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In 2011 all ECB publications feature a motif taken from the €100 banknote.

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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 two major findings. First, China's share on the European Union market is larger than would be justified by its relatively low average prices, implying that the quality of Chinese export products is relatively 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. The relatively high and improving quality of China's exports may be explained by 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

Non-technical summary

The opening up of China to the global economy has played a crucial role in the wide transformation that world trade has experienced in the last two decades. As a result, Chinese products have gained impressive market shares worldwide. Nevertheless, economic research on the factors behind the rise of Chinese exports is still scarce and ambiguous. This work aims at shedding some light on one of the most controversial determinants, the quality of China's exports.

China's share in extra EU15 imports has doubled between 1995 and 2007 and reached almost 20% by the end of the period. The gain in market shares has occurred mainly at the expense of the US and Japan. What are the factors behind China's rapid gain in market shares? Is it due to the delocalization of production or due to price competitiveness, partly driven by an undervalued currency? Is China gaining market shares in the high quality (and less exchange rate sensitive) product segments, or rather in the cheap less sophisticated more homogeneous sectors? Are the positions of advanced economies really threatened by China or is it more the low-cost countries that are crowded out from the market? How much the Chinese trade surplus can be corrected by an appreciation of the renminbi? All these questions are difficult to answer without measuring the quality of Chinese export products.

However, existing empirical evidence on the quality of Chinese products is scarce and ambiguous. This is related to the fact that product quality is unobservable and difficult to measure. According to one strand of the literature Chinese exports are over-sophisticated, i.e. China's export structure is much more sophisticated than suggested by its level of economic development (Rodrik, 2006 and Schott, 2008). Others, however, argue that China exports the low quality varieties of the same products as advanced economies (Schott, 2008, Fontagné et al., 2008 and Xu, 2010). This assumption may also lead to the conclusion that Chinese exports pose only limited competition on advanced economies.

Our analysis challenges this view. The existing literature 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 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 or 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, if consumers value variety, high cost producers can survive on the market not only due to higher quality, but also through horizontal differentiation, e.g. different design.

The novelty of this paper 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 quality*. Quality is derived from consumers' preferences through a discrete choice model. A recent application of this methodology to trade data is given by Khandelwal (2010). According to our knowledge our paper is the first to apply this methodology to a European database, namely, 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).

The paper has two major findings. First, it finds that China's share on the EU market is larger than would be justified by its relatively low average unit value. According to our model this is interpreted as the quality of Chinese export products being relatively high compared to many competitors, even to some advanced economies. Second, we find that China has gained quality relative to other competitors since 1995, i.e. China is climbing up the quality ladder. We believe that the relatively high and improving quality of China's exports is related to the increasing role of global production networks in China. This implies that it is not embedded in China's indigenous technological upgrading and does not necessarily benefit the Chinese economy itself.

1. Introduction

Analyzing the quality of Chinese exports is of interest for three main reasons. First it is an important factor behind China's long term growth. Over the ten years to 2008 China's real exports grew by above 20%, more than twice as fast as world trade. Looking forward it is a major issue whether this high growth rate is sustainable in the future, against the backdrop of increasing saving rate of the US consumers. According to the calculation of Guo and N'Diaye (2009), Chinese exports to grow by around 15% annually in the next 20 years requires that Chinese export market share will double from the recent 10% to 20% in 2030. Guo and N'Diaye (2009), based on historical experience from other export oriented countries, concludes that China will hardly be able to gain further market shares without significant price decreases, for which the room is limited due to already squeezed profit margins. Alternatively, one way of achieving higher market shares would be to increase the price elasticity of exports and diversifying the export structure, in other words, upgrading the quality of exported products.

Another important aspect of the quality upgrading of Chinese exports is the increased competitiveness of China's exports and the strategic response of exporters from both advanced and emerging economies. Several studies documented that Chinese exports are crowding out exports from other Asian economies, in particular that of ASEAN countries (Eichengreen et al., 2007, Haltmaier et. al., 2007 and Roland-Holst and Weiss, 2004). Findings on direct export competition of China with advanced economies such as the US, Japan or the EU are less clear. Schott (2006) finds that the export similarity of China with the OECD countries is, albeit increasing, but still significantly lower than with the Asian economies. As regards competition with the euro area, Baumann and di Mauro (2007) concludes that while China's comparative advantage has increased drastically in the high-tech product segment this had limited impact on the euro area's world market shares given the euro area's specialization in the medium-tech product segment.

