The University of Nottingham

# research paper series

Globalisation, Productivity and Technology

Research Paper 2008/06

## *Technology Gap, Foreign Direct Investment, and Market Structure*

**by**

Spiros Bougheas, David Greenaway, Kittipong Jangkamolkulchai and Richard Kneller

The Centre acknowledges financial support from The Leverhulme Trust under Programme Grant F114/BF

GEP Leverhulme Centre for Research on Globalisation and Economic Policy

**The Authors**

Spiros Bougheas is an Associate Professor at the University of Nottingham and an Internal Fellow in GEP; David Greenaway is a Professor of Economics and Director of GEP; Kittipong Jangkamolkulchai is a Regional Manager at Bryan Cave International Trade, Bangkok; Richard Kneller is an Associate Professor at the University of Nottingham and an Internal Fellow in GEP.

**Acknowledgements**

The authors thank Daniel Bernhofen and Chris Milner for helpful comments and suggestions. The authors gratefully acknowledge financial support from the Leverhulme Trust under Programme Grant F114/BF.

# Technology Gap, Foreign Direct Investment, and Market Structure

**by**

**Spiros Bougheas, David Greenaway, Kittipong Jangkamolkulchai and Richard Kneller**

**Abstract**

We develop and analyze an entry model that predicts that the likelihood that foreign firms enter a country increases with the productivity gap between foreign and domestic firms. The intuition is that foreign firms locate where their competitive advantage is highest and thus enter countries where their productivity is higher relative to domestic firms. We test this model using firm level data on acquisitions of British firms by foreign firms and find results that are consistent with our model's predictions.

**JEL classification:** F21, F23

**Keywords:** Technology gap, FDI, entry

**Outline**

1. *Introduction*
2. *The model*
3. *Evidence from foreign acquisitions*
4. *Concluding comments*

## Non-Technical Summary

We explore a link between the productivity advantage that Multinationals (MNCs) have over domestic firms in host countries and their location decisions that has not been explored at either the theoretical or empirical level. Our argument is that productivity differences directly influence the decision of foreign firms to enter new markets, because post-entry profitability will generally depend on the ability of domestic firms to compete with foreign firms. This ability, which is commonly known in the literature on technology diffusion as 'absorptive capacity', determines the extent to which technology transfer can take place. It then follows that the decision of MNCs to enter a foreign market must depend, among other things, on the costs that domestic firms must incur to bridge the technology gap. The theoretical literature on MNCs entry models has not explicitly considered this relationship since in general theoretical work on the link between the technology gap and technology transfer has been conducted within non-strategic frameworks.

We first present a stylised model of entry to foreign markets to examine how the strategic decisions of MNCs about where to locate can depend on their technology advantage. The novel feature of our model is the introduction of a 'quality ladder' in a standard two-firm model of entry. Our model predicts that the likelihood that a foreign firm enters increases with the technology gap. In addition, it also predicts that given entry the likelihood that the foreign firm dominates the market also increases with the productivity gap. We test the main prediction of our model using firm level data on the acquisition of domestically owned firms by foreign firms in the UK manufacturing sector for the period 1988 to 1996. We have found results that are consistent with our model's predictions.

## 1. Introduction

It is well documented that, in both developing and developed economies, there exists a 'productivity gap' between foreign-owned and domestic firms.[1] In fact, it is exactly because of this productivity advantage that many governments of developing nations offer incentives to multinationals (MNCs) to invest in their countries.[2] Their hope is that assimilation of foreign technologies will boost domestic productivity and hence economic development. But policies aimed at promoting FDI are not limited to developing countries. They are also common in developed economies where incentive packages often target the attraction of FDI in particular regions. Thus, the desire for national or regional development provides one link between the 'productivity gap' and location of MNCs.

