Quality and Input Choices: Evidence from Chinese Exporters

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June 2012

Abstract

Using the detailed Chinese firm level exports information between 2000 and 2006, this paper estimates market- and product-specific demand functions for China's Electrical Machineries exports and recover the latent quality ranking as the demand residual. I apply an instrument based on the idea of Hausman-Nevo instrument to this multi-market and multi-origin data for identification. I then combine the quality measure with other firm level observations to identify factors underlying the cross firm variation in the measured quality. I find quality of exports to rich countries to be positively correlated with importing activities, and especially the imports of intermediated inputs from rich countries for Chinese non-state owned firms. I also find a positive correlation with wage which holds for not only Chinese non-state owned firms, but also for foreign invested firms, including those with investment from by Hong Kong, Macao and Taiwan.

JEL Classifications: F12, F14, O12, O14.
Keywords: Trade; Quality; Imported Inputs; Learning by Exporting; Firm Heterogeneity.

I thank my committee members Loren Brandt, Gilles Duranton, Peter Morrow for their invaluable guidance throughout the work. I also benefit tremendously from discussions with Victor Aguirregabiria, Daniel Trefler and Xiaodong Zhu. I would also like to thank participants in the trade workshops, the CEPA Brown Bag lunch seminars at the University of Toronto and the Young Fellow seminar during the 35th PAFTAD conference for helpful comments. All remaining errors are my own.

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1. Introduction

Quality and cost advantages can both contribute to a firm's profitability. Improving quality enables a firm to charge a higher price without losing market share, while cost advantage allows a firm to profit from selling more at lower prices. In the early stage of their participation in international trade, less-developed economies export mainly products with low quality content to make the best use of the abundant resource of cheap and unskilled labour. One concern about this development strategy is that when product quality and quantity are imperfect substitutes, the markets for low quality products are limited; as a result, it is not guaranteed that the less-developed economies can benefit from trade and the economic growth supported by this specialization in low-end manufacturing products may not be tenable.[1] Studies on the industrial policies of the newly industrialized economies also suggest that the transition toward more sophisticated products and the cultivation of dynamic comparative advantage are crucial.[2]

Despite the important role of quality, there are not many empirical studies explicitly focusing on the quality differentiation by exporters from developing countries. This is possibly due to the lack of directly observable information on quality.[3] In this study, I use the rich export information from China's customs records to estimate the quality ranking among Chinese exporters at the firm-, product- and market-specific level. I then combine the quality estimates with other firm level information to identify possible channels through which quality is differentiated across firms. I find importing activities and wage to be positively and significantly associated with the quality of firms' exports to rich countries, especially for Chinese non-state owned firms.

Direct measures of quality are rare. One common practice is to use unit value as a proxy for

[1] The discussion on the demand-side determinants of the pattern of trade can be traced back to Linder (1961). Summaries of early literature can be found in Deardorff (1984) and Leamer and Levinsohn (1995). Later related developments include the theoretical models developed in Copeland and Kotwal (1996), Murphy and Shleifer (1997) and empirical test by Hallak (2006, 2010). Sutton (2007) provides a mechanism that can generate a quality threshold. Hallak and Sivadasan (2009) introduces quality minimum requirement into the seminal heterogeneous firm trade model of Melitz (2003) and analyses the consequence.

[2] For summaries on related studies, see Balassa (1988), Rodrik (1995), Harrison and Rodriguez-Clare (2010).

[3] Brooks (2006) argues that low quality contributes to the low export intensity observed among Colombian plants. But the quality measure is based on unit value and constructed at industry level. Hallak and Sivadasan (2009) investigates firm level data and finds conditional exporter premium in output unit value and/or factor use in India, the United States, Chile, and Colombia. The conditional premium in unit value is interpreted as reflecting selection on quality.

quality.[4] However, this is problematic because high price may indicate either high quality or low cost efficiency. When information on both price and quantity is available, a better alternative can be constructed. Conceptually, quality can be taken as a demand shifter that captures any attribute of a product affecting consumers' willingness to pay.[5] A quality improvement thus shifts a demand curve upward and outward. Holding price constant, larger market share is a reflection of higher quality.[6] Based on this intuition, I estimate market group- and product group-specific demand functions to measure price elasticities as precisely as possible[7] and then take the residuals from estimating such a demand system as a measure of quality. The reliability of this empirical measure of quality depends crucially on consistently estimating the demand system. One econometric challenge is that the unobserved quality affects both quantities demanded and prices,[8] as a result, the OLS estimate of the price coefficient would be biased toward zero. In turn, the quality ranking based on the OLS residuals would be reversed for some observations. This point is illustrated in Figure 1. In Figure 1, each point represents an observation of a firm exporting product HS85291020[9] to the United States in year 2006. For simplicity, I divide the observations into two groups, those of low quality and those of high quality.[10] The blue points represent observations with low quality and the orange points represent observations revealed to be of high quality. The green line represents the OLS fitted line pooling the orange points and blue points together. The distance of each point to this fitted line would be the quality estimate based on OLS estimation. A reversal means the low quality blue points above the fitted line would have higher quality than the orange points below the OLS fitted line.

To address this endogeneity problem, I require an instrument that captures only the quality-

[4] Hallak and Schott (2011) provides a list of research based on this measure.

[5] The attribute can be related to either objective characteristics of a product or subjective evaluation by consumers.

[6] This idea of relating unobserved quality to conditional market share originated from the IO literature. Examples of recent studies on trade based on this idea are Hummels and Klenow (2005), Hallak and Schott (2011), Gervais (2010), and Khandelwal (2010). This method does not distinguish between objective aspects of quality such as technology and the subjective evaluation by consumers.

[7] Throughout the paper, product group is defined as one 4-digit HS line; product is defined as one 8-digit HS line. I refer to one 8-digit product produced by a firm as a variety.

[8] Quality is positively correlated with price because higher quality usually costs more to produce; on the other hand, since quality is a demand shifter, it is positively correlated with quantity.

[9] According to the 8-digit Chinese classification of products, HS85291020 includes "Aerials and aerial reflectors of all kinds; parts suitable for use therewith for radio-broadcast receivers and their combinations, television receivers".

