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Exports versus FDI: An Empirical Test

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Exports versus FDI: An Empirical Test

Sourafel Girma, Richard Kneller and Mauro Pisu

Abstract: In a recent paper Helpman, Melitz and Yeaple (2002) argue firm heterogeneity leads to self-selection in the structure of international commerce. Only the most productive firms find it profitable to meet the higher costs associated with FDI; the next set of firms find it profitable to serve foreign markets through exporting; while the least productive firms find it profitable to serve only domestic markets. The paper tests this conclusion using the concept of stochastic dominance. Robust support is found for the model, the productivity distribution of multinational firms dominates that of export firms, which in turn dominates that of non-exporters.

Keywords: Exports, Foreign direct investment, Productivity.

JEL classifications: D24, F14, F23.

Outline

1. *Introduction*
2. *The productivity of multinationals and exporting firms*
3. *Empirical methodology, description of the data base and construction of TFP*
4. *Results*
5. *Conclusions*

Non-Technical Summary:

Two stylised features of markets are the co-existence of firms with different levels of productivity within the same industry and the co-existence of firms that serve just the domestic market with firms that serve both domestic market and foreign markets (either by exporting or as a multinational). Helpman, Melitz and Yeaple (2002) argue these two stylised facts are related; firm heterogeneity leads to self-selection in the structure of international commerce. Only the most productive firms find it profitable to meet the higher costs associated with FDI; the next set of firms find it profitable to serve foreign markets through exporting; while the least productive firms find it profitable to serve only the domestic market. This paper tests this prediction.

The relationship between firm heterogeneity and international trade is a novel feature of the heterogeneous-firm models. This paper can therefore also be viewed as a test of the heterogeneous-firm model against alternatives such as the representative firm model. The HMY theoretical framework predicts a strict relationship between the productivity of a firm and their type of involvement in the international commerce however. Firms with productivity above a given cut-off value enter exports markets or become multinational with certainty. The productivity level of *all* multinational firms must therefore be greater than that of *all* exporting firms, which in turn must be greater than that of *all* non-exporting firms. In this paper we consider a variation of the model in which the productivity distribution of multinational firms lies to the right of domestically owned export firms and non-export firms, but for a given level of productivity there may be firms that choose not to export or become multinational. This difference in the outcome might be explained by uncertainty surrounding the fixed costs of entering export markets or undertaking FDI.

This paper provides, as far as we are aware, the first complete test of the relationship between international trade and firm level productivity as implied by the HMY model, although partial tests can be found elsewhere. For example, a number of studies have previously established that the mean level of productivity in export firms is higher than that of non-export firms, while others have tested whether multinational firms have higher productivity than domestically owned firms. The empirical analysis performed in this paper uses the Kolmogrov-Smirnov test of stochastic dominance.

We find in this paper strong support for the heterogeneous firm model. There is clear support for the ordering of productivity levels according to the type of commerce. The productivity distribution of multinational firms lies to the right of that of exporting firms, which in turn is to the right of that of non-exporting enterprises. The same ordering of firms is also found to exist when we replace domestic multinational firms with foreign multinational firms. Evidence is also established to suggest these differences are permanent since there are no significant dissimilarities in the growth rate of productivity across firms.

1. Introduction

Two stylised features of markets are, the co-existence of firms with heterogeneous levels of productivity within the same industry (Haltiwanger, 1997; Foster, Haltiwanger & Krizan, 1998) and the co-existence of firms that serve just the domestic market with firms that serve both domestic market and foreign markets (either by exporting or as a multinational). Helpman, Melitz & Yeaple (2002) (hereafter HMY) argue these two stylised facts are related; firm heterogeneity leads to self-selection in the structure of international commerce.[1] Only the most productive firms within an economy find it profitable to meet the higher costs associated with FDI; the next set of firms find it profitable to serve foreign markets through exporting; while the least productive firms find it profitable to serve only the domestic market. This paper tests the conclusion that firm heterogeneity determines the structure of international commerce.

The relationship between firm heterogeneity and international trade is a novel feature of the heterogeneous-firm class of models. This paper can therefore also be viewed as a test of the heterogeneous-firm model against alternatives such as the representative firm model. Representative firm models, for example new trade theory models (Helpman & Krugman, 1985), while accounting for increasing returns to scale, imperfect competition and product differentiation in the same way as HMY, yield knife-edge solutions. Exogenous industry characteristics lead all firms to either serve foreign markets (as well as domestic markets) or not to do so and when they do this is achieved through foreign direct investment or export.[2] Thus, these models, contrary to the class of heterogeneous firm model, do not allow for the co-existence of firms involved in the international trade in different fashion (except for the knife edge points).

The HMY theoretical framework predicts a strict relationship between the productivity of a firm and their type of involvement in the international commerce. Firms with productivity above a given cut-off value enter exports markets or become multinational with certainty. The productivity level of *all* multinational firms must therefore be greater than that of *all* exporting firms, which in turn must be greater than that of *all* non-exporting firms. In this

paper we consider a variation of the model in which the productivity distribution of multinational firms lies to the right of domestically owned export firms and non-export firms, but for a given level of productivity there may be firms that choose not to export or become multinational. This modification allows the model to conform better to reality. This difference in the outcome might be explained by shocks to the level of productivity or uncertainty surrounding the parameters of the model (for example the fixed costs of entering export markets, undertaking FDI or the productivity level of the firm).

This paper provides, as far as we are aware, the first complete test of the relationship between international trade and firm level productivity as implied by the HMY model, although partial tests can be found elsewhere. For example, a number of studies have previously established that the mean level of productivity in export firms is higher than that of non-export firms (e.g.: Aw & Hwang 1995; Bernard & Wagner 1997; Clerides, Lach & Tybout 1998; Bernard & Jensen 1999; Kray 1999; Castellani 2001; Girma, Greenaway & Kneller, 2003). Indeed this result is robust to differences in the sample country and statistical methodology. While others have previously investigated whether multinational firms have higher mean productivity than domestically owned firms (e.g.: Girma, Greenaway & Wakelin 1999; Conyon *et al* 2002). These tests are partial in the sense that they consider only one part of the possible relationship between productivity and international commerce and do so by only comparing differences in the mean. Delgado *et al*. (2001) are an exception, although again they deal only with differences between exporters and non-exporters.

The empirical analysis performed in this paper test for differences in all moments of the distribution using the Kolmogrov-Smirnov test of stochastic dominance. Establishing stochastic dominance implies that one cumulative distribution lies to the right of another, in the same way as that implied by the HMY theory for productivity and the structure of commerce.

We find in this paper strong support for the heterogeneous firm model. There is clear support for the ordering of productivity levels according to the type of commerce. The cumulative productivity distribution of multinational firms lies to the right of that of

exporting firms, which in turn is to the right of that of non-exporting enterprises. The same ordering of firms is also found to exist when we replace domestic multinational firms with foreign multinational firms. Evidence is also established to suggest these differences are permanent since there are no significant dissimilarities in the growth rate of productivity across firms. Finally we investigate whether firms that transit between states, for example they become exporters or multinationals (through brownfield FDI), are different from other firms in the pre-entry period. It appears they are not, the cumulative productivity of new-exporters does not stochastically dominate that of non-exporters, while there is some weak evidence that the cumulative productivity distribution of domestic companies recently acquired by foreign ones dominates that of other domestically owned export firms.

