Sorting by Quality or Efficiency? Theories of Heterogeneous Firm Trade and Chinese Exports

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Abstract

Recent developments with theories of international trade have highlighted the importance of firms in forming aggregate trade flows. These models fall into one of two types, described as 'efficiency' and 'quality' models, depending on the mechanism that leads to the selection of the best firms into export markets. The empirical counterpart to this literature has so far been applied only to developed countries (Belgium, France and US). In this paper we develop a theory of heterogeneous firm trade that embeds existing results but is also capable of explaining discrepancies with the current empirical evidence. We then apply this model to Chinese data. The data suggest strong differences compared to trade by developing countries. The data supports the efficiency view of trade, but where the effects of distance and market size on Chinese export prices is substantially weaker than for other countries. Processing trade and the importance of foreign owned firms in Chinese exports does not provide a complete explanation of these differences.

Introduction

Within the last decade a new class of models of international trade has begun to burgeon, offering new insights into the role that firms play in forming aggregate trade flows. Stressing differences in productivity between firms within the same industry, these models show that firms self-select into their degree of exposure to the global economy: high productivity firms export and low productivity firms remain purely domestic (Melitz, 2003). Trade liberalisation induces reallocations of market share towards exporters and away from non-exporters leading to an overall productivity gains.[1]

Two principal mechanisms have been assumed in the theoretical models to generate the pattern of self-selection. Within the original Melitz (2003) version of the heterogeneous firm models of international trade differences in productivity between firms manifest themselves in the model as differences in efficiency – firms differ in their marginal costs. It then follows that when faced with fixed beachhead cost of breaking into export markets only the low cost firms can recover the fixed costs of exporting and earn positive profits. We call this "sorting by efficiency" hypothesis.

In contrast, in Baldwin and Harrigan (2007) differences in the quality of products drive the export behaviour of firms. High cost firms produce high quality products. If the quality-cost elasticity is high, high cost firms may be more profitable and competitive, due to their lower quality-adjusted-price. As a result, when allowing for quality differences in the original Melitz model it could be the high cost, high quality firms that export, whereas low cost, quality firms remain domestic. We call this "sorting by quality" hypothesis.

The general patterns of export behaviour generated in the two types of heterogeneous firm are consistent with those found in the associated empirical literature (Greenaway and Kneller, 2007): export firms are on average bigger and more productive than non-exporters, and firms are persistent exporters or non-exporters. However as Baldwin

[1] The original Melitz (2003) model has been extended, amongst many others, by Helpman, Melitz and Yeaple (2004), Melitz and Ottaviano (2006) Bernard, Redding and Schott, (2007), and Falvey, Greenaway and Yu (2006).

and Harrigan (2007) demonstrate there are sharp differences between the models regarding the relationship between the average product prices charged by exporting firms within a given export market and the standard variables used in empirical (gravity)[2] models of international trade, specifically measures of market size and distance. In both models markets that are distant for example attract only the most productive firms. However where under the efficiency hypothesis this means that the average price charged by exporting firms is lower than that in markets that are shorter distances away, under the quality efficiency hypothesis the best firms are those that charge higher prices. Unit values therefore vary negatively with distance under the efficiency hypothesis and positively under the quality model.

These predictions can therefore be used to test whether quality or efficiency factors help to determine the pattern of trade between country pairs. The empirical evidence, for the US by Bladwin and Harrigan (2007), Bernard, Jensen, Redding and Schott (2007), and for Belgium and France by Mayer and Ottaviano (2007), suggest support for the 'quality' version of the heterogeneous firm model, although there is disagreement in the details of the results between these papers.

In this paper we make three contributions to this emerging aspect of the trade literature. Firstly, we develop the 'efficiency' and 'quality' models to offer some explanation for the differences in empirical finding between Bladwin and Harrigan (2007), Bernard, Jensen, Redding and Schott (2007) and Mayer and Ottaviano (2007). Specifically we extend the quality difference model of Baldwin and Harrigon to allow for the demand structure modelled in Melitz and Ottaviano (2006).

Second, we add a new data point, that of China. The size and the growth of Chinese trade over recent years provides obvious motivation for undertaking this exercise, to which the differences in the results we find compared to the three developed countries investigated so far in the literature suggests additional value. Other features of Chinese trade appear interesting however. Schott (2007) compares Chinese exports to US with those of OECD countries and finds that across products China's exports has high similarity to those from OECD, but within products the unit value of Chinese

[2] Since Tinbergen (1969) trade economists have found robust evidence that bilateral trade is positively correlated to size of the trading partners but negatively to the distance between them.

exports is substantially lower than those from OECD. Over time, China export budle has become more similar to those of OECD countries, but experienced falls in the price relative to exports of OECD countries. He also found that China's export similarity is substantially higher than that of other countries with comparable relative endowment or size. This is echoes an argument found in Rodrik (2006) that the overall sophistication of China's exports is far above its per capita income level, being similar to a country with per capita income three times higher than China. This might be attributed to Chinese government's active industrial and export promotion policy.