Finally, 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[1]. Ceteris paribus, the higher the quality of Chinese export products the lower the price elasticity of demand for these products. Thus, the higher the quality of exports the less export volumes are expected to fall in case of an appreciation of the renminbi. The overall impact on the trade surplus can be calculated by taking into account several other elements, most importantly cost factors. The correction of global imbalances via the exchange rate adjustment of systematic surplus countries has become a central topic of international discussions and an important element of the G20 agenda.

This paper is restricted in its aim to reveal stylized facts and at measuring quality competitiveness of Chinese exports relative to other competitors. The investigation of main determinants of product quality and the analysis of pricing behaviour of Chinese exporters and the exchange rate pass-through is left for further work.

[1] Another interesting aspect of the relationship between the exchange rate and product quality is via selection. A loss in the price competitiveness of firms due to exchange rate appreciation may push companies to (i) cut the exports of low-quality / high price elasticity products or (ii) upgrade the quality of their existing products. Both of these steps would result in an overall quality upgrading. Quality upgrading as firms' adjustment to a loss in price competitiveness is well documented in Aw and Roberts (1986) and in Boorstein and Feenstra (1987).

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. In the following we summarize the results from the various approaches of the prevailing literature by using the Eurostat's product level trade database. 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.[2] 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

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[2] 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:

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

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.

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 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). According to our knowledge 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).[3]

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 two 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. Our quality estimates indicate significant cross-product heterogeneity. As an example, in the group of computer related products, the quality of Chinese varieties is higher and improving faster in relation to other varieties exported than for clothing and apparel (to mention the two most important Chinese export sectors).

The cross-product pattern of our results reveals the importance of the link between product quality and processing trade. Recently, several papers have documented a positive relationship between the presence of foreign firms / processing activity in a certain sector and the quality of products (Xu and

[3] 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 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.

Lu, 2009, Amiti and Freund, 2010, Wang and Wei, 2010, and Van Assche and Gagnes, 2010). Based on a qualitative inspection, we also find that sectors with higher share of foreign inputs tend to export higher quality products. These results suggest that quality upgrading in China is not embedded in the country's indigenous technological upgrading and does not necessarily benefit the Chinese economy itself.

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. Section 4 summarizes the results and the sensitivity analysis 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

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

The random utility consists of four terms. The first term $x_{j,t} = (x_{j,t,1},...,x_{j,t,K})$ is a Kx1 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: ξ_j is the time-invariant valuation that the consumer attaches to variety *j*; ξ_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,…,*I* = ∞) the market share for variety *j* at time *t* can be written as follows:

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

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

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

substituting this into (3) gives

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

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:

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

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

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

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.[4] 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…, G. The utility of consumer *i* for variety *j* in group g can be written as follows:

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

[4] 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.

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 σ 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 all varieties in group *g* for consumer *i* and it has a distribution that depends on σ. 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):

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

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.[5] This database contains the values and quantities of imports of 15 selected EU countries.[6] 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 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

[5] 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).

[6] The EU15 includes Austria, Belgium, Finland, France, Denmark, Greece, Germany, Italy, Ireland, Luxemburg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

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.[7]

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.[8]

Taking all the specifics of our database into consideration we can rewrite (9) in the following form[9]:

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

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.[10] The market share is calculated in quantities. Since the outside variety is 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 (ξ_j) is measured by a variety fixed effect; the common shock (ξ_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).[11]

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[7] In this example the cotton shirt and the nylon shirt are two distinctive nests.

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

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

[10] 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.

[11] 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.

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 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[12]. 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.[13] 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.[14] On the other hand, to obtain unbiased and consistent estimates of the substitution parameter, σ, 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

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The substitution parameter σ can be interpreted the following way. As σ 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*.

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

[13] 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.

[14] However, if these instruments pick up demand shocks they are invalid.

