from the World Bank's World Development Indicators database. In our empirical

[13] Developed countries correspond to the high-income countries defined by the World Bank as those that had a GNI per capita of about 12,056 US dollar or more.

analysis, we also include some product-destination specific controls capturing the level of foreign demand and the level of export concentration in the destination country. These two variables are computed using information from the BACI, a dataset containing year-product level information on imports and exports for a large set of countries.[14] Our demand measure is defined as

$$Demand_{pdt} = \sum_{o \in O_{pdy}} \text{IMP}_{podt} \quad , \tag{1}$$

where $\text{IMP}_{podt}$ is the import value of product $p$ from the country of origin $o$ to destination $d$ in the year $t$. Here, $O_{pd}$ is the set of countries, excluding China, exporting product $p$ to destination $d$. Similarly, to account for market concentration, we measure the level of import concentration in the destination country as

$$\text{HHI}_{pdt} = \sum_{o \in O_{pdt}} \left( \frac{\text{IMP}_{podt}}{\text{Demand}_{pdt}} \right)^2 \quad , \tag{2}$$

which is the Herfindhal-Hirschman index for product $p$ in destination $d$, again excluding imports from China.

Finally, to construct the instrumental variables, which will be discussed in Section 3, we exploit the information regarding the real exchange rate ($RER_{dt}$) and input tariffs ($Tariff_{pt}$). Information on the nominal exchange rates ($ER_{dt}$) comes from the International Financial Statistics of the IMF (2014), and for tariff we use the Most Favorite Nation (MFN) applied tariff at the HS6 level collected by the WITS (World Bank) database for 2001-2013. Following the convention, the real exchange rate $RER_{dt}$ is defined as the product between the nominal Chinese exchange rate expressed as the number of foreign currency units per home currency unit ($ER_{dt}$) and the ratio of the Chinese consumer price level to the consumer price index abroad ($\frac{CPI_t}{CPI_{dt}}$). By this definition, an upward (downward) movement of $RER_{dt}$ represents an appreciation (depreciation) of the Chinese RMB.[15] Although the RMB/dollar nominal exchange rate did not change before 2005, Li et al. (2015) show a substantial variation of the RMB against its trading partners both across destinations and over time.[16]

After dropping processing trade, observations that are subject to noise and errors, and merging the customs data with the macro-level variables, we are left with an estimated sample of approximately 163,268 firms that are either ordinary exporters or importers belonging to the manufacturing sector (approximately 12 million firm-product-destination transactions). Because our goal is to study the link between firms' imports and the quality of their exported products, this estimated sample does not include only importers or only exporters, as these firms do not report any information on the export and the import side, respectively. The number of two-way traders in the estimated sample is reported in column 2 of Table 1 for the three different years. While in the econometric analysis carried out in the following sections we focus mainly on two-way traders, we present some specifications with all exporters independently from their import status to ensure that our results are not driven by a selection issue related to differences in sample size.[17]

### *2.2. Estimator of export quality*

To obtain a measure of export quality at the firm-product-destination level, we employ the methodology developed by Khandelwal (2010) following the strategy implemented by Bernini

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

[15]Using a wholesale price index to construct the real exchange rate reduces the number of countries in the sample but does not change the results.

[16]As a robustness check we re-run the analysis for the period 2005-2013.

[17]Following Bas and Strauss-Kahn (2014) and Feng et al. (2016), in order to take into account all exporters, including those that do not import, the independent variable will be the log of a firm's total imports plus one.

and Tomasi (2015).[18] In what follows, we briefly present the main idea behind this procedure, but we refer to Bernini and Tomasi (2015) for a detailed description. To begin, the simple intuition behind Khandelwal (2010)'s approach is to infer the quality of each exported variety as the part of its market share within a market that is not explained by its price. The quality of each variety can therefore 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 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

$$\ln(s_{fpdt}) - \ln(s_{p4dt}) = \alpha uvx_{fpdt} + \sigma_{ns}\ln(ns_{fpdt}) + \delta_{dt} + \delta_{fp} + Q_{fpdt} \quad , \tag{3}$$

where $\ln(s_{fpdt})$ is the market share of the variety $fp$ in destination $d$ at time $t$, $\ln(s_{p4dt})$ is the market share of the 'outside variety' $p4$[20], $uvx_{fpdt}$ is the price of the exported variety, and $\ln(ns_{fpdt})$ is the 'nest share' of the variety $fp$. The latter variable 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 term allows a product market to be segmented in subclasses of closer substitute varieties. A proxy for quality $Q_{fpdt}$ can therefore be computed as a linear combination of the demand parameters on price and nest market share.

To estimate equation (3), we must build the empirical counterpart of these variables. We use the following expression as a proxy for the market share $s_{fpdt}$

$$s_{fpdt} = \frac{ExportQuantity_{fpdt}}{MKT4_{p4dt}} \quad ,$$

where $ExportQuantity_{fpdt}$ is the quantity exported by firm $f$ in the product-class $p$ to destination $d$ at time $t$ divided by a proxy for the destination market size in $p4$ at time $t$ ($MKT4_{p4dt}$). The latter variable is defined as

$$MKT4_{p4dt} = \frac{\sum_{p4dt} ExportQuantity_{fpdt}}{\frac{IMPQuantity^{China}_{p4dt}}{IMPQuantity^{Tot}_{p4dt}}} \quad ,$$

where the numerator is the total export quantity of Chinese firms to destination $d$ within the product-class $p4$ at time $t$ and the denominator measures the relative importance of the Chinese import quantity ($IMPQuantity^{China}_{p4dt}$) over the total imports ($IMPQuantity^{Tot}_{p4dt}$) in that product-class $p4$, in destination $d$ at time $t$. To compute the denominator of $MKT4_{p4dt}$, we rely on the information included in the BACI dataset.

The empirical counterpart of the outside variety share $s_{p4dt}$ is defined as the ratio of the total quantity of non-Chinese imports ($IMPQuantity^{NoChina}_{p4dt}$) over the total imports in the same $p4d$ at time $t$

$$s_{p4dt} = \frac{IMPQuantity^{NoChina}_{p4dt}}{IMPQuantity^{Tot}_{p4dt}} \quad .$$

As far as the right-hand side of equation (3) is concerned, the unit value is used to proxy for a variety's export price ($uvx_{fpdt}$); the empirical counterpart of the 'nest share' ($\ln ns_{fpdt}$) is

[18] See also Piveteau and Smagghue (2018) and Gervais (2015) for a similar strategy to estimate quality at the micro-level.