[10] This is based on my quality estimation, which will be discussed shortly.

independent part of the price variation to consistently estimate the price coefficient. The rich information I have on the origins and destinations of firms' exports provides a way to construct such an instrument, following the idea in Hausman (1996) and Nevo (2001). For each destination market m, I carefully select a set of markets that are subject to demand shifters independent of those on market m. I then use the average price that firms in the same production location charge on these other markets as an instrument for the prices they charge on market m. As expected, my instrumental variable strategy increases the magnitude of the OLS estimates by 100% on average. Moreover, the estimates are robust to different ways of constructing instruments. Firstly, ing trade rather than ordinary trade, and the former is excluded from this current analysis for the reasons mentioned above; on the other hand, for those involved in ordinary trade, they may not need to use imports to differentiate quality. Looking into the type of imported products, I find it is importers of intermediate inputs rather than capital goods that are more likely to produce higher quality products. Looking into the origin of imports, I find the positive association to be stronger if the imported inputs are from rich countries. Similar pattern is found using continuous measures of importing activities such as total value and the number of product lines imported. My data also allows me to investigate the association between quality and wage. I find wage to be positively correlated with quality for not only Chinese non-state owned firms, but also for foreign invested firms, including those invested by Hong Kong, Macao and Taiwan investors. The association is the strongest for Chinese non-state owned firms though.

My first contribution to the literature is to obtain an improved measure of quality at the micro level. The unit value and quantity information in my data allows me to use demand residual as a measure of quality ranking. This is an improvement over unit value as a proxy for quality as it is not confounded by difference in cost efficiency. Even though this method is not new, this paper is the first, to my knowledge, to explore the multi-origin and multi-market structure of the transaction-level trade data for identification and to recover the latent quality of exports at the firm- and market-specific level. The multi-market and multi-origin structure of the micro trade data also provides room for constructing instruments that better satisfy the identifying assumptions of the Hausman-Nevo instrument.[13]

Second, given that quality is one specific aspect of productivity, my investigation of the association between quality and importing activities is related to a more general literature on the impact of imports on firm productivity. Some studies have found positive impacts of imported inputs on productivity, for example, Amiti and Konings (2007) for Indonesia, Kasahara and Rodrigue (2008) for Chile and Halpern et al. (2005) for Hungary.[14] With a richer set of measures

[13]Firm level input prices, which affect production cost, have often been used as price instruments in estimating the output demand function. However, my investigation of the relationship between the estimated quality and firms' input choices suggests input prices are endogenous because firms use different input to produce output of different quality. This calls into question the validity of input prices as instruments for output price in demand estimation. My instrument is less susceptible to this concern because it is origin-destination specific instead of firm specific.

[14]Muendler (2004) finds no such evidence for Brazil.

on firm performance and importing activities, Kugler and Verhoogen (2009) and Manova and Zhang (2011) also find positive association for Colombian firms and Chinese firms respectively. Regarding the specific channels through which imported inputs affect productivity, Goldberg et al. (2010) identify expanded product scope to be an important one in India. Findings in this paper echo the existing evidence on positive impacts of imports on firm performance but suggests facilitating quality upgrading as a specific channel through which easier access to imported inputs contribute to firm productivity.

Third, my finding of a positive correlation between quality and wage also relates to a large literature on the impact of trade liberalization on wage inequality, especially in developing countries. During the process of trade liberalization in developing countries, skill premium has not been evolving as described by the Stolper-Samuelson theorem in the traditional Heckscher-Ohlin model.[15] Specifically, in a recent study on China, ? finds that skill premium rises faster in regions that are more exposed to international trade. Trade induced skill-biased technology adoption, which is absent in the traditional trade model, has been proposed as the main factor that could have offset the well-known Stolper-Samuelson force. Studies such as Acemoglu (2003)[16], Yeaple (2005) and Zhu and Trefler (2005) emphasizes technology changes at the firm level. Harrigan and Reshef (2011) and Burstein and Vogel (2012) further introduce the important interaction between a firm's productivity and the skill intensity of its production technology and hence allow reallocation of resource to contribute to skill premium as well. Verhoogen (2008) and Bustos (2011) find micro evidence among Mexican firms and Argentinian firms that are supportive of the skill-upgrading mechanism. My finding of a positive correlation between wage and export quality to the North American and European markets is consistent with this technology explanation of increasing skill premium in developing countries and suggests producing higher quality products for consumers in rich countries as a more specific driving force of the skill premium.

The remainder of the paper is organized as follows. In Section 2, I develop a simple model to motivate the empirical work and highlight my identification strategy. In Section 3, I give a brief overview of the data explored in this study. In Section 4, I present the demand estimation. In

[15] ? provides a review of the empirical facts on globalization and wage.

[16] StolperCSamuelson theorem predicts increasing skill premium for skill-abundant countries, but it should be accompanied by increasing prices of skill-intensive tradables which we do not observe. Skill-biased technology progress can generate increasing skill-premium without raising the prices of skill-intensive tradables.

Section 5, I present the empirical analysis on the association between quality and input choices. Section 6 concludes.

2. Model

This section presents a model of a rm's endogenous quality choice. The model is in the same spirit as existing work in that it esl4pers the same result of heterogeneous rms choosing di erent technology or inputs to di erentiate quality.[17] But it has a few distinct features. First, the model

shows that a rm's decision on input and output quality is indepen
factor price; as a result, the di erence in quality adjusted factor pri
would generate variation in output price that is independent of qu
can be used to identify the price coe cient in the output dema
foundation for the exclusion restrictions in the demand estimation i
shows that when the demand elasticities of quality vary across m
quality across markets. On one hand, rms ship higher quality g
where demand is more respons4pe to quality upgrading. On the
consumers' willingness to pay for quality is pery low, no rm has
quality persion of its pariety. As a result, the price pariation i
from di erent production locations will just re ect the pariation ir
factor price and can be used as instruments to identify the dem
quality is di erentiated. This provides a foundation for the con
variables from the data I hape for this study. Third, when there ex
between imported inputs and rms' e ciency in producing quality
in producing quality will self select to be importers and produce h
last two points, the model predicts a positipe correlation betwee
and the quality in high income markets. The predictions on the co
input choices, speci cally wage and importing activities, will be co
4.

[17] For example, models in Verhoogen (2008), Johnson (2011), Kugler and Verhoogen (2011), Baldwin and Harrigan (2011) and Hallak and Sipadasan (2009).