The rest of the paper is organised as follows. In section 2 the theoretical underpinnings of the following empirical analysis are elucidated. Section 3 contains a description of the empirical approach used, the database and the methodology employed to compute TFP. The results are discussed in Section 4. Finally section 5 concludes.

2. The productivity of multinationals and exporting firms

In this section of the paper we provide a brief description of the HMY model, in so doing we draw heavily on that paper. The properties of the model of interest are generated through the assumptions of different costs (largely fixed costs) associated with serving the domestic market, and serving foreign markets (through FDI or exports), along with heterogeneity in the level of productivity across firms. Before a firm can enter the industry it pays a fixed cost f_E. Upon entry it receives a level of labour productivity a drawn from a known distribution $G(a)$. Using its knowledge about the level of labour productivity the firm chooses whether to serve the domestic market only, in which case it bears the fixed cost f_D, or to bear additional costs and serve foreign markets also.

If the firm chooses to serve foreign markets it has the choice over whether to do so through exporting or through FDI. This is known as the proximity-concentration trade off. Exporting incurs both fixed and variable costs, while FDI incurs only additional fixed costs.

The fixed costs of exporting are labelled f_X, while f_I represents the additional fixed costs associated with setting up a foreign subsidiary. The fixed costs of FDI are assumed to be greater than those of exporting, i.e. $f_I > f_X$. The sunk-costs of exporting are typically thought to include the fixed costs of research into product compliance, distribution networks, advertising *etc*. The fixed costs of FDI are the duplication of costs in f_D as well as the building of new production facilities or acquisition of an existing firm. Goods that are exported are also subject to transportation costs, modelled as melting iceberg transport costs τ_{ij}, where *i* indexes the domestic country and *j* the foreign country. FDI therefore eliminates the variable transport costs of exporting, but involves higher fixed costs.

After entry firms engage in monopolistic competition. The demand side of the model is assumed to be of a form such that there is a demand function $A^i p^{-\varepsilon}$ for every brand of the product and the brand of a producer with labour coefficient *a* is offered for sale at a price $p=a/\alpha$, where $1/\alpha$ represents the mark-up factor. The level of profits (π), associated with serving only the domestic market, exporting or setting a foreign subsidiary are then given by the following expressions.

(domestic market only) $$\pi_D^i = a^{1-\varepsilon}\frac{(1-\alpha)A^i}{\alpha^{1-\varepsilon}} - f_D$$

(exporting) $$\pi_X^{ij} = (\tau^{ij}a)^{1-\varepsilon}\frac{(1-\alpha)A^j}{\alpha^{1-\varepsilon}} - f_X$$

(FDI) $$\pi_I^j = a^{1-\varepsilon}\frac{(1-\alpha)A^j}{\alpha^{1-\varepsilon}} - f_I$$

These expressions confirm that the profitability of each of these activities is increasing in the productivity of the firm. The slope of these lines are such that the level of profit a firm receives from each of these forms of commerce also differs according to the productivity level of that firm. Firms with productivity below $(a_D^i)^{1-\varepsilon}$ choose not to enter the domestic market, while firms with productivity between $(a_D^i)^{1-\varepsilon}$ and $(a_X^{ij})^{1-\varepsilon}$ make positive profits from serving the domestic market, but would make negative profits if they chose to serve foreign markets. Firms with productivity between $(a_X^{ij})^{1-\varepsilon}$ and $(a_I^{ij})^{1-\varepsilon}$ make positive profit from serving the domestic market and from exporting, but not FDI, and therefore serve foreign markets by the former two only. Finally, firms with productivity levels above

$(a_I^{ij})^{1-\varepsilon}$ can make positive profits from either exporting or FDI, but profits are greater if they choose to undertake FDI. Firms above this level therefore serve domestic markets and serve foreign markets through foreign subsidiaries.

For the case of symmetry in the level of fixed costs and the productivity distribution *G(.)* HMY produce a useful diagram that summarises the predictions regarding productivity and international commerce.

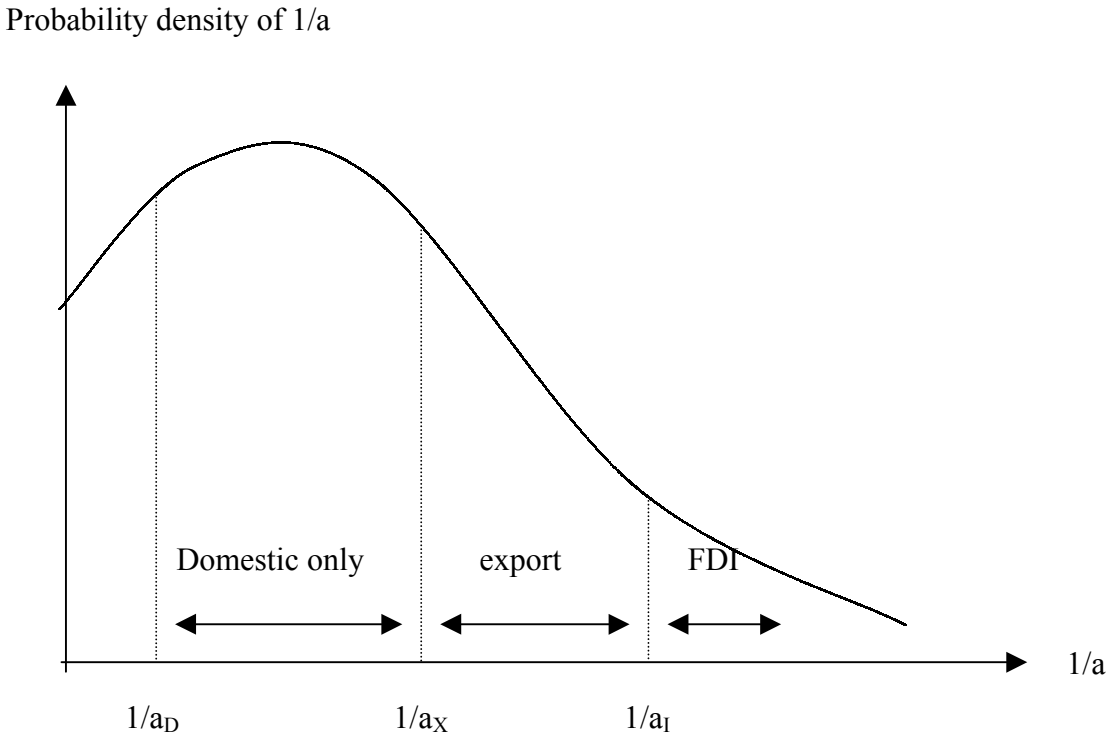


Figure 1: Probability density of productivity

Figure 1 suggests that firms with a productivity level to the right of a given cut-off point must strictly be more productive than all firms to the left of the same cut-off point. While this is a feature of the model as it is presented there are a number of reasons why we might not expect this to hold in reality. Firstly, within the model the productivity level of the firm is fixed across time. If instead the productivity of the firm is subject to random shocks then the fixed costs associated with entry and exit may result in the firm choosing to enter or not, or exit or not foreign markets in a given period. Similarly there may be uncertainty surrounding the parameters of the model. For example, firms may be uncertain about the fixed costs of entering export markets or undertaking FDI. Similarly, the firm may be un-

sure of its own productivity level. Finally, the fixed costs of exporting and FDI as well as the distribution from which productivity is drawn are unlikely to be symmetric across countries.[3] One possible representation of such a model that has parallels with Figure 1 is given by Figure 2.