[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' to the log market shares 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] Note that, from here on, the subscripts $p$ and $p4$ indicate a HS6-digit and a HS4-digit product-class, respectively.

defined as

$$ns_{fpdt} = \frac{ExportQuantity_{fpdt}}{MKT6_{pdt}} = \frac{ExportQuantity_{fpdt}}{\frac{\sum_{pdt} ExportQuantity_{fpdt}}{1-s_{p4dt}}} \quad ,$$

where, as before, the numerator is the $ExportQuantity_{fpdt}$ exported by firm $f$ in the product-class $p$ to destination $d$ at time $t$, and the denominator $MKT6_{pdt}$ is the destination market size constructed as before but at a finer level of disaggregation.[21]

Equation (3) includes also a set of destination-time fixed effects ($\delta_{dt}$) that control for shocks in demand that are common across the varieties exported to the same destination, and a set of firm-product fixed effects ($\delta_{fp}$) that remove the firm-product specific component from the error term. To identify the coefficients, we therefore exploit the time and country variations in market shares and prices for a particular product $p$ exported by the same firm $f$. Once we obtain consistent estimates of the demand parameters $\hat{\alpha}$ and $\hat{\sigma}_{ns}$, we can obtain the estimator of quality $Q_{fpdt}$.

The estimates of $\alpha$ and $\sigma_{ns}$ in equation (3) are generally upward biased because $Q_{fpdt}$ in the error term correlates positively with the unit value $uvx_{fpdt}$ (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 unit values and nest shares we estimate equation (3) by Two Stage Least Squares (2SLS) with two instruments. The first instrument is the average price computed across all Chinese varieties of the same 6-digit product $p$ exported to country $d$ at time $t$: $z_{pdt} = N_{pdt}^{-1} \times (\sum_{pdt} uvx_{fpdt})$, where $N_{pdt}$ is the number of Chinese varieties exported to that market. Arguably, variations in the product-destination specific average price $z_{pdt}$ 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 on export prices. Second, we instrument for the nest shares of individual firms by using the number of different 6-digit product categories exported by the same firm to $d$. This last instrument was used by Khandelwal (2010) under the assumption that the intensive (i.e., quantities exported) and the extensive (i.e., number of different products exported) margins of trade are correlated but that the number of different varieties exported is uncorrelated with the quality of each individual variety.[22]

Equation (3) is regressed separately on groups of observations belonging to different HS4 product categories. This approach allows for changes in the demand parameters across product classes. 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. As expected, the distribution of the estimates for the price elasticity, $\alpha$, from the IV models has lower mean and median than the one obtained from FE models. This evidence suggests that by instrumenting 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 $Q_{fpdt}$. The range of values obtained for the quality measures is consistent with the ones reported by Bernini and Tomasi

[21] Again, to compute $MKT6_{p4dt}$ and the outside variety $s_{p4dt}$ we use the BACI dataset.

[22] In some robustness checks, available upon request, we also slightly change the instrumental variable strategy that we followed to obtain our measure of quality. As an alternative instrument for the price, we use a variety average price computed across the varieties of all competitors ($f'$) operating in the same HS6 product-destination-year market: $Z_1 = (N_{pdt}-1)^{-1} \sum_{f' \neq f, pet} uvx_{f'pdt}$. Alternatively, we re-estimate equation (3) by using the median price $Z_2$ computed within a market as an instrument for a variety's own price. When we compute these alternative instruments, we also exclude from the estimation sample all markets (i.e., product-destination cells) with fewer than five competitors to minimize the risk of strategic interactions in the price-setting process.

Table 3: Quality estimation results

| | Mean | Median | 1st Quart. | 3rd Quart | Sd. |
|---|---|---|---|---|---|
| FE price coefficient | -0.002 | -0.0001 | -0.000 | -0.000 | 0.031 |
| IV price coefficient | -0.006 | -0.0002 | -0.001 | -0.000 | 0.187 |
| FE nest shares coefficient | 0.896 | 0.912 | 0.864 | 0.942 | 0.063 |
| IV nest shares coefficient | 0.930 | 0.951 | 0.910 | 0.999 | 0.349 |
| $Q_{fpdt}$ | -0.132 | 0.131 | -0.822 | 0.778 | 1.493 |

*Note*: Table summarizes the results obtained from repeating the estimation of model 3 on different HS4 product categories.

(2015).

Because of the difficulty of estimating demand equations at the firm level, an alternative strategy has been proposed by Khandelwal et al. (2013) that calibrates a CES demand system with price-elasticity estimates from Broda and Weinstein (2006). This methodology has been applied in several empirical works (Manova and Yu, 2017; Bernini and Tomasi, 2015; Fontagné et al., 2018; Bas and Strauss-Kahn, 2015). As a robustness check, we follow this alternative methodology and obtain a measure of quality as the residual of a regression of $\ln q_{fpdt} + \sigma \ln uvx_{fpdt}$ on $\alpha_p + \alpha_{dt} + \epsilon_{fpdt}$. Rather than using the price-elasticity computed for the US, we adopt the estimated elasticities of substitution $\sigma$ available for China at the 3-digit ISIC (Revision 2) level provided by Imbs and Mejean (2017). The estimated log quality is then given by $Q^{\sigma}_{fpdt} = \epsilon_{fpdt}/\sigma - 1$. This alternative measure is indeed closer in the spirit to the one developed above, but it differs in two important respects. First, it does not depend on the strategy to estimate the parameter of the demand equation, and second, the dependent variable of the demand equation is not a market share but rather a variety export quantity adjusted for its price.