2.1. Demand

Assume a Dixit-Stiglitz CES utility function for a representative consumer in country m

$$U_m = \int_{i \in V_m} {}_i{}^{m} q_i^{\frac{\quad 1}{}} \, di^{\frac{}{\quad 1}} \tag{1}$$

where i denotes varieties, V_m is the set of varieties available to consumers in market m, q_i denotes the consumption of variety i and $_i$ is the quality of variety i. As in Hallak (2006), $_m$ captures the intensity of consumers' preference for quality in market m. is the elasticity of substitution hours of labour embedded. To allow firms to differentiate quality across markets, I denote the variety by firm f in market m by fm. Using L_{fm} and S_{fm} for the hours of quality-independent and quality-differentiating activities respectively, I assume the following production function for variety fm with quality $_{fm}$

$$Q(L_{fm}; S_{fm}; \ _{fm}) = min \left\{ \ _f L_{fm} \ ; \ \frac{S_{fm}^{\frac{1}{}}}{\left(\frac{_{fm}}{1-} \ \frac{_f}{1-} \right)^{\frac{1}{}}} \right\} \quad (3)$$

The parameters deserve some detailed explanation. Regarding the quality-independent part, $_f$ represents firm f's efficiency in conducting quality-independent activity (or in using quality-independent input) in the sense that no matter the quality of the final product, firm f always needs $\frac{1}{_f}$ amount of quality-independent activity to produce one unit of output. Regarding the quality-differentiating part, first, > 1 captures the degree of diminishing return in producing quality; second, $_f$ represents firm f's efficiency in conducting quality-differentiating activity (or in using quality-differentiating input; third, < 0 captures the degree of complementarity between quality efficiency and the amount of quality-differentiating input in producing output quality; fourth, captures the relative importance of quality-differentiating efficiency versus labour hour is w_j. As a result, the unit cost function conditional on input quality $\mathbf{s}_{fm}$ for rm f at location j is[20]

$$c_j(\ _f; \mathbf{s}_{fm}) = w_j \quad \frac{1}{\ _f} + \mathbf{s}_{fm} \tag{5}$$

2.2.2. Firm Optimization

Given the demand equation speci ed in (2), the optimal price conditional on input quality $\mathbf{s}_{fm}$ is a constant mark-up over unit cost:

$$p(\mathbf{s}_{fm};\ _f) = \frac{}{\ 1} w_j(f) \quad \frac{1}{\ _f} + \mathbf{s}_{fm} \tag{6}$$

De ne $\overline{A}_m = \frac{1}{} \quad \frac{}{-1}^{1-} \quad A_m$. The associated operating pro ts from market m will be

$$(\mathbf{s}_{fm};\ _f;\ _f) = \overline{A}_m w_{j(f)}^{1-} \quad _f + (1 \quad)\mathbf{s}_{fm}^{\frac{m(\quad 1)}{}} \quad \frac{1}{\ _f} + \mathbf{s}_{fm}^{\quad 1-} \tag{7}$$

Firm f chooses input quality $\mathbf{s}_{fm}$ to maximize the pro ts in (7). The rst order condition gives

$$\frac{m}{f} = \frac{}{1} \quad _f \mathbf{s}_{fm}^{*\ -} \quad + (\quad _m)\mathbf{s}_{fm}^{*} \tag{8}$$

It can be proved that the solution to (8) exists and is unique. A su cient condition for the second order condition to hold is $_m <$, i.e, the cost function is su ciently convex in quality relative to the demand function. Equation (8) suggests the optimal input quality by rm f for its shipment to market m, $\mathbf{s}_{fm}^*$, is a function of consumers' preference for quality $_m$ and the two e ciencies $_f$ and $_f$, i.e, $\mathbf{s}_{fm}^* = \mathbf{s}(\ _f;\ _f;\ _m)$. Given the quality production function in (4), the

[20] Notice from (4) that for a given rm, there is a one-to-one relationship between input quality $\mathbf{s}$ and . The corresponding unit cost function conditional on output quality $_{fm}$ is $c_j(\ _f;\ _f;\ _{fm}) = w_j \quad \frac{1}{\ _f} + \frac{\ _{fm}}{1} \quad \frac{\ _f}{1}^{\ !}$.

optimal output quality depends on the same factors, thus higher quality.

$$(C) \qquad \frac{d \ ^{*}_{fm}}{d \ _{m}} > 0$$

This means the optimal quality increases in the intensity of consumers' preference for quality . This is because a same quality improvement boosts demand more in the more quality sensitive markets. For the extreme case of $_{m'} = 0$, the pro t maximization condition in (8) suggests all rms will choose $e^{*}_{fm'} = 0$. The optimal pricing in (10) then becomes

$$p^{*}_{fm'} = \frac{}{1} w_j \frac{1}{_f} \qquad (11)$$

The average over all rms from the same production location j is then

$$\overline{p}^{*}_{jm'} = \frac{}{1} w_j \int \frac{g_{jm'}(\ )}{} d \qquad (12)$$

where $g_{jm'}(\ )$ is the marginal distribution of conditional on producing in location j and selling to market m'. Assuming the same distribution of conditional on selling to m' across production locations, i.e, $g_{jm'}(\ ) = g_{m'}(\ ) \ for \ \forall j$, the variation in $\overline{p}^{*}_{jm'}$ across j would re ect only variation in w_j.

2.2.4. Introducing Imported Inputs

Imported inputs are introduced as quality-di erentiating inputs with stronger complementarity with rms' quality-di erentiating e ciency . The quality production function associated with imported input is then

$$_{fm} = \left(\ _f^{\ '} + (1 \ ) e_{fm}^{\ '} \right)^{\frac{1}{'}} \qquad (13)$$

where $' < \ < 0$, implies a higher degree of complementarity between **s** and . It can be proved that firm f with $\ _f \ _f = \frac{(1-\ )\ _m}{-(1-\ )\ _m}$ is indifferent between domestic and imported quality-differentiating input. Firms with either higher or lower will find it more profitable to import input with higher quality content **s** and produce higher ; on the opposite, it is more profitable for firms with either lower or higher to use domestic quality-differentiating input with lower quality content **s** and produce lower quality .

2.2.5. Summary

Summarizing the model delivers three important results. First, firms' underlying attributes and consumers' quality preference are the common factors that determine firms' choices on input quality, output quality and price. The optimal price depends on these factors as well as the local quality adjusted factor price. As a result, the variation in the quality adjusted factor price across production locations generates a price variation that is orthogonal to the variation in quality. This provides a micro-foundation for my instrumental variable strategy in the demand estimation in Section 4. Second, firms have a stronger incentive to upgrade quality when and where demand is more responsive to quality change and do not do so when consumers' willingness to pay for a quality upgrade is too low. This implies one can use prices charged in markets where consumers are not quality sensitive to capture information on the location specific quality-independent part of production cost. Third, when imported quality-differentiating inputs are more complementary to firms' ability in producing quality, more capable firms will find it more profitable to use imported inputs to produce higher quality. Combining this with the second point on quality differentiation across market, I expect to see imported inputs to allow quality upgrading for sales to quality sensitive markets.