Drawing on this evidence the final contribution we make is to exploit the detailed nature of the data regarding ownership (state owned, privately owned and foreign owned) and final versus processing trade, aspects not investigated in the current literature but prominent features of Chinese trade, allow us to examine what the heterogeneous firm model allows us to say about Chinese trade and what it does not.

The empirical section of the paper suggests that for China the pattern of export unit values between countries matches that suggested by the "efficiency-sorting" hypothesis. The within product category unit value of exports decreases in both the size and the distance of importers, consistent with the view that only the lowest cost firms that quote lowest prices could sell in larger and distant markets. There is some non-linearity in the sorting pattern, the effect of distance is positive for relatively short distances but negative for longer distances. Perhaps of more interest however is the relatively low values of the elasticity for distance and market size, perhaps explaining the high levels of penetration of Chinese exports. The sorting pattern also seems to differ across the nature of product group, and countries' income group. The pattern of sorting by efficiency (low cost) is less strong for products with smaller degree of heterogeneity (the reference price group) and countries with higher income, but does not significantly differ across firm ownership (SOE , private , foreign) and trade regime (ordinary , processing).

The next section provides a model . Section 3 describes the data and our method, followed by section 4 that shows the main results and robustness check. The last section 5 concludes.

1. The model

Consider an economy with L consumers. L is the natural measure of the country's market size. We follow Melitz and Ottaviano (2007) and assume that their preferences across differentiated varieties within a sector are characterised by a quasi-linear utility with a quadratic sub-utility, but where we modify their demand system to accommodate *asymmetric* varieties as follows:

[1] $$u = q_0 + \alpha\int_0^M (z_i q_i)di - \frac{\gamma}{2}\int_0^M (z_i q_i)^2 di - \frac{\eta}{2}\left(\int_0^M (z_i q_i)di\right)^2$$

Where q_0, z_i, q_i and M are respectively, consumption by the representative consumer of the homogeneous good, quality of variety *i*, the quantity of variety *i* in the differentiated sector, and the number of varieties. Note that z_i indexes the quality of a variety and consumers enjoy greater utility from a variety with higher z_i. Parameter γ indexes the degree of product differentiation across varieties, the larger γ the more differentiated the varieties. Parameter α and η index the degree of substitution between the numeraire good and differentiated goods: the consumer's demand is biased towards the differentiated good relative to the numeraire good the higher α or lower η. We assume that α, η and γ are all positive and all identical across countries. These preferences lead to the following inverse demand function

[2] $$\frac{p_i}{z_i} = \alpha - \gamma q_i - \eta Q$$

Where $Q = \int_o^M q_i di$ is the aggregate quantity of consumption. This in turn yields the following linear demand system for each individual variety:

[3] $$q_i = \frac{L}{\gamma}\left(\hat{P} - \frac{p_i}{z_i}\right)$$

where $\hat{P} \equiv \dfrac{\eta M\overline{P} + \alpha\gamma}{\eta M^n + \gamma}$ is the quality-adjusted price ceiling common for all varieties above which demand for an individual variety will be zero, and $\overline{P} = \int_0^M \left(\dfrac{p_i}{z_i}\right)di \Big/ M$ represents the average quality-adjusted price of the differentiated varieties.

Firms randomly draw their marginal cost c_i from an exogenous common distribution $G(c)$ with support $[0, c_M]$. In the absence of fixed overhead cost, firm profit is given by

[4] $$\pi_i = (p_i - c_i) q_i$$

Substituting [3] into [4] , we derive the optimal pricing rule that maximises firm level profit for given cost *c(we drop the firm index i hereafter)*:

[5] $$p(c,z) = \left(z \cdot \hat{P} + c\right)/2$$

This in turn yields the optimal quantity of production, revenue and profit

[6] $$q(z,c) = \frac{L}{2\gamma}\left(\hat{P} - \frac{c}{z}\right), \qquad \frac{c}{z} < \hat{P}$$

[7] $$r(z,c) = \frac{L}{4\gamma}\left[\hat{P}^2 - \left(\frac{c}{z}\right)^2\right] z, \qquad \frac{c}{z} < \hat{P}$$

[8] $$\pi(z,c) = \frac{L}{4\gamma}\left[\hat{P} - \left(\frac{c}{z}\right)\right]^2 z, \qquad \frac{c}{z} < \hat{P}$$

Note that for a given cost, a variety with higher quality has a higher level of demand, charges a higher price and has greater revenues and profits.