## 3. Empirical analysis

To capture the effect of a firm's imports on the quality of its exported products, we propose the following empirical equation

$$Q_{fpdt} = \alpha + \beta \ln Imports_{ft} + \lambda X_{pdt} + \gamma Y_{dt} + \mu \ln \#ExportedProducts_{ft} + \delta_{fpd} + \delta_t + \epsilon_{fpdt} \quad , \quad (4)$$

where the dependent variable $Q_{fpdt}$ is the quality of the variety $fp$ in destination $d$ at time $t$, and our main independent variable corresponds to the (log) firm's total imports at time $t$ ($\ln Imports_{ft}$). Our primary interest is estimating the coefficient $\beta$. A potential caveat of this regression framework is that the determinants of firm-product-destination in export quality are poorly controlled, as they could be related to firms' import decisions. We take into account this identification problem by including firm-product-destination fixed effects $\delta_{fpd}$ which control for the time-invariant component of firms' characteristics. We thus explore how within-firm variation in product quality to a specific destination over time relates to within-firm increase in imports. Equation (4) also includes time dummies, $\delta_t$, to control for time-varying determinants of quality that affect all firms. We also add a vector of controls that vary at the destination-product-time level ($X_{dpt}$) and destination-time level ($Y_{dt}$), which allows us to account for changes over time in the demand preferences and in the competition level of the destination country. As described in Section 2, we consider the (log) level of foreign demand ($\ln Demand_{pdt}$), the (log) level of concentration ($\ln Concentration_{pdt}$), the (log) market income ($\ln Gdp_{dt}$) and the (log) size ($\ln Pop_{dt}$) of the destination country $d$. Finally, our regression includes a time-varying firm characteristic expressed by the (log) number of products exported by a firm ($\ln \#ExportedProducts_{ft}$) that can be safely considered as a proxy of firm size. Since our main variable of interest is measured at the firm level, all regressions include standard errors

Table 4: Export quality and firms' imports

| Dep.Var | $Q_{fpdt}$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) Within | (2) Within | (3) Within | (4) Within | (5) Within | (6) IV |
| $\ln Imports_{ft}$ | 0.002*** | 0.002*** | 0.002*** | 0.002*** | 0.005*** | 0.028** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.011) |
| $\ln Gdp_{dt}$ | | 0.185*** | 0.175*** | 0.173*** | 0.173*** | 0.183*** |
| | | (0.011) | (0.012) | (0.012) | (0.018) | (0.029) |
| $\ln Pop_{dt}$ | | 0.089*** | 0.097*** | 0.096*** | 0.108*** | 0.175*** |
| | | (0.015) | (0.015) | (0.015) | (0.025) | (0.038) |
| $\ln Demand_{pdt}$ | | | 0.020*** | 0.019*** | 0.022*** | 0.019*** |
| | | | (0.001) | (0.001) | (0.002) | (0.004) |
| $\ln Concentration_{pdt}$ | | | -0.010*** | -0.010*** | -0.013*** | -0.012*** |
| | | | (0.001) | (0.001) | (0.002) | (0.004) |
| $\ln \#ExportedProducts_{ft}$ | | | | 0.020*** | 0.022*** | 0.013** |
| | | | | (0.002) | (0.003) | (0.007) |
| $\delta_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\delta_t$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 9,394,535 | 9,019,725 | 8,758,741 | 8,758,741 | 4,538,334 | 2,222,542 |
| adj. $R^2$ | 0.758 | 0.758 | 0.762 | 0.762 | 0.847 | |
| Number of Instruments | | | | | | 2 |
| KP (F-stat) | | | | | | 38.016 |
| Hansen J-Stat (p-value) | | | | | | 0.743 |

*Note*: Table reports the results of regressions at the firm-product-country level, obtained by using Chinese data between 2001 and 2013. The dependent variable is the estimated proxy for quality $Q_{fpdt}$. In columns (1)-(4) the sample includes two-way traders and only exporters, while in columns (5)-(6) it includes only two-way traders. In column (6) the instrumental variables include the lagged imported inputs $\ln Imports_{ft-2}$ and the lagged firm-level weighted real exchange rates $IV^{RER}_{ft-1}$. Robust standard errors clustered at the firm-level are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.

clustered at the individual level, but the results are robust to alternative treatments of the error terms, such as clustering by firm-product-country.

Table 4 reports the results of the within estimates by progressively including the controls that vary by destination-time, those that vary by product-destination-time and, finally, those that vary by firm-time. In columns (1)-(4) the sample includes all exporters (two-way traders and only exporters), independently from their import status[23], while in column (5) we restrict the sample to firms that both export and import (two-way traders). Looking at our main variable of interest, $\ln Imports_{ft}$, we observe that the coefficient $\beta$ is always positive and statistically significant, confirming that importing stimulates export quality. The magnitude of the coefficient does not change across specifications and, as expected, it is slightly larger when considering only two-way traders. While our main focus is on the link between imports and export quality, our regressions provide further insight into the determinants of export quality. Destination and product-destination characteristics are related to export quality. In line with Hallak and Schott (2011) and Khandelwal (2010), we find that export quality increases with the market size and level of development of the destination country. It also correlates with the foreign demand and the level of market competition computed at the product-destination level. Finally, bigger and more diversified firms are more likely to export higher quality products.

One of the main problems in estimating equation (4) concerns the potential endogeneity of our key covariate. The introduction of firm-product-destination fixed effects ensures that our results are not driven by the time constant unobserved heterogeneity, which is correlated with the decisions on imported inputs. However, endogeneity can still arise because of time-variant omitted variables, simultaneity problems, as the choice of a firm's imports is likely to both affect and be affected by the quality of its exported products, or measurement error. To identify the causal effect of firms' import activities on export quality, we therefore apply an instrumental variable (IV) approach.

[23] For only exporters, the measure of import value is given by the logarithm of the variable plus one.

