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## Is China climbing up the quality ladder?

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Gabor Pula and Daniel Santabárbara

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the quality ladder?



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Gabor Pula\* and Daniel Santabárbara<sup>□</sup>

## Is China climbing up the quality ladder?

### Abstract

There is an ongoing debate in the literature about the quality content of Chinese exports and to what extent China imposes a threat to the market positions of advanced economies. While China's export structure is very similar to that of the advanced world, its export unit values are well below the level of developed economies. Building on the assumption that unit values reflect quality the prevailing view of the literature is that China exports low quality varieties of the same products than its advanced competitors. This paper challenges this view by relaxing the assumption that unit values reflect quality. We derive the quality of Chinese exports to the European Union by estimating disaggregated demand functions from a discrete choice model. The paper has three major findings. First, China's share on the European Union market is larger than would be justified only by its low average prices, implying that the quality of Chinese exports is high compared to many competitors. Second, China has gained quality relative to other competitors since 1995, indicating that China is climbing up the quality ladder. Finally, our analysis on the supply side determinants reveals that the relatively high quality of Chinese exports is related to processing trade and the increasing role of global production networks in China.

Keywords: Chinese exports, vertical product differentiation, quality ladder, global production networks, discrete choice model, COMEXT database

JEL Classification: F1, F12, F14, F15, F23

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# 1 Introduction

Analyzing the quality of Chinese exports is of interest for three reasons. First the quality upgrading of Chinese exports could threaten the export market positions of both emerging and advanced economies. In order to implement an adequate policy response, it is necessary to have a deeper understanding of the nature of China's quality upgrading. The quality of Chinese exports has also implications for the exchange rate pass-through, i.e. how much the appreciation of the renminbi may reduce China's trade surplus. *Ceteris paribus*, the higher the quality of Chinese products the lower the price elasticity of demand for them, implying that, in case of an appreciation of the renminbi, export volumes fall less and the trade surplus is more sustained. Finally, historical experience suggests that there are limits to gains in global market shares. This means that China, if it intends to sustain its export-led growth strategy will have to move away from extensive export growth towards exports with higher quality and value-added content. Thus, the pace of quality upgrading also has implications for China's long term growth.

Existing empirical evidence on the quality of Chinese export products is scarce and ambiguous. This is related to the fact that product quality is unobservable and difficult to measure. One simple way of assessing the quality content of exports is looking at the *sectoral composition of exports by technological intensity*. Table 1 shows the composition of various country groups' exports to the EU markets by technological intensity, where sector classification is given by the OECD's methodology. According to the table, China's export structure has changed dramatically since the mid-nineties and the share of high-tech sectors in China's exports has increased from 7% in 1995 to 33% in 2007. This indicates a significant technological / quality upgrading of Chinese export products. By 2007 one-third of China's export was high tech, higher than that of Japan or the EU15. The finding that China's export structure is more sophisticated than suggested by its level of economic development is well documented by the literature (Rodrik, 2006 and Schott, 2008). The most likely explanation for the "over-sophistication" of Chinese exports is the increasing role of production networks, which are dominantly present in high-tech industries of IT, electronics and car manufacturing.

An alternative way of assessing product quality is using the *prices (unit values) of products as proxies for quality*. Chart 1 shows the relative unit values of imports of the EU

from main country groups, in 1995 and 2007.<sup>1</sup> Chart 1 has two important findings. First, it shows that unit values of products from China are 30% lower than the average unit value of all importers. Actually, Chinese products are imported at the lowest prices across the country groups presented on the Chart. Second, there is no sign of catching up in the relative import prices of Chinese goods in the 1995-2007 period, i.e. the negative unit value gap of China is persistent. Assuming that unit values are good proxies for quality, looking at Chart 1 one may conclude that (1) of all the trading countries, China exports the lowest quality goods to the EU market and (2) there was no quality upgrading (relative to other competitors) in the recent decades. All in all, evidence on sectoral composition by technological intensity and on prices as proxies for quality provide different conclusions on the question whether China is climbing up the technology ladder.

Academics bridged this contradictory evidence by using the most recent findings of the trade literature, which suggest that *countries specialize within products rather than across products*. As set out by Schott (2004), contrary to the predictions of traditional trade theory, both advanced and developed countries export the same set of products, but more developed countries tend to export more expensive varieties of the same product. Assuming that price reflects quality it means that there is *a within product specialization* in world trade, i.e. more developed countries export the higher quality varieties of the same product and less developed countries export lower quality varieties. The fact that China exports low quality varieties of the same products as advanced economies would help to understand why it has an “over-sophisticated” export structure on the one hand and has low unit values on the other (Schott, 2008, Fontagné et al., 2008 and Xu, 2010). This finding may also lead to the conclusion that Chinese exports pose only limited competition on advanced economies.

Our analysis challenges this view. The literature summarized above builds on the assumption that prices and unit values reflect quality. There are several reasons why this may not be the case. First, the unit value is not the market price, but rather a proxy for the

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<sup>1</sup> In line with the literature relative unit values or unit value gaps are calculated at the product and country level based on the following formula:

$$UVgap_i^c = \sum_g (UV_{gt}^c / UV_{gt}^{EU}) * w_{gt}^c$$

The unit value gap of an import product from a given country equals the unit value of the product imported from the country divided by the average unit value of the same product on the EU15 market (i.e. the average unit value of the same product across all import origins). To get a country unit value we aggregate the product unit value gaps across all products.

import price. Tariffs, taxes and distribution mark-ups, which are not represented in the unit value, all have an impact on the final price of the product, but not on its quality. Chinese companies have to export cheaper even high-quality products, if tariffs on their products are higher than their competitors. Second, production costs and exchange rates may also drive a wedge between price and quality. Chinese shirts may be sold at lower prices if their production cost is below that of the competitors, or the renminbi is depreciating against the competitors' currencies, even if there is no difference in the quality of the products. Finally, under product differentiation, high cost producers can survive on the market not only due to actual or perceived higher quality (vertical attribute), but also due to horizontal attributes, such as design.

The novelty of this paper compared to the summarized literature is that it relaxes the assumption that import prices reflect quality. We estimate quality following the methodology introduced by Berry (1994) and Berry et al. (1995), who use *not only prices, but also information on market shares to derive a quality measure*. Quality is obtained from a nested logit demand function derived from a discrete choice model. A recent application of this methodology to trade data is given by Khandelwal (2010). Our paper is the first to apply this methodology to a European database. We use the Eurostat's COMEXT database, which provides information on EU imports from 240 partner economies at the CN-8 digit product level (approximately 8500 product headings).<sup>2</sup>

Two attempts to identify export quality using information on US import prices and market share, by Hallak and Schott (2010) and Khandelwal (2010), find contradictory results. Hallak and Schott, who develop a technique for estimating quality using information in countries' export unit values, quantities and trade balances find that China's quality is low compared to developed economies. Khandelwal, however, finds that Chinese quality is relatively low in some products (e.g., transmission receivers) but high in others (e.g., footwear).