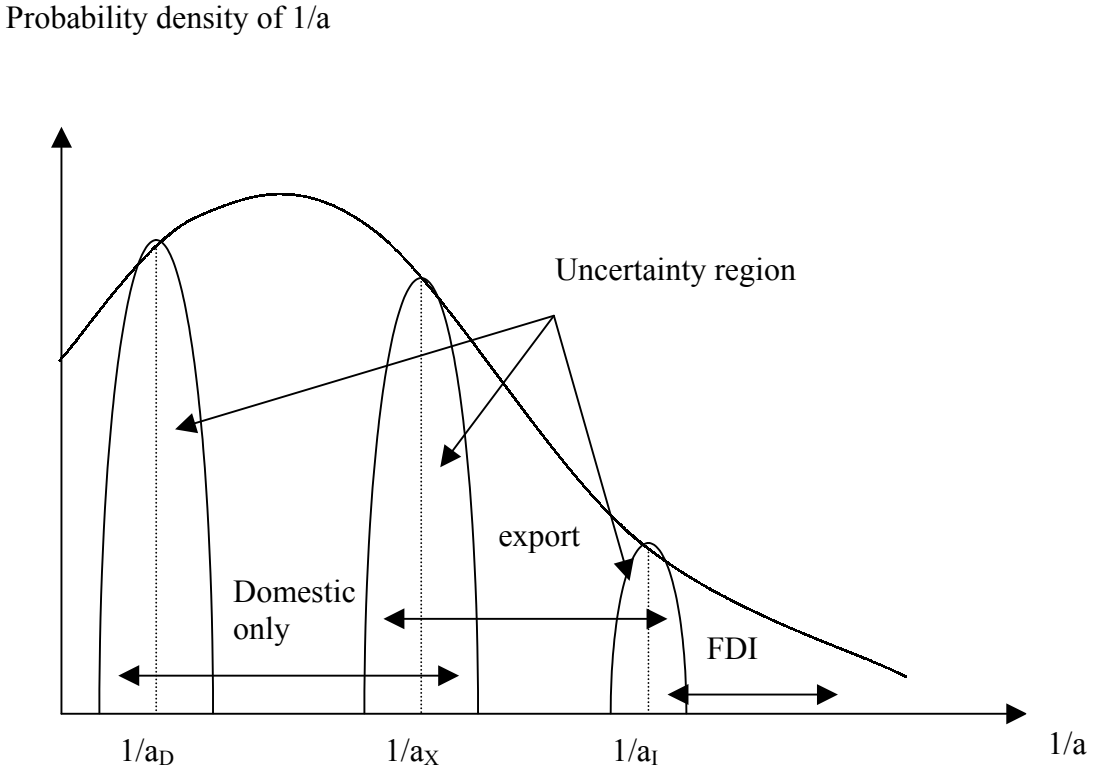


Figure 2: Probability density of productivity

In the above exhibit, the cut-off points have been substituted by uncertainty areas. In these zones the relationship between productivity and international trade is not so deterministic as in graph 1. For instance in the left uncertainty region it is likely to observe firms exiting the market having around the same productivity as those deciding to sell in the domestic market only. By the same token in the right uncertainty area there could be some exporting firms as much productive as multinationals.

On the contrary, graph 1 rules out these cases. In fact, the multinational enterprise with the lowest productivity level must be more productive than the exporter with the highest

productivity level. Similarly, the least productive business must have a higher productivity level than the most productive firm choosing to exit the market. Therefore, the relation between productivity and international commerce implied by graph 1 could be tested by simply comparing the productivity of the marginal firms, but this is likely to be violated by the data.

Hence, graph 2 is probably a more apt representation of the actual connection between productivity level and international trade. Indeed, notwithstanding the absence of cut-off points it is still possible to deduce the existence of a precise ordering of the productivity distribution among the different type of enterprises. Hence a possible way to test this is comparing the cumulative productivity distribution function of firms of different kind.

3. Empirical methodology, description of the data base and construction of TFP

Empirical methodology

To test the HMY model we adopt the nonparametric one-sided and two-sided Kolmogorov-Smirnov tests (e.g. Conover, 1999; Sprent 1989). These tests rank the productivity distributions using the concept of stochastic dominance. Establishing stochastic dominance requires that the productivity distributions of firms within the three types of international commerce differ across all moments of the distribution. It therefore provides a stricter test of the model than simply comparing mean levels of productivity. In the context of this paper these tests encompass the possibility that firms of the same productivity level may choose different forms of commerce around a given cut-off point, but restrict the test such that there must be statistically robust differences between the distributions. That is, the degree of uncertainty in behaviour or the size of random shocks cannot be too large that the structure of commerce and firm heterogeneity are no longer meaningfully related.

To perform this test we define two cumulative distribution functions F and G. G corresponds to the group of interest, for example domestically owned permanent exporters,

and F the comparison group, for example UK multinationals. First-order stochastic dominance of F with respect to G is defined as: $F(z) - G(z) \leq 0$ uniformly in $z \in \Re$, with strict inequality for some z. The two-sided Kolmogorov-Smirnov statistics tests the hypothesis that both distributions are identical, and the null and alternative hypotheses can be expressed as:

$$H_0 : F(z) - G(z) = 0 \ \forall z \in \Re \text{ vs. } H_1 : F(z) - G(z) \neq 0 \text{ for some } z \in \Re . \qquad (2)$$

By contrast, the one-sided test of stochastic dominance of *F(z)* with respect to *G(z)* can be formulated as :

$$H_0 : F(z) - G(z) \leq 0 \ \forall z \in \Re \text{ vs. } H_1 : F(z) - G(z) > 0 \text{ for some } z \in \Re . \qquad (3)$$

For the two-sided test, for example, the Kolmogorov-Smirnov statistics is given by $KS = \sqrt{\frac{n.m}{N}} \max_{1 \leq i \leq N} \left| F_n(z_i) - G_m(z_i) \right|$, where n and m are the sample sizes from the empirical distributions of F and G respectively, and $N = n+m$. Rejection of the null hypothesis in (2) and not rejection of the null in (3) imply that the distribution of F is to right of G. In this case, F is said to stochastically dominate G.