Following the previous works by Feng et al. (2016); Mion and Zhu (2013), we rely on an instrumental variable strategy using real exchange rate for firm-level imports as our main instrument ($IV_{ft-1}^{RER}$). The main insight of our IV strategy is to exploit the movements in exchange rates, which are mainly driven by financial and macro determinants and are therefore less likely to be correlated with the error term. By exploiting the disaggregated nature of our dataset that reports information on firms' imports by country of origin, we construct a firm-level measure of (log of) real exchange rates by taking a weighted average where the weights reflect the relative importance of the different source countries in a firm's total imports. We use one-year lagged import shares as weights because current shares could be affected by exchange rate movements at time $t$, which creates an endogeneity problem.[24] As the second instrument, similar to Bas and Strauss-Kahn (2014), we use firms' lagged (log) import value at time $t-2$ as a measure of import costs.[25]

Column (6) of Table 4 reports the results of the IV strategy applied on the sample of two-way traders. Note that the number of observations decreased substantially with respect to that reported in column (5) because the estimation with IV requires the consideration of lagged firms' import information for the construction of the instruments.[26] The results suggest that for each 10% increase in imports, the quality of an exported variety to destination $d$ at time $t$ increases by approximately 0.2-0.3%. At the bottom of column (6), we report the weak identification (Kleibergen-Paap Wald F) statistics and the overidentifying restriction (Hansen J) p-values. The results indicate that our instruments for firm-level imports have predictive power, and the Hansen J statistics never reject the null of the validity of the instruments. Our IV estimate involves a first stage strategy that reports how a firm's imports correlate with our instruments. As shown in column (1) of Table A1 in the Appendix, a firm's imports are positively associated with its lagged imports and with the real exchange rate appreciation.

The coefficient on imports is positive and statistically significant and higher than that observed for the within estimator. We suspect that measurement error in the explanatory variable contributes to the downward bias in the within estimates (Hausman, 2001). Indeed, because we use import value rather than import quantity, we cannot isolate the effect of an increase in price due to cost, demand or other shocks. As a result, if the observed increase in the value of imported inputs overstates the actual rise in the use of imported quantity, the resulting within coefficient will be biased downward.[27]

While our regressions strongly confirm that increasing the import activities of firms boosts export quality, as suggested by the literature, there might be different channels responsible for this connection. A leading explanation is that the high quality of imported varieties provides a great contribution to the quality upgrading of exported products. Quality upgrading should therefore be particularly strong when firms buy inputs from developed countries (Bas and Strauss-Kahn, 2015; Feng et al., 2016). Following this idea, we draw inferences on the quality of inputs by distinguishing imports from different countries of origin: the most developed countries produce goods with a high technology content, and developing countries provide lower quality

[24] While in the main tables we show the IV lagged import shares, as a robustness check we adopt alternative weighting strategies with weights computed using: *(i)* the import shares of the first year in which the firm is observed importing (results are reported in the Appendix); *(ii)* the import shares of the initial year (2001); and *(iii)* the average import shares across the entire period. These two results are available upon request.

[25] Table A3 in the Appendix also presents the IV specifications in which the two instruments, the lagged firm-level imports $\ln Imports_{ft-2}$ and the lagged firm-level weighted real exchange rates $IV_{ft-1}^{RER}$ are used separately. Although the results do not change, we use two instruments throughout the paper. Using many valid instrumental variables can improve precision and allows us to test for overidentifying restrictions (Wooldridge, 2015).

[26] In a robustness check, available upon request, we run within estimates on the same number of observations as in the IV specification. The results are consistent regardless of the sample considered, suggesting that they are not driven by selection issue.

[27] The same downward bias is observed in other empirical analyses looking at the relationship between imports and firms performance. See, among others, Bas and Strauss-Kahn (2014); Feng et al. (2016).

Table 5: Export quality and firms' imports by country of origin

| Dep.Var | $Q_{fpdt}$ | |
|---|---|---|
| | (1) | (2) |
| | Within | IV |
| $\ln Imports_{ft}^{DC}$ | 0.003*** | 0.030** |
| | (0.000) | (0.013) |
| $\ln Imports_{ft}^{LDC}$ | 0.001*** | 0.001 |
| | (0.000) | (0.002) |
| $\ln Gdp_{dt}$ | 0.172*** | 0.192*** |
| | (0.018) | (0.032) |
| $\ln Pop_{dt}$ | 0.107*** | 0.179*** |
| | (0.025) | (0.039) |
| $\ln Demand_{pdt}$ | 0.019*** | 0.019*** |
| | (0.002) | (0.004) |
| $\ln Concentration_{pdt}$ | -0.013*** | -0.012*** |
| | (0.002) | (0.004) |
| $\ln \#ExportedProducts_{ft}$ | 0.021*** | 0.010 |
| | (0.003) | (0.007) |
| $\delta_{fpd}$ | Yes | Yes |
| $\delta_t$ | Yes | Yes |
| $N$ | 4,538,334 | 2,222,542 |
| adj. $R^2$ | 0.758 | |
| Number of Instruments | | 4 |
| KP (F-stat) | | 12.482 |
| Hansen J-Stat (p-value) | | 0.990 |

*Note*: Table reports the results of regressions at the firm-product-country level, obtained by using Chinese data between 2001 and 2013. The dependent variable is the estimated proxy for quality $Q_{fpdt}$ and the sample includes only two-way traders. In column (2) the IV instrumental variables include the lagged imported inputs $\ln Imports_{ft-2}$ and the lagged firm-level weighted real exchange rates $IV_{ft-1}^{RER}$. Robust standard errors clustered at the firm-level are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.

inputs. We modify our regression and introduce separate import measures for developed and developing countries as follows:

$$Q_{fpdt} = \alpha + \beta_1 \ln Imports_{ft}^{DC} + \beta_2 \ln Imports_{ft}^{LDC} + \lambda X_{pdt} + \gamma Y_{dt} + \mu \ln \#ExportedProducts_{ft} + \delta_{fpd} + \delta_t + \epsilon_{fpdt} \quad (5)$$

where the coefficients $\beta_1$ and $\beta_2$ enable us to test whether the benefits from imports are higher when firms source from developed rather than developing countries. Intuitively, under the assumption that imported inputs from developed countries have higher quality, we would expect the effects on quality to be stronger when imports are imported from high-income countries. This intuition is confirmed by the results presented in Table 5. The estimated results in column (2) for the IV regressions imply that an increase in imports from the most developed countries of 10% improves export quality by 0.3%, while imports from developing countries do not have any impact.[28]

### *3.1. Robustness checks*

In this section, we run a set of exercises aimed at testing the robustness of our results. We appeal to changes in the sample composition, to the adoption of alternative measures of imports and export quality. The results are presented in Table 6. The same set of robustness

[28]Note that when using the IV approach, we create a different set of instruments for developed and developing countries. The first stage is reported in columns (2)-(3) of Table A1 in the Appendix.