This paper has three major findings. First, it finds that despite its lower unit value, the average quality of China's exports to EU markets is high relative to other developing economies. Second, we find that China has gained quality competitiveness relative to other competitors since 1995. With other words, China is climbing up the quality ladder. The

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<sup>2</sup> Trade balance has been used as additional variable to determine product quality by Aiginger (1997) and Hallak and Schott (2010) on a US database. Recently Benkovskis and Rimgailaite (2010) estimated quality



cross-product pattern of our quality estimates suggests a link between the quality and the domestic value-added content of a product.<sup>3</sup> To test this relationship, we also analyze some supply side factors related to export quality. Our results indicate that processing trade, i.e. exports with high import and low domestic value added content, are indeed associated with higher export quality. That implies that quality upgrading in China so far is not embedded in the country's indigenous technological upgrading and it largely benefits multinational rather than Chinese companies.

The paper is structured as follows. Section 2 summarizes the theoretical discrete choice model and the derivation of the demand functions. Section 3 gives an overview of the empirical implementation, the dataset and the estimation methodology. It also provides a description of our methodology to assess the role of processing trade in determining export quality. Section 4 summarizes the results and their robustness and Section 5 concludes.

## 2 Theoretical model

Following Berry (1994) and Berry et al. (1995), our demand curve specification is derived from a discrete choice model. In the following, unlike in the standard literature, the unit of consumer choice is called *variety* rather than *product* in order to take into account the specifics of our database, which has both a product and country dimension. Variety is defined as a specific product imported from a given country.

We assume the following random utility function for the consumer  $i$  ( $j$  indexes variety and  $t$  is time):

$$U_{i,j,t} = x_{j,t}\beta - \alpha p_{j,t} + \xi_{j,t} + \varepsilon_{i,j}, \quad (1)$$

where

$$\xi_{j,t} = \xi_j + \xi_t + \Delta\xi_{j,t}. \quad (2)$$

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and variety of exports of new EU member states. They followed a methodology introduced by Feenstra (1994), which account for quality based on unit values, market shares and firms' market power.

<sup>3</sup> Recently, several papers have documented a positive relationship between the presence of foreign firms / processing activity in a certain sector and the sophistication of its exports (Xu and Lu, 2009, Amiti and Freund, 2010, Wang and Wei, 2010, and Van Assche and Gagnes, 2010).

The random utility consists of four terms. The first term  $x_{j,t} = (x_{j,t,1}, \dots, x_{j,t,K})$  is a  $K \times 1$  vector of attributes for variety  $j$ , which may evolve over time. The second term,  $p_{j,t}$  denote the price of variety  $j$  at time  $t$ . The terms  $\xi_{j,t}$  and  $\varepsilon_{i,j}$  stands for unobserved characteristics of the variety.

$\xi_{j,t}$  is commonly interpreted as the vertical attribute, i.e., the unobserved *quality* of the variety. All else equal, all consumers are more willing to pay for varieties for which  $\xi_{j,t}$  is high (that is why the term is not subscripted by  $i$ ). The unobserved quality term is decomposed into three components:  $\xi_j$  is the time-invariant valuation that the consumer attaches to variety  $j$ ;  $\xi_t$  captures common (demand) shocks across all varieties; and  $\Delta \xi_{j,t}$  is a variety-time variation from the quality fixed effect, which is observed by the consumer but not by the researcher.

The horizontal attribute of a variety is measured by  $\varepsilon_{i,j}$ . Unlike quality, the horizontal variety attribute is valued by some consumers but not by others. The horizontal variety attribute helps to explain why some consumers buy low quality but expensive varieties.

Assuming that the error term  $\varepsilon_{i,j}$  is distributed *i.i.d.* type I extreme value across  $i$ , the choice probabilities (the probability that consumer  $i$  chooses variety  $j$ ) take a multinomial logit form. Using a further assumption that the number of consumers are infinite ( $i = 1, \dots, I = \infty$ ) the market share for variety  $j$  at time  $t$  can be written as follows:

$$S_{j,t} = \frac{\exp(V_{j,t})}{\sum_{j'=1}^J \exp(V_{j',t})} = \frac{\exp(x'_{j,t}\beta - \alpha p_{j,t} + \xi_{j,t})}{\sum_{j'=1}^J \exp(x'_{j',t}\beta - \alpha p_{j',t} + \xi_{j',t})}. \quad (3)$$

Based on Berry (1994) the following transformation can be made:

$$\log(S_{j,t}) = e_t + x'_{j,t}\beta - \alpha p_{j,t} + \xi_{j,t} \quad (4)$$

substituting this into (3) gives

$$e_t = -\log\left(\sum_{j'=1}^J \exp(x'_{j',t}\beta - \alpha p_{j',t} + \xi_{j',t})\right). \quad (5)$$

An outside variety is needed to complete the demand system. The purpose of the outside variety is to allow consumers the possibility to not purchase any of the inside varieties. For example, consumers may choose to purchase a domestic variety or simply not purchasing anything. If we normalize the utility of the outside variety ( $j = 0$ ) to zero, the market share of the outside variety can be expressed as follows:

$$S_{0,t} = \frac{\exp(0)}{\sum_{j=1}^J \exp(x'_{j,t}\beta - \alpha p_{j,t} + \xi_{j,t})} \quad \text{and } \log(S_{0,t}) = 0 - e_t. \quad (6)$$

Substituting (6) to (4) and rearranging gives the following demand curve:

$$\log(S_{j,t}) - \log(S_{0,t}) = x'_{j,t}\beta - \alpha p_{j,t} + \xi_{j,t} \quad (7)$$

The above model can be estimated by an instrumental variable derived estimator, where the independent variable is  $\log(S_{j,t}) - \log(S_{0,t})$ , the independent variables are  $x'_{j,t}$ ,  $p_{j,t}$  and  $\bar{s}_{j/g,t}$ , and the error term is  $\xi_{j,t}$ .

Nonetheless, a major limitation of the simple multinomial logit demand curve in (7) is that it assumes the same substitution pattern across all products' varieties.<sup>4</sup> To remedy this shortcoming we have to extend (7) and use a nested logit model. In contrast to the simple logit model the nested logit model preserves the assumption that consumer tastes have an extreme value distribution, but allows consumer tastes to be correlated across varieties.