Data sources and construction of variables

The data used in the paper is from the *OneSource* data base. *OneSource* is one of the few UK firm level data sets to contain information on the export status of the firm. It includes information on all public limited companies, all companies with employees greater than 50, and the top companies based on turnover, net worth, total assets, or shareholders funds (whichever is largest) up to a maximum of 110,000 companies. Companies that are dissolved or in the process of liquidation are excluded[4]. In this paper we concentrate on manufacturing firms from this data source.

OneSource provides information on employment, physical capital, output and cost of goods sold in a consistent way both across firms and across time. The data were screened to select those firms for which there are a complete set of information about the value of output,

factors of production and export. This left a total sample of 31,486 observations containing information of some 5,332 firms, of which more than 50% were observed for 5 or more years. Nominal aggregates were deflated using 5 digit level industry deflators.

OneSource does not provide any information on the multinational activity of U.K-owned firms. For this reason we have matched it with information on ownership structure of European companies provided by Who Owns Whom[5], and a list of U.K firms that made foreign acquisitions, compiled from various issues of *Acquisitions Monthly.* The UK-owned multinational indicator is for 1996 only. This was extended backward for all the previous years. It is worth noting that the performed backward linkage works against the hypothesis under scrutiny.

Domestic firms are split into three types; domestically owned firms that export in all years of the sample (labelled domestic permanent exporters - DPE); domestically owned firms that do not export during the sample period (labelled domestic never exporters - DNE); and UK multinational firms (UKMNE).

Levels and growth rates of TFP were constructed using the index number (i.e. non-parametric) approach (e.g.: Caves, *et al,* 1982a; Good *et al*, 1997) and previously employed among others by Aw *et al* (2000) and Delgado *et al* (2001). The principle advantage of using this methodology over alternatives, such as the econometric estimation of the production function, is that it allows to make transitive multilateral comparisons of productivity growth rates and levels between firms. Further information on the construction of the index employed can be found in the Appendix.

4. Results

Tests of Stochastic Dominance

In Table 1 we report the results of the comparison of the cumulative productivity distributions of TFP levels for combination of these sets of firms. The results are reported on a cross-section by cross-section basis. We adopt this approach firstly because the limiting distribution of the Kolmogorov-Smirnov statistics is only known under independence of observations. Secondly, we might reasonably expect the sunk-costs associated with exporting and FDI to change across time as a result of policy changes, such as the tax treatment of multinationals, as well as cross-time changes in the exchange rate and reductions in transport costs. Finally, it overcomes problems associated with the observed transition of firms between groups, for example starting to export. We consider the productivity distribution of these transition firms further below.

The findings for export firms and domestic multinationals relative to firms that do not export match those from the previous literature. The productivity distributions of exporters and multinational firms both dominate that of non-exporters. In all of the comparison years the cumulative productivity distribution of exporting firms and domestic multinationals is found to lie to the right of non-exporting firms and these differences are statistically significant in 7 and 6 (out of 7) of the comparison time periods respectively. In Figure 3 we provide a graphical example of the productivity distributions of domestic export firms and UKMNE for 1992. Even with relatively small sample sizes available a clear difference in the position of the cumulative productivity distribution is evident from this graph.

The cumulative productivity distribution of domestic multinational firms is also found to lie to the right of firms that export in every year of the sample period. The productivity distribution of UKMNE's dominates that of exporters. These differences are significant in 6 of the 7 years considered, with the differences most significant in the later years of the sample period. This relationship has not previously been investigated in the literature.

While in Table 1 there is clear support for the modified HMY model we investigate more closely the failure to accept stochastic dominance in the first year of the sample period, viz. 1990. Figure 4 exhibit the graphs of the productivity level comparison for this year. There is evidence from these graphs that in two of the three cases the ordering of productivity distributions is as expected, specifically the cumulative distribution of UKMNE lies to the

right of that of DPE and DNE. This is confirmed by a simple t-test for difference in means. The null of no difference in the mean of the two distributions is rejected for UK multinationals versus exporters (p-value 0.015) and UK multinationals versus non-exporters (p-value 0.008) but not between exporters and non-exporters (p-value 0.276). While this may suggest some caution in the complete acceptance of the heterogeneous firm assumption the relatively low number of observations available could provide one possible explanation for the lack of statistical significance in Table 1. [6]

As an extension of the results just discussed and in order to increase the size of the sample we employ information on foreign multinationals from the *OneSource* database. Symmetry within the model implies that foreign multinational firms operate within each industry and that these firms have productivity levels akin to those of domestic multinationals. *OneSource* contains information of foreign-ownership for the latest year only, so to track the dynamics of ownership we matched the population of manufacturing firms to a list of U.K. firms acquired by foreign multinationals[7]. Foreign multinational firms are labelled *FOR* in the tables.

Here we again receive strong, but not complete support, for the HMY model. The productivity distributions of *FOR* dominate those of both *DPE* and *DNE* in Table 2. In all of the comparison years the cumulative productivity distribution of foreign firms is found to lie to the right of domestically owned firms. These differences are statistically significant in all years for the *FOR v DNE* comparison and in 6 (out of 7) of the time periods for the *FOR v DPE* comparison. The year in which this test fails is 1991.

To assess whether or not these productivity level discrepancies are persistent over time we have tested for stochastic dominance for the annual growth rate of TFP and the results are shown in table 3. The HMY (2002) model assumes that once the productivity of the firm is drawn from the productivity distribution there is no time variation in its value. These suggest that differences in the productivity distribution across firms in Table 1 should be long-run phenomenon. The convergence literature, in contrast, suggests that technology transfer across firm over time should lead to convergence of productivity levels. The greater the size of the technological gap then the faster the rate of growth will be in a given

period. Given the ordering of productivity levels in Table 1 we would expect, if absolute convergence holds, that the distribution of the annual growth rate of TFP of non-exporters should lies to the right of that of exporting firms, which should in turn dominates that of domestic multinationals.[8]

We find from Table 3 however that the differences in the level of productivity evident from Table 1 are persistent across time, convergence does not seem to be occurring. While there are differences in the growth rate amongst the three types of firm considered these differences are never significant. This result confirms evidence against convergence in the manufacturing sector by (Bernard & Jones, 1996; Carree et al., 2000; Togo, 2000).

Overall we conclude that the cumulative productivity distribution of permanent exporters dominates that of never exporters, while the cumulative productivity distribution of domestic multinationals dominates that of other domestic firms, irrespective of their export status. The results from the tests of stochastic dominance between foreign owned firms and domestically owned exporters suggest a specific ordering of the productivity distributions and confirm the prediction of the HMY (2002) model with this respect. Productivity heterogeneity at firm level is associated with the structure of international trade.

New exporters and recent foreign acquisitions

Within the data set there are a number of firms that transit from states of commerce. The possibility of the transition of firms is allowed in the model only if there is a change in the level of fixed costs and cannot explain the simultaneous movement of firms in both directions. An interesting question that arises out of the results in Table 1 is whether these firms display significantly different productivity characteristics in the period before the change in export status takes place. That is, are these firms the marginal firms with the highest/lowest productivity levels?

