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Firm Heterogeneity and the Geography of International Trade

by

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Abstract

A key distinction which has emerged from heterogeneous firm models of international trade is that of exporting at the intensive and extensive margins. Empirically however, the two are often conflated, leading to biased estimates of the impact of falling trade costs. This paper exploits detailed firm level data, which includes information on the destination of exports to investigate causal links between enterprise productivity and the number of markets a firm serves as well as the relative size of those markets. Our focus is Sweden's Food and Beverage sector, which is not only highly open, but has been subject to policy induced changes in trade costs (as well as falling natural barriers) over our sample period. We have data on almost 10,000 firm / time / destination observations across 6 years and 138 destinations. Our results confirm that conflating adjustment at the internal and external margins does bias trade resistance effects. Combining detailed firm specific information with data on destination characteristics confirms the importance of a range of country specific characteristics (including exchange rate risk) and facilitates the estimation of both distance and market size elasticities, from firm level data.

JEL classification: F19

Keywords: trade costs, firm characteristics, destination characteristics, market size, distance

Outline

Non-Technical Summary

Recent years have seen the emergence of a new model of international trade, the heterogeneous firm model, as the dominant model used for explaining patterns of international trade. In part, its success can be attributed to its ability to describe adjustment on either the margin of entry and exit into export markets (the extensive margin) and the volume of export sales by existing exporters (the intensive margin) of trade. Empirical evidence on the determinants of these margins of adjustment is now widespread covering many country and industry settings as well as time periods (see the reviews in Greenaway and Kneller, 2007). More recently this has been extended to provide a more complete decomposition of the extensive and intensive margins, adding changes in the number of markets served by established exporters.

The emergence of this new theory of trade has contributed to a re-evaluation of the dominant empirical models explaining trade flows. At the aggregate level an important implication of the heterogeneous-firm model is the suggestion that the extensive margin may have important implications for our estimation of how different trade-policy measures affect firm exports. In particular the model suggests that most current empirical testing conflates the intensive margin of exporting with what is in fact adjustment at the extensive margin.

In this paper we also exploit detailed firm data on the destination of international trade, but to shed new light on a second dominant empirical model. There has now developed a large literature modelling the extensive and intensive margins of firm exports. The concern here mirrors that at the aggregate level: adjustment at the intensive margin is being conflated by adjustment at the extensive margin. Again this suggests that the effects of policy change on exports might be missed in traditional estimates.

Our specific focus is Sweden's Food and Beverage sector, which is not only highly open, but has been subject to policy induced changes in the costs of trade costs over our sample period. We have data on almost 10,000 firm/time/destination observations across 6 years and 138 destinations. Our results confirm that conflating adjustment at the internal and external margins does bias the relationship found for key variables such as distance.

I Introduction

Recent years have seen the emergence of the heterogeneous firm model as the dominant model used for explaining micro patterns of international trade (Melitz, 2003; Bernard, Eaton, Jensen and Kortum, 2003). In part, its success can be attributed to its ability to describe adjustment on either the *extensive* (non-export firms becoming exporters) and *intensive* margins (the volume of export sales by existing exporters) of trade. Empirical evidence on the determinants of these margins of adjustment is widespread (see the reviews in Greenaway and Kneller, 2007; and Wagner 2007). Chaney (2008) adds to this heterogeneous firm literature to provide a more complete decomposition of the extensive and intensive margins, adding changes in the number of markets served by established exporters.

The emergence of this new theory of trade has contributed to a revaluation of the dominant empirical models explaining trade flows. At the aggregate level an important implication of the heterogeneous-firm model is the suggestion that the extensive margin may have important implications for our estimation of how different trade-policy measures affect firm exports in a gravity framework. In particular the model suggests that most current empirical testing conflates the intensive margin of exporting with what is in fact adjustment at the extensive margin, biasing the relationships found for key variables such as distance. Helpman *et al* (2007) showed how to incorporate the extensive margin at an aggregate level with the help of exporter and importer characteristics. Others have begun to exploit newly available firm data on the destination of trade to reveal how the components of aggregate trade flows, such as varieties, quantities and unit values, respond to various characteristics of trading partners. Important works here include the exploration of the anatomy of international trade by Eaton, Kortum and Kramarz (2004) for France and Bernard, Jensen and Schott (2006) for the US.

In this paper we also exploit detailed firm data on the destination of international trade, but to shed new light on a dominant empirical model. There has now developed a large literature modelling the extensive and intensive margins of firm exports using a wide range of firm an industry level variables. Important early contributions here include Roberts and Tybout (1997), Bernard and Jensen (2004) and Bernard and Wagner (1998), while a more comprehensive review can be found in Greenaway and Kneller (2007). The concern here mirrors that at the aggregate level: adjustment at the intensive margin is being conflated by

adjustment at the extensive margin. In our data around 3.5 per cent of all non-exporting firms starts exporting each year and around 13 per cent of all exporters stops exporting, and these changes in the extensive margin would be subsumed into the intensive margin in the standard empirical set-up.

Our analysis is based on a very detailed census of firms in the Swedish Food and Beverage sector. This sector is especially interesting since Sweden's EU-accession in the mid 1990's meant that it had to become more open towards the rest of the EU. Furthermore, focusing on one sector may yield important insights since as Chaney (2008) argues, differences in the elasticity of substitution can affect results (although Eaton Kortum and Kramarz (2004) suggest cross-industry differences are not important, albeit in a cross-section).

Our highly disaggregated data allows us to test several hypotheses derived form core firm heterogeneity models. In particular, we are interested in whether higher productivity is associated with serving a larger number of countries; the links between firm productivity and the size of foreign markets; and links between productivity and revenue.

The remainder of the paper is orgainised as follows. Section II briefly refers to the theoretical literature on firm heterogeneity and exporting, setting out the hypotheses in which we are particularly interested. Section III explains our modelling framework and sets out our empirical specification. In Section IV we report and discuss our results for our firm level estimations. Finally, Section V concludes.