We follow Berry (1994) and Cardell (1997) in the exposition of the nested logit model. Let's group the varieties into  $G+1$  exhaustive and mutually exclusive sets,  $g = 0, 1, \dots, G$ . The utility of consumer  $i$  for variety  $j$  in group  $g$  can be written as follows:

$$U_{i,j,t} = x_{j,t}\beta - \alpha p_{j,t} + \xi_{j,t} + \mu_{i,g,t} + (1 - \sigma)\varepsilon_{i,j} \quad (8)$$

where similarly to (1)  $\varepsilon_{i,j}$  is distributed *i.i.d.* type I extreme value across  $i$ .  $0 \leq \sigma < 1$  is the substitution parameter. As  $\sigma$  approaches one the within group correlation of utility levels goes to one and the across group correlation goes to zero. The nest term  $\mu_{i,g,t}$  is common to

<sup>4</sup> This is the so called independence of irrelevant alternatives property, which ensures that the ratio of the probability of two choices does not change depending on the set of choices that are available.

all varieties in group  $g$  for consumer  $i$  and it has a distribution that depends on  $\sigma$ . Cardell (1997) shows that the distribution of  $\mu_{i,g,t}$  is the unique distribution with the property that, if  $\varepsilon_{i,j}$  is an extreme value random variable, then  $\mu_{i,g,t} + (1 - \sigma)\varepsilon_{i,j}$  is also an extreme value random variable.

Based on the distributional assumption on the random component and following the transformations under (1) to (7) one can derive the following demand-function (see Berry, 1994):

$$\ln(S_{j,t}) - \ln(S_{0,t}) = x'_{j,t}\beta - \alpha p_{j,t} + \sigma \ln(\bar{s}_{j/g,t}) + \xi_{j,t} \quad (9)$$

where  $\bar{s}_{j/g,t}$  is the nest share, measured as the market share of variety  $j$  as a fraction of the total group market share. In equation (9)  $\xi_{j,t}$  is expected to be correlated with both  $p_{j,t}$  and  $\bar{s}_{j/g,t}$ . This implies that the OLS estimates of (9) are biased and we need to use valid instruments to estimate our model. The procedure will be discussed in the next section.

### 3 Data and empirical implementation

We estimate the demand function (9) using data from the Eurostat's COMEXT database. The COMEXT database collects EU customs data and it contains information on trade flows as reported by EU countries. It is a disaggregated data source, which provides trade data at the CN8-digit product level.<sup>5</sup> This database contains the values and quantities of imports of 15 selected EU countries.<sup>6</sup> Given that the analysis of the heterogeneity of various EU markets is out of the scope of this paper, we consider one single EU15 market and use the aggregated imports of all the 15 selected countries. Accordingly, our database is three dimensional: it contains EU15 import data under 8500 product labels ( $g$ ) from 240 trade partners ( $c$ ) for the 1995-2007 period ( $t$ ). Under the same product label different goods can be imported from the various trade partners. In the following, we call the good

<sup>5</sup> For example we are able to distinguish within the men's knitted shirt category (CN 4 digit code 6105) by the material of the shirt, i.e. whether the shirt is made of cotton (61051000), synthetic fibre (61052010), artificial fibre (61052090), wool (61059010), or other material (61059090).

imported under product label  $g$  from country  $c$  as a *variety* ( $j=g,c$ ) of product  $g$ . Since consumers are choosing between varieties, *a variety can be seen as the basic unit of consumer choice in our analysis.*

As indicated by (9) our nested logit model allows correlation patterns to depend on groupings of varieties, which however have to be determined prior to the estimation. We group the varieties based on CN-8 digit product labels, i.e. products, which serve as nests. This means that we assume that consumer preferences are more strongly correlated among varieties within the same product than among varieties across product. For example, a Chinese shirt made of cotton is more substitutable with a Vietnamese shirt made of the same material than with a Chinese shirt made of nylon.<sup>7</sup>

The estimation of demand functions requires some sort of substitutability across products. Using a nested logit model helps us to take into account the correlation of consumer preferences. Furthermore, we have to guarantee a certain level of homogeneity of products in our demand function estimation. We achieve this by estimating a separate demand function for each NACE 4-digit industries in our database.<sup>8</sup>

Taking all the specifics of our database into consideration we can rewrite (9) in the following form<sup>9</sup>:

$$\ln(S_{j,t}) - \ln(S_{0,t}) = \xi_j + \xi_t - \alpha p_{j,t} + \sigma \ln(ns_{j,t}) + \xi_{j,t} \quad (10)$$

This is the equation that we ultimately estimate separately for each industry. As regards quantification,  $S_{j,t}$  is measured as the import share of variety  $j$  in the total consumption of the respective industry, where the latter is proxied by the sum of the industry's production and its imports.<sup>10</sup> The market share is calculated in quantities. Since the outside variety is

<sup>6</sup> The EU15 includes Austria, Belgium, Finland, France, Denmark, Greece, Germany, Italy, Ireland, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

<sup>7</sup> In this example the cotton shirt and the nylon shirt are two distinctive nests.

<sup>8</sup> The sectoral level is chosen at NACE 4-digits, while this is the most disaggregate level, where data is available for calculating market shares.

<sup>9</sup> The first term, which describes observed product attributes, is dropped from (9) because our database does not contain information on product attributes.

<sup>10</sup> Theoretically consumption = industrial production + imports – exports, but given that calculation with Eurostat data provided negative consumption figures for many sectors, we decided to leave exports aside and proxy consumption with the sum of industrial production and imports. Data on industrial production is taken from the Eurostat's PRODCOM database. The PRODCOM data are only available in NACE Rev. 2 and thus needs to be transformed to NACE Rev 1.1 in order to be able to match with the COMEXT database.

seen as the domestic substitute for imports the market share of the outside option  $S_{0,t}$  is calculated as one minus the industry's overall import penetration.

In equation (10) we estimate quality as a sum of three components: the time invariant component of quality ( $\xi_j$ ) is measured by a variety fixed effect; the common shock ( $\xi_t$ ) is calculated as year fixed effects; while the third term ( $\xi_{j,t}$ ) is unobserved and plays the role of the estimation error. Intuitively, equation (10) assumes that *the quality of a variety is higher when its market share is higher, after controlling for the variety's relative price*.

The nest term  $ns_{j,t}$  has the important role of controlling for the substitutability of varieties in equation (10) in order to get unbiased estimates on quality. In case of an increase in its relative price, a variety which is easier to substitute will have a stronger decline in its market share, despite no changes in its relative quality. Without using the nest term to control for the different level of substitutability, the lower market share would imply a lower quality estimate. That is the reason why the nested term must be included in equation (10). The nest term  $ns_{j,t}$  is calculated as the import share of variety  $j$  in the total imports of product  $g$  (the nest).<sup>11</sup>

Table 2 gives an overview of the database by 2-digit sectors. Overall, the database contains 189 NACE 4-digit industries, thus we have 189 separate estimates of equation (10). On average per equation, we have 30 products (nests), above 2000 varieties and close 14000 observations. The coverage of the database varies significantly across the 2-digit industries. For example, wearing apparel has on average more than 70 products per equation, while the computer industry has only 16. This suggests that the demand curves are

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<sup>11</sup> Theoretically,  $ns_{j,t}$  should be calculated as a market share. However, given that we have no information on the size of the domestic market at the product level, we calculate it as an import share, i.e. the share of variety  $j$  import in the total imports of product  $g$ . This is equivalent to the assumption that each product market has the same import penetration ratio.