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, 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. The quality estimates 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.[15] 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.[16] 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 fourth 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 4th 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)[17]. In the office equipment industry China was ranked 5th 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 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? The vigorous analysis of these

[15] 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).

[16] 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.

[17] 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.

questions is beyond the scope of this paper. Nonetheless, we believe that one possible explanation for the findings has to do with 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.[18] 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.

We experimented with alternative ways of estimating quality in order to check the *robustness* of the analysis. 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.[19] 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.[20] 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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[18] 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.

[19] Due to the fact that a product to realize the same market share at a higher price has to have higher quality.

[20] 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. 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 by lifting the assumption that prices reflect quality. Our work 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 hypothetical 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 multinational companies are involved and the domestic share in total value added is relatively low. Nonetheless, a more thorough analysis of the relationship between product quality and domestic value added content is justified. One possible way to extend our analysis is to investigate the link between the quality estimates and detailed firm characteristics in the various industries, based on the databases used by Xu and Lu (2009).

Another interesting issue open to further investigation is the pricing behaviour of China's exporting firms on the EU markets. Chart 7 scatters the unit value gap versus the quality gap of major country groups for the years 1996 an 2007.[21] The chart indicates a positive relationship between price and quality: countries with higher relative quality sell their products at a relatively higher price. Nonetheless, China seems to be an outlier. Given their quality, products from China are sold relatively low price. This is increasingly so during the years: China's unit value gap remained persistently low despite the quality upgrading of its export products. However, data indicate a significant sectoral heterogeneity here as well. In the office machinery industry, the price and quality of Chinese products are more in line with the cross country pattern and the relative prices increased even more than the quality. The above phenomenon hints that Chinese exporters are not pricing to market, which may suggest that firms intend to gain market shares rather than realize profits. Nonetheless, the persistence of this phenomenon across 10 years may be suboptimal.[22] This paradox calls for further investigation.

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[21] Quality gap is calculated by normalizing our quality estimates across countries and years under each product label.

[22] Price competitiveness sustained via undervalued exchange rates may also be one explanation. Nonetheless, the Chinese renminbi has depreciated vis-à-vis the euro by 82% in the 1995-2007 period, less than currencies of most competitors, including the US dollar which depreciated by 96%

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Tables and Charts

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

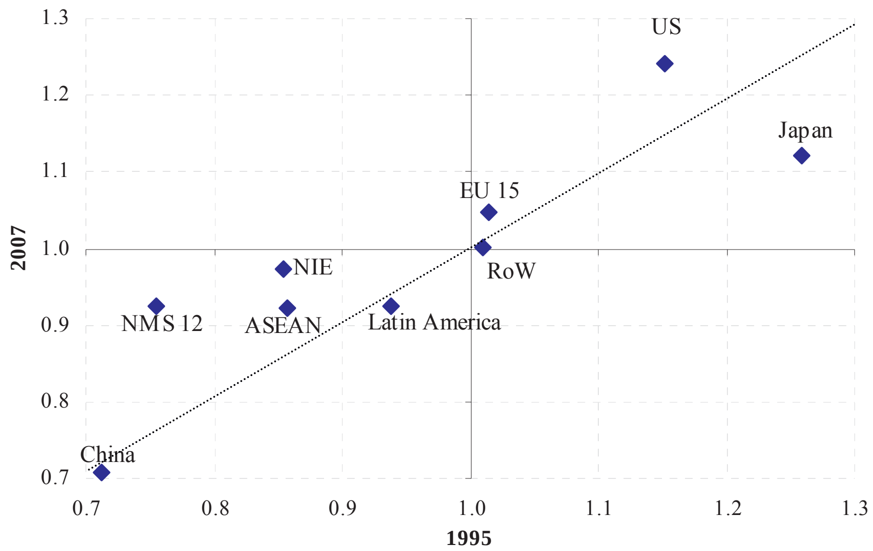
	1995			2007		
	high-tech	medium	low-tech	high-tech	medium	low-tech
China	*7%*	*24%*	*69%*	*33%*	*33%*	*34%*
Japan	16%	82%	2%	20%	78%	1%
US	45%	44%	11%	51%	44%	4%
EU 15	8%	67%	25%	11%	71%	17%
NMS 12	4%	52%	44%	8%	68%	24%
Latin America	6%	28%	66%	11%	41%	48%
NIE	15%	63%	22%	28%	68%	4%
ASEAN	10%	18%	72%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