In this paper, we explore a second link, associated with strategic location decisions of MNCs that has not been explored at either the theoretical or empirical level. Our argument is that productivity differences directly influence the decision of foreign firms to enter new markets, because post-entry profitability will generally depend on the ability of domestic firms to compete with foreign firms. This ability, which is commonly known in the literature on technology diffusion as 'absorptive capacity', determines the extent to which technology transfer can take place.[3] It then follows that the decision of MNCs to enter a foreign market must depend, among other things, on the costs that domestic firms must incur to bridge the technology gap. The theoretical literature on MNCs entry models has not explicitly considered this relationship since in general theoretical work on the link between the technology gap and technology transfer has been conducted within non-strategic frameworks.[4]

Our paper is motivated by the abundance of evidence that suggests that the relative presence of foreign firms differs considerably across industries; see for example Tables 1 and 2 which show employment shares of MNCs across industries in the manufacturing sector for the United Kingdom and United States, respectively. How can we explain this variation?

[Please insert Tables 1 and 2 about here]

[1] See, for example, Criscuolo and Martin (2005), Davies and Lyons (1991), Doms and Jensen (1998), Griffith (1999), and Lipsey and Sjoholm (2002).
[2] See Blonigen (2005) for a review of the determinants of FDI that includes a number of policy variables.
[3] This literature is vast and is extensively reviewed by Keller (2004).
[4] Below, we review both of these literatures.

We first present a stylised model of entry to foreign markets to examine how the strategic decisions of MNCs about where to locate can depend on their technology advantage. We keep the theory simple by abstracting from other issues related to entry in foreign markets and only use it to provide guidance for our empirical work. With that in mind, we analyze a market that is initially serviced by a domestic firm. A foreign firm with a superior technology, captured by a product that is higher in the 'quality ladder' relative to that provided by the domestic firm, considers whether to enter. If the foreign firm enters, the domestic firm will have to incur some cost to upgrade the quality of its product. To keep things simple, we assume that entry of the new product implies that demand for the old one vanishes. Then, conditional on the decisions of both firms, there are three possible market outcomes: a domestic monopoly, a foreign monopoly or a duopoly.

The novel feature of our model is the introduction of a 'quality ladder' in a standard two-firm model of entry. The strand of the vast theoretical literature on MNC entry that is most closely related to our work examines the emergence of equilibrium market structures in oligopolistic international environments (Horstman and Markusen, 1992; Rowthorn, 1992; Petit and Sanna-Randaccio, 2000). The same basic framework has also been used for the analysis of the decision of foreign firms between foreign direct investment and acquisitions (Hennart and Park, 1993; Smarzynska, 2000; Mueller, 2001; Ferret, 2003; Eicher and Kang, 2005). All these papers consider more complex market environments than ours but do not allow for goods of different qualities. Product quality competition has been explicitly considered in models of North-South trade (Flam and Helpman, 1987; Stokey, 1991, Glass, 1997; Glass and Saggi, 1998). In contrast to our work, these models derive the technology gap endogenously but abstract from strategic entry decisions.

Our model predicts that the likelihood that a foreign firm enters increases with the technology gap. In addition, it also predicts that given entry the likelihood that the foreign firm dominates the market also increases with the productivity gap. We need to be careful about how to interpret these predictions for markets where, first, there is more than one domestic firm and more than one foreign firm and, second, firms with different levels of technology co-exist. To address the first issue we would need to allow sequential entry in a multi-firm market which is beyond the scope of the present paper. Nevertheless, our duopoly model allows us to derive the following implication: when there are many firms there must be a positive correlation between the relative concentration of foreign firms in the market and the technology gap. Note that if the latter did not persist after entry, as we have assumed, we would not be able to observe it in the first place. The very fact that it

persists implies a degree of product differentiation that allows different qualities to co-exist. Because we do not allow for product differentiation we have to assume there is only one equilibrium quality.

We test the main prediction of our model using firm level data on the acquisition of domestically owned firms by foreign firms in the UK manufacturing sector for the period 1988 to 1996. Since our theoretical model is about greenfield investment rather than acquisitions we need to be careful in the interpretation of our test results.[5] That said, the main prediction of our model is independent of entry mode. That is we still expect foreign firms to enter when the productivity gap between them and domestic firms is high. We would also expect foreign firms to target the best firms and this is exactly what the data suggests.

In the following section we develop and analyze our theoretical model. In section 3 we present the empirical analysis and we conclude in the final section.