The substitution parameter  $\sigma$  can be interpreted the following way. As  $\sigma$  approaches one there will be perfect substitution among varieties within the nest (e.g. between Chinese and Vietnamese shirts made of cotton), but no substitution across the nests (e.g. no substitution between Chinese cotton and nylon shirts). As a result, if the price of a given variety increases, consumers will substitute it with varieties from the nest but not outside of the nest. This implies that the varieties' relative market share will change within the nest, but not outside of the nest, and thus changes in the overall market share ( $S_{j,t}$ ) will be exclusively determined by the market share within the nest ( $ns_{j,t}$ ). As an example, if the price of the Chinese cotton shirt goes up, consumers will substitute it with Vietnamese shirts made of cotton and not by Chinese shirts made of nylon. The overall market share of both cotton and nylon shirts will remain unchanged while the market share of Chinese cotton shirt within the *outwear sector* will fall together with its market share within the cotton shirt *nest*.

estimated on a more heterogeneous product sample in the wearing apparel than in the computer industries.

As mentioned in the previous section,  $p_{j,t}$  and  $ns_{j,t}$  are endogenous, i.e. they are correlated with  $\xi_{j,t}$ . In order to obtain consistent and unbiased estimates of the coefficient of  $p_{j,t}$  we use two sets of instruments. First, given that the COMEXT database contains neither variety-level transportation costs nor rival variety characteristics (which are widely used instruments in the literature since Hausman, 1997), we have to rely on *non-variety specific instruments*, i.e. country level data, namely the bilateral exchange rate and a proxy for transportation costs calculated as the interaction of bilateral country distances and the oil price<sup>12</sup>. This set of instruments has the advantage of being available for the whole sample. The second set of instruments is taken from the US Customs database. While these data are available at the variety level, i.e, they are *variety specific*, they cover only 40% of our sample.<sup>13</sup> We use two instruments from the US database. One is the variety specific transportation cost, which we re-scale in order to express distances from the EU15. The other is the varieties' unit values on the US market. The idea behind using these so called Hausman instruments is that changes in unit values in third markets (US) can be assumed to reflect cost shocks and thus be used as instruments for prices on the reference (EU15) market.<sup>14</sup> On the other hand, to obtain unbiased and consistent estimates of the substitution parameter,  $\sigma$ , we instrument the nest term with the number of varieties within the nest and the number of varieties exported by a country.

To give an overview of the “quality” of the regressions and the validity of the various sets of instruments, Table 3 provides an overview of the test statistics of the estimates. Given the large number of separate equations the table shows the distribution of the test statistics across estimations. We compared three estimation methods, the OLS, the IV using the subset of *non-variety specific* instruments and an IV using the full set of variety and non-variety specific instruments. When estimated by OLS, 72% of the regressions have a negative and significant price coefficient. This share falls to around 40% and 30% in the case of IV estimation using the non-variety specific and the full set of instruments,

<sup>12</sup> Bilateral exchange rates are taken from IFS database, distances are from the CEPII database (<http://www.cepii.fr/anglaisgraph/bdd/distances.htm>)

<sup>13</sup> The database was obtained from the Center for International Data at UC Davis (<http://cid.econ.ucdavis.edu>). The partial coverage of the US Customs' import data are mainly due the differences in country-product coverage and losses due to the different classifications of the two databases.

respectively. The average IV price coefficient is lower than the OLS price coefficient, indicating that the OLS estimator is biasing the price coefficient upwards as expected. The price coefficients are more negative when using the subset of non-variety specific instruments only. The nested term coefficient is positive and significant, which indicates that the use of the nested logit structure is appropriate. According to the Hausman test we cannot reject the hypothesis that the estimator based on variety-specific instruments is efficient. However, we disfavour the full instrument set due to the lower sample coverage and the worse performance on the over-identifying restriction test. As a result, we use the non-variety specific instruments in our benchmark estimate.

In a second stage, we assess to what extent export quality is related to global production networks. The literature (Xu and Lu, 2009, Wang and Wei, 2010, and Van Assche and Gagnes, 2010) suggests that export quality is higher in sectors with higher role of multinationals and lower domestic value added content. To formally test the relationship between our quality estimates and processing trade (and cross-check the plausibility of our quality measures) we estimate the following equation:

$$quality_{j,h,t} = \delta + \delta_h + \delta_t + \gamma_1 proc_{j,h,t} + \gamma_2 foreign_{j,h,t} + \gamma_3 private_{j,h,t} + \gamma_4 \ln(GDPpc_{h,t}) + \gamma_5 educ_{h,t} + v_{j,h,t} \quad (11)$$

where  $quality_{j,h,t}$  indicates our relative quality estimates normalized within each nest,  $proc_{j,h,t}$  is the share of processing exports<sup>15</sup> in total exports of city  $h$ ,  $foreign_{j,h,t}$  and  $private_{j,h,t}$  are the shares of exports by foreign invested enterprises and private firms in total exports of city  $h$ , respectively,  $GDPpc_{h,t}$  is the real GDP per capita of city  $h$ , and  $educ_{h,t}$  is the share of high education graduates in non-agricultural population, which we use as a proxy for human capital.

Data on processing and firm ownership are available from the China Customs Administration electronic database at prefecture city and HS6 product level. However, we only got the data for the years 1995, 2005 and 2007. The source of GDP per capita and education data is from the official national statistics. Given that educational data is only

<sup>14</sup> However, if these instruments pick up demand shocks they are invalid.

<sup>15</sup> According to the “broad” Chinese definition, processing exports include all exports that contain imported input elements.



available at the provincial level we intra-polated these data at the more disaggregated prefecture city level. Equation 11 is estimated with the OLS estimator.

The quality estimates and their relationship with global production networks are presented in the next section.

## 4 Results

Our quality estimates are presented in Chart 2. The Chart shows the distribution of the quality estimates across varieties by major country groups for the years 1995 and 2007.<sup>16</sup> Chart 2 has two important findings. First, *the quality of Chinese exports to the EU has been relatively high compared to the country's level of development.*<sup>17</sup> In 1995 the mean of China's quality distribution was already higher than that of other emerging economies, such as Latin America, the New Member States and the ASEAN countries and it came as fifth in the group ranking after Japan, the US, EU15 and the New Industrialized Economies (NIEs). Second, *since 1995 Chinese exports have further improved their quality competitiveness relative to other regions of the world.* Between 1995 and 2007 the quality of advanced economies' exports has increased slightly, while a more pronounced upgrading occurred in the quality of developing economies. The quality upgrading was the largest in China, the NMS, and the ASEAN. By 2007, China has taken over the NIEs in terms of export quality and has been placed fourth in our country group ranking after Japan, the US and the EU15.