II Heterogeneity and Firm Exports

The most common way to describe firms' sales on different markets is to start with what is often called a 'new trade theory' perspective, as synthesised in Helpman and Krugman (1985), and in particular the assumption of identical preferences across countries. This implies that any demand effects on trade patterns are neutralised, and the use of "love for variety", as in Krugman (1980), implies that consumers around the world always demand a product as soon it is produced. The pattern of trade is therefore solved as soon as we determine where each product or variety is produced. This is ensured by monopolistic competition and

differentiated products.[1] If we also assume a variable transport cost for exporting, implying price differences across countries, we derive the following export volume of firm *f* in country *i* to country *j*:

$$x_{ji}^{f} = \lambda Y_j \left[\frac{p_{jf}}{P_j} \right]^{1-\varepsilon}, \quad P_j = \left[\int_{l \in E_j} p_{jl}^{1-\varepsilon} dl \right], \tag{1}$$

where p_{jf} is the price of variety *f* in country *j*, Y_j is country *j*'s income, ε is a constant demand elasticity, P_j is country *j*'s ideal price index, λ is the utility function's distribution parameter across products, and E_j is the set of products available at market *j*. The price of *f*'s products on market *j* depends on demand elasticities, factor prices in *j*, and transport costs between production locations *i* and market *j*. This demand function is similar to the demand for "region *i* goods by region *j* consumers" as used in Anderson and Van Wincoop (2003) but for a single variety produced in *i*. The price index in market *j* depends on the costs of exporting from all locations to market *j*, and hence it is labelled the "multilateral trade resistance" variable in Anderson and Van Wincoop (2003). That is, any shift in trade costs between two trade partners effects the importer's propensity for importing from all regions because relative prices change.

If we also assume, as in Helpman *et al* (2006) and Chaney (2008), that firms are heterogeneous (in that they have different productivity levels), the price of *f*'s variety on market *j* also depends negatively on the firm's productivity level. The higher the productivity levels, the higher are export volumes. Finally, if all firms also face a fixed cost of exporting, firm *f* only serves market *j* as long as exporting is profitable. This implies that firms select themselves into export activities, and whether a firm elects to export to market *j* depends on its productivity level and the fixed costs of exporting to that particular market. In this setting we have the following firm-level export equation:

$$x_{jf}(a, a_f \geq a^j) = \lambda Y_j P_j^{\varepsilon-1} \left[m \tau_{ij} a_f \right]^{1-\varepsilon}, \tag{2}$$

[1] Other possibilities to determine specialisation patterns across countries are products differentiated across countries (Anderson, 1979; Anderson and Wincoop, 2004) or factor proportion/technology differences

where a_f is firm f's productivity level, a^j is the productivity of the firm which is indifferent to exporting, m is a constant mark-up ($=\varepsilon/[\varepsilon-1]$), and τ_{ij} is the variable transport cost. Although this firm-level equation is comparable to export equations of representative-firm models, it differs since firms select into exporting and the ideal price index depends on the trade costs (variable and fixed) facing all firms exporting to market j. In other words, one firm may export to one country but not to another since sunk costs of exporting differ across export destinations.

In common with models of this type (like Chaney, 2008; Yeaple, 2005; Eaton, Kortum and Kramarz, 2005; Helpman et al., 2006) this equation yields a number of testable predictions. In this paper we are interested into the following:

- the more productive a firm the greater the number of countries it will serve;
- for a given level of firm productivity the probability of serving an export market is increasing in the size of the foreign market and decreasing with the fixed and variable costs of exporting;
- for any firm with productivity sufficient to serve a foreign market, the revenue earned in that market is proportional to its productivity.

III Modelling Framework and Empirical Specification

The selection process One important implication of the heterogeneous-firm model is the incorporation of the extensive margin of international trade and the selection of exporters, as a consequence of sunk costs. The evidence of self-selection into export activities is robust (see Wagner, 2007), and we will use this selection process to reveal information on why some firms are more successful than others in a particular market.

We define our selection equation as follows: [2]

$$\Pr(D_{jft} = 1 \mid observables) = \Phi\left(\sum_k \delta_k z_{kjft} + \sum_l \delta_l z_{lijt} + \delta_j D_{jft-1}\right), \qquad (3)$$
$$D_{jft} = 1 \mid x_{jft} > 0,$$

(Deardorff, 1998; Haveman and Hummels, 2004).

[2] This selection equation is similar to the parameterised reduced-form of export activity in Roberts and Tybout (1997) as well as in Bernard and Jensen (2004).

where z_{kjf} is a set of K explanatory firm-level variables, z_{lij} is a set of L explanatory country-level variables, and δ_j is an estimation of the importance of sunk-cost of exporting (or the importance of last year's export decision on this year's).

According to the heterogeneous firm model participation decisions are determined completely by a combination of sunk-costs and firm productivity. In the empirical counterpart to this, the set of firm characteristics has been extended to include factors such as size, age, human capital, relative capital-intensity, ownership and so on. While there are differences in the exact methodology employed (the choice over logit or probit models and attempts to correct for bias from inclusion of lagged export status of the firm) results are for the most part robust. Some if not all firm level variables are strongly correlated with export market entry. Here the set of firm level controls include a measure of firm productivity, ownership (owned by a foreign firm or owner of foreign firms), size (measured by employment), capital intensity (measured by the ratio of capital stock to the number of employees), and skill intensity (measured by the share of employees with a university degree).[3] We would expect all to have a positive association with the margins of exporting. All these indicate whether a firm is successful or not on foreign markets, and hence we use lagged (one period) firm characteristics to avoid problems of endogeneity. We also consider export hysteresis due to sunk costs by controlling for lagged export activities (i.e. a dummy variable taking the value of one if the firm exported to a particular partner last year), which was used in, for example, Bernard and Jensen (2004).

The decision to export to a particular country does not, however, only depend on the characteristics of the firm but also on the characteristics of the export destination, which we uniquely have the opportunity to analyse. The probability of exporting to a particular country may increase with the economic size of the destination market, which we consider by including trading partners GDP. As discussed in Melitz and Ottaviano (2008), the size of the importing country may have a positive as well as a negative effect on firms export decision since the positive effect of increased export opportunities may be dampened by a more competitive environment. We also include the population of the importing country since, as

[3] See the Appendix for variable definitions and sources.

discussed in Anderson and Van Wincoop (2203), richer countries may use a bigger share of their income on tradables. In addition, we include several bilateral trade resistance variables such as distance, membership of the EU15, and a dummy indicating whether the importing country is low or middle-income. We also include exchange rate information, and in the selection equation consider exchange rate risk since a firm may avoid markets with high exchange rate fluctuations. Or measure of exchange rate risks is calculated as the differences between the maximum and minimum exchange rate divided by its mean.

The gravity equation Theoretical models (representative as well as heterogeneous firm-models) which underpin gravity equations all point out two essential macro variables which explain bilateral trade volumes; market size and trade barriers. Market size is, of course, important for the demand facing each firm in each export market, but is also important for explaining aggregate trade volumes as it tells us something of the export potential of each country. Trade barriers are important in explaining both firm-level and aggregate export volumes. It is quite obvious that any explanation of bilateral trade volumes has to consider bilateral trade-barriers that may hinder a firm's exports. However, a country's propensity for importing is affected by its trade relations with all export countries, which underlines the importance of controlling for multilateral trade-resistance. One way to control for this is to introduce time-invariant export destination effects, to take account of unobserved price indices effects.[4] This, in our sample, would make it impossible to estimate the effects of time-invariant bilateral effects (such as destination or regional trade agreements), which is the reason for using regional export-destination effects (the 19 regions are presented in Table A3 in the Appendix). We also incorporate bilateral trade resistance variables (distance, members of the EU, English speaking or not, low and middle-income countries) and the real exchange rate in order to explain firms export volume to different markets. In addition to macro variables, heterogeneous-firm models emphasise that export volumes depend on the characteristics of firms. In the gravity equation we include firm size (measured by the number of employees), TFP, ownership status (foreign owned, owner of foreign firms or domestic) and capital intensity.[5]

[4] See Rose and Wincoop (2001). An alternative specification is to solve these price indices implicitly (as in Wincoop and Anderson, 2003).
[5] See Table A1 for variable definitions and sources.