3. Data

3.1. Customs Data

My primary data set is China's Customs records for 2000-2006. This dataset provides information on the 8-digit HS product code, quantity, total value, exporter and importer identity, ownership

3.2. China's Annual Manufacturing Survey Data

The second source of data is China's Annual Manufacturing Survey (AMS) 2000-2006 data. ASM covers all State Owned Enterprises (SOE) and rms of other types of ownership with annual sales above 5 million RMB. The survey collects information on rms' industry classi cation (CIC), capital stock, wage cost, total employment, total exports, total output value, etc. I match the Customs data and the ASM data by rms' names. I summarize the exporting and importing activities of the matched sample in bottom panel of Table 1. Given that ASM selects rms on size, it is not a surprise that rms in the matched sample are on average larger in export scale. However, there is no substantial and systematic di erence in other measures of trading activities between the two samples.

3.3. Other Data

Information on destination markets' per capita GDP is from the Penn World Tables. Pair-wise distances between countries are from CEPII.

4. Demand Estimation

4.1. Speci cation

The unit of observation is by exporting rm f, destination market m, 8-digit HS product h and year t. My estimation equation is

$$ln(Q_{fmht}) = {}_{g(m)j(h)} \; ln(P_{fmht}) + A_{mht} + {}_{fmht} + {}_{fmht} \tag{14}$$

where $ln(Q_{fmht})$ is the log of physical quantity sold of product h by rm f to country m in year t; $ln(P_{fmht})$ is the log of the associated unit value; A_{mht} is a market-product-time xed e ect independent of price. $g_{(:)}$ and $j_{(:)}$ refer to the market group that country m belongs to and the product group that product h belongs to respectively.

The purpose of estimating the demand function is to recover the latent quality ranking as demand residuals. It is essential to estimate the price coefficient properly. There are two issues that need to be addressed. First, unobserved quality simultaneously determines price on the right hand side and quantity on the left hand side, for the reason that varieties of better quality are usually more costly to produce and priced higher and that varieties of better quality are demanded in larger quantities conditional on price. This leads to an upward bias of the OLS estimates of the price coefficient. I am going to construct and use a Hausman-Nevo instrument that captures the quality-independent part of the cost variation across different production locations in China to identify the price coefficient. I will discuss this in more details in the next subsection. The second issue is that the price coefficient is not necessarily the same across markets and products. It is not enough just to be able to consistently estimate an average price coefficient since imposing a constant demand elasticity while heterogeneity exists will contaminate the residual as a quality measure. So I allow the price coefficient to vary across market group g and product group j. I divide the global markets into seven groups according to geographic location and level of development.[25] The seven groups are: the United States and Canada (NA); Latin American countries (LA); European Union member countries(EU); Singapore, Japan and Korea (SJK); other countries in Asia (RAS); Australia and New Zealand (AZ); African countries (AF). Product group g is defined along the 4-digit HS lines.[26] Once I get consistent estimates of the elasticities, I can purge the influence of price by subtracting $b^{g(m)j(h)} \; ln(P_{fmht})$ from $ln(Q_{fmht})$ as well as the influence of aggregate demand factors A_{mht} by demeaning within each mht cell. In the end, the quality measure would be an estimate of the residual $\;_{fmht} + \;_{fmht}$

4.2. Identification Strategy

Given the rich information I have on the origins and destinations of firms' exports, I can construct a Hausman-Nevo instrument to identify the price coefficients. With multi-market observations on prices, such an instrument uses prices on other markets as instruments. This type of instrument has been used in studies on ready-to-eat cereal markets by Hausman (1997) and Nevo (2001). In general, there are two sources of variation in observed prices: one is variation in supply side factors such as production, transportation or distribution cost and the other is variation in demand side factors such as product quality. The first type of variation is useful in identifying the price coefficient in the demand function, while the second gives rise to endogeneity problems and leads to inconsistent estimates if not taken care of. A useful instrument must pick up variation of the first type to be relevant, and be free of the second type to be valid. In a multi-market context,

$In\,(P_{fmht})$ if

1. The geographical distance between country m and m' is above the 30th percentile in the distribution of geographical distance among all country pairs.

2. The per capita GDP of country m' is at least 1.5 times the standard deviation of the world distribution away from that of country m.

The instrument for $In\,(P_{fmht})$ is then the average of prices of observations with subscript $f'm'h't$

$$IV_{fmht} = \overline{InP}_{f^0m^0h^0t} \tag{15}$$

Notice the average is taken across all f', m' and h'. The f's and m's are chosen as aforementioned; the h's cover all the 8-digit HS lines under the same 4-digit HS line.[28] It is the destination and year speci c, across 4-digit zip code region variation that is kept in the instrument for identi cation. The exclusion restriction, which in this context requires that the demand shocks from markets where the average is taken to be independent of the demand shocks in the market where the prices are instrumented for, are embedded in the market selection criteria. The rst criterion rules out markets that may share geographically local demand shocks; the second addresses the possibility that exporting rms may ship products of the same quality to markets with similar degree of development and thus similar preference for quality.[29]

4.3. Sample Description and Estimation Results

Table 2 summarizes the sample for demand estimation. Column (1) reports the number of observations for each(sample316(umoroup)28(y)83(.)]TJ 0 g 0 G /F31 7.909644 Tf 9.578 3.309 Td [(28)]TJ 0 g of observations with non-missing value for instrument. For richer markets such as the United States, Canada, European Union members countries, Australia, New Zealand, Singapore, Japan and Korea, less than 10% of the observations have missing value for instrument. The forth column reports the number of 4-digit HS lines with negative and signi cant[31] estimates for the price coe cient. The best results are achieved for the North American market and the EU market, with about 2/3 of the 4-digit product lines having signi cant and negative estimates. The last two columns report the number and percentage of observations associated with the count in column (4). For the North American and EU markets, more than 85% of the total observations are associated with negative and signi cant estimates for price coe cient.

Table 3 summarizes the OLS and IV estimates of the price coe cients. The means and medians are over product lines with negative and signi cant IV estimates using all observations for each market group.[32] Column (1) reports the average of OLS estimates; column (2) reports the average of the OLS estimates using only the sample taking non-missing value for instrument. Column (3) and (4) are for the IV estimates. Column (5) to (8) are the medians of the estimates. In general, for product lines with precise IV estimates, the magnitude of the IV estimates is about 1.5 to 2 times as large as the OLS estimates, suggesting the instrument is correcting the inconsistent OLS estimates in the expected direction. Moreover, the similarity between the estimation results with full sample and the sub-sample with non-missing values for instrument suggests the proxy strategy does not a ect the estimation substantially.

Given my interest in quality di erentiation and the precision of the estimates, I will focus on two markets groups in my analysis - the North American market, which includes the United States and Canada, and the EU member countries. The two panels of Figure 2 show the OLS and IV estimates for these two market groups.

4.4. Robustness check

As illustrated by the model on rms' decisions on input and output quality, the identi cation strategy in the demand estimation relies on a few key assumptions. Any violation of these assumptions will make the instrument invalid and the estimates of the price coe cient inconsistent.