We provide some evidence on this point. In Table 4 we compare the distribution of productivity levels of first-time exporters with domestically owned firms that never export

in the period before they start exporting. Unfortunately we do not have data on UK multinational firms in the period before they become multinational and so we use instead information on firms before they are acquired by foreign multinationals (brownfield FDI).

From Table 4 there is no evidence that the productivity distribution of first time exporters stochastically dominates that of firms that never export. While positive the test of differences in the distribution is not significant in any years of the sample. The evidence that the cumulative productivity distribution of newly acquired foreign firms stochastically dominates that of domestic export firms is while also, suggestive, not overwhelming. Again the cumulative productivity distribution of domestic firms acquired by foreign firms lies to the right of their domestic non-acquisition counterparts. Statistical significance is established in if 3 of the 6 years between new foreign acquisitions and domestically owned permanent exporting companies. Therefore while there is some weak evidence for self-selection for new (foreign) multinational firms the evidence in the case of export firms is weaker. This is perhaps one area that requires further empirical research before strong conclusions are drawn.

4. Conclusion

Recently developed theoretical models (e.g.: Bernard, Eaton, Jensen and Kortum (2001); Melitz (2002); Yeaple (2002); Helpman, Melitz and Yeaple (2002)) link the heterogeneous productivity level of firms with their involvement in the international trade. The aim of this paper was to provide (to the authors' knowledge) the first complete test of this association, taking as a reference the model of Helpman *et al* (2002). This model predicts that multinational enterprises are the most productive type of business followed, in order, by domestic exporting firms and domestic non-exporting companies. Furthermore, these differences do not regard only the productivity mean, but the entire cumulative productivity distribution; the productivity distribution of multinationals lies to the right of that of exporters, which in turn, is to the right of that of non-exporting firms.

Tests regarding the connection between international trade and productivity have already appeared in the literature. Nevertheless, these tests are partial in two ways. Firstly they have dealt, on one hand, with exporting and non-exporting firms (e.g.: Aw & Hwang 1995;

Bernard & Wagner 1997; Clerides, Lach & Tybout 1998; Bernard & Jensen 1999; Kray 1999; Castellani 2001; Girma, Greenaway & Kneller, 2003), and, on the other hand, with multinational and non-multinational enterprises (e.g.: Girma, Greenaway & Wakelin 1999; Conyon *et al* 2002). Non of them, as far as we are aware, has compared multinationals and exporting firms. Secondly, they have been concerned with detecting dissimilarities in the mean of productivity and not across the entire distributions; the only notably exception is Delgado *et al* (2001) who compared the productivity distribution of exporters and non-exporters.

Therefore, for the purpose of this paper the concept of stochastic dominance between cumulative distribution was employed using the non-parametric Kolmogorov-Smirnov test. This is an important feature of the present paper owing to the fact that it permits to test for productivity differences across their entire cumulative distributions as the Helpman *et al* (2002) model predicts.

UK firm level data for the 1990-1996 period were used. The findings of this investigation clearly support the theoretical insights of the model under examination. In so doing we provide a clear acceptance of the heterogeneous firm framework over alternatives such as those using the idea of a representative firm. The cumulative productivity level distribution of multinational enterprises was found to dominate (i.e. lies to the right of) that of non-multinationals, while that of exporters dominates the one of non-exporters.

In addition, the comparison of the distribution of productivity growth rates suggest there is not any significant dissimilitude among the three type of firms, with this respect. These same patterns were found to hold when domestic multinational firms were replaced with information on foreign multinationals.

These results lead us to believe, as the Helpman *et al* (2002) model predicts, that only the most productive companies find profitable to pay the higher costs associated to export and to build/acquire production facilities abroad. While this study has taken a step further in

the direction of examining the relationship between firms level productivity and international trade it is possible that the results obtained are specific to the database used or the country considered. We fell it would therefore beneficial to investigate the same assumption for different countries and time periods.

Table 1: Kolmogorov-Smirnov tests on the distribution of the productivity levels of UK multinational enterprises (UKMNE), domestic permanent exporting (DPE) and domestic never exporting (DNE) firms.

Year	Numb. of Observations			DNE v DPE			DNE v UKMNE			DPE v UKMNE		
	DNE	DPE	UKMNE	Equality of distributions	Difference favourable to		Equality of distributions	Difference favourable to		Equality of distributions	Difference favourable to	
					DNE	DPE		DNE	UKMNE		DPE	UKMNE
1990	169	1135	116	0.1023 (0.076)	0.1023 * (0.046)	-0.0082 (0.981)	0.1149 (0.275)	0.1149 (0.163)	-0.0030 (0.999)	0.0894 (0.325)	0.0637 (0.425)	-0.0894 (0.186)
1991	225	1341	130	0.1122* (0.012)	0.1122 ** (0.008)	-0.0088 (0.971)	0.2009** (0.002)	0.2009 ** (0.001)	-0.0137 (0.970)	0.1176 (0.060)	0.1176* (0.038)	-0.0275 (0.836)

1992	267	1420	149	0.1412** (0.000)	0.1412** (0.000)	-0.0111 (0.946)	0.2223** (0.000)	0.2223** (0.000)	-0.0128 (0.969)	0.1297* (0.016)	0.1297* (0.011)	-0.0145 (0.945)
1993	322	1465	164	0.1246** (0.000)	0.1246** (0.000)	-0.0055 (0.984)	0.2423** (0.000)	0.2423** (0.000)	-0.0000 (1.000)	0.1444** (0.003)	0.1444** (0.002)	-0.0021 (0.999)
1994	318	1445	177	0.1041** (0.006)	0.1041** (0.004)	-0.0060 (0.981)	0.2230** (0.000)	0.2230** (0.000)	-0.0070 (0.989)	0.1268** (0.010)	0.1268** (0.006)	-0.0076 (0.982)
1995	340	1435	175	0.1233** (0.000)	0.1233** (0.000)	-0.0236 (0.736)	0.1976** (0.000)	0.1976** (0.000)	-0.0119 (0.968)	0.1351** (0.005)	0.1351** (0.003)	-0.0139 (0.941)

1996	277	1341	185	0.0883* (0.047)	0.0883* (0.028)	-0.0116 (0.940)	0.1816** (0.001)	0.1816** (0.001)	-0.0126 (0.965)	0.1095* (0.033)	0.1095* (0.020)	-0.0149 (0.930)

Note:

(i) Aymptotic P-values are within parentheses

(ii) * Significant at 5% confidence interval

(iii) ** Significant at 1% confidence interval

Figure3: Productivity levels differences between DPE and UKMNE in 1992

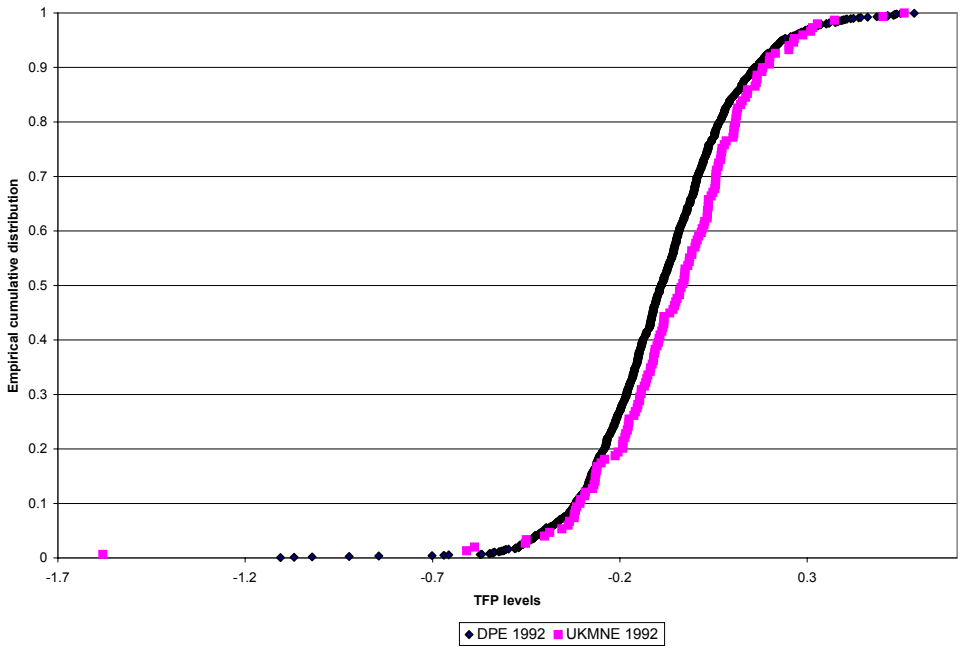
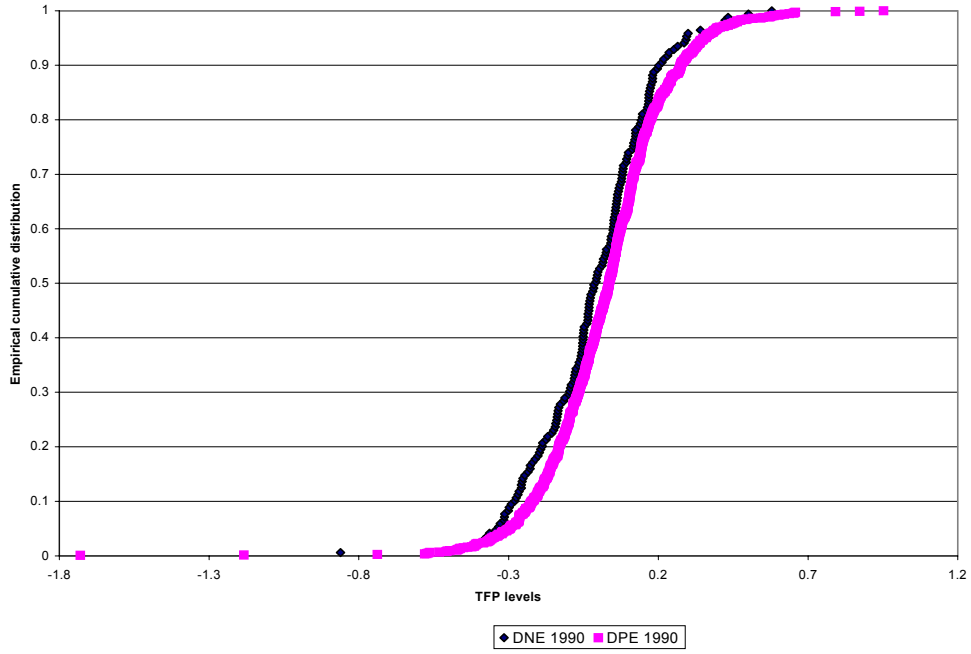
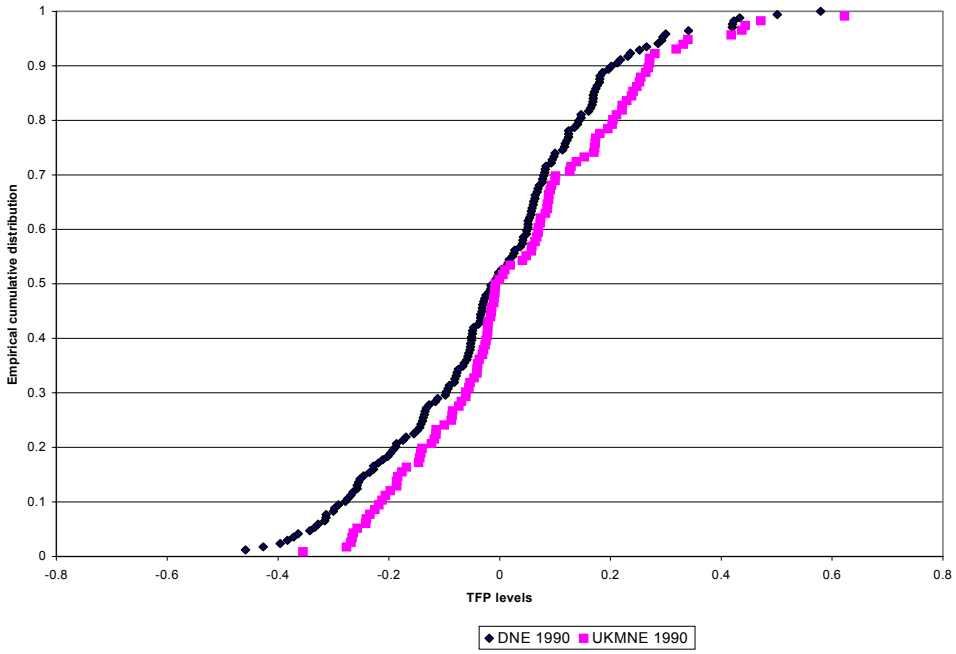


Figure 4: Productivity levels differences between DPE and DNE in 1990 (part a), UKME and DNE in 1990 (part b), UMNE and DPE in 1990 (part c)

(a)



(b)


Empirical cumulative distribution
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
TFP levels
DNE 1990
UKMNE 1990

(c)