Next we follow Baldwin and Harrigan (2007) and assume that z is positively correlated to c. Higher cost firms produce higher quality products:

[9] $$z = c^{\sigma}, \qquad \sigma \in [0, \infty)$$

When $\sigma < 1$, the quality elasticity is small , our survival condition $\frac{c}{z} < \hat{P}$ implies only low cost firms can have positive demand and survive:

[10] $$c < c_D \equiv \hat{P}^{\frac{1}{1-\sigma}}$$

Hence the average price of surviving firms and expected profit of entry is

[11] $$\bar{p} = \int_0^{c_D} p(c)d\frac{G(c)}{G(c_D)} = \frac{\int_0^{c_D}\left(c^{\sigma}c_D{}^{1-\sigma} + c\right)dG(c)}{2G(c_D)}$$

[12] $$\Pi = \int_0^{c_D} \pi(c)dG(c) = \frac{L}{4\gamma}\int_0^{\hat{P}^{\frac{1}{1-\sigma}}}\left[\hat{P} - c^{1-\sigma}\right]^2 c^{\sigma} dG(c)$$

Hence the average price and profit are increasing in $\hat{P}$. Under free entry, $\Pi = f_e$. Hence the equilibrium $\hat{P}$ is determined by

[13] $$\frac{L}{4\gamma}\int_0^{\hat{P}^{\frac{1}{1-\sigma}}}\left[\hat{P} - c^{1-\sigma}\right]^2 c^{\sigma} dG(c) = f_e$$

This implies that $\hat{P}$ is decreasing in L, such that the cost cut-off c_D also decreases in L. This indicates that the average price $\bar{p}$ also decreases in L, i.e. larger markets has lower average price, since $\bar{p}$ is increasing in c_D according to (11).This result is standard from Melitz and Ottaviano (2006) and it reverses the relationship between market size and prices found in Melitz (2003).

When $\sigma > 1$ the pattern of results is very different however. Now $\frac{c}{z} < \hat{P}$ such that only high-cost high-quality firms survive in the markets, a quality sorting hypothesis:

[14] $$c > c_D \equiv \hat{P}^{\frac{1}{1-\sigma}}$$

Hence the average price of surviving firms and expected profit of entry is

[15] $$\bar{p} = \int_{c_D}^{\bar{c}} p(c)d\frac{G(c)}{1 - G(c_D)} = \frac{\int_{c_D}^{\bar{c}}\left(c^{\sigma}c_D{}^{1-\sigma} + c\right)dG(c)}{2\left[1 - G(c_D)\right]}$$

[16] $$\Pi = \int_{c_D}^{\bar{c}} \pi(c)dG(c) = \frac{L}{4\gamma}\int_{\hat{P}^{\frac{1}{1-\sigma}}}^{\bar{c}}\left[\hat{P} - c^{1-\sigma}\right]^2 c^{\sigma} dG(c)$$

Under free entry, the equilibrium price ceiling is given by

[17] $$\frac{L}{4\gamma}\int_{\hat{P}^{\frac{1}{1-\sigma}}}^{\bar{c}}\left[\hat{P} - c^{1-\sigma}\right]^2 c^{\sigma} dG(c) = f_e$$

It is still the case in this version of the model that $\hat{P}$ decreases in L (the left hand side of (17) is increasing in $\hat{P}$), but unlike where efficiency factors dominate c_D now decreases in $\hat{P}$ according to equation (14), so c_D is increasing in market size L. However, the impact of market size on $\overline{p}$ is ambiguous; it can be either positive or negative. Although increasing market size raises the cost cut-off, and therefore increases average cost of surviving firms, which tends to raise average prices, it reduces the price mark up of surviving firms[3], which tends to reduce average prices. The net effect is ambiguous, depending on which effect dominates.

Next we consider the open economy version of the model and generate testable predictions on the effects of trade costs and market size on the average product price. The export profit of the home country, such as China, to country j is $\pi_X^j(z,c) = \frac{L^j}{4\gamma}\left[\hat{P}^j - \left(\frac{c}{z}\right) - \tau^j\right]^2 z$. Where τ_j represents the variable trade cost..Substituting z with c^σ yields :

[18] $$\pi_X^j(c) = \frac{L^j}{4\gamma}\left[\hat{P}^j - \tau^j - c^{1-\sigma}\right]^2 c^\sigma$$

$\pi_X^j(c)$ is increasing(decreasing) in c, when $\sigma > 1$ ($\sigma < 1$). Let c_X^j denote the export cut off cost such that $\pi_X^j(c_X^j) = 0$, then from [18]

[19] $$c_X^j = \left(\hat{P}^j - \tau^j\right)^{\frac{1}{1-\sigma}}$$

Only firms with marginal cost $c > c_X^j$ ($c < c_X^j$) export , when $\sigma > 1$($\sigma < 1$)[4]. In words, firms are sorted into the export market according to their high(low) cost high(low) quality ,when the quality-cost elasticity is higher (lower) than one. What are the empirical implications for these two export sorting patterns ?

When $\sigma < 1$, firms with costs below c_X^j will export , and according to (19) c_X^j is decreasing in τ_j but increasing in P^j. The average price of exporters is then,

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[3] The firm level price mark up is $m = p - c = \left(c^\sigma \hat{P} - c\right)/2$ that is increasing in $\hat{P}$ and thus decreasing in *L*.