[31] The signi cance level is set at 10%.

[32] This is corresponding to the count in column (4) to (6) in Table 2.

In the end, this will cause reversal in the measured quality ranking as illustrated in Figure 1. In this subsection, I check the robustness of the estimates shown above by constructing several alternative instruments and comparing the estimation results. Similarity between results based on di erent instruments is reassuring.

The key potential threat to the validity of the instrument is the existence of quality di erentiation in the set of markets selected in constructing instrument. This would introduce correlation between the instrument and the instrumented through the quality channel and make the instrument invalid. To address this concern, I rst utilize the large number of markets available in my data and change the criteria in selecting the set of markets in constructing instruments. More speci cally, I supplement the main instruments with another two stricter alternative instruments.[33] One of the alternative instruments is constructed by adopting a per capita GDP disparity criterion of 1.75 times the standard deviation away while holding the geographical distance criterion at 30th percentile; for the second alternative, I hold the per capita GDP criterion at 1.5 times the standard deviation and increase the geographical criterion to be above the 40th percentile. It turns out the rank correlation coe cients among quality estimates based on di erent instruments are above 0.98. Figure 3 shows the estimates with the additional IVs together with the ones based on the main IV. The important observation is that stricter rules in selecting markets to construct instruments does not systematically change the magnitude of the estimates. Accordingly, overidenti cation tests fail to reject that the main instrument in exogenous for 41 out of the 48 4-digit products in the North American market and 42 products in the European market.

The overidenti cation test is informative about the validty of the main instrument based on the assumption that the stricter instruments are valid. In other words, passing the overidenti cation test only suggests that the estimates based on di erent instruments are similar but not necessarily consistent. In the case that exports to even the poorest destinations are vertically di erentiated, the estimates would be inconsistent no matter how strict the criteria are. To

[33] I face a trade-o between instrument validity and instrument strength in selecting the geographical distance and per capita GDP disparity cut-o s: the further away the two markets, the more likely they have independent demand shocks and the more con dent I am in the validity of the instrument; on the other hand, the stricter I am in selecting markets, the more observations would need proxy values for instruments and the less variation can be utilized, and in turn, the less e cient the estimates would be. Thus it is desirable to nd a balance point where the estimation results are robust to small changes in cut-o s.

address this concern, I explore the product dimension of my data and use only unit values of products classified as homogeneous goods in Rauch Rauch (1999) that are also used as inputs in producing products under HS85 as instruments.[34] It turns out the instruments constructed this way are much weaker and the first stage F-statistic is less than 6 for more than half of the 4-digit products in the estimations for the North American and European markets. However, the rank correlation coefficients among quality estimates based on my main instrument and this alternative instrument is still as high as 0.75. Figure 4 shows the comparison between the estimates of price coefficient that are significant with both instruments. Again, The magnitude of the estimates with the alternative instrument is not systematically larger than that with the main instrument.

5. Quality and Input Choices

With price coefficients in hand, I calculate the following firm, product, market and year specific residuals as a measure of quality.

$$\widehat{\lambda}_{fhmt} = ln(Q_{fmht}) - \widehat{\alpha}^{g(m)j(h)} ln(P_{fmht}) - \widehat{\delta}_{mht} \tag{16}$$

This measure contains the last two terms $\lambda_{fmht} + \epsilon_{fmht}$ in (14). In this section, I use these quality measures to identify input factors that are related to firm's quality choice in their exports to the North American and European markets, as well as the heterogeneity of this input-output association across firms of different ownership types.

The regression specification is

$$\widehat{\lambda}_{fhmt} = \sum_k \beta_1^{k;O} IMPORT_{ft}^k + \beta_2^O WAGE_{ft} + \beta_3^O KLRatio_{ft} + CONTROLS_{ft} + \epsilon_{fhmt} \tag{17}$$

The variables of interest on the right hand side are $IMPORT$, $WAGE$ and $KLRatio$. They

[34] I use a concordance between the HS product classification and sectors in China's 2002 input-output table to identify inputs.

all vary at the rm and year level. *IMPORT* stands for measures of importing activities from China's customs data. *WAGE* is measured with a rm's total wage bill divided by its total employment size. *KLRatio* is the ratio of real capital stock [35] and total employment. $_1$, $_2$ and $_3$

indicating whether a firm imports anything at all. The first finding is that importers on average have a quality premium and it is significant among Chinese firms. Specifically, holding price constant, the market share of Chinese non-state owned firms who are also importers is about 14.5% higher than the non-importers in the same ownership category. This positive correlation between quality and importing activities is consistent with the existing evidence that imports have a positive impact on firm productivity, as argued in Amiti and Konings (2007), Kasahara and Rodrigue (2008), Halpern et al. (2005), Kugler and Verhoogen (2009) and Manova and Zhang (2011), but suggests quality upgrading, as opposed to cost saving, as a specific channels through which this impact takes place. Notice that I am using the same data source as Manova and Zhang (2011). However, I focus on a different set of firms. Manova and Zhang (2011) study firms involved in processing trade while I focus on firms that export through ordinary trade. The advantage of focusing on processing and assembly exporters is that one knows for sure the related imports will be used in producing for foreign markets. This does not apply to firms exporting through ordinary trade as these firms sell a substantial portion of their output to China's domestic market. However, one may be concerned to what extent firms involved in processing and assembly trade are behaving like profit maximizing agents in making decisions on input, output and price. Many of the processing firms operate only as a producing unit of a much longer value-generating chain with important decisions made elsewhere. Firms that export through ordinary trade are less of concern in this aspect.[39]

The second finding is that wage is positively associated with quality and the correlation is significant for all ownership categories except Chinese state-owned firms. My interpretation is that higher quality and more expensive labour is needed to produce higher quality products. This relates to a large literature on the impact of globalization on wage inequality, and especially skill premium. The Stolper-Samuelson theorem in the classical Heckscher-Ohlin model predicts that skill premium will increase with trade in skill-abundant countries but decrease in skill-scarce countries because of the opposite changes in the relative price of skill-intensive tradables in the two types of countries. This prediction is inconsistent with what actually happened:

[39] Another difference is that Manova and Zhang (2011) covers all HS product lines while I am investigating only one Chapter of HS products. I choose not to cover all products in this paper is because my quality measure is recovered from estimating a demand system instead of being inferred from unit value alone. Demand systems for different products should be estimated separately and the work here can be easily applied to other HS chapters.

rst, the observed stable price of the skill-intensive products in the skill-abundant countries has been stable or declining; second,skill premium has been increasing in the skill-scarce countries. To explain the observed patterns, skill-biased technology adoption has been proposed in many studies as the missing factor in the traditional trade model that can o set the Stolper-Samuelson force and lead to increasing skill premium in all countries. Acemoglu (2003), Yeaple (2005) and Zhu and Tre er (2005) emphasize the technology change at the rm level. Harrigan and Reshef (2011) and Burstein and Vogel (2012) extend the model by introducing the interaction between the heteogeneity in rm productivity and the skill intensity of production technology to further allow impacts through the reallocation channel. Verhoogen (2008) and Bus-6U(een)-36[(+ Td1(V)84(erho production. Interesting, the previous negative but insignificant result for foreign invested firms are mainly driven by imports from countries other than the top 20 advanced ones. In these regressions, the relation between quality and wage remains, but of slightly smaller magnitude.