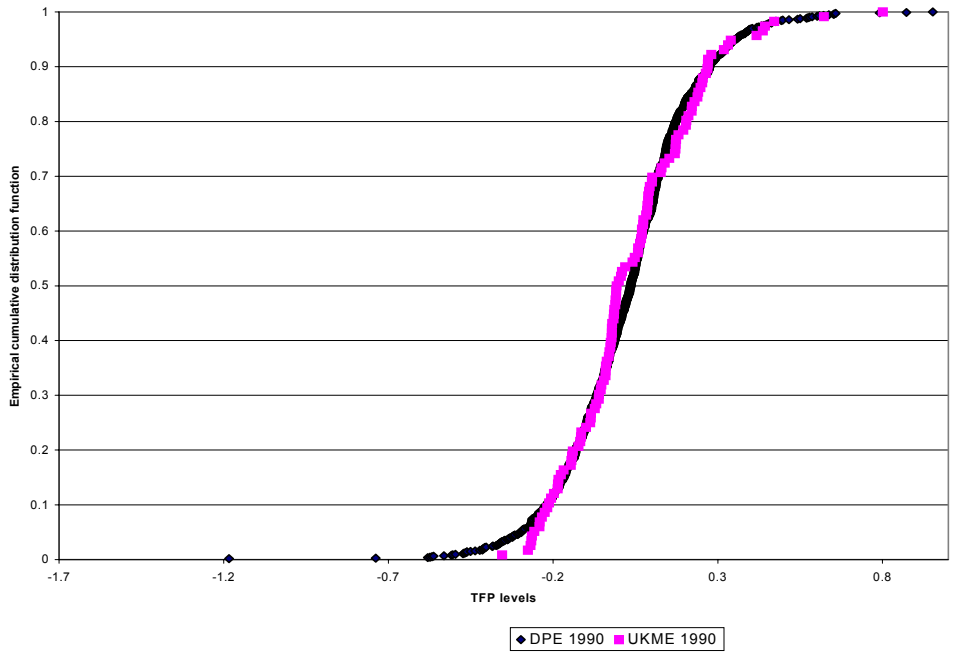

Empirical cumulative distribution function
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1.7
-1.2
-0.7
-0.2
0.3
0.8
TFP levels
DPE 1990
UKME 1990

Table 2: Kolmogorov-Smirnov tests on the distribution of the productivity level of foreign firms (FOR), domestically owned permanent exporters (DPE) and domestically owned never exporting (DNE) firms.

Year	Numb. of Observations			DNE v FOR			DPE v FOR		
	DNE	DPE	FOR	Equality of distributions	Difference favourable to		Equality of distributions	Difference favourable to	
					DNE	FOR		DPE	FOR
1990	233	1304	834	0.1482** (0.005)	0.1482** (0.004)	-0.0141 (0.950)	0.0769* (0.022)	0.0769* (0.013)	-0.0237 (0.659)
1991	288	1407	978	0.1465** (0.001)	0.1465** (0.001)	-0.0178 (0.896)	0.0467 (0.201)	0.0467 (0.109)	-0.0285 (0.438)
1992	350	1486	1093	0.2040** (0.000)	0.2040** (0.000)	-0.0151 (0.911)	0.0864** (0.000)	0.0864** (0.000)	-0.0061 (0.959)
1993	340	1550	1109	0.1606** (0.000)	0.1606** (0.000)	-0.0009 (1.000)	0.0811** (0.000)	0.0811** (0.000)	-0.0061 (0.955)
1994	361	1591	1158	0.1620** (0.000)	0.1620** (0.000)	-0.0054 (0.986)	0.0786** (0.001)	0.0786** (0.000)	-0.0103 (0.872)
1995	374	1681	1181	0.2024** (0.000)	0.2024** (0.000)	-0.0106 (0.942)	0.0926** (0.000)	0.0926** (0.000)	-0.0178 (0.659)

1996	610	1623	687	0.1565** (0.000)	0.1565** (0.000)	-0.0138 (0.926)	0.0756** (0.008)	0.0756** (0.005)	-0.0076 (0.948)

Note:

(i) P-values are within parentheses

(ii) * Significant at 5% confidence interval

(iii) ** Significant at 1% confidence interval

(iv) DPE and DEE are domestic firms that have never been acquired by foreign companies in our sample.

Table 3: Kolmogorov-Smirnov tests on the distribution of the productivity growth rate of UK multinational enterprises (UKMNE), domestically owned permanent exporters (DPE) and domestically owned never exporting (DNE) firms.

Year	Numb. of Observations			DNE v UKMNE			DNE v DPE			DPE v UKMNE		
	DNE	DPE	UKMNE	Equality of distributions	Difference favourable to		Equality of distributions	Difference favourable to		Equality of distributions	Difference favourable to	
					DNE	DPE		DNE	DPE		DPE	UKMNE
1990	169	1135	116	0.0721 (0.622)	0.0494 (0.610)	-0.0721 (0.348)	0.0885 (0.807)	0.0885 (0.473)	-0.0824 (0.523)	0.1008 (0.388)	0.1008 (0.224)	-0.0491 (0.702)
1991	225	1341	130	0.0819 (0.296)	0.0733 (0.240)	-0.0819 (0.168)	0.1101 (0.357)	0.1101 (0.208)	-0.0278 (0.905)	0.0880 (0.360)	0.0880 (0.205)	-0.0327 (0.804)
1992	267	1420	149	0.0427 (0.892)	0.0385 (0.596)	-0.0427 (0.530)	0.0825 (0.610)	0.0825 (0.344)	-0.0478 (0.699)	0.0622 (0.721)	0.0622 (0.406)	-0.0537 (0.511)
1993	322	1465	164	0.0452 (0.761)	0.0247 (0.731)	-0.0452 (0.426)	0.0627 (0.720)	0.0389 (0.756)	-0.0697 (0.407)	0.0608 (0.669)	0.0367 (0.699)	-0.0608 (0.373)
1994	318	1445	177	0.0274 (0.991)	0.0263 (0.715)	-0.0274 (0.694)	0.0549 (0.891)	0.0443 (0.664)	-0.0549 (0.534)	0.0532 (0.781)	0.0532 (0443)	-0.0496 (0.492)
1995	340	1435	175	0.0700 (0.467)	0.0232 (0.772)	-0.0700 (0.094)	0.0927 (0.277)	0.0085 (0.985)	-0.0927 (0.159)	0.0429 (0.934)	0.0242 (0.840)	-0.0429 (0.577)

1996	277	1341	185	0.0485 (0.681)	0.0333 (0.630)	-0.0485 (0.376)	0.0768 (0.551)	0.0768 (0.308)	-0.0758 (0.318)	0.0539 (0.759)	0.0539 (0.428)	-0.0507 (0.472)

Note:

(i) Aymptotic P-values are within parentheses

(ii) * Significant at 5% confidence interval

(iii) ** Significant at 1% confidence interval

Table 4: Kolmogorov-Smirnov tests on the distribution of productivity levels at year t of domestic firms acquired by foreigners at t+a (a>0) (labelled new foreign firms, NFOR), domestically owned permanent exporters (DPE) and domestically owned never exporting firms (DNE).