Our benchmark specification of the firm gravity equation is:

$$x_{fjt} = \alpha_0 + \sum_k \beta_k z_{kjft} + \sum_l \beta_l z_{lijt} + \gamma_j + \beta_\Phi \Phi_{ftj} + \varepsilon_{fjt}, \qquad (4)$$

where lower-case letters indicate logged variables, x_{fjt} is the export volume of firm f to importer j, z_{kjft} is a set of K explanatory firm-level variables, z_{lijt} is a set of L explanatory export-destination variables including bilateral trade resistance variables, γ_j is an export-destination effect, and Φ_{fj} is the mills ratio controlling for unobserved characteristics leading to export success.

Data: Our firm-level data is provided by *Statistics Sweden* and consists of an unbalanced panel of 1,570 firms in the food and beverage sector covering the period 1997 until 2002. For all years we have detailed information on factor inputs, firm ownership and firms' export volume to individual countries.[6] Our sample consists of 9,858 firm-time-destination observations spread over six years and 138 export destinations.[7] Around 20 per cent of all firms export, but the degree of export participation in different size groups varies significantly. A vast majority of our dataset, around 70 per cent, consists of rather small firms with less than 50 employees, and around 16 per cent of these firms export. The share of exporters in the group of firms with more than 49 employees is much higher, around 80 per cent, while the same figure is only around 4 per cent of the group of self-employed. The export activity of these firms shows a rather dynamic pattern since a firm tends to only stay in an export market, conditional on whether the firm ever exported to this market, for approximately 50 per cent of its observations. Furthermore, around 23 per cent of the firms exporting in a particular year exit an export market the following one. This is considerably greater than entry/exit rate as usually modelled.

[6] We have information on the number of employees (skilled and unskilled), capital, energy, raw materials, ownership (foreign owned or owner of foreign firms) and total sales. We calculate the multilateral productivity index as in Aw *et al* (2003). In addition to this index we used an alternative productivity measure based on the method recommended by Levinsohn and Petrin (2003) using skilled and unskilled labour as free inputs, raw materials as a proxy for unobserved chocks, and capital as a fixed input.

[7] Note that we only consider firms that exit for at least 3 sequential years.

Table A2 reveals that the characteristics of exporting firms are in line with other studies. If we compare firm-destination exporter with firm-destination non-exporter, we see that exporting is characterised by higher productivity, more skill intensive production techniques, bigger firms and an international ownership structure. The same table also reveals that exports are concentrated on nearby and large markets as well as markets with a relatively high share of agricultural production. The latter may indicate that particular export destination has a relatively large food and beverage sector, which implies a relatively competitive environment and relatively high demand for intermediates.

A closer look at our sample shows that the export activity of firms varies greatly. Figure 1 shows that firms' export activity within an industry may be highly concentrated as well as very diversified. Some concentrate their exports on a few destinations; while others spread their exports to different markets. This figure also reveals, as expected, that the concentration of a firms export sales falls with the number of export markets, i.e. firms tend to distribute exports more equally across destinations as the number of destinations grow. In Figure 2 we compare the number of export destinations with firms' productivity level, and the results are in line with theoretical predictions. More productive firms tend to reach out to more markets. The relationship is not one-to-one, but a simple Poisson regression of TFP on the number of export destinations reveals that a unit increase in TFP increases the number of export destinations by 1.22.

Figure 3 plots the number of firms exporting to each market together with the average number of markets firms in that market export to. It reveals a pattern consistent with the expectation that successful firms export to a greater number and to more marginal markets. If we define marginal markets as those with few Swedish entries, then Figure 3 reveals that firms in these markets tend to export to a greater number of destinations. The extensive margin declines quickly in Sweden as in France (Eaton et *al.*, 2004). Countries penetrated by many Swedish firms tend, on the other hand, to attract firms that export to only a few markets. Finally, Figure 4 shows the distribution of firms and exports across markets in 2002. The most important market is the Nordic countries (Norway, Denmark, Finland and Iceland), which made up more than 30 per cent of all exports and was penetrated by more than 20 per cent of all exporting firms. The data also suggest a strong role for market size on the intensive margin. The USA was the most important single country when countries are ranked by export

volume, it accounts for around 30 per cent of all exports, but is served by four per cent of all firms. Other important markets are EU-members such as Germany, Great Britain and France.

IV Gravity at the firm level

In Tables 1 and 2 we report results for the extensive and intensive margins of trade using two different data sets. In Table 1 we present results from a multilateral dataset when firms are characterised as exporters or non-exporters without considering the number of markets, or which markets they serve. These are typical of regressions found in the literature (Wagner, 2007) and serve as the benchmark against which we compare the results in Table 2, where we exploit information on firm export destinations. Both tables are structured in the same way: regressions 1, in both report the firm and country determinants of the extensive margin and regressions 2-4 the intensive margin. Equations 1 and 2 result from a maximum-likelihood estimation for a sample selection model where the selection process into different export destinations is allowed to affect the intensive margin. Regressions 3 and 4 are not corrected for selection bias, but in regression 4 we use fixed firm-destination effects to control for possibly unobserved persistent time-invariant export factors.

The significance of the estimated correlation (rho in Table 1 and 2) between the errors of the selection and the outcome/gravity equation suggests that a sample selection model should be used. The negative sign of this correlation term suggests that unobservables making exporting more likely, decrease the intensive margin of exporting. As the correlation between error terms is sensitive to our specification (or the unobservables in the error term), we do not try to interpret or speculate about the nature of this particular correlation. What we can say is that our results support the view of Helpman *et al* (2007) that traditionally gravity models conflate trade resistance variables effect on firms' export levels with their effect on firms' selection into exporting. For example, since the probability of exporting decreases with distance, the proportion of firms exporting decreases with distance, which decreases aggregate trade flows independently of the effects of distance on the intensive margin. The possibility for conflating the extensive and intensive margin in the traditional gravity model is aggravated by the significance of all other destination characteristics.