The data reveal a significant sectoral heterogeneity of quality estimates. To give an example, on Chart 3 we show the quality rankings of each country group in the two most important 4-digit Chinese export industries, namely manufacturing of office equipment, i.e. computers (13% share in total Chinese exports to EU) and manufacturing of other wearing apparel (with a 5% share)<sup>18</sup>. In the office equipment industry China was ranked 5<sup>th</sup> in the mid-nineties and improved its relative position gradually to become the second highest quality exporter by 2007, after the US. In the wearing apparel industry, on

<sup>16</sup> To control for the possible bias in the distribution of quality estimates due to the different product structure of exports from various countries, we normalized the quality estimates from (10) within each product group (nest).

<sup>17</sup> Recalling that quality is determined against the market share and price of a given variety, the results imply that China's market share is higher than justified by its price.

the other hand, China has been exporting goods with low quality and the estimates indicate no quality upgrading during the years.

Why is export quality of office equipment so different from that of the apparel industry? And how can China export higher quality products than many advanced economies? A possible explanation is the role of global production networks in China. As an illustration, Chart 4 plots the share of domestic value added in the total value added of 4-digit industries versus the quality ranking of China in these industries.<sup>19</sup> The relationship is far from clear, nonetheless the position of the two most important industries are clearly distinguishable. As regards wearing apparel, it has a domestic value added share above 60% with a large part of input material produced domestically. In office equipment, on the other hand, the share of domestic value added is below 5% indicating that the industry is almost exclusively involved in the assembling of high quality parts that are imported from more advanced economies. This may explain how China is able to export products, which have as high quality as products of technologically more advanced economies.

Empirical evidence of other studies also supports this hypothesis. Using a detailed database on industrial firms in China, Xu and Lu (2009) also came to the conclusion that export sophistication of industries is positively related to the share of wholly foreign owned enterprises and the share of processing exports in a given industry. Amiti and Freund (2010) and Wang and Wei (2010) has similar findings. Van Assche and Gagnes (2010) argue that high sophistication of Chinese electronics exports may simply be due to the high sophistication of imported inputs in the processing trade.

Our results also support the hypothesis that *the increasing role of global production networks is associated with the quality upgrading of Chinese exports*. According to the estimate of equation (11), the share of processing in total exports has indeed a positive significant impact on the quality of exported goods (Table 4). This result is robust across all the alternative specification (no location specific fixed effects, prefecture city level versus provincial fixed effects).<sup>20</sup> Foreign ownership seem to have no significant positive impact

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<sup>18</sup> China is also the main source of imports in these industries. Imports from China account for 58% and 63% of total extra-euro area imports in the office equipment and other wearing apparel industries, respectively.

<sup>19</sup> The share of domestic value added is taken from Koopman et al. (2010). Unfortunately, the two databases could be matched only with a significant loss in information.

<sup>20</sup> The low R squared can be explained by the fact that endogeneous variable (relative quality of each variety) has significantly more variation than our explanatory variables (prefecture city level data). However, given that our aim is to analyze the relationship between export quality and processing trade rather than capturing the variation of export quality in full, the low explanatory power of the equation is irrelevant regarding our conclusion.

on export quality, which is not surprising given that processing trade is largely associated with foreign firms (85% of processing trade was made by foreign firms in 2010) and, hence, highly correlated with processing exports. The relation between quality and private ownership is positive and significant in two of our specifications. Real GDP per capita and human capital seems to have a negative correlation with export quality, suggesting that processing activity is strong in less developed regions. Nonetheless, when prefecture city fixed effects are used both coefficients turn insignificant.

To assess the *robustness of our quality measures*, we experimented with alternative ways of estimating quality. Given that our quality measures are derived partly from the residuals of the estimated demand functions, they may contain non-quality related components, i.e. the effect of tariffs, the exchange rate and measurement errors. For this reason, we checked what impact tariffs and any measurement error in prices would have on our results. In addition, we tested the implications of using an alternative set of instruments. The alternative instruments, namely the instrument list including variety specific instruments, has already been discussed in the previous section.

As regards measurement errors, given that quality includes the residual term from equation (10) any measurement error to prices will result in a bias of the quality estimate. As discussed in the introductory section, import unit values do not contain tariffs and mark-ups, which both may affect the final selling price of a variety. Omitting these factors, which tend to set the actual price above the import unit value, would result in an underestimation of quality.<sup>21</sup> For this reason, we also estimate (10) with including a term for tariffs and a trend (in order to proxy non-tariff barriers). Tariffs are calculated from the COMEXT database.<sup>22</sup> Unfortunately tariff data are only available after 2000, thus data have to be imputed for the years before (Chart 2).

As a final step, we also tried to use an alternative way of calculating the quality term. According to our definition, quality consists of three elements: a variety fixed effect, a time dummy and the residual term. To control for all the unexplained factors included in the residual term, we decided to calculate the quality estimate excluding this component.

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<sup>21</sup> Due to the fact that a product to realize the same market share at a higher price has to have higher quality.  
<sup>22</sup> COMEXT contains information on varieties falling under certain tariff regimes. COMEXT distinguishes four regimes: (i) imports under most favoured nation (MFN) regime but duty free, (ii) imports under any preferential regime that grants duty free, (iii) imports under a preferential tariff, and (iv) imports under the MFN tariff. We calculate our time-variety specific tariff measure by combining the last two regimes. Given that data are only available after 2000, we impute the data for the years before (with the extrapolation of the after 2000 shares of the various regimes).

The results provided by the above three alternative scenarios have a strong correlation with the results from our benchmark model (Table 5). At the product level, the correlation of quality estimates is as high as 0.93 and 0.74 when tariffs are included and quality is calculated excluding the residual term. The correlation falls to 0.54 when we use the variety specific instruments. The low correlation is partly explained by the difference in the sample size, as discussed in the previous section the coverage of the sample is only 40% when we use the variety-specific instruments from the US Customs database.

## 5 Conclusion

This paper challenges the view that China exports low quality products to European markets. The paper lifts the assumption that prices reflect quality and estimates measures of quality derived from a discrete choice model following the nested logit approach introduced by Berry (1994) and Berry et al. (1995).

According to our findings China not only exports the same kind of products as developed economies, but also the quality of these products is similar to the technologically most advanced competitors. In addition, China has increased the quality of its export products and thus poses a potential threat to the market position of the US, Japan or the EU economies.

Our explanation to these findings lays down in China's active role in Asian production networks as an assembler. Quality of Chinese products seems to be higher in industries where processing trade is dominant and the domestic share in total value added is relatively low. Our analysis of the relationship between product quality and various supply side determinants indicate a positive relationship between processing trade and export quality.