Table 5 investigates the imports in intermediate inputs in more details. In Panel (a), a continuous measure of the log value of total imports of intermediate input replaces the status dummy. Again, a positive association is found for Chinese non-state owned firms. The estimates of the coefficients of wage and capital labour ratio are about the same as before. In Panel (b) the total imports are divided into imports from advanced countries and imports from other countries. Interesting, for the Chinese non-state owned firms, the positive association found in earlier results is purely driven by imports from the advanced countries; for foreign invested firms, the imports from advanced countries are positively associated quality with a magnitude even stronger than the Chinese firm, while the imports from other countries are negatively correlated with quality. In stead of total value, Panel (c) looks at the number of different products at the 8-digit HS level of firms' imports of intermediate input. The pattern is similar to the regressions with values of imports. Table 6 replicates these exercises for capital goods. Overall, imports of capital goods are not correlated with quality production in the Chinese firms. For Hong Kong, Macao and Taiwan invested firms, imports of capital goods from countries other than the most advanced ones are negatively correlated with quality, both in terms of value of imports and the number of different products imported. For other foreign invested firms, the association is positive for imports from the most advanced countries and negative for other countries. The patterns found in Table 5 and Table 6 do not change if imports of intermediate input and capital goods are included simultaneously.

6. Conclusion

Using the detailed price and quantity information on firms' exports between 2000 and 2006 from China's customs data, I estimate market-product specific demand functions for China's exports and recover the latent quality as the demand residual. I then proceed to investigate the channel through which quality varies across firms and over time. Combining my quality measure with the customs imports data and China's Annual Manufacturing Survey data, I investigate the association between quality and rms' input choices. I nd importing activities, primarily by non-state owned Chinese rms and in some cases foreign invested rms, are positively and signi cantly associated with higher quality in exports to the more quality demanding North American and European destinations. This suggests facilitating quality upgrading as a speci c channel through which easier access to imported inputs may contribute to rm productivity. I also nd wage to be positively correlated with quality which suggests incentive to upgrade quality of exports to rich countries can be one of the forces behind the documented increasing skill premium, especially in the coastal region, in ? and Han et al. (2012).

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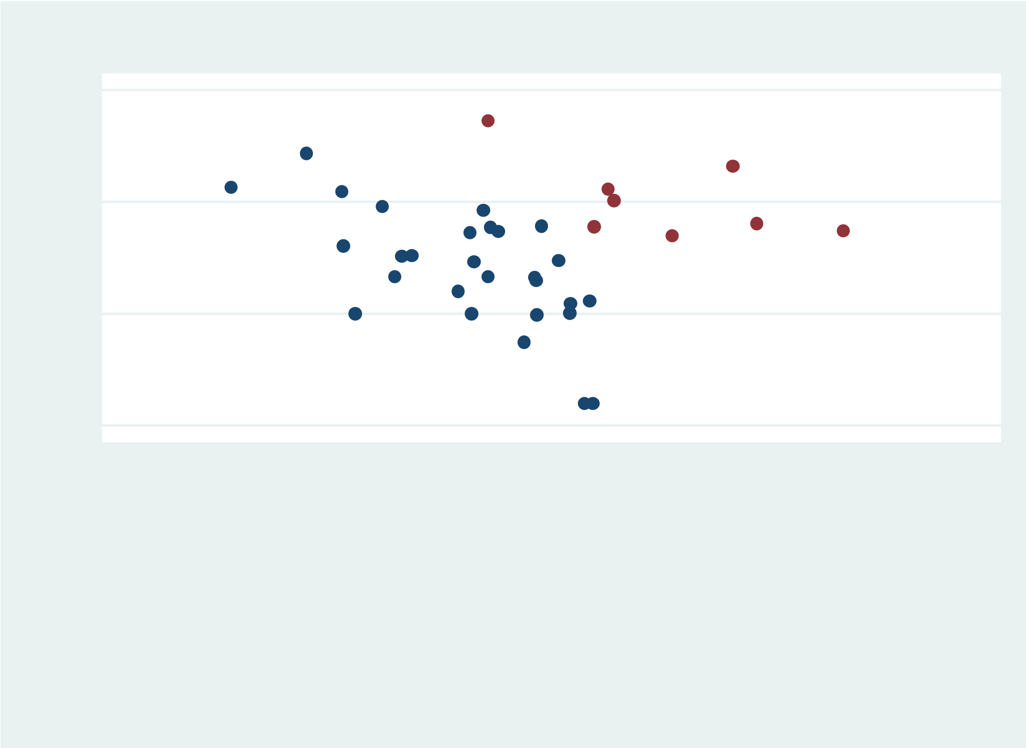