In addition to possible biased effects on estimated firm-level export elasticities of ignoring the extensive margin, we find there are important unobserved firm and/or destination characteristics which may be biasing these elasticities. The results suggest, for example, that the elasticity of exporting with respect to distance at the firm level is likely to be overestimated.

Comparing the results across Tables 1 and 2 there are a number of noticeable differences that appear to confirm that the extensive margin becomes conflated with the intensive margin when we do not have firm-specific trade data. This bias manifests itself in two main forms. Firstly, on the regressions for the extensive margin, although consistent with our prior expectations and with the existing empirical evidence (Greenaway and Kneller, 2007), there is a greater number of significant coefficients in Table 2 compared to Table 1. In Table 1 we find evidence that large firms that use skilled labour intensively are significantly more likely to export. However we use firm-level bilateral trade flows in Table 2, we also find that exporters are more likely to be productive, capital-intensive firms that have an international ownership structure.

In line with Roberts and Tybout (1997), Bernard and Jensen (2004), Bernard and Wagner (1998) and Greenaway and Kneller (2008) we find strong evidence of export persistence due to sunk-costs captured by the lagged export status of the firm. [8] Perhaps unexpectedly however, we find that the effect of experience on the probability of exporting is very similar across Tables 1 and 2 at just over 0.1. This is also true of the other firm level variables that are significant in Table 1. For comparison the effects of persistence in similar countries has been estimated at 30 per cent for the UK (Kneller et al., 2008) 40 per cent for the US (Bernard and Jensen, 2004) and between 38 and 85 per cent (with 50 per cent seen as the most likely figure) for Germany (Bernard and Wagner, 1998). [9]

[8] All firm characteristics are lagged one period in order to minimise any simultaneity problems.

[9] The relatively low impact of earlier export decision on this year's decision is only found in non-linear regressions and when the whole sample is used. If we use dynamic panel data methods in order to estimate a linear-probability model, then last year exporters is more than 30 per cent likely to export compared to non-exporters. The results are also more in line with the results from a linear-probability model when we exclude low and middle-income countries, which is the same as excluding a large set of zeros.

The second noticeable difference between Tables 1 and 2 is on the intensive margin of firm exports. Here we find that the number of significant coefficients are similar, comparing regression 2 from both tables for example shows that the only difference is the significance of the dummy indicating foreign ownership in Table 1. However the effect of any given change in the firm variables is much stronger in Table 1 compared to Table 2. The marginal effects, calculated at the mean of the right hand side variables, are reported in Table A4. According to these , the effect of a 1 per cent change in productivity or employment on trade volumes is about twice as strong when we do not include information on export destinations.

In terms of the number of significant coefficients the firm level variables have a more sensitive relationship when comparing across regressions 2-4 in both tables. In Table 2 the productivity of the firm is the only variable to have a significant relationship in all of the regressions, and in Table 1 the only significant relationship is foreign ownership. In columns 2 and 3 it would also appear that larger and more skill intensive firms export more. The relationship for these variables would appear however, to be driven primarily by the between firm variation in size and skill levels. The inclusion of firm-destination effects in column 4 leads to the loss of the significance of the skill variable.

Of interest to the literature on export platform FDI (see for example Yeaple, 2003 and Ekholm et al., 2003) we find that foreign multinational firms behave in line with other firms once their productivity and size adavnatages are controlled for. Similarly of interest to the literature on the proximity-concentration trade off we find some evidence of a positive relationship in column 3.

It is possible to model the country-specific determinants of trade only in Table 2. Of the country level variables again most are significant and in general in line with our prior expectations. They show that Swedish firms are more likely to export when country *j* is closer to Sweden, and has a larger market size when measured by GDP. Conditional on these measures of market size and distance we do also find that it is less likely to trade with highly populated countries. This is in line with the Balassa-Samuelson effect since poorer countries are expected to demand less tradables. In addition we find that Swedish firms in the food and beverage industry are less likely to export to risky markets (measured by volatility in exchange rate). The importance of local taste in the food industry and the location of Sweden

near Norway (see Figure 4) is reflected in the negative impact of EU15, low and middle-income countries, and English speaking countries on the probability of exporting. On the other hand, the positive effect of EU15 together with the negative effect of English speaking countries on the intensive margin of exporting reveals the importance of nearby EU-markets as soon as a decision to export has been taken.

Of greatest interest perhaps are the coefficients on distance and market size, where there exist no comparable regressions in the literature. In their meta analysis of gravity models Disdier and Head (2008) report that the average elasticity on distance is -0.9, with 90 per cent of estimates within the range -0.28 to -1.55. Clearly the elasticities reported in Table 3 are in the low end of this range at -0.54. Perhaps a better comparison comes from Helpman et al. (2007) who report an elasticity of around -1.1, as do Bernard et al. (2006) for their regressions of the number of exporters and number of products, the later also using firm level export destination data. The elasticity with respect to GDP of 0.34 is again somewhat smaller compared to the results found in Bernard et al. (2006).

This may, of course, be a result of focusing on the Swedish food and beverage industry, but when we use aggregated data we find that our estimate of the elasticity on distance (see Table 3) is close to the average found in the literature. This is so independent of the estimation approach (i.e. using a Heckit or OLS while excluding zero-trade flows). To compare the results from the firm-level gravity equation, we estimate distance as well as size elasticities with the help of aggregate trade flows and several different specifications: first, a maximum-likelihood model controlling for sample selection; second, a regression model controlling for zero-trade flows and acknowledging that not all firms export (HMR-specification); third, a traditional gravity model excluding all zero-trade flows.

In short we found that our estimate of the elasticity on distance (see Table 3 and 4) is much closer to the average found in the literature using aggregated data compared to our firm-level analysis. That is, the elasticity is around 1.14 in all but one regression. When it comes to the elasticity with respect to market size, we found that this is also higher when we use sectoral trade flows. It is much closer to the theoretical (according to Anderson and Van Wincoop) level of one. The exception to both these observations is regression 4 in Table 4, which differs from all the other regressions. In all other specifications when regional dummies are used, the

selection problem seems to be unproblematic. Finally, the elasticity with respect to size of the destination market is only in line with our firm-level estimates when we do not control for the extensive margin of exports on firm level but correcting for firm-specific effects. One explanation of this could be that export-market size affects sunk-costs, and hence the probability of exporting. That is, the high elasticity is inflated by the extensive margin of trade on aggregated trade flows, and hence does not represent how firms actually react to market size.

V Conclusions

This paper starts from a key distinction which has emerged from heterogeneous firm models of international trade, namely exporting at the intensive and extensive margins. Although these are distinct and are likely to impact differently on productivity, the two are often conflated in empirical analysis, leading to biased estimates of the impact of falling trade costs.