This finding suggests that China's export quality and technological upgrading is related to the high-technology content of imported inputs and thus not embedded in the country's indigenous technological development. Given that processing trade is largely benefiting multinational companies our findings also suggest that China's export quality upgrading is a side-effect of the global trend of production delocalization.

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## Tables and charts

Table 1 The composition of exports by technology intensity, 1995 vs 2005  
(in % of total exports)

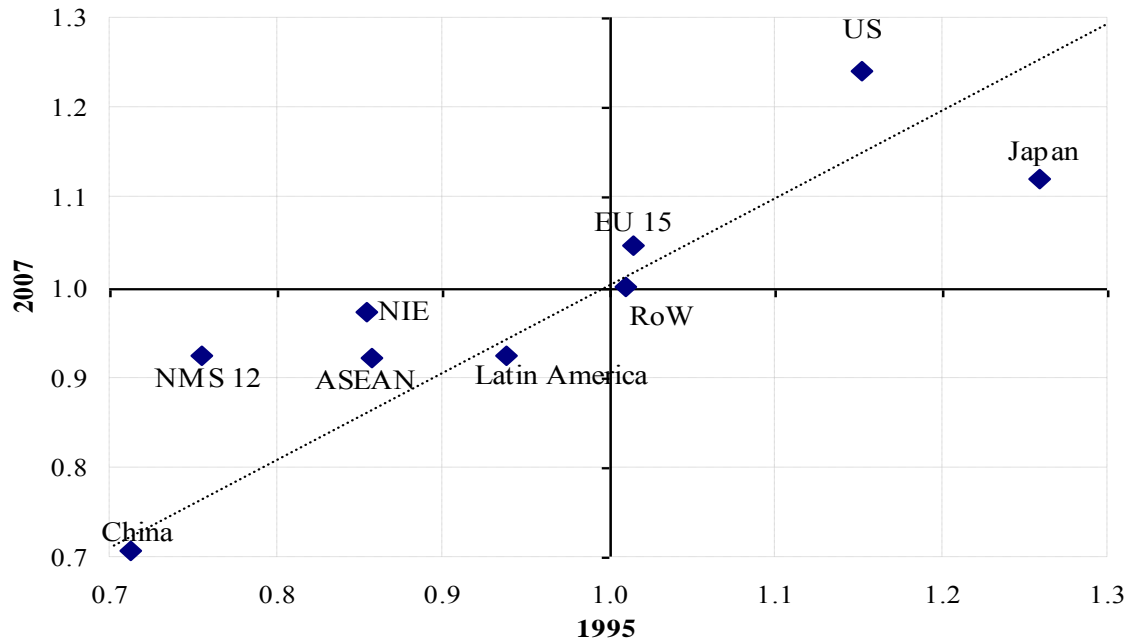
	1995			2007		
	high-tech	medium	low-tech	high-tech	medium	low-tech
China	7%	24%	69%	33%	33%	34%
Japan	16%	82%	2%	20%	78%	1%
US	45%	44%	11%	51%	44%	4%
EU 15	8%	67%	25%	11%	71%	17%
NMS 12	4%	52%	44%	8%	68%	24%
Latin America	6%	28%	66%	11%	41%	48%
NIE	15%	63%	22%	28%	68%	4%
ASEAN	10%	18%	72%	23%	32%	45%
RoW	13%	39%	48%	9%	57%	34%

Source: own calculations based on COMEXT

NMS 12 = New Member States: Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Latin-America: Mexico, Brazil, Argentina; NIE: Korea, Singapore, Taiwan; ASEAN: Indonesia, Philippines, Malaysia, Thailand, Vietnam

Calculation based on the OECD's classification of industries by technology intensity. High-tech: pharmaceuticals, office and computer, electrical appliances (radio, TV), medical, optical appliances. Medium-tech: basic chemicals, machinery, electrical machinery, transport machinery, rubber and plastic, non-metals, basic and processed metals. Low-tech: food, textile, clothes, footwear paper and furniture, other manufacturing

Chart 1 Unit value gaps 1995 and 2007, by country groups  
*The ratio of the exporters' unit value to the unit value of all EU imports*



UV gaps are calculated at the product level  $g$ , for each country  $c$ , at time  $t$  according to the following formula:

$$UVgap_i^c = \sum_g (UV_{gt}^c / UV_{gt}^{EU}) * w_{gt}^c$$

The unit value gap of product  $g$ , country  $c$ , equals the unit value of product  $g$  exported by country  $c$  divided by the average unit value of the same product on the EU15 market (i.e. the average of the unit values of all imported product is on the EU market). To get a country unit value we aggregate the product UV gaps across all products.



Table 2 Structure of the database (by NACE 2 digit industries)

Sector		No. of 4 digit sectors	No. of products (g)	No. of varieties (j=product,c ountry)	No. of obs (j,t)	No. of products per equation	No. of varieties per equation	No. of obs per equation
14	Mining	7	51	3,606	22,539	7	515	3,220
15	Food	21	744	34,192	196,886	35	1,628	9,376
16	Tobacco	1	9	546	2,948	9	546	2,948
17	Textile	9	661	44,457	282,938	73	4,940	31,438
18	Wearing apparel	6	337	32,235	237,452	56	5,373	39,575
19	Leather and shoes	3	162	14,064	89,836	54	4,688	29,945
20	Wood	4	44	4,027	27,352	11	1,007	6,838
21	Paper	6	64	4,659	30,511	11	777	5,085
22	Publishing	7	38	3,982	28,429	5	569	4,061
24	Chemicals	12	463	26,336	155,315	39	2,195	12,943
25	Rubber and plastic	6	175	13,156	88,058	29	2,193	14,676
26	Non-metallic mineral	24	187	13,973	91,548	8	582	3,815
27	Basic metals	10	501	27,561	173,563	50	2,756	17,356
28	Fabricated metals	13	343	27,388	186,276	26	2,107	14,329
29	Machinery	22	848	66,976	398,241	39	3,044	18,102
30	Computers	2	32	2,936	14,880	16	1,468	7,440
31	Electrical machinery	7	251	21,552	130,621	36	3,079	18,660
32	Radio and television	3	88	6,113	36,966	29	2,038	12,322
33	Medical, precision, optical	4	290	22,154	130,168	73	5,539	32,542
34	Motor vehicles	3	98	7,326	43,851	33	2,442	14,617
35	Other transport	8	138	9,880	55,480	17	1,235	6,935
36	Furniture and other	11	211	17,966	122,491	19	1,633	11,136
<b>Total</b>		<b>189</b>	<b>5,735</b>	<b>405,085</b>	<b>2,546,349</b>	<b>30</b>	<b>2,143</b>	<b>13,473</b>