[4] When $\sigma = 1$,we have a standard homogenous firm framework and all firms export or remain domestic.

[19] $$\overline{p}_X^j = \int_0^{c_X^j} p(c)d\frac{G(c)}{G(c_X^j)} = \frac{\int_0^{c_X^j}\left(c^\sigma \hat{P}_j + c\right)dG(c)}{2G(c_X^j)}$$

It can be shown that $\overline{p}_X^j$ is increasing in c_X^j, thereofore other things being equal $\overline{p}_X^j$ is decreasing in τ_j and increasing in P^j. Hence we have a negative correlation between average price and trade costs. Furthermore, recall that P^j is decreasing in L^j in the closed economy, and it can be shown that this result also carries over to the open economy (see appendix) , because a larger economy attracts a larger number of sellers from the worldwide and has tougher competition therefore drive down the price ceiling and mark up. Hence from (19) $\overline{p}_X^j$ is also decreasing in L^j, yielding a negative correlation between average price and market size.

When $\sigma > 1$, firms with marginal costs above c_X^j will export, and c_X^j is increase in τ_j and decreasing in P^j. The average price of exporters is then,

[20] $$\overline{p}_X^j = \frac{\int_{c_X^j}^{\overline{c}} p(c)dG(c)}{1-G(c_X^j)} = \frac{\int_{c_X^j}^{\overline{c}|}\left(c^\sigma P^j + c\right)dG(c)}{2\left[1-G(c_X^j)\right]}$$

Again, it can be shown that $\overline{p}_X^j$ is increasing in c_X^j, and therefore increasing in τ_j, other things being equal. Hence, we have a positive correlation between average price and trade cost. The effect of market size on average price, however, is more complicated. Reasoning analogous to the closed economy version of the model, increase in market size reduces the price ceiling P^j (see appendix). But this has two opposite effects on the average price when the quality elasticity is greater than 1. Falling P^j increases the export cost cut off c_X^j but reduces price mark up of individual exporters. While the former effect increase average price, the latter decrease it. The overall effect is therefore ambiguous, depending on which effect dominates. We summarize the above results in the following hypothesis:

Hypothesis: *Under the heterogeneous firm trade model with linear demand and quality differences, (i) when elasticity of quality is less than one, firms are sorted by efficiency and lowest cost firms export, average price decreases with market size and* *distance of the export market. (ii) When elasticity of quality is greater than one, firms are sorted by quality and high cost high quality firms export, average price increase with distance, and can either increase or decrease in market size of the export market.*

As shown in Baldwin and Harrigan(2007), allowing quality differences in the original Melitz(2003) with CES demand will predict a positive(negative) sign on the coefficient of market size and distance when quality elasticity is low , and a negative(positive) sign when quality elasticity is high. The model developed in this paper with linear demand has same predictions on the sign of distance as CES demand heterogeneous firm trade models, but yield different predictions on the effects of market size. In particular, we show that both the sign of distance and market size could be positive under linear demand, a pattern that is found in European exporters (Mayer and Ottaviano 2007) but can not be explained by existing heterogeneous firm trade models. The predications from theories of heterogeneous firm trade can be summarised as below:

Table 1: Summary of Model Predictions with respect to Market Size and Distance

Model		Effect of Distance	Effect of Market Size
CES+ Heterogeneous Firms (*e.g.* Melitz, 2003; Baldwin and Harrigan, 2007)	Quality sorting	+	-
	Efficiency Sorting	-	+
Linear Demand+ Heterogeneous Firms (e.g. Melitz and Ottaviano, 2006; Kneller and Yu, 2007)	Quality Sorting	+	+/-
	Efficiency Sorting	-	-

3. Data and Method

The data used for the empirical analysis are originally drawn from Customs General Administration of the People Republic of China for the years 1997-2002. These data record all export transactions, detailing information on the number of units traded (as well as the type of unit), the 'free on board' cost, the destination country and the HS8 industry as well as information on the ownership of the firm (broken into 9 different types), and the type of trade (ordinary, processing etc. broken into 18 different types). We aggregate firms ownership according to whether they are state owned enterprises, are privately owned or have some degree of foreign ownership and split the type of trade according to whether it is ordinary trade or processing trade.[5] We detail more fully the information included in the data in the Appendix, along with any aggregations of the data that we use. Data are of a similar type have been previously used by Swenson (2007), Chen and Swenson (2007) and detailed more fully in Feenstra, Deng, Ma and Yao (2004) but where they have information on the location (city – these include in some cases city districts) from which the exports originate.

We use information for the year 1997, 2000 and 2002 and for the Chemicals and Machinery and Manufacturing Equipment Sectors. We focus on these two sectors following evidence in Schott (2006) that suggests that the relative price declines of Chinese exports relative to OECD countries, the countries for which its export bundle is most similar, are strongest in the Machinery and Equipment sector and weakest in the Chemicals sector. The reductions in the total sample size means we are left with a total of 3181 HS8 industry codes observed for three periods. For completeness, we provide examples of the detail of this level of classification in Table ~2 below.