This paper exploits takes advantage of very detailed firm level data, which includes information on the destination of exports and investigates causal links between enterprise productivity and the number of markets a firm serves as well as the relative size of those markets. Our specific focus is Sweden's Food and Beverage sector, which is not only highly open, but has been subject to policy induced changes in trade costs (as well as falling natural barriers) over our sample period. We have data on almost 10,000 firm / time / destination observations across 6 years and 138 destinations. Our results confirm that conflating adjustment at the internal and external margins does bias trade resistance effects. Combining detailed firm specific information with data on destination characteristics confirms the importance of a range of country specific characteristics (including exchange rate risk) and facilitates the estimation of both distance and market size elasticities, from firm level data.

References

Anderson, J.E. and Van Wincoop, E. (2003). 'Gravity with Gravitas: A Solution to the Border Puzzle', *American Economic Review*, vol. 93, pp. 170-192.

Bernard, A. and Jensen, J.B. (2004). 'Why some firms export', *Review of Economics and Statistics*, vol. 86, pp.561-569.

Bernard, A. and Wagner, J. (1998). 'Export entry and exit by German firms' *Review of World Economics/Weltwirtschaftliches Archiv*, 2001, vol. 137, pp. 134-157.

Bernard, A. B., Eaton, J., Jensen, B. and Kortum, S. (2003), 'Plants and Productivity in International Trade', *American Economic Review*, vol. 93, pp. 1268-1290.

Bernard, A.B., Bradford Jensen, J. and Schott, P.K. (2006). 'Survivial of the Best Fit: Exposure to Low-Wage Countries and the (Uneven) Growth of U.S. Manufacturing Plants', *Journal of International Economics*, vol. 68, pp. 219-237.

Chaney, T. (2008). 'Distorted Gravity: Heterogeneous Firms, Market Structure and the Geography of International Trade', *American Economic Review* vol. 98, pp. 1707.

Eaton, J, Kamarz, F. and Kortum, S (2004). 'Dissecting Trade: Firms, Industries, and Export Destinations', *American Economic Review*, vol. 94, pp. 150-154.

Ekholm, K., Forslid, R. and J. R. Markusen (2003). 'Export-platform foreign direct investment', NBER Working Paper No. 9517.

Greenaway, D., and Kneller, R. (2007). 'Firm Heterogeneity, Exporting, and Foreign Direct Investment', *Economic Journal*, vol. 117, pp. 134-161.

Helpman, E. and Krugman, P.R. (1985). *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*, Cambridge: MIT Press.

Helpman, E., Melitz, M. and Rubenstein, Y. (2007). 'Estimating Trade Flows: Trading Partners and Trading Volumes', *NBER Working Paper Series* No. 12927.

Krugman, P.R. (1980). 'Scale Economies, Product Differentiation, and the Pattern of Trade', *American Economic Review*, vol. 70, pp. 950.

Melitz, M. (2003). 'The impact of trade on intra-industry reallocations and aggregate industry productivity', *Econometrica*, Vol. 71, pp. 1695-1725.

Melitz, M.J. and Ottaviano, G.I.P. (2008). 'Market Size, Trade, and Productivity', *Review of Economic Studies*, vol. 75, pp. 95-316.

Roberts, M. J. and Tybout J. R. (1997). 'The Decision to Export in Colombia: An Empirical Model of Entry and Sunk Costs', *The American Economic Review*, vol. 80, pp. 545-564.

Roberts, M.J. and Tybout, J. (1996). *Industrial evolution in developing countries*, Oxford University Press, Oxford, UK.

Wagner, J. (2007). 'Exports and Productivity: A Survey of the Evidence from Firm-Level Data', *The World Economy*, vol. 30, pp. 60-82.

Yeaple, S. R. (2003). 'The complex integration strategies of multinationals and cross country dependencies in the structure of foreign direct investment', *Journal of International Economics*, Vol. 60, pp. 293-314.

Tables

Table 1: *Firm- level regression 1998-2002, multilateral trade flows* [a]

Margin	Extensive		Intensive	
	Selection (probit) equation for export	Corrected regression due to selection (marginal effects)	Excluding zeros	Within estimation excluding zeros
	1	2	3	
Export dummy	**2.41** (*.00*)			
Ln(TFP)	0.14 (*.06*)	**1.19** (*.00*)	**1.93** (*.00*)	0.26 (*.23*)
Ln(Employees)	**0.25** (*.00*)	**0.41** (*.00*)	**0.63** (*.00*)	0.27 (*.14*)
Foreign owned	0.39 (*.06*)	**0.98** (*.00*)	**1.11** (*.00*)	**1.10** (*.00*)
Own foreign	-0.14 (*.18*)	**0.88** (*.00*)	**0.17** (*.00*)	0.07 (*.49*)
Capital per labour	0.73 (*.00*)	**0.64** (*.00*)	**0.87** (*.00*)	
Share of high skilled workers	**0.73** (*.00*)			
Constant	**-3.11** (*.00*)	**2.12** (*.00*)	**-1.30** (*.01*)	
Sigma		**2.32** (*.00*)		
Rho		**-0.70** (*.00*)		
Lambda[b]		**-2.16** (*.00*)		
Time dummies	Yes	Yes	Yes	
Industry dummies (3-digit level)	Yes	Yes	Yes	
Fixed firm effects	No	No	No	Yes
Likelihood		-4 142		
R^2 (adjusted)			0.46	
R^2 (within)				0.05
Nobs.		7 206	1 334	1 334

Notes: P-values based on robust standard errors in parentheses. The selection model is based on a maximum-likelihood estimation. [b] Lambda stems from a two-step estimation.

Table 2: *Firm-level regression 1998-2002, bilateral trade flows* [a]

Margin	Extensive		Intensive	
	Selection (probit) equation for export	Corrected regression due to selection	Excluding zeros	Excluding zeros with fixed firm-destination effects
	1	2	3	4
	Destination characteristics			
Ln(distance)	**-0.25** (*.00*)	**-0.32** (*.00*)	**-0.51** (*.00*)	
Ln(GDP)	**0.18** (*.00*)	**0.18** (*.00*)	**0.28** (*.00*)	**0.87** (*.00*)
Ln(population)	**-0.06** (*.00*)			