## 2. The Model

Consider a market for a product defined by its quality, $q \in [0,1]$, where quality not only reflects a firm's level of technology but also the quality of its resources and ability and readiness to commit resources for R&D for quality upgrading. Initially, a domestic firm serves the domestic market at product quality *m*. A foreign firm with the ability to produce a higher quality *n* decides whether or not to enter the domestic market. To keep things simple, we assume that the introduction of a higher quality product drives out of the market the old lower quality one. If both firms decide to compete at the higher quality they will engage in Cournot competition.

We assume that demand for the product is linear:

$$X = A(q) - P$$

where $X$ denotes total demand for the product, $P$ denotes its price. In order to capture the effect of a change in quality on demand, we assume that the vertical intercept is an increasing function of quality; $A'(q) > 0$.

On the supply side, we assume both firms hire workers from the domestic (competitive) labour market. The domestic firm's unit cost of production, $w(q)$, is

[5] Actually, our data is about Brownfield investment which refers to acquisitions where the foreign firm is dominant.

increasing in the quality of the product, reflecting the cost of training workers to use more advanced technologies; $w'(q) > 0$. In addition, if the domestic firm decides to compete in a higher quality product market it will face a fixed cost $C(n-m)$. This is incurred by expenditure on R&D aimed at upgrading the technology so that it catches up with that employed by the foreign firm. We assume this increases at an increasing rate with the gap between the two technologies; $C' > 0$ and $C'' > 0$.

The foreign firm faces a fixed cost, *F*, before entering the domestic market. This captures expenditure associated with the establishment of a new plant. We also allow its unit cost to differ from the domestic firm's corresponding cost for a number of reasons. For example, managers of the foreign firm might find that cultural differences between them and domestic workers imply a higher unit cost relative to the domestic firm. By contrast, it may cost less to train workers so they can cope with more advanced production technologies as the foreign firm already possesses the knowledge to do so. Then let $f(n-m)$ denote the ratio of the foreign firm's unit cost divided by that of the domestic firm.

We are now ready to solve the model. Denote by $\pi_f$ and $x_f$ the profits and output level of the foreign firm given that it enters and by $\pi_d$ and $x_d$ the profits and output level of the domestic firm given that it decides to compete at the higher quality *n*:

$$\pi_d = \left(a(n) - x_d - x_f\right)x_d - w(n)x_d - C(n-m)$$

$$\pi_f = \left(a(n) - x_d - x_f\right)x_f - w(n)\,f(n-m)x_f$$

Note that the fixed cost *F* does not appear in the foreign firm's profit function because it is a sunk cost. Solving the system of the two reaction functions derived by the maximization of the two profit functions yields the following equilibrium output levels:

$$x_d^* = \frac{A(n) - 2w(n) + w(n)\,f(n-m)}{3}$$

$$x_f^* = \frac{A(n) + w(n) - 2w(n)\,f(n-m)}{3}$$

Total Cournot output, $X_C$, is given by:

$$X_C \equiv x_d^* + x_f^* = \frac{2A(n) - w(n)\left(1 + f(n-m)\right)}{3}$$

and the Cournot price, $P_C$, is equal to:

$$P_C \equiv A(n) - X_C = \frac{A(n) + w(n)\left(1 + f(n-m)\right)}{3}$$

After substituting the above solutions back into the two profit functions we derive the following two equilibrium profit levels:

$$\pi_d^*(n,m) = \left( \frac{A(n) - 2w(n) + w(n) f(n-m)}{3} \right)^2 - C(n-m) \qquad (1)$$

$$\pi_f^*(n,m) = \left( \frac{A(n) + w(n) - 2w(n) f(n-m)}{3} \right)^2 \qquad (2)$$

**2.1. Taxonomy of equilibria**

Equilibrium conditions (1) and (2) imply three possible scenarios:

i *MULTINATIONAL MONOPOLY*: If $\pi_d^* < 0$, the domestic firm would make negative profits and therefore exit the market. This should be the case when the product quality introduced by the multinational firm is too advanced in comparison with the initial quality level of the domestic firm, which implies that the cost of upgrading, $C(n-m)$, exceeds the domestic firm's revenues. In this case, $\pi_f^* - F$, becomes irrelevant and the foreign firm becomes a monopoly, as long as its monopoly profit is positive.

ii *COURNOT COMPETITION*: If $\pi_d^* > 0$ and $\pi_f^* - F > 0$, both firms will make positive profits in the high quality market. This represents the case where the new product quality is such that it is not too costly for the domestic firm to invest resources so it can upgrade product quality and it is also profitable for the foreign firm to enter the market.

iii *DOMESTIC MONOPOLY*: If $\pi_d^* > 0$ and $\pi_f^* - F < 0$, the foreign firm will not enter the market as its technological advantage over the domestic firm is not sufficiently strong to allow it to make positive profits. The absence of FDI in this case implies that the domestic firm will keep producing at the low quality level *m*.