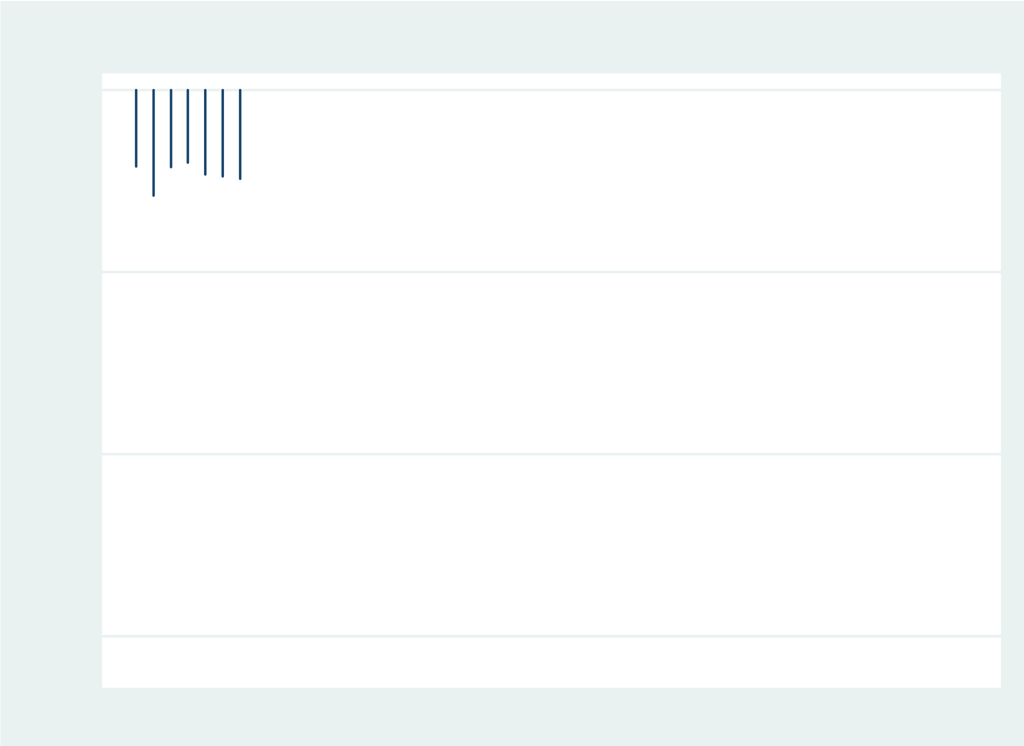

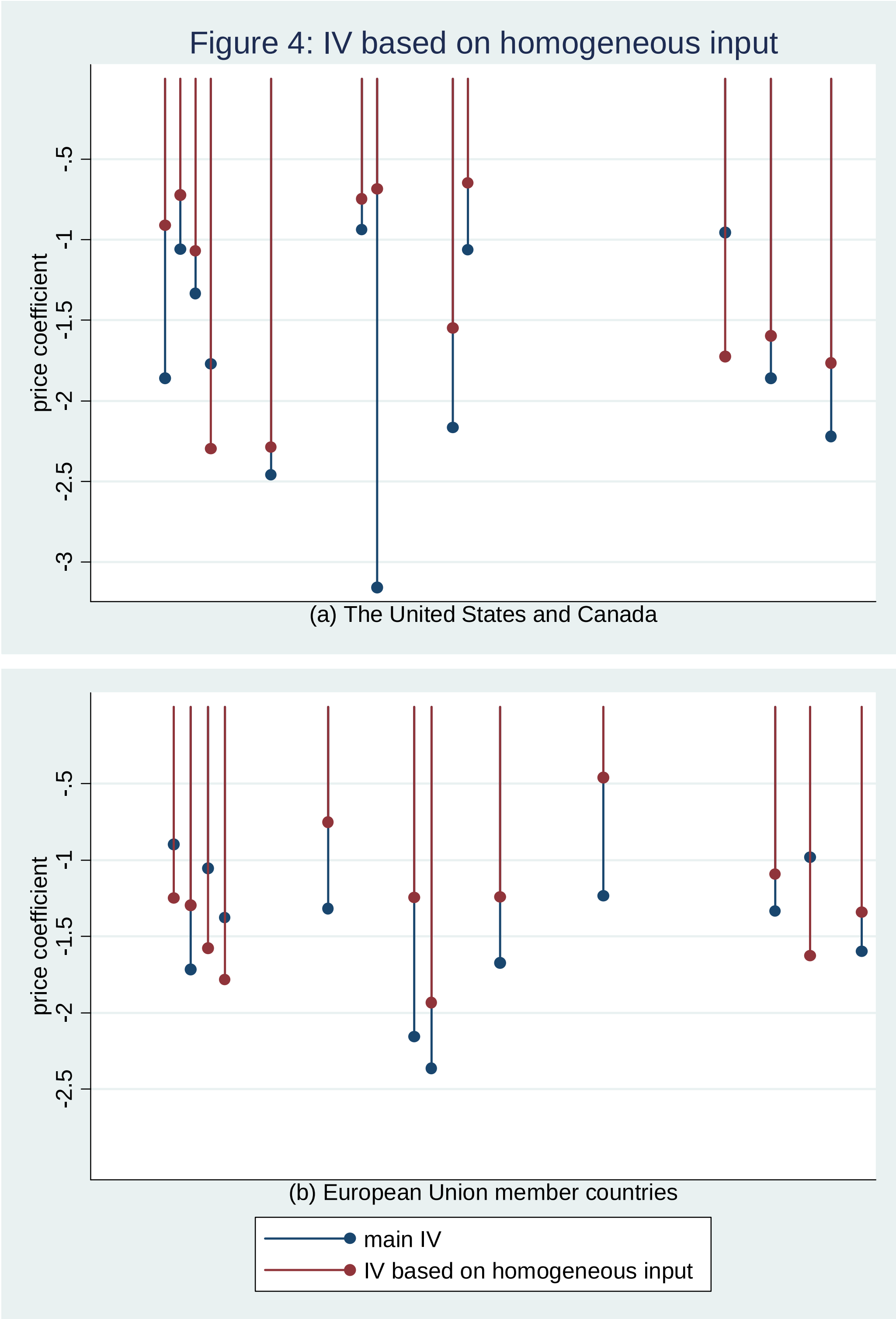
Figure 4: IV based on homogeneous input
price coefficient
-.5
-1
-1.5
-2
-2.5
-3
(a) The United States and Canada
price coefficient
-.5
-1
-1.5
-2
-2.5
(b) European Union member countries
main IV
IV based on homogeneous input

Table 1: Data summary

	2000		2003		2006	
Exports Decomposition:						
Billion USD	**ordinary trade**	other trade	**ordinary trade**	other trade	**ordinary trade**	other trade
Indirect	**3.2**	4.7	**4.7**	70	**9.2**	9.7

Table 2: Demand estimation: sample count

Market group	(1) # of obs.	(2) # of obs. with nonπmissing value for instrument	(3) % of obs. with nonπmissing value for instrument	(4) # of HS4 lines with sig.[(1)] and neg. estimate of price elasticity (out of 48)	(5) # of obs. with sig. and neg. estimate of price elasticity	(6) % ofobs. with sig. and neg. estimate of price elasticity
U.S. and Canada	**67,714**	**66,346**	**98%**	**30**	**57,967**	**86%**
European Union countries	**177,444**	**165,824**	**93%**	**31**	**155,188**	**87%**
Australia and New Zealand	21,957	21,309	97%	20	12,201	56%
Singapore, Japan and Korea	79,227	71,446	90%	18	31,088	39%
Rest of Asia	219,819	156,651	71%	22	129,246	59%
Latin American countries	63,258	47,835	76%	15	30,142	48%
African countries	52,786	12,056	23%	18	29,968	57%