EU15 dummy	**-0.21** (*.00*)	**0.91** (*.00*)	**0.79** (*.00*)	
Low and middle-income dummy	**-0.17** (*.00*)	0.18 (*.08*)	-0.15 (*.14*)	
English speaking market	**-0.29** (*.00*)	**-0.69** (*.00*)	**-0.97** (*.00*)	
Ln(real exchange rate)		-0.01 (*.45*)	-0.02 (*.18*)	-0.004 (*.98*)
Exchange rate risk	**-0.05** (*.02*)			
	Firm characteristics (all lagged one period)			
Export dummy	**2.53** (*.00*)			
Ln(TFP)	**0.31** (*.00*)	**0.44** (*.00*)	**0.79** (*.00*)	**0.49** (*.00*)
Ln(Employees)	**0.23** (*.00*)	**0.16** (*.00*)	**0.33** (*.00*)	-0.05 (*.53*)
Foreign owned	**0.15** (*.00*)	-0.005 (*.93*)	0.09 (*.18*)	
Swedish multinational	**0.12** (*.00*)	**0.13** (*.03*)	**0.23** (*.00*)	
Capital per labour	**0.29** (*.00*)	**0.35** (*.00*)	**0.54** (*.00*)	0.06 (*.31*)
Share of high skilled workers	**0.88** (*.00*)			
Constant	**-7.02** (*.00*)	0.91 (*.34*)	**-3.43** (*.00*)	
Sigma		**2.21** (*.00*)		
Rho		**-0.42** (*.00*)		
Lambda [b]		**-0.93** (*.00*)		
Time dummies	Yes	Yes	Yes	Yes
Regional dummies (see Appendix)	Yes	Yes	Yes	No
Industry dummies (3-digit level)	Yes	Yes	Yes	No
Fixed firm-destination effects	No	No	No	Yes
Likelihood		-31 689		
R^2 (adjusted)			0.21	
R^2 (within)				0.02
Nobs.		1 087 666	8241	8241

Notes: P-values based on robust standard errors in parentheses. The selection model is based on a maximum-likelihood estimation. [b] Lambda stems from a two-step estimation.

Table 3: *Sector-level analysis correcting for zero-trade flows*

	Maximum likelihood specification		ML with fixed destination effects		HMR-specification	
	Selection equation	Gravity equation	Selection equation	Gravity equation	Gravity equation	Gravity equation
	1		2		3	4
Constant	-10.63 (*.25*)	-1.24 (*.76*)			-0.84 (*.89*)	10.39 (*.00*)
Ln(distance)	-0.21 (*.82*)	**-1.14** (*.00*)	-1.58 (*.18*)		**-1.14** (*.03*)	**-0.81** (*.00*)
Ln(GDP)	**0.71** (*.00*)	**0.87** (*.00*)	**-18.91** (*.00*)	**0.88** (*.00*)	**0.86** (*.00*)	0.15 (*.26*)
Ln(population)	-0.15 (*.27*)					
EU15 dummy	-0.52 (*.99*)	-0.64 (*.39*)			-0.61 (*.39*)	**-4.17** (*.00*)
Low and middle-income dummy	1.28 (*.09*)	-0.96 (*.14*)			-0.96 (*.12*)	-2.65 (*.00*)
Real exchange rate	-0.31 (*.85*)	-0.04 (*.47*)	-0.04 (*.59*)	**0.36** (*.00*)	-0.04 (*.59*)	**0.31** (*.00*)
Exchange rate risk	-3.56 (*.77*)		1.31 (*.72*)			
Sigma		**1.41** (*.00*)		**0.86** (*.00*)		
Rho		0.03 (*.93*)		-0.01 (*.85*)		
Correcting for zeros					-0.09 (*.14*)	-0.24 (*.60*)
Correcting for share of exporting firms					-3.78 (*.77*)	**-1.27** (*.00*)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	No	No	Yes	No
Fixed destination effects	No	No	Yes	Yes	No	No
Likelihood / R^2 (adjusted)		-1 238		-772	-8 923	-1 242
Nobs.		716		716	617	617

Note: Standard errors for ML with fixed effects are based on 999 bootstraps. A Heckit specification did not revealed any selection problems.

Table 4: *Sector-level analysis excluding zero-trade flows*

	OLS	Fixed effect
	5	6
Constant	-1.38 (*.57*)	
Ln(distance)	**-1.13** (*.00*)	
Ln(GDP)	**0.88** (*.00*)	**1.40** (*.00*)
Ln(population)		
EU15 dummy	**-0.64** (*.00*)	
Low and middle-income dummy	**-0.94** (*.00*)	
Real exchange rate	-0.04 (*.09*)	**-2.90** (*.00*)
Exchange rate risk		
Time dummies	Yes	Yes
Regional dummies	Yes	No
Fixed destination effects	No	Yes
Likelihood / R^2 (adjusted)	0.22	-1 724 / 0.58
Nobs.	617	617

Table 5: *Determinants of the number of market penetrations*

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	# markets (poisson estimation)		
	1	2	3
	Marginal effects		
Ln(TFP)	**0.25** (*.00*)	**0.08** (*.00*)	
Ln(Employees)	**0.19** (*.00*)	**0.17** (*.00*)	
Foreign owned	**0.13** (*.00*)	0.02 (*.21*)	
Own foreign	**0.10** (*.00*)	0.01 (*.28*)	
Capital per labour	**0.20** (*.00*)	**0.09** (*.00*)	
Share of high skilled workers	**0.72** (*.00*)	0.14 (*.08*)	
Share of intermediates	**-0.80** (*.00*)	**-0.38** (*.00*)	
Constant	**-4.93** (*.00*)	**-4.93** (*.00*)	
Time dummies	Yes		
Industry dummies (3-digit level)	Yes		
Fixed firm-market effects	No	Yes	
Likelihood	-8 771	-8 771	
R^2 (pseudo)	0.60	0.60	
Nobs.	7 206	7 206	

Notes:

Appendix

Tables

Table A1: *Definitions and sources*

Characteristics	*Definition*
Firm level	
Size	Number of employees
Productivity	Total factor productivity, multilateral index as in Aw et al (2003),
Foreign owned	One when more than 50 per cent of the firm is owned by a foreign firm, zero otherwise
Own foreign affiliations	One when the firm own affiliations in another country, zero otherwise
Market level	
Size	Gross domestic product (constant prices) from the World Development Indicators (World Bank)
Population	From the World Development Indicators (World Bank)
Share of agriculture	Measured as the share of agricultural land in total land area.
Distance	Kilometres, calculated with the great-circle distance formula based on longitudes and latitudes from the CSI's World Fact. The distance is calculated from Stockholm to the capital of the export destination.
Real exchange rate	Annual average from the Bank of Sweden (SEK/currency of the export destination) times the ratio of CPI (consumer price index) of the destination to the CPI of Sweden (from UNdata, see http://data.un.org). Currencies not available are replaced by the exchange rate of the USA.
Exchange rate risks	Exchange rate volatility is measured as the ratio of the difference between the highest and the lowest rate to the average rate.