In the remainder of this section, we identify the conditions under which each will prevail. Let $\bar{\pi}^*$ denote the level of profits given that $n = m$.[6] Then we have that

[6] Notice that in this limiting case (1) and (2) are equal.

$$\bar{\pi}^{*}(n) = \left( \frac{A(n) - w(n)}{3} \right)^2$$

It is clear that $\bar{\pi}^{*}(n)$ is increasing in *n*. Now, denote by $\bar{n}$ the level of technology such that the foreign firm makes zero profits; i.e. $\left( \frac{A(\bar{n}) - w(\bar{n})}{3} \right)^2 - F = 0$. In order to limit our attention to the more interesting cases we make the following assumptions:

**Assumption 1:** $\frac{\partial \pi_f^*(n,m)}{\partial n} > 0$ and $\frac{\partial \pi_f^*(n,m)}{\partial m} < 0$.[7]

**Assumption 2:** There exist two real numbers $n^*$ and $m^*$ in the unit interval such that $\pi_d^*(1,m^*) = 0$ and $\pi_d^*(n^*,0) = 0$.[8]

The following result identifies combinations of technological levels for the two firms such that the foreign firm would not break even under Cournot competition.

**Result 1:** *For every m then for every* $n < \bar{n}$ *there exists a real number* $m(n)$ *such that for any* $m > m(n)$ *the foreign firm's Cournot profits net of entry costs are negative. For* $n > \bar{n}$ *the foreign firm's corresponding profits are positive.*

The result follows directly from Assumption 1 and the fact that $\bar{\pi}^{*}(n)$ is increasing in *n*. It implies that there exists a real number in the unit interval, $\tilde{n}$, such that $\pi_f^*(\tilde{n},0) - F = 0$. The function $m(n)$ together with all the above mentioned cut-offs is depicted in Figure 1. Notice that along the diagonal the technology gap vanishes while it increases as we move in the South-East direction.

[Please insert Figure 1 about here]

[7] We argue that these assumptions identify the most plausible case. For example, they will hold when the premium $f(n-m)$ is relatively low. Anyway, in the following section, where we analyze the predictions of our model we also address alternative restrictions.

[8] The first condition states that given that the foreign firm's technological level is at the highest possible level, there exists a level for the domestic firm's initial quality such that at any lower level ($m < m^*$) the domestic firm's profit are negative. The second condition states that if the domestic firm's initial quality is at the lowest possible level, there exists a cut-off level of quality such that at any higher level produced by the foreign firm ($n > n^*$) the domestic firm's profits are negative.

The following result establishes conditions for the foreign firm to become a monopoly.

**Result 2:** *For every* $m < m^*$ *there exists a real number* $n(m)$ *such that for every* $n > n(m)$, *the foreign firm enters the market as a monopoly.*

The result is a direct consequence of Assumption 2. The function $n(m)$ and the new cut-offs are also depicted in Figure 1. Notice that Figure 1 is drawn under the supposition that $n^* > \tilde{n}$. In this case, for all combinations of technology levels for the two firms that lie to the left of the $m(n)$ locus the foreign firm does not enter the market. For all such technology level pairs that lie to the right of the $n(m)$ locus the domestic firm exits the market and for pairs in between the two loci we have Cournot competition. The following result addresses the case where $n^* < \tilde{n}$ which is depicted in Figure 2. Notice that in that case the two loci intersect.

**Result 3:** *If* $n^* < \tilde{n}$ *then for all technology level pairs that lie to the right of the* $n(m)$ *locus and to the left of the* $m(n)$ *locus there is predation.*

[Please insert Figure 2 about here]

Result 1 implies that to the left of the $m(n)$ locus the foreign firm's net of entry cost Cournot profits are negative. However, if the foreign firm enters Result 2 implies that the domestic firm will exit the market. Thus, the foreign firm commits by incurring the fixed entry cost and becomes a monopoly. The technology level pairs that lead to predation lie in the area of Figure 2 denoted PR.