Table 2: Example HS8 Product Codes

HS8 Code	Product
28259011	Tungstic acid
31023000	Ammonium nitrate, whether or not in aqueous solution
84807100	Injection of compression types moulds for rubber or plastics
85203210	Digital audio cassette-tape recorders incorporating sound reproducing apparatus, not elsewhere specified or included

[5] We drop the residual observations measuring trade of other types following this classification.

The variable of interest in the study is the unit value price of exports for each HS8 product from China to each of the 105 countries listed in the sample.[6] That is we calculate the unit value of product *p* to country *j*, u_{pj}, by dividing the f.o.b. export value, V_{pj}, by export quantity, Q_{pj},

$u_{pj} = V_{pj} / Q_{pj}$.

We regress these unit values in period t against a measure of distance from China to country j, $dist_{jt}$, as well as a measure of market size, GDP_{jt}, wealth per capita, $GDPpc_{jt}$, a Border dummy, BORDER, as well as a separate time dummies for each of the three years within the sample, TD, and product fixed effects. The product fixed effects control for differences in average unit value across products as well as any differences in units (kilograms, tonnes etc.).[7]

$$\log(u_{pjt}) = a_p + \beta_1 \log(dist_j) + \beta_2 \log(GDP_{jt}) + \beta_3 \log(GDPpc_{jt}) + \beta_4 BORDER_j + \beta_5 TD + \varepsilon_{pjt}$$

Data on GDP and GDP per capita are from the Penn World Tables, while the data on distance and the border dummy is from Feenstra, Markusen and Rose (2001). The average distance from China is 9,842 kilometres. The closest country is recorded as South Korea (956km) and the furthest is Argentina (19,286km).

4. Results

In the statistical model of the quality of Chinese exports we regress the unit-price of each HS8 commodity code for each country against a series of control variables that include country size (measured by the GDP of the importer country) and distance.

In column 1 we report the regression against the full sample set of observations, whereas in columns 2 to 4 we remove possible outlier observations from the sample. Product level unit values are noisy indicators of prices. In columns 2, 3 and 4 we test for the possible effect of small and therefore potentially volatile unit values by

[6] As discussed in Schott (2006) unit values are likely to include measurement error as a result of the misclassification of products. For that reason he, as do we, focus on heterogeneity in prices within product ranges. It should also be noted that Schott (2006) as well as Bernard et al. (2007) and Baldwin and Harrigan (2007) use HS 10 digit data.

[7] The data have been checked that the units of measurement are the same within every hs8 category.

trimming the data. In all columns we remove observations where the count of the quantity (kilograms, number of computers) is equal to one. In column 2 we also remove observations when the value of export transaction is below $1000, $5000 in column 2 and $10,000 in column 3. The restriction results in 11 per cent of observations being dropped in column 2, 24 per cent in column 3 and 33 per cent from column 4. The final row in Table 3 suggests that loss of observations is primarily of countries from the sample, the number of HS8 codes drops by 3.5 per cent between columns 1 and 4. The results themselves are insensitive to these choices except for the effect of GDPpc, which switches from being negative to positive once the exclusion of observations from the sample are made. The sensitivity of the results for GDP per capita is a feature of the results within the paper.

Consistent with Bernard et al. (2006) and Baldiwn and Harrigan (2007) the coefficient on GDP is negative and statistically significant at conventional levels. Goods sold to countries that are large in size are significantly lower. The elasticity on GDP is somewhat smaller than that estimated by Baldwin and Harrigan (2007) at -0.02 compared to -0.06.

Unexpected in terms of the quality model however, is the significant negative coefficient on distance. Countries that are far from China pay lower unit values than countries that are close by. Here the elasticity is in the order of -0.04 to -0.022. This would appear to suggest that Chinese exports are sold on the basis of the efficiency of their producers. The coefficient is small however. Calculating the effect of distance from the closest to the furthest within the data set suggests a difference in unit values of only 0.128 log points. Baldwin and Harrigan (2007) find much larger effects of distance on US export prices.

In the final column of Table we test how the relationships that we observe for export unit values, which appear different from those of developed countries in the existing literature, compare to those for unit values on imports. While the theoretical model makes no predictions about the relationship between foreign country size and import unit values the relationship with distance should be the same between imports and exports. The results in column 5 are striking in this regard. The estimated effect of distance with import unit values into China is positive, while that for GDP is negative.

The positive coefficient on distance is consistent with the quality version of the heterogeneous firm model. Perhaps of greater interest is the value for the estimated elasticity, which at 0.32 is around ten times that found for export unit values, and is within the range found by Baldwin and Harrigan (2007) for the US. Out of interest the elasticity of import unit values with respect to the market size of the export country is also very similar in size to that found for the US. It would appear that the relationships found for Chinese export unit values are very different to those for imports and would tend to decrease the possibility that they are due to measurement error in the Chinese data compared to that for developed countries.