Table A2: *Descriptive figures (al firm-time-export destination observations)*

Variables	Mean of non-exporters (# 1 314 791)	Mean differences	Mean of exporters (# 9 858)
Destination characteristics			
Distance	6441	>	2789
GDP (constant $US)	1.95e+11	<	7.73e+11
Share of agriculture	0.31	<	0.53
Population (million)	38	<	47
EU15 dummy	0.09	<	0.41
English as first language	0.19	>	0.13
Firm characteristics			
TFP	1.17	<	1.74
Labour productivity	365	<	694

Sales (1000 SEK)	73 649	<	1 072 261
Share of high skill	0.03	<	0.06
Foreign owned	0.03	<	0.30
Own foreign	0.06	<	0.43
Age	3.34	<	3.45
Employees	33	<	436

Note: > (<, ~) indicates that the mean of non-exporters is significantly (at a 0.001 level) larger than (smaller than, equal to) the mean of exporters.

Table A3: *Regions*

South America (reg 1)	Northern Africa (reg 6)	Eastern Asia (reg 11)	Western Asia (reg 16)
Oceania (reg 2)	Middle Africa (reg 7)	South-Eastern Asia (reg 12)	Eastern Europe (reg 17)
Western Africa (reg 3)	Southern Africa (reg 8)	Sothern Europe (reg 13)	Northern Europe (reg 18)
Central America (reg 4)	Northern America (reg 9)	Southern Asia (reg 14)	Western Europe (reg 19)
Eastern Africa (reg 5)	Caribbean (reg 10)	Central Asia (reg 15)	

Note: These regions are based on UN's regional coding.

Table A4: *Marginal effects, conditional on selected observations, of the gravity*

	Bilateral trade flows Based on column 2 in Table XX	Bilateral trade flows Based on column 2 in Table XX
	Destination characteristics	
Ln(distance)	**-0.54** (*.00*)	
Ln(GDP)	**0.34** (*.00*)	
EU15 dummy	**0.72** (*.00*)	
Low and middle-income dummy	**0.26** (*.00*)	
English speaking market	**-0.95** (*.00*)	
Ln(real exchange rate)	**-0.01** (*.45*)	
	Firm characteristics (all lagged one period)	
Ln(TFP)	**0.72** (*.00*)	**1.38** (*.00*)
Ln(Employees)	**0.36** (*.00*)	**0.75** (*.00*)
Foreign owned	**0.12** (*.00*)	1.50 (*.30*)
Own foreign	**0.23** (*.00*)	0.68 (*.20*)
Capital per labout	**0.61** (*.00*)	**0.87** (*.00*)
	Influences from the selection equations	
Export dummy	**2.13** (*.00*)	2.83 (*1.00*)

Share of high skilled workers	**0.78** (*.00*)	0.98 (*1.00*)
Ln(population)	**-0.05** (*.00*)	
Exchange rate risk	**-0.04** (*.02*)	

Figure 1: *Firm's export concentration (Herfindahl index based on export shares to different destinations) vs number of export destinations*

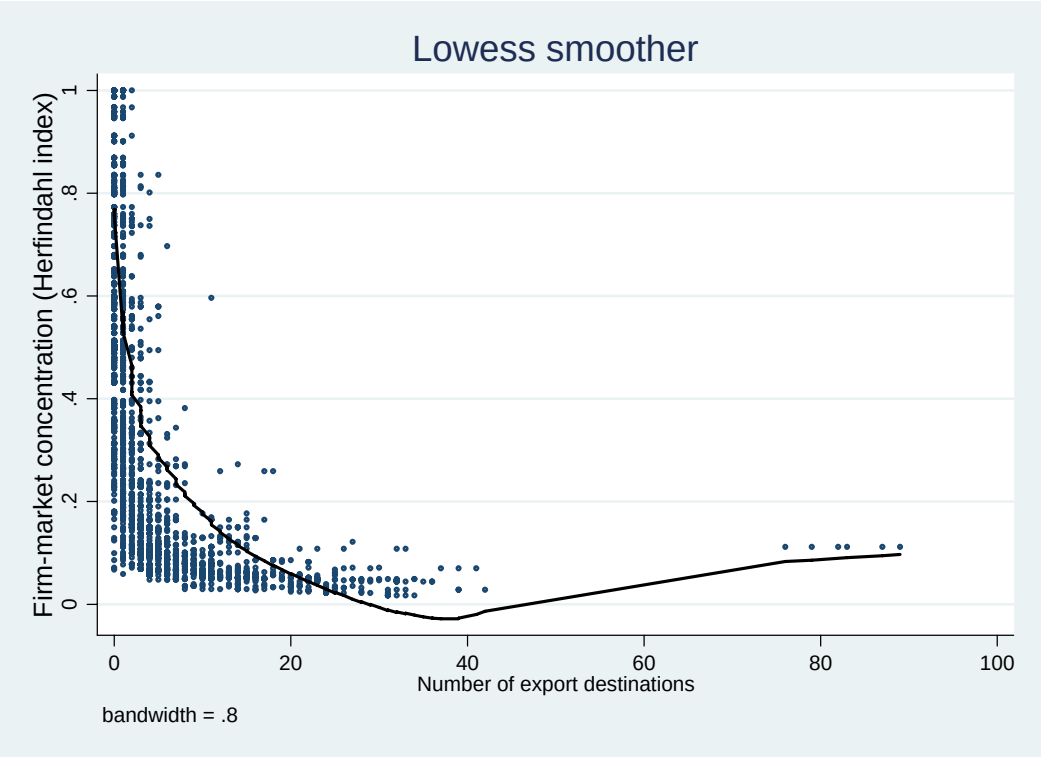


Figure 2: *Total Factor productivity and number of export destinationss at firm level*