Table 6: Export quality and firms' imports: robustness check

| Dep.Var | $Q_{fpdt}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) IV | (2) Intermediate | (3) Private | (4) Survival | (5) $Q^{\sigma}_{fpdt}$ | (6) Diversification | (7) 2005-2013 | (8) Top product$_{ft}$ |
| $\ln Imports_{ft}$ | 0.017* | 0.024** | 0.025* | 0.026*** | 0.035** | | 0.037*** | 0.121*** |
| | (0.009) | (0.011) | (0.014) | (0.010) | (0.015) | | (0.012) | (0.035) |
| $\ln \#ImportedProducts_{ft}$ | | | | | | 0.075** | | |
| | | | | | | (0.033) | | |
| $\ln Gdp_{dt}$ | 0.170*** | 0.187*** | 0.148*** | 0.197*** | -0.607*** | 0.184*** | 0.205*** | 0.109* |
| | (0.028) | (0.030) | (0.038) | (0.031) | (0.036) | (0.029) | (0.034) | (0.057) |
| $\ln Pop_{dt}$ | 0.168*** | 0.153*** | 0.123** | 0.179*** | 0.077* | 0.172*** | 0.203*** | 0.224*** |
| | (0.038) | (0.041) | (0.050) | (0.041) | (0.047) | (0.038) | (0.051) | (0.082) |
| $\ln Demand_{pdt}$ | 0.019*** | 0.021*** | 0.018*** | 0.021*** | 0.019*** | 0.019*** | 0.020*** | 0.012*** |
| | (0.004) | (0.004) | (0.003) | (0.005) | (0.002) | (0.004) | (0.005) | (0.004) |
| $\ln Concentration_{pdt}$ | -0.011*** | -0.012*** | -0.011*** | -0.014*** | -0.011*** | -0.011*** | -0.012** | -0.009 |
| | (0.002) | (0.004) | (0.004) | (0.005) | (0.002) | (0.004) | (0.005) | (0.006) |
| $ln\#ExportedProducts_{ft}$ | 0.017*** | 0.015** | 0.012* | 0.012 | 0.064*** | | 0.008 | -0.012 |
| | (0.006) | (0.007) | (0.007) | (0.008) | (0.008) | | (0.007) | (0.012) |
| $\delta_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\delta_t$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 2,222,197 | 2,032,081 | 1,524,241 | 1,451,196 | 2,490,737 | 2,222,542 | 1,738,649 | 484,173 |
| Number of Instruments | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| KP (F-stat) | 35.598 | 34.701 | 37.361 | 42.782 | 35.598 | 23.942 | 49.976 | 32.537 |
| Hansen J-Stat (p-value) | 0.358 | 0.445 | 0.229 | 0.587 | 0.358 | 0.174 | 0.936 | 0.560 |

*Note*: Table reports the results of regressions at the firm-product-country level, obtained by using Chinese data between 2001 and 2013. The dependent variable is the estimated proxy for quality $Q_{fpdt}$. In column (1) the instrumental variables include the lagged imported inputs $\ln Imports_{ft-2}$, the lagged firm-level weighted real exchange rates $IV^{RER}_{ft-1}$, and the firm-level tariff $IV^{Tariff}_{ft}$. In column (2) firms' imports is computed considering only intermediate inputs using the BEC classification. In column (3) the sample includes only private firms and in column (4) continuous exporters. In column (5) the dependent variable is the quality computed using the methodology applied by Khandelwal et al. (2013). In column (6) the variable firms' imports is replaced with the number of imported products. In column (7) the regression is run on the period 2005-2013. In column (8) we consider a firm's most important product in terms of export sales. All specifications (except column(1)) are run using the lagged imports $\ln Imports_{ft-2}$ and the lagged firm-level weighted real exchange rates $IV^{RER}_{ft-1}$ as instruments. Robust standard errors clustered at the firm-level are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.

checks distinguishing imports from developed and less-developed countries is reported in Table 7.

We first run a specification with an additional instrument given by the simple average of all tariffs on imported products at the HS6 level by firm $f$, $IV^{Tariff}_{ft}$.[29] As shown in column (1) of Tables 6 and 7, there is a positive link between imported values and firm export quality, and this link is particular strong for firms that import from advanced economies.[30] We then check whether our results are robust when considering only a firm's imports of intermediate inputs, as identified by the BEC classification system. The results with this alternative measure of imports, reported in column (2) of Tables 6 and 7, are essentially unchanged.[31]

We next include only private firms in column (3) of Tables 6 and 7 to account for the sample composition and for the differences between private and state-owned firms. This is motivated by the fact that during the period under analysis, China has witnessed a deep and fast process of transformation characterized by a decline in the role of state-owned enterprises and collective firms and by a massive entry of private enterprises, often replacing previously established public firms. As shown by previous analyses, state-owned firms largely differ from private companies, with the former showing lower profitability and growth, as well as softer budget constraints (Bai et al., 2006; Guariglia et al., 2011; Yu et al., 2017). The results reveal that increases in

[29]We take a simple average to compute $IV^{Tariff}_{ft}$ rather than a weighted measure to avoid the collinearity problem with the $IV^{RER}_{ft-1}$ instrument.

[30]The first stage is reported in columns (4)-(6) of Table A1 in the Appendix.

[31]In an additional robustness check, available upon request, we run a regression in which we estimate the impact of imports on export quality, distinguishing between exported intermediate goods and other products (including capital and consumer goods). The results do not change when making this distinction on the export side.