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

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)

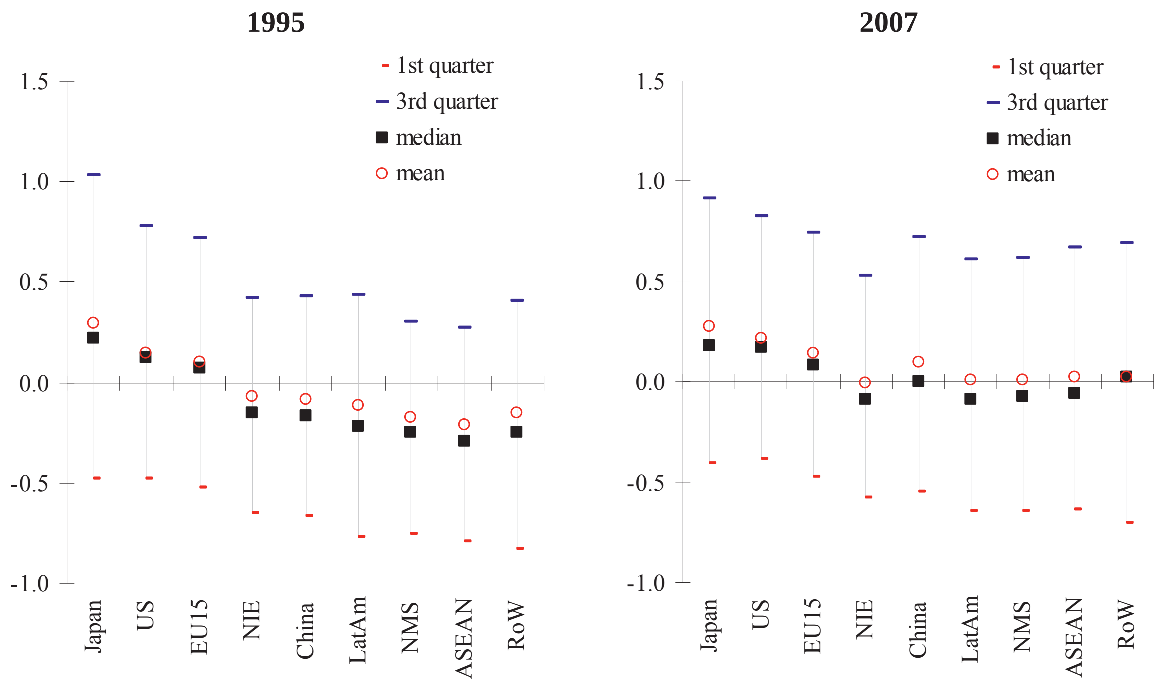
	Sector	No.of 4 digit sectors	No. of products *(g)*	No. of varieties *(j=product,c ountry)*	No. of obs *(j,t)*	No. of products per equation	No. of varieties per equation	No. of obs per equation
14	Mining	7	51	3,606	22,539	7	515	3,220
15	Food	21	744	34,192	196,886	35	1,628	9,376
16	Tobacco	1	9	546	2,948	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
	Total	**189**	**5,735**	**405,085**	**2,546,349**	**30**	**2,143**	**13,473**

Table 3. An overview of estimation test statistics*

	Mean	1st Quartile	Median	3rd Quartile
OLS				
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		
Non-variety specific instruments				
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		
Full set of instrument (non-variety + variety specific instruments)				
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