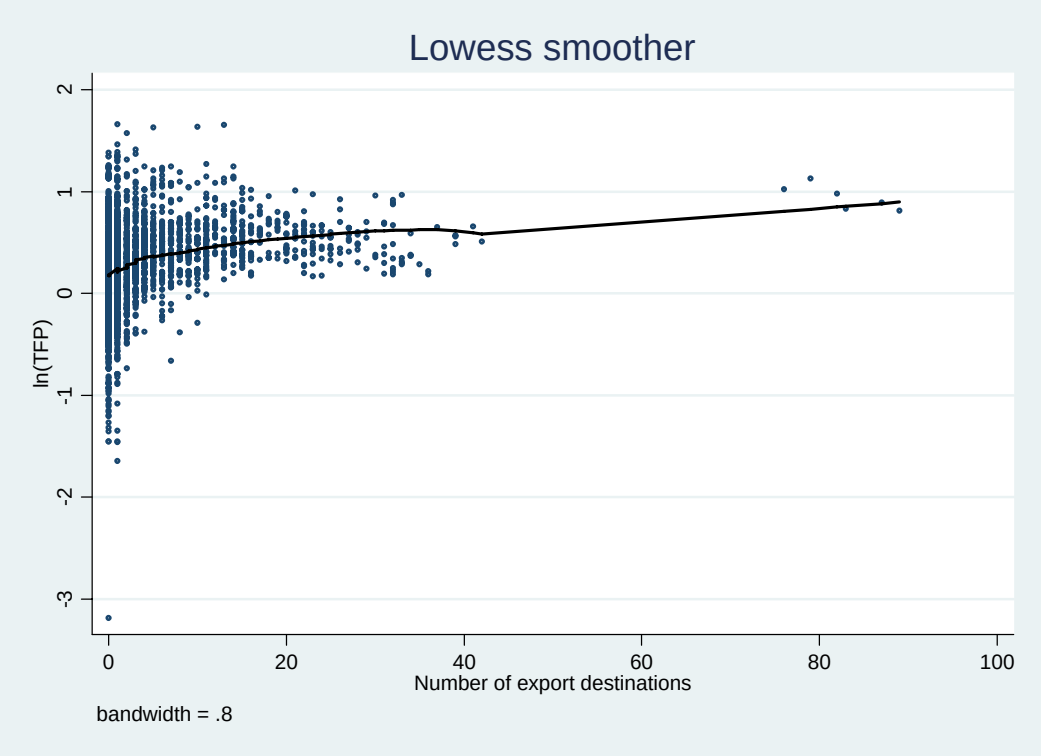


Figure 3: *Number of firms in a market vs the average number of export destinations of the firms in a market, 2002*

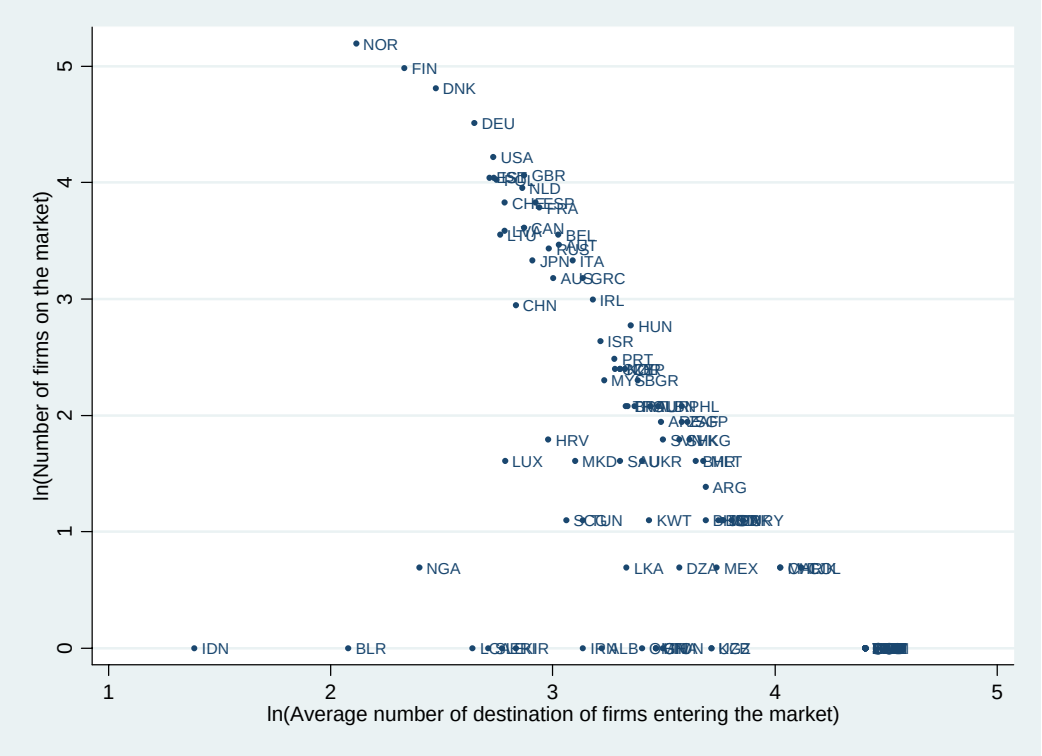
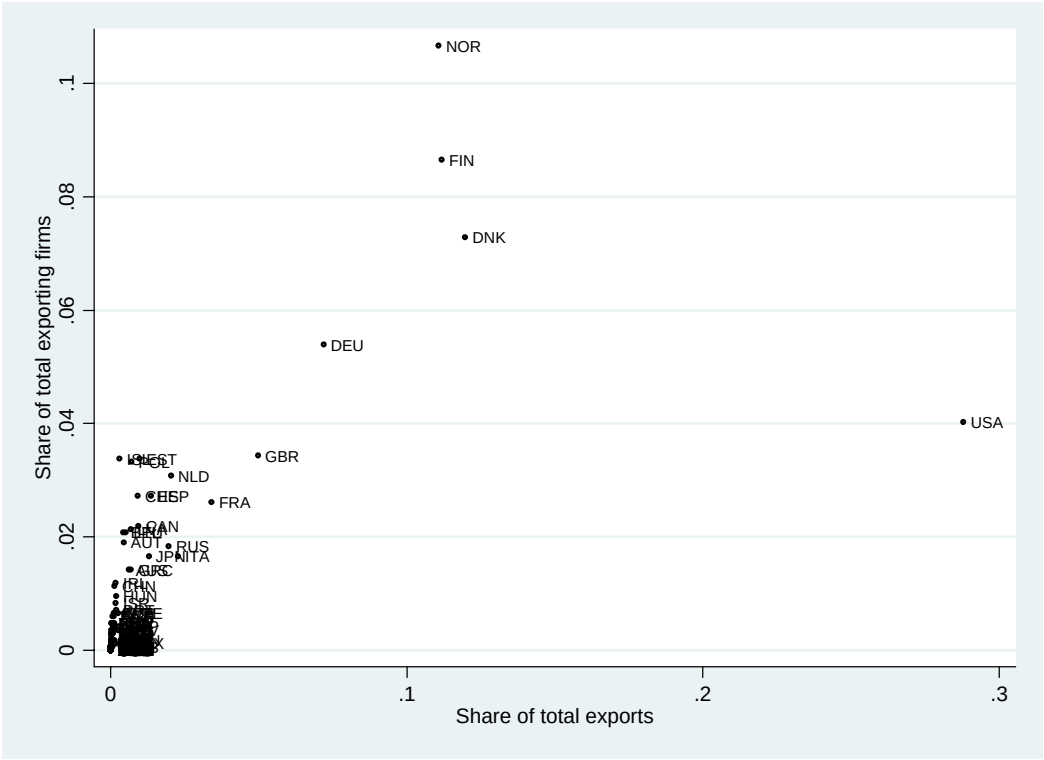


Figure 4: *Share of total number of exporting firms vs share of total exports, 2002*


NOR
FIN
DNK
DEU
USA
GBR
NLD
FRA
RUS
Share of total exporting firms
0
.02
.04
.06
.08
.1
0
.1
.2
.3
Share of total exports