Table 3: Gravity Regressions of Average Product Destination Unit Values

	1	**2**	**3**	**4**	**5**
	Base	Remove values <1000	Remove values <5000	Remove values <10000	Import unit values
Log(GDP)	-0.019 (8.14)**	-0.020 (8.48)**	-0.021 (8.50)**	-0.022 (8.77)**	-0.077 (17.3)**
Log(distance)	-0.037 (7.12)**	-0.031 (6.03)**	-0.027 (5.12)**	-0.019 (3.64)**	0.324 (40.5)**
Log(GDPpc)	-0.007 (2.00)*	0.007 (2.00)*	0.008 (2.21)*	0.010 (2.67)**	0.385 (41.7)**
Border Dummy	-0.032 (2.70)**	-0.036 (3.09)**	-0.055 (4.72)**	-0.057 (4.79)**	-0.391 (18.8)**
Year 2000 Dummy	-0.254 (30.57)**	-0.246 (30.11)**	-0.238 (28.30)**	-0.231 (26.63)**	0.154 (10.8)**
Year 2002 Dummy	-0.310 (37.52)**	-0.307 (37.91)**	-0.296 (35.20)**	-0.293 (33.81)**	0.272 (19.25)**
Constant	3.281 (47.48)**	2.954 (43.41)**	2.941 (41.90)**	2.899 (40.08)**	-0.954 (6.99)**
Observations	170328	151011	129072	114370	87694
Number of hs8	3155	3096	3063	3041	3162

Note: Regressions are fixed effects regressions of average product-destination unit values. Products are measured at the HS8 level. T-statistics are in parenthesis. **, *, + denotes significance at the 1%, 5% and 10% level respectively.

In Table 4 we investigate the relationship with distance further by testing for any non-linearities in the relationship. Here we find evidence that supports the quality as well as the efficiency model, although the former is supported only over very short distances. We find that unit values are rising up to distances just over 3,600 kilometres, although they remain higher than the estimated unit value at 956 kilometres (the shortest distance in the sample) up to around 14,000 kilometres. There are just 8 countries within the data that have a distance to China that is smaller than 3600 kilometres, including Japan, Thailand and South Korea, and 14 countries that are located a distance greater than 14,000 kilometres from China.[8] Even accounting for the extent of the non-linearity the effect of distance is again small however. As with the simple linear model we find that export unit-values from China are insensitive to increases in distance compared to those of the US. Compared to the maximum effect of distance the estimated effect on the log of unit values at the maximum in our sample is 0.15 log points. This would appear to imply that the sunk-costs of exporting from China are relatively common across countries.[9]

Table 4: Non-linear Gravity Regressions of Average Product Destination Unit Values

	1	**2**	**3**	**4**
	Non-linear distance	Heterogeneous Products	Reference Priced Products	Homogeneous Products
Log(GDP)	-0.021 (9.01)**	-0.026 (8.78)**	-0.010 (2.46)*	0.107 (3.12)**
Log(distance)	0.886 (10.12)**	1.030 (9.00)**	0.680 (4.86)**	0.818 (0.75)
$Log(distance)^2$	-0.054 (10.49)**	-0.065 (9.69)**	-0.035 (4.19)**	-0.042 (0.65)
Log(GDPpc)	0.012 (3.34)**	-0.012 (2.70)**	0.108 (17.08)**	-0.083 (1.56)
Border Dummy	-0.045 (3.90)**	-0.064 (4.26)**	0.043 (2.28)*	-0.149 (1.11)
Year 2000 Dummy	-0.245 (30.11)**	-0.256 (24.44)**	-0.177 (12.87)**	-0.027 (0.24)
Year 2002 Dummy	-0.308 (37.96)**	-0.320 (30.77)**	-0.243 (17.75)**	-0.119 (0.96)
Constant	-0.929 (2.47)*	-0.567 (1.15)	-3.130 (5.21)**	-4.289 (0.92)
	3654	*2760*	*16552*	*16951*
Observations	151011	103515	32287	685
Number of hs8	3096	1970	763	36

Note: Regressions are fixed effects regressions of average product-destination unit values. Products are measured at the HS8 level. T-statistics are in parenthesis. **, *, + denotes significance at the 1%, 5% and 10% level respectively. We have removed observations with an export value less than $1000.

[8] These results do not change when we estimate the regression for each year separately. Nor do they change when we allow for differences in the unit of measurement used within HS8 product codes. Two forms of unit, number and kilograms, dominate the sample.

[9] This result does not change much if we allow for higher order transforms of the distance variable.