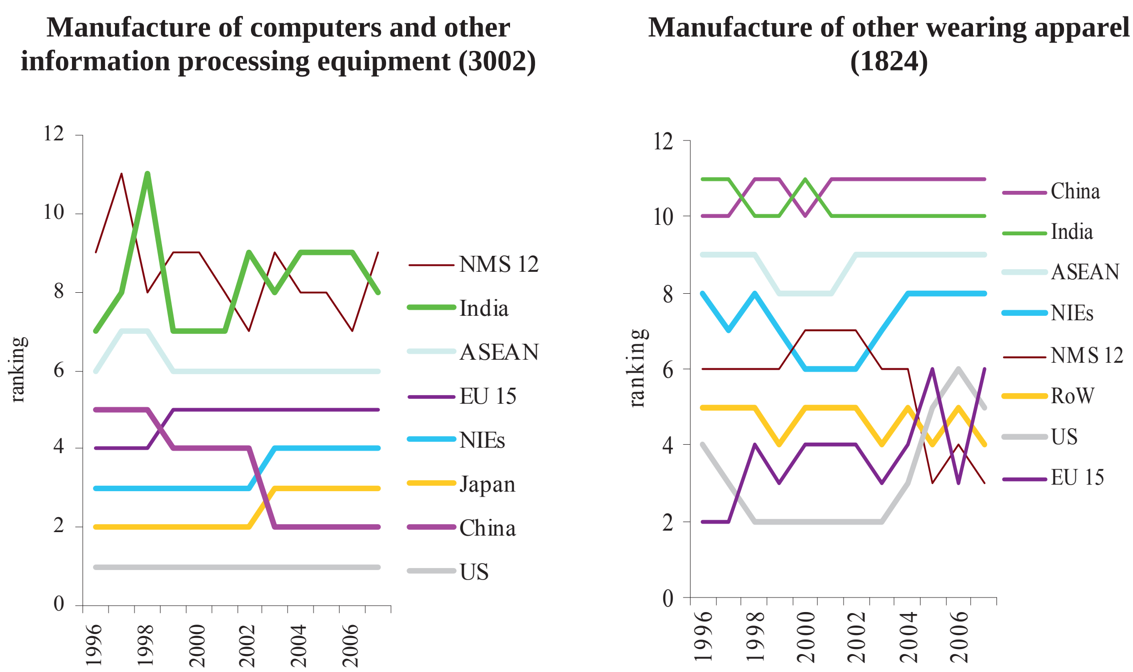
**Reported as the distribution of test statistics across estimations*
*Non-variety specific instruments: nominal bilateral exchange rate, distance*oil, the number of varieties within the nest, the number of varieties exported by a country*
*Full set of instruments: nominal bilateral exchange rate, distance*oil, the number of varieties within the nest, the number of varieties exported by a country + variety specific transportation cost and unit values on the US market*