Table 7: Export quality and firms' imports by country of origin: robustness check

| Dep.Var | | | | | $Q_{fpdt}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | IV | Intermediate | Private | Survival | $Q^{\sigma}_{fpdt}$ | Diversification | 2005-2013 | Top product$_{ft}$ |
| $\ln Imports^{DC}_{ft}$ | 0.030** | 0.030** | 0.025 | 0.032*** | 0.052*** | | 0.040*** | 0.159*** |
| | (0.013) | (0.013) | (0.016) | (0.012) | (0.019) | | (0.014) | (0.057) |
| $\ln Imports^{LDC}_{ft}$ | -0.000 | -0.001 | 0.001 | -0.002 | 0.001 | | 0.000 | 0.005 |
| | (0.001) | (0.002) | (0.002) | (0.003) | (0.003) | | (0.003) | (0.005) |
| $\ln \#ImportedProducts^{DC}_{ft}$ | | | | | | 0.080** | | |
| | | | | | | (0.045) | | |
| $\ln \#ImportedProducts^{LDC}_{ft}$ | | | | | | 0.002 | | |
| | | | | | | (0.016) | | |
| $\ln Gdp_{dt}$ | 0.191*** | 0.199*** | 0.153*** | 0.207*** | -0.579*** | 0.186*** | 0.215*** | 0.150** |
| | (0.031) | (0.032) | (0.042) | (0.032) | (0.037) | (0.030) | (0.036) | (0.070) |
| $\ln Pop_{dt}$ | 0.178*** | 0.157*** | 0.124** | 0.184*** | 0.090* | 0.175*** | 0.207*** | 0.240*** |
| | (0.039) | (0.041) | (0.050) | (0.041) | (0.047) | (0.039) | (0.052) | (0.086) |
| $\ln Demand_{pdt}$ | 0.019*** | 0.021*** | 0.018*** | 0.021*** | 0.019*** | 0.019*** | 0.019*** | 0.012*** |
| | (0.04) | (0.004) | (0.003) | (0.005) | (0.002) | (0.004) | (0.005) | (0.004) |
| $\ln Concentration_{pdt}$ | -0.012*** | -0.012*** | -0.011*** | -0.014*** | -0.011*** | -0.011*** | -0.012** | -0.010 |
| | (0.004) | (0.004) | (0.004) | (0.005) | (0.002) | (0.004) | (0.005) | (0.006) |
| $\ln \#ExportedProducts_{ft}$ | 0.011 | 0.012* | 0.011 | 0.011 | 0.054*** | | 0.006 | -0.029 |
| | (0.007) | (0.007) | (0.007) | (0.008) | (0.009) | | (0.007) | (0.018) |
| $\delta_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\delta_t$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 2,222,197 | 2,032,081 | 1,524,241 | 1,451,196 | 2,490,737 | 2,222,542 | 1,738,649 | 484,173 |
| Number of Instruments | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| KP (F-stat) | 9.170 | 12.672 | 12.199 | 14.512 | 12.154 | 9.215 | 16.981 | 5.954 |
| Hansen J-Stat (p-value) | 0.934 | 0.667 | 0.434 | 0.721 | 0.259 | 0.385 | 0.967 | 0.833 |

*Note*: Table reports the results of regressions at the firm-product-country level, obtained by using Chinese data between 2001 and 2013. The dependent variable is the estimated proxy for quality $Q_{fpdt}$. In column (1) the instrumental variables include the lagged imported inputs $\ln Imports_{ft-2}$, the lagged firm-level weighted real exchange rates $IV^{RER}_{ft-1}$, and the firm-level tariff $IV^{Tariff}_{ft}$. In column (2) firms' imports is computed considering only intermediate inputs using the BEC classification. In column (3) the sample includes only private firms and in column (4) continuous exporters. In column (5) the dependent variable is the quality computed using the methodology applied by Khandelwal et al. (2013). In column (6) the variable firms' imports is replaced with the number of imported products. In column (7) the regression is run on the period 2005-2013. In column (8) we consider a firm's most important product in terms of export sales. All specifications (except column(1)) are run using the lagged imports $\ln Imports_{ft-2}$ and the lagged firm-level weighted real exchange rates $IV^{RER}_{ft-1}$ as instruments. Robust standard errors clustered at the firm-level are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.

firms' import activities are helpful for private firms in upgrading their export quality.

Furthermore, as the entire sample used so far does not account for possible exit and entry, to avoid our results being driven by the change in the firms' composition due to the massive entries of private enterprises that have replaced the old established firms in China during the period under analysis, we consider a balanced sample, whereby companies are retained if they appear for at least 10 consecutive years between 2001 and 2013.[32] Although the sample size is greatly reduced, column (4) of Table 6 shows that the coefficient on imports is still positive and statistically significant. Moreover, when we distinguish between developed and less-developed countries, as in column (4) of Table 7, we observe that the positive impact of imports on quality is specific to imported inputs from advanced economies, while it has no significant effect when inputs come from less developed countries.

In column (5) of Tables 6 and 7 we replace the dependent variable using the quality estimates from the methodology provided by Khandelwal et al. (2013). As explained above, this alternative measure is closer in the spirit to the one used in the rest of the paper. Again, this sensitivity test confirms that our results are robust. Refining the measure of quality reinforces our hypothesis that firms' importing activities indeed contribute positively to upgrading the quality of their exported goods.

Theoretical models have recognized that imports of goods can increase export quality through a variety effect due to the access to more varieties of inputs and a better match between input mix and technology or product characteristics. If the variety mechanism is at work and importing offers a choice among a wide variety of inputs, we should observe a positive impact of firms' import diversification on quality output. We therefore test how import

[32] The results do not change if we consider firms that are present over the entire period.

varieties, measured by the number of distinct HS6 products imported by the firm, affect export quality.[33] The results, presented in column (6) of Tables 6 and 7, suggest that firms' import diversification boosts export quality, and this effect is further magnified when inputs come from developed economies.

We also examine the robustness of our results by considering the period 2005-2013. As stated above, the Chinese RMB was pegged to the US dollar before July 2005, meaning that the bilateral real exchange movements between the US and China come entirely from the variations in inflation before that year. Because the US is a major export destination for Chinese traders, to avoid the potential problem in the IV approach related to this, we exclude from our sample the years between 2001 and 2004. Both the sign and the magnitude of the coefficients of interest remain unchanged, as seen from column (7) of Tables 6 and 7.