Year	Numb. of Observations			DNE v NDE			DPE v NFOR		
	DNE	NFOR	NDE	Equality of distributions	Difference favourable to		Equality of distributions	Difference favourable to	
					DNE	NDE		DPE	NFOR
1990	169	293	73	0.0871 (0.790)	0.0871 (0.461)	-0.0447 (0.816)	0.1861* (0.038)	0.1861* (0.026)	-0.0753 (0.552)
1991	225	267	137	0.0643 (0.844)	0.0523 (0.628)	-0.0643 (0.495)	0.1921** (0.003)	0.1921** (0.002)	-0.0453 (0.712)
1992	267	221	134	0.0650 (0.814)	0.0610 (0.515)	-0.0650 (0.471)	0.1791** (0.008)	0.1791** (0.006)	-0.0100 (0.984)
1993	322	180	115	0.0739 (0.700)	0.0578 (0.568)	-0.0739 (0.396)	0.1250 (0.185)	0.1250 (0.113)	-0.0058 (0.995)
1994	318	115	79	0.0901 (0.628)	0.0522 (0.708)	-0.0901 (0.358)	0.1364 (0.288)	0.1364 (0.174)	-0.0275 (0.931)
1995	340	51	53	0.1548 (0.174)	0.1548 (0.111)	-0.0938 (0.446)	0.2181 (0.126)	0.2181 (0.087)	-0.0741 (0.754)

Note:

(i) P-values are within parentheses

(ii) * Significant at 5% confidence interval

(iii) ** Significant at 1% confidence interval

(iv) DPE and DNE are domestic firms that have never been acquired by foreign companies in our sample.

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Appendix

To compute productivity levels the index number approach was chosen as suggested by Diewert (1987) reviewing different methodologies to calculate productivity. The chosen method allows to eschew the difficulties involved in estimating flexible production functions and to obtain transitive comparisons among the productivity of firms in a multilateral setting.

The particular index used is a Tornqvist-type index. This index was first introduced by Tornqvist (1936) to make binary comparisons (i.e. comparison between two entities) and was subsequently used as output, input and productivity index. Two main advantages of the binary Torniqvist index are that it is superlative and transitive. Transitivity is one of the desiderable properties set by Fisher (1927) index numbers should respect. Diewert (1976) introduced the concept of superlative index numbers, which are those that can be directly derived from flexible functional forms. The binary Torniqvist index is superlative since it can be derived from a translog function.

In economics we are mostly interested in multilateral comparisons (i.e. comparison between more than two agents). The binary Torniqvist index could be used in this case as well to generate the set of all possible binary comparisons, but transitivity would not be necessarily respected. In time series studies to bypass this difficulty the Tornqvist index has been employed chain-linking observations so that to attain, in addition to transitive bilateral comparisons between adjacent observations, bilateral transitive comparisons between non-contiguous ones, the latter by means of intervening observations. In cross section studies this method cannot easily applied since there is not an inherent way of arranging observations.

For this reason Caves *et al* (1982a) introduced a modification of the binary Tornqvist index, which preserves its transitivity in a multilateral context even when there is not a precise ordering of the observations, as in cross section data sets. This multilateral Tornqvist index allows to construct a total factor productivity (TFP) index, which, in the one output case, is computed as the log of output of, say, plant *f* (expressed as difference of the log output of this plant from a reference point) minus the cost share weighted sum of the log of inputs

(expressed as cost share weighted difference of the log of input from a reference point). The log of output and inputs are expressed as differences from a reference point to indeed ensure transitivity among all comparisons.

The reference point is constructed as a hypothetical firm whose output and inputs levels are calculated, respectively, as the log of the geometric mean, across all firms, of the output and inputs levels. By the same token, the cost share of a certain input is computed as the arithmetic mean, across all firms, of the cost share of that input. Thus, the index can be represented by means of the following expression,

$$\ln TFP_f = \left(\ln y_f - \overline{\ln y}\right) - \frac{1}{2}\sum_{i=1}^{n}\left(s_{if} - \overline{s_i}\right)\left(\ln x_{if} - \overline{\ln x_i}\right)$$

$$\overline{\ln y} = \frac{1}{m}\sum_{f=1}^{m}\ln y_f \qquad \overline{\ln x_i} = \frac{1}{m}\sum_{f=1}^{m}\ln x_{if} \qquad \text{and} \quad \overline{s_i} = \frac{1}{m}\sum_{f=1}^{m}s_{if}$$

$f = 1,2,3,...m$ firms; $i = 1,2,3,...n$ inputs

The terms with an upper bar represent the log of the output, inputs and their cost share of the reference firm. It is worth stressing that this reference point is not chosen arbitrarily. Indeed, it descends from the fact that the multilateral Tornqvist index ideated by Caves *et al* (1982a) compares the productivity of firm *f* with respect not to another single firm, but with respect all the other firms. This comparison is conducted subtracting the mean across all firms of their productivity, in log, from the productivity, in log, of firm *f*. Assuming a translog functional form it is possible to show that the mean of the logarithmic productivity across all firms is equal to the productivity of the reference firm (Caves *et al* 1982a).

The above index has been extended by Good, *et al* (1997) to suit panel data set, which feature both time series and cross section characteristics. In this situation both the chaining and the reference firm approaches have appealing facets. The authors proposed to construct a hypothetical firm for each cross section and to chain-link it over time as in time series studies. The index above then becomes

$$\ln TFP_{ft} = \left(\ln y_{ft} - \overline{\ln y_t}\right) - \frac{1}{2}\sum_{i=1}^{n}\left(s_{ift} - \overline{s_{it}}\right)\left(\ln x_{ift} - \overline{\ln x_{it}}\right) +$$

$$+\sum_{s=2}^{t}\left(\overline{\ln y_s}-\overline{\ln y_{s-1}}\right)-\sum_{s=2}^{t}\sum_{i=1}^{n}\frac{1}{2}\left(\overline{s_{is}}-\overline{s_{is-1}}\right)\left(\overline{\ln x_{is}}-\overline{\ln x_{is-1}}\right)$$

The first part of this index is equal to the Caves *et al* (1982) index. The second part, instead, allows to chain the reference firm through time.

In this study the above index has been used to calculate the productivity level of each firm for each year and its yearly productivity growth rates. The inputs used are labour, material and capital. The labour factor is measured as the total number of workers employed by the firm and its cost as the total wage bill. The cost of material is the cost of production of goods sold. The capital is the fixed capital stock. Due to the lack of reliable measure of the user-cost of capital its expenditure share was calculated assuming constant return to scale so that it can be computed as one minus the cost-share of the other inputs.

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1 Bernard, Eaton, Jensen and Kortum (2001), Melitz (2002) and Yeaple (2002) develop models with similar characteristics.

2 Only on the knife-edge solution economies or firms choose to sell abroad through both foreign direct investment and export.

3 From a statistical point of view an additional reason might that we measure productivity with error.

4 For this study we used the OneSource CD-ROM entitled "UK companies, Vol. 1", for October 2000.

5 This is a product of Dun and Bradstreet, and Girma wishes to express his gratitude to Davide Castellani and Antonello Zanfei for providing him with some list of UK multinationals derived from this database.

6 Conover (1999) underlines as the p-values of limiting distribution are conservative in small samples.

7 This information which is in hard copy format is obtained from the Office of National Statistics upon special request. The matching process required considerable effort, and I wish to thank Mehtap Hisarciklilar for helping me in this regard.

8 Strictly this provides a test of absolute convergence