Table 3 An overview of estimation test statistics\*

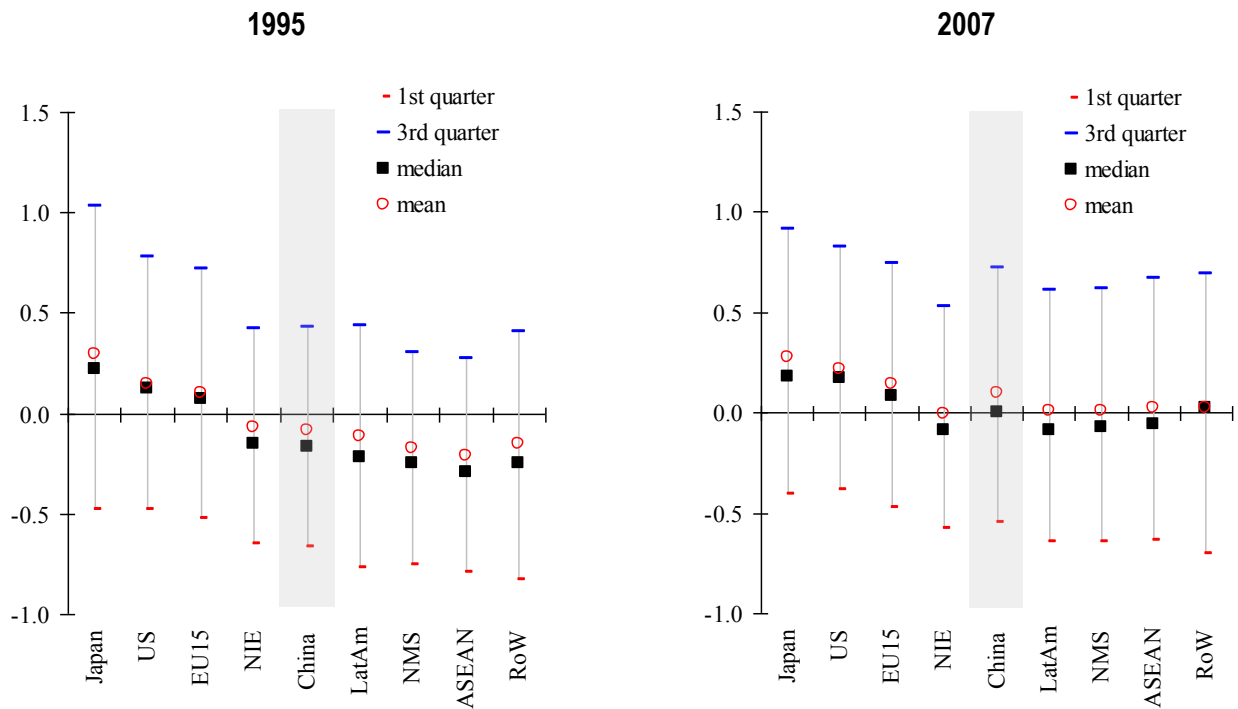
	Mean	1st Quartile	Median	3rd Quartile
<b>OLS</b>				
Price coeff	-0.002	-0.002	-0.001	0.000
Price coeff, p-value	0.140	0.000	0.000	0.127
Nest coeff	0.888	0.925	0.962	0.981
Nest coeff, p-value	0.000	0.000	0.000	0.000
Observations per equation	13112	2429	7261	15884
R2	0.92	0.90	0.95	0.97
Share of eqs with significant and negative price coefficient			72%	
No. of equations			166	
<b>Non-variety specific instruments</b>				
Price coeff	-0.079	-0.136	-0.015	0.003
Price coeff, p-value	0.226	0.007	0.092	0.351
Nest coeff	0.861	0.643	0.987	1.035
Nest coeff, p-value	0.088	0.000	0.000	0.016
Overidentifying restrictions, p-value	0.306	0.000	0.141	0.635
Observations per equation	11410	2780	6431	13528
R2	0.575	0.326	0.652	0.820
Share of eqs with significant and negative price coefficient			41%	
No. of equations			155	
<b>Full set of instrument (non-variety + variety specific instruments)</b>				
Price coeff	-0.007	-0.009	-0.001	0.001
Price coeff, p-value	0.299	0.012	0.176	0.538
Nest coeff	0.950	0.948	1.000	1.028
Nest coeff, p-value	0.014	0.000	0.000	0.000
Overidentifying restrictions, p-value	0.185	0.000	0.002	0.210
Observations per equation	4795	919	2620	5470
R2	0.73	0.64	0.76	0.87
Share of eqs with significant and negative price coefficient			31%	
No. of equations			145	
Hausman Test , p-value	0.726	0.459	0.997	1.000

\* Reported as the distribution of test statistics across estimations

Non-variety specific instruments: nominal bilateral exchange rate, distance\*oil, number of varieties within the nest, and number of varieties exported by a country

Full set of instruments: nominal bilateral exchange rate, distance\*oil, number of varieties within the nest, number of varieties exported by a country, variety specific transportation cost and unit values in the US market

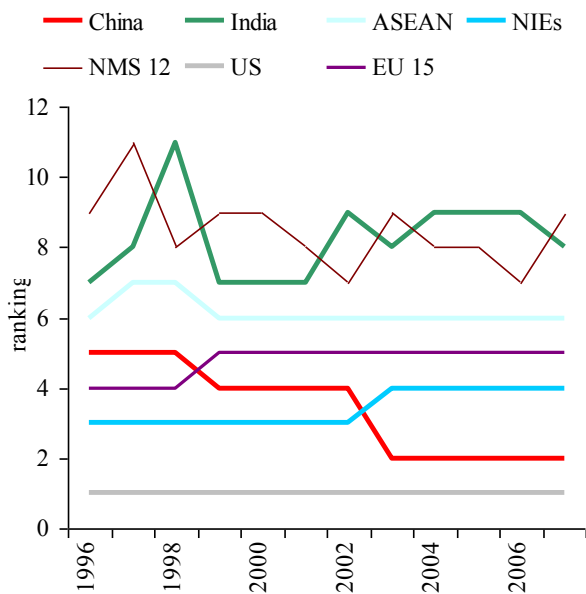
Chart 2 Distribution of standardized quality estimates



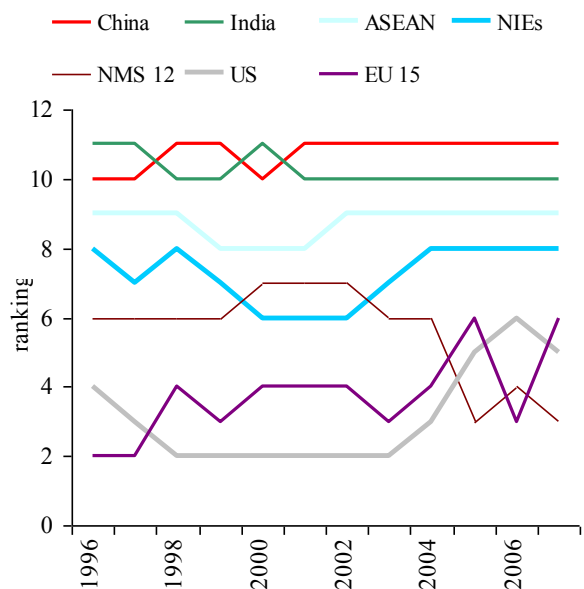
Source: own calculations.