### 2.2. The technology gap and market structure

The main prediction of our model is:

P1. There is a positive relationship between the technology gap and the relative presence of multinationals in the domestic market.

In addition, our model suggests that when testing the above prediction we must control for the following observation:

P2. The presence of multinationals is positively related to the overall profitability of the industry.

## 3. Evidence from Foreign Acquisitions

In this section, we test the theoretical prediction that the probability of entry by foreign firms is increasing with their productivity advantage over domestic firms. [9] We test this using data on the acquisition of domestically owned firms by foreign owned firms in the UK manufacturing sector for the period 1988 to 1996. What matters in the case of entry via an acquisition is not the productivity of the entrant but the productivity of the new firm created by the merger.

To investigate the effects of firm and industry-level variables on the probability of acquisition we estimate the following probit model

$$P(ACQ_{ijt} = 1) = F(X_{it-1}, Z_{jt})$$

where *i* denotes firms, *j* industries and *t* time. To control for the effect on the standard errors from the repeated observation of variables on micro units (Moulton, 1990) we report firm clustered standard errors. The vector *X* consists of a set of potentially important firm level controls and *Z* are industry level variables. We begin with a description of the data detailing acquisition of UK firms as well as the variables included in the vector *X*.

### 3.1. Firm Data

Detailed information on firms' characteristics are taken from the *OneSource* database, which includes information on all UK 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) in both manufacturing and service industries. Companies that are dissolved or are in the process of liquidation are excluded from the *OneSource* sample.[10] Here, we concentrate on manufacturing firms.

*OneSource* provides information on employment, physical capital, output and cost of goods sold in a consistent way both across firms and across time. Nominal aggregates were deflated using five-digit level industry deflators. The data were then screened to select those manufacturing firms for which there is a complete set of information about the value of output and factors of production.

Each edition of *OneSource* contains foreign-ownership indicators for the latest year only, so that it is not possible to identify when a firm became a subsidiary of a foreign multinational. To track the dynamics of ownership, we matched the population of

[9] This data has been previously used by Girma et al. (2007 a,b) to examine the productivity and exporting performance of acquired firms against a set of matched counterparts.
[10] For this study we used the OneSource CD-ROM entitled "UK companies, Vol. 1", for October 2000.

manufacturing firms in the database to a list of U.K. firms acquired by foreign multinationals using data from the ONS.[11] In Table 1 we report the number of domestic companies acquired by foreign multinationals by year. While there are noticeable differences across years there appear few obvious patterns to the rate of foreign acquisition.

[Please insert Table 1 about here]

To control for the characteristics of the acquired firm we draw on the results reported in Girma et al. (2007a,b). There the probability of acquisition depends upon size (measured by employment), size squared, age, average wage, a measure of labour productivity and the export status of the firm. We use the same firm controls in the regressions reported here.

### 3.2. Relative Productivity Gap

The key variable within the empirical model is a measure of the productivity gap between foreign and domestic firms. The productivity of the domestic firm is measured as the mean of all domestic firms within a given (3-digit) industry and year. The next choice is the productivity of foreign firms. Girma et al. (2007) demonstrate using the same dataset that the productivity of acquired firms improves relative to matched domestically-owned counterparts. This raises the possibility that the current productivity of the firm, which is observable, is a poor proxy for the productivity of the foreign owned firm in its home market and therefore of the productivity potential of the acquired firm. Given the productivity improvement identified by Girma et al. (2007), this would suggest that using the current productivity of the acquired firm would tend to underestimate the size of the productivity gap hypothesised in the model, although we continue to control for the productivity of the acquired firm amongst the control variables. Given the *ex-ante* uncertainty that is likely to exist regarding the extent of the productivity improvement that would be realised by the foreign firm following acquisition we use a measure of productivity potential that is common to all firms, the maximum TFP of foreign owned firms, in each 3-digit SIC industry and year.