A reasonable question is whether the non-linearity we observe is due to the nature of the goods being traded, whether we are conflating changes in the mix of products. In Table 4 we the follow the Rauch classification to separate products according to whether they are likely to be heterogeneous, have a reference price or are traded on an exchange (are homogenous). Rauch classifies 4-digit industries under a conservative and a liberal classification. We use the conservative classification because it gives a slightly larger set of heterogeneous products, although the results change little when use the liberal classification. Using the Rauch data gives us only 36 product codes that are classified as homogenous. We report the results for reasons of completeness. We again concentrate on the data removing observations with a value less than $1000.

The differences between the types of good traded has a strong impact on the results found above. Most noticeably is the behaviour of goods classified as reference priced or homogenous. For these goods the effect of distance is for the average country positive and the turning point occurs close to the end of the data. There are only six countries in the data set that are located a distance greater than 16,500 kilometres from China (Peru, Brazil, Paraguay, Chile, Uruguay and Argentina). These results match those found for Mayer and Ottaviano (2007) for Belgium and France.

For products classed as heterogeneous under the Rauch classification the non-linear effect dominates past 2,760 kilometres (there are only four countries in the data set located this close to China) and again the efficiency model would appear to be a closer description of trade in China.

Gravity by Type of Trade and by Type of Trade

A unique feature of the data used in this study is the ability to separate total trade according to whether it relates to processing or ordinary trade[10] and to whether the seller is owned by the state, by a private firm or is fully-owned or part-owned by a firm from outside of China. We explore first the effect of the type of trade. As the heterogeneous firm models relate to ordinary trade for profit maximising firms these

[10] There is a third classification of ‘other trade’ This is relatively small so we exclude these observations. More details on this can be found in the Appendix.

distinctions are potentially important and may have an important bearing on the results.

According to the data in Table 5 31 per cent of the value of international from China relates to ordinary trade, 65 per cent to processing trade and 4 per cent to other types of trade. Perhaps surprisingly the ratio of processing has fallen over the data period; from 72 per cent in 1997, to 67 per cent in 2000 and 65 per cent in 2002. As the Table also makes clear foreign (including joint Foreign-Sino enterprises) contribute by far the largest share of total trade. Some 62 per cent of total trade is by foreign owned firms, compared to 26 per cent for state owned enterprises and close to 12 per cent for privately owned firms. The share of trade by foreign owned firms has risen over the sample period, up from 56 per cent in 1997. As is also very clear from the Table over half of the value of trade is processing trade by foreign owned firms.

Table 5: Percentage Share of Trade by Type of Trade and Trader for 2002

	State Owned Enterprises	Foreign (Foreign-Sino) Enterprises	Privately Owned Enterprises	*Total*
Ordinary Trade	14.77	7.42	8.68	*30.87*
Processing Trade	9.40	52.84	2.81	*65.06*
Other Trade	1.75	2.16	0.17	*4.08*
Total	*25.92*	*62.42*	*11.66*	*100.00*

In Table 6 we explore whether the relationship between distance and GDP differ between ordinary and process trade. Column 1 reports the estimates for ordinary trade and column 2 for processing trade. Columns 3 and 4 repeat the exercise but using a lower minimum export value (now >$500) to be included in the regression. The results appear robust to this change.

There are some noticeable differences as a result of separating trade according to the type of nature of trade. Perhaps most obviously the effect of GDP is now insignificant in column 2, whereas it remains significant in column 1. Given the source of much of the FDI into China has been from the advanced developed countries this appears to have skewed the effect of GDP on export prices. In comparison the effect of distance is somewhat similar. The relationship is again identified as non-linear, while at the mean value of distance the estimated elasticity is -0.15 for ordinary trade and -0.13 for processing trade.

Table 6: Gravity Regressions of Average Product Destination Unit Values by Type of Trade

	1	**2**	**3**	**4**
	Ordinary trade	Processing trade	Ordinary trade	Processing trade
Log(GDP)	-0.006 (2.04)*	-0.004 (0.79)	-0.005 (1.76)+	-0.001 (0.31)
Log(distance)	1.270 (10.66)**	0.676 (4.00)**	1.285 (10.87)**	0.684 (4.07)**
Log(distance)^2	-0.077 (11.06)**	-0.044 (4.41)**	-0.078 (11.30)**	-0.045 (4.54)**
Log(GDPpc)	0.005 (1.03)	0.040 (5.14)**	0.006 (1.37)	0.039 (5.07)**
Border Dummy	-0.101 (6.45)**	-0.188 (8.51)**	-0.097 (6.18)**	-0.181 (8.19)**
Year 2000 Dummy	-0.314 (28.25)**	-0.116 (7.42)**	-0.313 (28.42)**	-0.125 (8.07)**
Year 2002 Dummy	-0.416 (37.80)**	-0.040 (2.52)*	-0.414 (37.95)**	-0.048 (3.02)**
Constant	-2.306 (4.49)**	-0.500 (0.69)	-2.405 (4.72)**	-0.562 (0.78)
	3815	*2169*	*3779*	*1998*
Observations	89570	37533	93153	38650
Number of hs8	1919	1613	1925	1619

Note: Regressions are fixed effects regressions of average product-destination unit values. Products are measured at the HS8 level. T-statistics are in parenthesis. **, *, + denotes significance at the 1%, 5% and 10% level respectively. We have removed observations with an export value less than $1000 in columns 1 and 2 and less than $500 in columns 3 and 4.