Table 3: Demand estimation: summary of results

Market group	Mean				Median			
	OLS		IV		OLS		IV	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	all obs.	obs. with nonπ missing instrument	all obs.	obs. with nonπ missing instrument	all obs.	obs. with nonπ missing instrument	all obs.	obs. with nonπ missing instrument
Pooled	π0.85	π0.84	π1.54	π1.74	π0.91	π0.89	π1.48	π1.52
U.S. and Canada	**0.85**	**0.85**	**1.92**	**2.0**[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 4: Quality and importing status (N=112452)

(a) Importing status dummy

	(1)	(2)	(3)
	Dummy for importing	log of wage	capital labour ratio
Non-SOE	0.145*	0.178***	0.005
	(0.062)	(0.047)	(0.032)
SOE	0.331*	0.068	-0.040
	(0.159)	(0.073)	(0.091)
HMT	0.130	0.128**	-0.131**
	(0.074)	(0.049)	(0.042)
FGN	-0.054	0.155***	0.042
	(0.089)	(0.046)	(0.040)

(b) Importing status dummy by types of products

(1)

Table 5: Quality and importing intermediate inputs

(a) Value of imports (N=112452)

	(1)	(2)	(3)
	value of imports	log of wage	capital labour ratio
NonπSOE	0.027***	0.155**	π0.005
	(0.007)	(0.048)	(0.033)
SOE	0.006	0.099	π0.031
	(0.014)	(0.072)	(0.088)
HMT	0.011	0.126**	π0.128**
	(0.009)	(0.047)	(0.042)
FGN	0.015	0.129**	0.012
	(0.009)	(0.047)	(0.042)

(b) Value of imports by origins (N=112452)

	(1)	(2)	(3)	(4)
	value of imports from rich countries	value of imports from other countries	log of wage	capital labour ratio
NonπSOE	0.023**	0.009	0.139**	π0.003
	(0.009)	(0.008)	(0.048)	(0.033)
SOE	π0.004	0.006	0.092	π0.023
	(0.014)	(0.014)	(0.075)	(0.087)
HMT	0.021*	π0.009	0.107*	π0.127**
	(0.010)	(0.009)	(0.046)	(0.042)
FGN	0.040***	π0.022*	0.101*	0.005
	(0.009)	(0.009)	(0.048)	(0.043)

(c) Number of imported

Table 6: Quality and importing capital goods

(a) Value of imports (N=112452)

	(1)	(2)	(3)
	value of imports	log of wage	capital labour ratio
NonπSOE	0.006	0.185***	0.011
	(0.007)	(0.048)	(0.032)
SOE	π0.001	0.101	π0.027
	(0.014)	(0.076)	(0.090)
HMT	π0.003	0.139**	π0.115**
	(0.010)	(0.047)	(0.041)
FGN	0.009	0.129**	0.021
	(0.009)	(0.048)	(0.041)

(b) Value of imports by origins (N=112452)

	(1)	(2)	(3)	(4)
	value of imports from rich countries	value of imports from other countries	log of wage	capital labour ratio
NonπSOE	0.000	0.003	0.177***	0.015
	(0.008)	(0.008)	(0.048)	(0.032)
SOE	π0.004	π0.002	0.095	π0.017
	(0.013)	(0.014)	(0.076)	(0.089)
HMT	0.022	π0.026*	0.118*	π0.110**
	(0.012)	(0.010)	(0.047)	(0.041)
FGN	0.033***	π0.015	0.094	0.002
	(0.010)	(0.009)	(0.049)	(0.042)

(c) Number of imported product lines by origins (N=112452)

	(1)	(2)	(3)	(4)
	Number of varieties from rich countries	Number of varieties from other countries	log of wage	capital labour ratio
NonπSOE	π0.023	π0.011	0.181***	0.020
	(0.065)	(0.074)	(0.048)	(0.033)
SOE	π0.033	0.070	0.053	π0.031
	(0.087)	(0.103)	(0.080)	(0.091)
HMT	0.033	π0.164*	0.142**	π0.095*
	(0.090)	(0.067)	(0.047)	(0.040)
FGN	0.159**	π0.148*	0.104*	0.009
	(0.055)	(0.061)	(0.048)	(0.041)

Table Appendix 1: HS4 Description

HS4	Description
8501	Electric motors and generators (excluding generating sets)
8502	Electric generating sets and rotary converters Generating sets with compression-ignition internal combustion piston engines (diesel or semi diesel engines):
8503	Parts suitable for use solely or principally with the machines of heading 8501 or 8502
8504	Electrical transformers, static converters (for example, rectifiers) and inductors
8505	Electro/magnets; permanent magnets and articles intended to become permanent magnets after magnetisation; Electro-magnetic or permanent magnet chucks, clamps and similar holding devices; Electro-magnetic couplings, clutches and brakes; Electro-magnetic li
8506	Primary cells and primary batteries
8507	Electric accumulators, including separators therefore, whether or not rectangular (including square)
8509	Electro-mechanical domestic appliances, with self-contained electric motor
8510	Shavers, hair clippers and hair-removing appliances, with self-contained (including

Electric 8510 A M

8524	Records, tapes and other recorded media for sound or other similarly recorded phenomena, including matrices and masters for the production of records, but excluding products of chapter 37
8525	Transmission apparatus for radio-telephony, radio-telegraph, radio-broadcasting or television, whether or not incorporating reception apparatus or sound recording or reproducing apparatus; Television cameras; still-image video cameras and other video camer
8526	Radar apparatus, radio navigational aid apparatus and radio remote control apparatus
8527	Reception apparatus for radio-telephony or radio-broadcasting, whether or not combined, in the same housing, with sound recording apparatus or a clock
8528	Reception apparatus for television, whether or not incorporating radio-broadcast receivers or sound or video recording or reproducing apparatus; Video monitors and video projectors Reception apparatus for television, whether or not incorporating radio-bro
8529	Parts suitable for use solely or principally with the apparatus of headings 8525 to 8528
8530	Electrical signaling, safety or traffic control equipment of railways, tramways, roads, inland waterways, parking facilities, port installations or airfields (other than those of heading 8608)
8531	Electric-sound or visual signalling apparatus (for example, bells, sirens, indicator panels, burglar or fire alarms), other than those of heading 8512 or 8530
8532	Electrical capacitors, fixed, variable or adjustable (pre-set)
8533	Electrical resistors (including rheostats and potentiometers), other than heating resistors
8534	Printed circuits
8535	Electrical apparatus for switching or protecting electrical circuits, or for making connections to or in electrical circuits (for example, preand

8547	Insulating fittings for electrical machines, appliances or equipment, being fittings wholly of insulating material apart from any minor components of metal (For example, threaded sockets) incorporated during moulding solely for purposed of assembly, other
8548	Waste and scrap of primary cellpurpormaP[illegible] K