The productivity gap is measured as the log ratio of the maximum TFP of foreign firms to the average domestic firm. Our theoretical model predicts that the relationship between this ratio and the probability of entry is positive. To capture the likelihood acquisition may take place over long periods of time we lag this variable twice Given some

[11] This information which is in hard copy format is obtained from the Office of National Statistics upon special request.

of the strong assumptions used in constructing this measure we test its robustness to the use of alternative measures for the productivity gap between domestic and foreign firms.

### 3.3. Other Control variables

Entry into a given industry into the UK is likely to be more common in industries in which the UK is relatively more successful. This suggests that the extent of foreign ownership is likely to be an important determinant of entry by new foreign firms for reasons in addition to the strategic ones suggested by our model (prediction P2). The measure of the productivity gap we use varies across industries but varies little across time. This limits our ability to control for other potentially important industry level variables through the use of time invariant industry fixed effects in the standard way. For that reason we attempt to control a large number of other factors that might influence the likelihood of acquisition. These include measures of the extent of existing foreign ownership, international trade and the technology intensity of the sector.

To capture the current stock of FDI we use a measure of the share of foreign in total industry output used previously by Girma, Görg and Pisu (2007) to measure FDI spillovers, as well as a count of the number of foreign firms relative to domestic firms. It might also seem likely that rates of acquisition are higher in industries that the UK is relatively successful at exporting, because this reflects some comparative advantage of the UK (Yeaple, 2003) or sheltered from international competition, so that FDI substitutes for current export activity by the foreign multinational (see for example the model by Buckley and Casson, 1981). Alongside measures of total export trade, the extent of foreign competition through imports (import penetration), and the nature of the product, using a measure of intra-industry trade, we also separate the FDI variable according to the share of total exports controlled by foreign multinational firms. This controls for the use of the UK as an export platform, as set out for example in Motta and Norman (1996).

Our final set of industry variables includes a measure of R&D to total sales, to control for the technological intensity of the sector if technology sourcing motives to FDI are important.[12] We also include in the regression a measure of the Herfindahl index of industry concentration, which may help capture other aspects of the strategic motives of acquisition, and of industry agglomeration from Duranton and Overmans (2005). These data, previously used by Greenaway and Kneller (2008), are from the OECD, with the trade variables constructed at the 3 or 4 digit level. Finally, to control for the effect of factors

[12] To avoid conflating acquired firms in these measures all are lagged one period.

such as exchange rates, taxes and institutions that are common across UK manufacturing industries but which may vary across time and may influence the timing of foreign acquisition (Blonigen, 2005) we include a full set of time dummies.

### 3.4. Results

In Table 4 we report results from our base specification. Those for the control variables match many of those reported in Girma et al. (2007a,b). The probability of acquisition is increasing in the size of the firm and labour productivity and decreasing in firm age. Current export status, which is correlated with other aspects of firm performance in models such as Melitz (2003) has no residual impact on the probability of acquisition. Taken together, it would appear that foreign firms cherry-pick the best domestic firms to acquire.

[Please insert Table 4 about here]

Of the industry control variables a number enter the regression with statistically significant coefficients. Acquisition is more likely for example in industries where foreign firms account for a higher share of employment, contrary to the view that export-platform motives are important in a UK context, where rates of import penetration are high and exports are low. We also find that agglomeration factors might be important, acquisition is more likely in industries that are more agglomerated according to the Duranton and Overmans (2005) measure.

Of interest to this study we also find that the probability of foreign acquisition is increasing with the productivity gap between foreign firms and the average domestic firm at standard significance levels. That is the productivity gap measure suggested by our theoretical model. The reported effects are marginal effects estimated at the mean of the right hand side variables. The coefficients suggest that the size of this effect is around 1/3$^{rd}$ of that of the observed probability of acquisition.

In columns two to four we test the robustness of this result to the measure of the productivity potential of foreign firms. In column two we use the foreign firm that lies at the 95$^{th}$ percentile of the productivity distribution; column three replaces this with the foreign firm at the 90$^{th}$ percentile; column four the productivity of the average foreign firm; and column five with the median rather than the mean domestic firm.

There is some sensitivity to this choice. In columns two, three and five the main result holds, entry is more likely in industries in which the gap to the average domestic firm is greater, where this result is robust to measuring the productivity of the foreign firm down

to the 90th percentile and to minimise the effect of possible outliers in the data, to measuring domestic firms with the median. When the productivity potential of foreign firms is measured using the average productivity of foreign firms within the industry the result no longer holds however.[13] The effect appears specific to the gap to the best foreign firms as suggested by our theoretical model.