In Tables 7 we take these results further by separating firms according to whether the trade being observed is by a state owned enterprise, a foreign (including foreign-Sino partnerships) or a private firm. In columns 1 to 3 we consider ordinary trade for each firm type and in columns 4 to 6 we repeat the exercise for processing trade.

It would appear from this exercise that the differences between the ownership and whether the trade is ordinary or of processed goods does not provide strong insights into the characteristics of Chinese trade. For ordinary trade it would appear that privately owned and foreign owned firms are not affected by market size variables, whereas state owned firms are. The effect of distance would appear similar between the three types of firm however. For processing trade there is again some evidence that state owned are affected by market size but not distance, whereas foreign owned are affected by distance but not market size. Privately owned firms are unaffected by both market size and distance.

Table 7: Gravity Regressions of Average Product Destination Unit Values by Type of Trade and Type of Trader

	1	**2**	**3**	**4**	**5**	**6**
	Ordinary Trade	Ordinary trade	Ordinary trade	Processing trade	Processing trade	Processing trade
	State Owned Enterprises	Foreign Enterprises	Private Enterprises	State Owned Enterprises	Foreign Enterprises	Private Enterprises
Log(GDP)	-0.007 (1.93)+	-0.008 (1.37)	-0.008 (1.47)	0.021 (2.85)**	-0.007 (1.29)	-0.004 (0.41)
Log(distance)	1.054 (7.93)**	1.201 (5.72)**	1.132 (5.62)**	0.101 (0.36)	0.843 (4.48)**	0.339 (0.79)
Log(distance)^2	-0.064 (8.26)**	-0.072 (5.75)**	-0.067 (5.67)**	-0.011 (0.67)	-0.052 (4.68)**	-0.020 (0.81)
Log(GDPpc)	-0.029 (5.48)**	0.044 (4.67)**	0.017 (2.11)*	0.004 (0.29)	0.051 (5.70)**	0.058 (3.29)**
Border Dummy	-0.099 (5.78)**	-0.060 (2.28)*	-0.188 (7.42)**	-0.204 (5.82)**	-0.192 (7.89)**	-0.266 (5.54)**
Year 2000 Dummy	-0.336 (27.84)**	-0.147 (6.57)**	-0.354 (11.76)**	-0.042 (1.79)+	-0.153 (8.62)**	-0.031 (0.71)
Year 2002 Dummy	-0.401 (33.07)**	-0.155 (7.12)**	-0.428 (14.65)**	0.067 (2.48)*	-0.114 (6.33)**	-0.033 (0.75)
Constant	-0.937 (1.63)	-2.472 (2.77)**	-2.385 (2.76)**	1.351 (1.14)	-1.150 (1.43)	0.579 (0.32)
Observations	80245	30382	28402	15895	30498	4108
Number of hs8	1937	1612	1499	1378	1505	577

5. Conclusions

To be completed

Appendix

Table A1: Type of Trade observed in the dataset

Type of Trade	*Classification used in this study*
Outward processing Process and assembly Process with imported materials	Processing trade
Ordinary trade	Ordinary trade

Note: Within the data there are 14 other classifications of trade. These include International aid; Donation by overseas Chinese; compensation trade; goods on consignment; border trade; equipment for processing trade; contracting projects; goods on lease; equipment investment by foreign-invested enterprise; barter trade; duty-free commodity; warehousing trade; entrepot trade by bonded area; other.

Table A2: Ownership Structure in the Dataset

Ownership structure	*Classification used in this study*
Chinese-foreign contractual joint venture Chinese-foreign equity joint venture Foreign-owned enterprises	Foreign owned enterprises
Collective enterprises Private enterprises Other	Privately owned enterprises
State owned enterprises	State owned enterprises

Table A3: HS 2-digit Industries and their Description

HS Code	*Description*
1-5	Live animals and animal products
6-14	Vegetable products
15	Fats oils and waxes
16-24	Food products, beverages & tobacco
25-27	Mineral products
28-38	Chemicals
39-40	Plastics and rubber
41-43	Leather, fur etc.
44-46	Wood and Wood products
47-49	Wood pulp, paper and paper articles
50-63	Textiles
64-67	Footwear, headware etc.

68-70	Glass, glassware, stone and ceramics
71	Pearls, precious metals and jewelery
72-83	Base metals
84-85	Machinery, mechanical, electrical equipment
86-89	Vehicles, aircraft and transportation equipment
90-92	Clocks, watches and specialist instruments
93	Arms and ammunition
94-96	Other manufactured goods