Manufacturing multiproduct firms play an important role in export markets, and their quality and productivity differ with the scope of products they produce (Mayer et al., 2016, 2014; Manova and Yu, 2017). For these firms, the effect of imports can be heterogeneous across products, with changes in quality more pronounced for products that are closer to the core competency, i.e., those with higher quality or for which the firms have greater productivity. To take this issue into account, we keep among multiproduct exporters only the most relevant product in terms of sales defined as the one with the highest exports at a given time $t$. By considering the top product, we improve the identification strategy by excluding those products with a marginal position, which could be less affected by import activities.[34] The results in column (8) of Tables 6 and 7 show that the positive coefficients for the import variable are preserved and magnified with respect to the baseline results. Inputs sourced from abroad appear to provide a stronger increase in export quality for the top product: given a 10% increase in firms' imports, the quality of the top product rises by 1.2%.

Finally, we provide additional robustness check in Table A2 in the Appendix. In column (1), we use the import shares of the first year in which a firm is importing as an alternative way to measure the weights for construction of the IV. In column (2), standard errors are clustered at firm-product-destination level. In column (3), we redefine the core product as the one with the highest exports to a given destination $d$ at a given time $t$. In column (4), we consider the number of source countries as an alternative way to measure import diversification. Our findings remain robust to all these alternative specifications. In column (5), we also check for possible nonlinear effects of our main variables. Indeed, the result seems to suggest that the effect on quality is particularly strong for those firms importing a large amount of inputs and less relevant for those companies sourcing less from abroad.

It is also important to recognize that when firms export to and import from the same country, the movements of real exchange rates can directly affect quality upgrading on the export side, thus violating the exclusion restriction in our IV regression (Bastos et al., 2018).[35] In a recent paper, Ludema and Yu (2016) show that exporting firms respond to foreign tariff reductions by upgrading product quality and increasing prices. A similar direct effect could indeed be observed following real exchange rate fluctuations. To reduce the concern that the changes in real exchange rates may directly affect the quality of products exported by a firm, we run a robustness check, in column (6), where we drop, within each firm, those observations in which the firm exports to and imports from the same country and consider only the trade

[33]Since multiproduct exporters are likely to be multiproduct importers in this specification we drop the variable $\ln \#ExportedProducts_{ft}$ as it suffers from multicollinearity problem with our main variable of interest, $\ln \#ImportedProducts_{ft}$.

[34]Note that, as recently suggested by Fontagné et al. (2018), firms' core competencies could not simply be related to export sales but could reflect richer forms of interdependence that can be captured by those goods that are more likely to be co-exported. While our aim here is simply to check the robustness of our main result with respect to a different sample composition, the possible heterogeneous effects of imports across products within a firm taking into account such type of complementarities is an important area for future research.

[35]We thank for the anonymous referee for this insightful suggestion.

transactions from different markets.[36] The result remains robust to this specification.

As a final robustness check, we employ the Rauch (1999) measure, based on whether a good is traded on a commodity exchange or whether it has quoted price in industry trade publications. This measures overall differentiation (i.e., both horizontal and vertical). We re-estimate our main equation separately on different subsamples of export transactions involving products with different degrees of differentiation. Consistent with our expectation, the results – reported in columns (7) and (8) – show that the effect is positive and statistically significant for relatively more differentiated products for which there is more scope of quality upgrading, and it is not statistically significant for homogeneous goods.

## 4. Conclusion

This paper contributes to the vast empirical literature on firms in international trade, documenting a positive connection between firms' imported inputs and their export performance. By using highly disaggregated Chinese customs data between 2001 and 2013, we provide direct evidence of the "quality channel", which demonstrates that access to foreign inputs enables firms to upgrade the quality of their products and, therefore, to be competitive in the export markets. Rather than using export prices as a proxy for quality, we implement an empirical methodology that estimates product quality at the firm-product-destination level. We test for the causal impact of firms' imports on product export quality by applying an instrumental variable strategy that utilizes real exchange rate movements and input import tariffs as instruments. We find strong evidence that imported inputs play a significant role in enhancing quality of traded products. Moreover, imported inputs that originate from high-income economies lead firms to have larger export quality improvements. This result reinforces the idea that quality upgrading is related to the access to higher quality and technological level inputs sourced from abroad.

We believe our findings provide valuable information for policymakers concerned with the structure and determinants of a country's foreign competitiveness. A greater openness to trade in the form of expansion in import scale could not only stimulate the diffusion of the modern technologies embodied in imported inputs but also improve the quality of exported products. Policies directly aimed at restricting imports by increasing trade costs can indirectly harm the export performance of domestic firms. In contrast, policies that facilitate the inflows of foreign inputs are important for contributing to growth.

[36] Alternatively, we follow Bastos et al. (2018) by including the real exchange rate directly as a covariate in the main outcome equation.

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## Appendix

Table A1: First Stage of the IV estimation

| Dep.Var | $\ln Imports_{ft}$ (1) | $\ln Imports^{DC}_{ft}$ (2) | $\ln Imports^{LDC}_{ft}$ (3) | $\ln Imports_{ft}$ (4) | $\ln Imports^{DC}_{ft}$ (5) | $\ln Imports^{LDC}_{ft}$ (6) |
|---|---|---|---|---|---|---|
| $\ln Imports_{ft-2}$ | 0.059*** | | | 0.059*** | | |
| | (0.008) | | | (0.008) | | |
| $IV^{RER}_{ft-1}$ | 0.048*** | | | 0.048*** | | |
| | (0.009) | | | (0.010) | | |
| $\ln Imports^{DC}_{ft-2}$ | | 0.032*** | | | 0.032*** | |
| | | (0.008) | | | (0.008) | |
| $\ln Imports^{LDC}_{ft-2}$ | | | -0.026*** | | | -0.012* |
| | | | (0.008) | | | (0.007) |
| $IV^{RER^{DC}}_{ft-1}$ | | 0.042*** | | | 0.042*** | |
| | | (0.011) | | | (0.011) | |
| $IV^{RER^{LDC}}_{ft-1}$ | | | 0.515*** | | | 0.356*** |
| | | | (0.026) | | | (0.024) |
| $IV^{Tariff}_{ft}$ | | | | -0.050*** | | |
| | | | | (0.009) | | |
| $IV^{Tariff^{DC}}_{ft}$ | | | | | 0.007 | |
| | | | | | (0.010) | |
| $IV^{Tariff^{LDC}}_{ft}$ | | | | | | -0.563*** |
| | | | | | | (0.012) |
| Vector of Controls $X_{pdt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| Vector of Controls $Y_{dt}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\delta_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $\delta_t$ | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 2,222,542 | 2,222,542 | 2,222,542 | 2,222,197 | 2,222,197 | 2,222,197 |

*Note*: Table reports the results of the first stage of IV regressions. Columns (1)-(3) reports the first stage for column (6) and column (2) of Tables 4 and 5. Columns (4)-(6) reports the first stage for column (1) of Tables 6 and 7. All specifications include the vector of controls at product-destination-time level $X_{pdt}$ and those at destination-time level $Y_{dt}$. Robust standard errors clustered at the firm level are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.