Chart 2. Distribution of standardized quality estimates



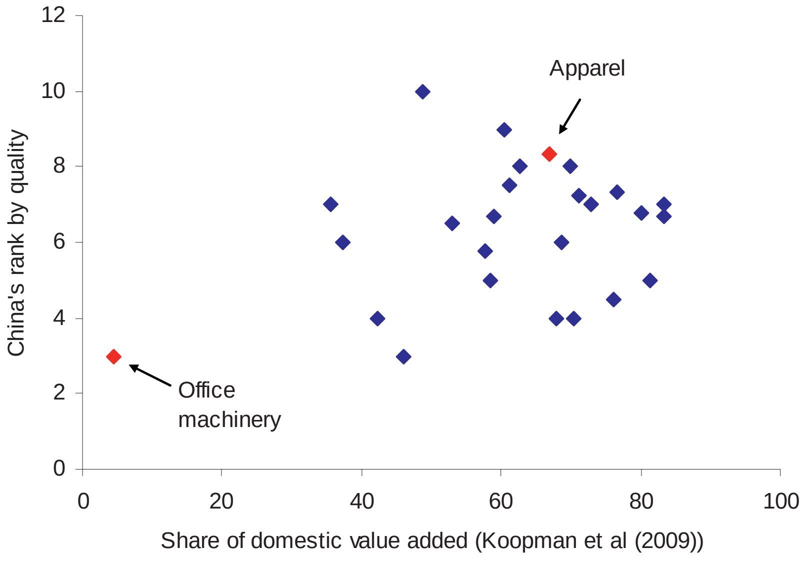
Source: own calculations

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



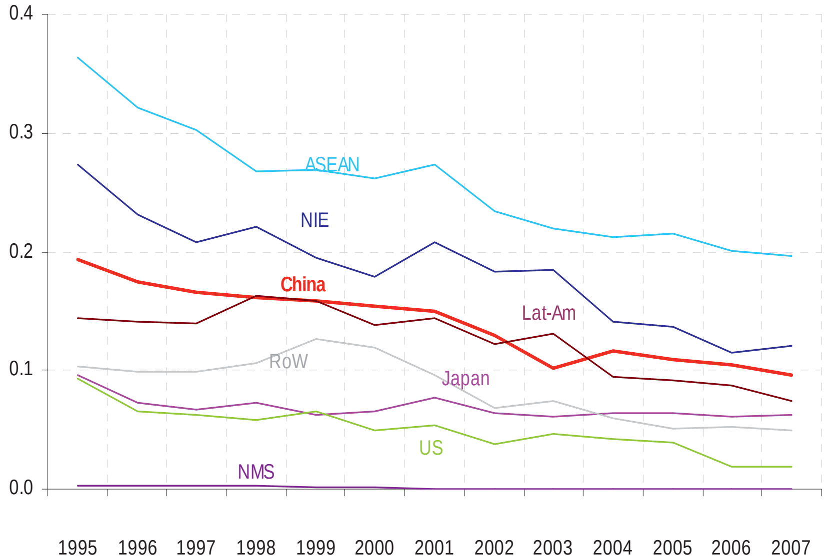
Source: own calculations

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



Source: own calculations

Chart 5. Imputed tariffs by main country groups



Source: COMEXT database and own calculations

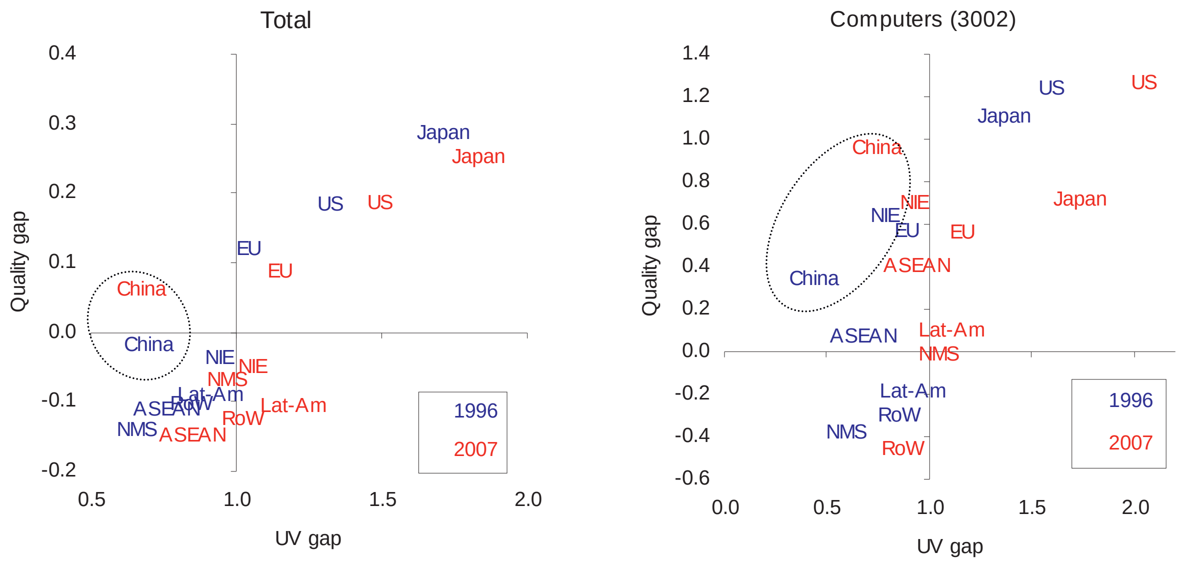
Chart 6. Correlation of results from alternative specifications at the product level

	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: COMEXT database and own calculations

Chart 7. Quality vs. unit value gap, Total economy and computers sector 1996 and 2007



Source: COMEXT database and own calculations