Chart 3 Quality rankings in China's two most important export sectors (NACE 4-digit)

Manufacture of computers and other information processing equipment (3002)

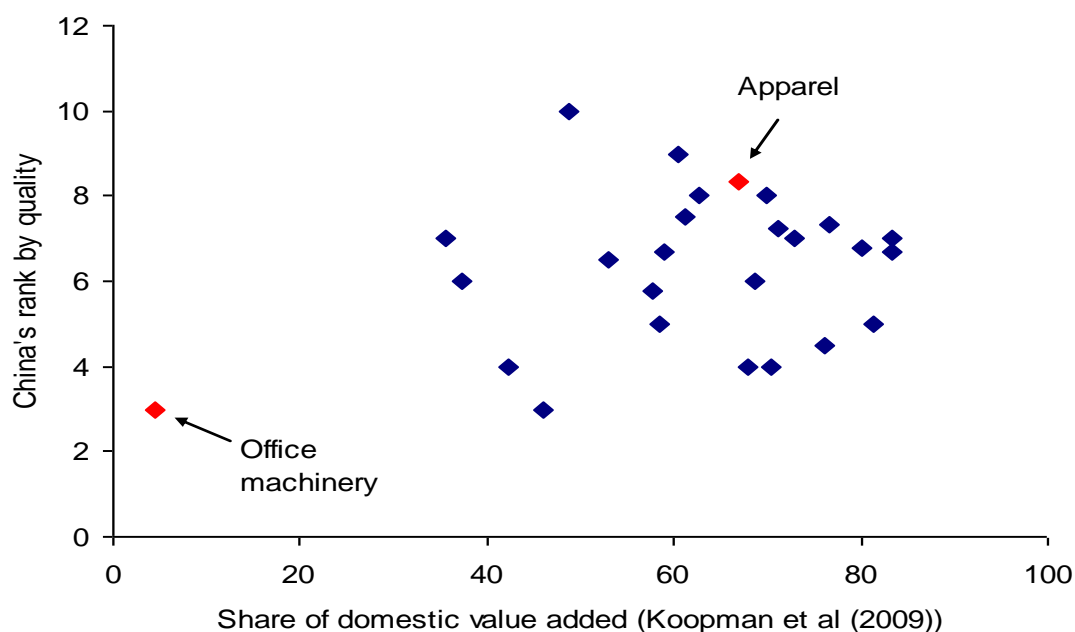


Manufacture of other wearing apparel (1824)



Source: own calculations. Japan and Rest of the world not reported

Chart 4 Quality ranking vs the share of domestic value added by NACE 4-digit sectors



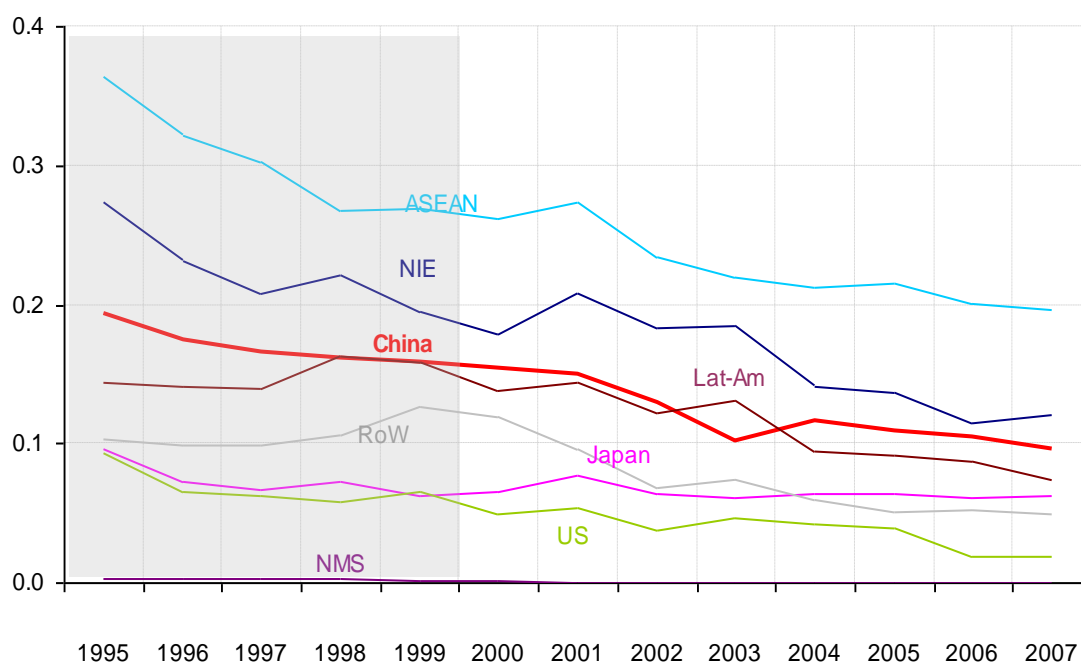
Source: own calculations

Table 4 Export quality and firm characteristics

Dependent variable	(1)	(2)	(3)
<i>Standardized product quality (hs6 and city level data)</i>	Time fixed effects	City and time fixed effects	Province and time fixed effects
Share processing trade	0.119*** (0)	0.0984*** (0)	0.114*** (0)
Share foreign ownership	0.00268 (0.782)	-0.0161 (0.116)	0.00867 (0.382)
Share private ownership	0.0150* (0.0743)	-0.000833 (0.926)	0.0168* (0.0509)
Real GDP per capita	-0.00423*** (0)	0.00135 (0.386)	-0.00360*** (0)
Graduates/non-agricultural population	-11.79*** (0)	-1.524 (0.718)	-4.195 (0.302)
Constant	0.0169 (0.439)	-0.0724 (0.126)	0.0130 (0.723)
Observations	119,035	119,035	119,035
R-squared	0.015	0.026	0.018

OLS estimates. Time and location fixed effects not reported. Sample: 1995, 2005, 2007. City level data. p-value in parentheses, \*\*\*p<0.01, \*\* p<0.05, \* p<0.1

Chart 5 Imputed tariffs by main country groups



Source: COMEXT database and own calculations

Table 5 Correlation of results from alternative specifications at the product level

	1	2	3	4
Sample	EU extra+intra	EU extra+intra	EU extra+intra	EU extra+intra
Instrument	EU	US	EU	EU
Tariff	no	no	yes	no
Resid	yes	yes	yes	no
	1	2	3	4
1	1.000			
2	0.540	1.000		
3	0.930	0.436	1.000	
4	0.735	0.435	0.647	1.000

Source: own calculations

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