Table A2: Additional robustness checks

| Dep.Var | $Q_{fpdt}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Instrument | Cluster | Top Product$_{fdt}$ | Diversification | Nonlinear | Mixed Countries | Homogeneous | Differentiated |
| $\ln Imports_{ft}$ | 0.030*** | 0.028*** | 0.079*** | | -0.079 | 0.030** | 0.027 | 0.031** |
| | (0.008) | (0.006) | (0.023) | | (0.057) | (0.014) | (0.022) | (0.013) |
| $\ln \#Imports^2_{ft}$ | | | | | 0.004* | | | |
| | | | | | (0.002) | | | |
| $\ln \#ImportedCountries_{ft}$ | | | | 0.081** | | | | |
| | | | | (0.041) | | | | |
| $\ln Gdp_{dt}$ | 0.201*** | 0.183*** | 0.142*** | 0.173*** | 0.153*** | 0.214*** | 0.092 | 0.219*** |
| | (0.025) | (0.023) | (0.049) | (0.028) | (0.032) | (0.033) | (0.058) | (0.033) |
| $\ln Pop_{dt}$ | 0.148*** | 0.175*** | 0.135* | 0.167*** | 0.165*** | 0.179*** | 0.046 | 0.181*** |
| | (0.033) | (0.035) | (0.072) | (0.038) | (0.038) | (0.043) | (0.080) | (0.045) |
| $\ln Demand_{pdt}$ | 0.020*** | 0.019*** | 0.014*** | 0.019*** | 0.019*** | 0.017*** | 0.015*** | 0.022*** |
| | (0.003) | (0.002) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.005) |
| $\ln Concentration_{pdt}$ | -0.012*** | -0.012*** | -0.008 | -0.011*** | -0.011*** | -0.011** | 0.004 | -0.017*** |
| | (0.003) | (0.003) | (0.006) | (0.004) | (0.004) | (0.005) | (0.006) | (0.005) |
| $\ln \#ExportedProducts_{ft}$ | 0.009 | 0.013*** | 0.015 | | 0.013** | 0.012 | 0.001 | 0.016** |
| | (0.005) | (0.003) | (0.009) | | (0.007) | (0.007) | (0.012) | (0.008) |
| $\delta_{fpd}$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $\delta_t$ | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $N$ | 2,807,585 | 2,222,542 | 620,080 | 2,222,542 | 2,222,542 | 1,827,212 | 479,238 | 1,689,885 |
| Number of Instruments | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| KP (F-stat) | 38.580 | 3459.403 | 62.892 | 19.960 | 22.661 | 38.175 | 30.527 | 31.097 |
| Hansen J-Stat (p-value) | 0.334 | 0.541 | 0.531 | 0.048 | 0.269 | 0.890 | 0.224 | 0.985 |

*Note*: Table reports the results of regressions at the firm-product-country level, obtained by using Chinese data between 2001 and 2013. All specifications are run using the lagged imports $\ln Imports_{ft-2}$ and the lagged firm-level weighted real exchange rates $IV^{RER}_{ft-1}$ as instruments (except column (1)). In column (1) we use the import shares of the first year in which the firm is importing to construct the weights for the IV ($IV^{RER}_{f,firstyear}$). In column (2) standard errors are clustered at firm-product-destination level. In column (3) the top products is defined at the firm-destination-time level. In column (4) we use the number of countries a firm sourced from to measure import diversification. In column (5) we check for nonlinear effects. In column (6) we exclude, within each firm, those transactions in which a firm imports from and exports to the same country. In columns (7) and (8) we distinguish between homogeneous and differentiated products, respectively, using the Rauch (1999) classification. Robust standard errors clustered at the firm-level (except column (2)) are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.

Table A3: Export quality and firms' imports

| Dep.Var | $Q_{fpdt}$ | |
|---|---|---|
| | (1) | (2) |
| | IV | IV |
| $\ln Imports_{ft}$ | 0.046** | 0.031* |
| | (0.021) | (0.018) |
| $\ln Gdp_{dt}$ | 0.220*** | 0.194*** |
| | (0.034) | (0.035) |
| $\ln Pop_{dt}$ | 0.157*** | 0.166*** |
| | (0.035) | (0.036) |
| $\ln Demand_{pdt}$ | 0.020*** | 0.020*** |
| | (0.003) | (0.004) |
| $\ln Concentration_{pdt}$ | -0.012*** | -0.012*** |
| | (0.003) | (0.004) |
| $\ln \#ExportedProducts_{ft}$ | 0.001 | 0.013 |
| | (0.010) | (0.008) |
| $\delta_{fpd}$ | Yes | Yes |
| $\delta_t$ | Yes | Yes |
| $N$ | 2,887,467 | 2,645,137 |
| Number of Instruments | 1 | 1 |
| KP (F-stat) | 23.853 | 29.166 |

*Note*: Table reports the results of regressions at the firm-product-country level, obtained by using Chinese data between 2001 and 2013. The dependent variable is the estimated proxy for quality $Q_{fpdt}$ and the sample includes only two-way traders. In column (1) the instrumental variable is the lagged imported inputs $\ln Imports_{ft-2}$. In column (2) the instrumental variable is firm-level weighted real exchange rates $IV^{RER}_{ft-1}$. Robust standard errors clustered at the firm-level are reported in parenthesis below the coefficients. Asterisks denote significance levels $^{***} < 0.1$, $^{**} < 0.05$, $^{*} < 0.01$.