A key assumption in generating the productivity gap variable is that the productivity of the foreign firm is captured by the productivity of those foreign firms that lie on the technical frontier within the industry. The idea is that these firms compare themselves with firms that face similar constraints. An alternative assumption would be that foreign firms benchmark themselves against the best firms within the industry, rather than just the best foreign firms. In Table 5 we therefore measure the productivity gap between the average domestic firm and frontier firm (whether domestic or foreign). It would appear that the assumption used in generating the original variable has support. The productivity gap to the frontier, while positive, is not statistically significant using this measure. Thus, it is the foreign aspect that is important.

In column two we then replace this variable with the gap between the best foreign and best domestic firm. This variable enters the regression with a significant coefficient, although the productivity gap to the average domestic firm remains unaffected by its inclusion.

[Please insert Table 5 about here]

In column three we investigate whether the relative productivity gap is something that is specific to the determinants of entry of foreign firms as suggested by our model. If the gap also determines acquisitions by domestic firms, for example, it may be more likely we have neglected some aspect of the acquisition process that is correlated with this variable. With that in mind we also examine the impact of the gap on acquisitions of domestic firms by other domestic firms. The data for domestic-to-domestic acquisitions are again from ONS. The results from this regression are striking. Of the industry variables we find that acquisition is more likely in industries in which foreign firms account for a greater share of domestic output but not by the relative productivity gap between the average domestic firm and frontier foreign firm.

In the next three columns of Table 5 we again replace our measure of the productivity gap with another aspect of the productivity distribution. In column three we

[13] We find that the effect of the productivity gap remains significant when measured by the foreign firm that lies at the 85th percentile (t-statistic 1.72) but not the 80th percentile (t-statistics 1.30).

test whether it captures diversity of productivity levels between domestic firms using a measure of the standard deviation, and in column four whether it has anything to do with the skewness of the distribution. In both cases the answer would appear to be no.

Thus far we have been measuring productivity as labour productivity. This in part reflects a desire to capture aspects of multinational firm performance reflected in physical and human capital. As a final exercise we test the robustness of our findings to the use of a measure of total factor productivity, and employ four measures of TFP constructed by Girma at al (2007). The first is constructed using the index number (i.e. non-parametric) approach (Caves, *et al*, 1982a, b; Good *et al*, 1997) and has been previously employed amongst others by Aw *et al* (2000) and Delgado *et al* (2001). The principle advantage of using this measure over alternatives, such as the econometric estimation of the production function, is that it allows the comparison of productivity growth rates and levels between firms over time. The second and third measures are based on the residuals from a production function estimated by generalised least squares and with an AR(1) error term. The second measure assumes that the production function is Cobb-Douglas and the third that it is translog. Further details on these measures can be found in Girma et al. (2007a). The relative TFP measure between foreign and domestic firms is then constructed in the same manner as before.

As can be seen from Table 6 the results are robust to the use of these various measures of TFP. In each case the technology gap variable enters the regression with the expected significant coefficients, which occurs despite the insignificance of the firm level measure of TFP in the same regression. It would appear that even when using a narrower description of the advantage that foreign firms might possess relative to domestic firms it remains an important influence over the likelihood of entry into UK manufacturing through acquisition FDI.

[Please insert Table 6 about here]

## 4. Concluding Comments

The relative presence of multinationals (measured either by number of firms or by output volume) varies considerably from industry to industry. The productivity gap between foreign and domestic firms also exhibits great variability across industries. In this paper, we have developed a simple entry model that predicts that these two variations will be positively correlated. The intuition is that foreign firms locate where their competitive

advantage is highest and thus enter countries where their productivity is higher relative to domestic firms. We have tested our model using firm data on acquisitions of British firms by foreign firms and have found results that are consistent with our model's predictions.

**Table 1: Share of foreign employment, by industry; United Kingdom, 1992**

| | |
|---|---|
| Extraction and preparation of metalliferous ores | 0.00 |
| Metal manufacturing | 0.19 |
| Extraction of Minerals not elsewhere specified | 0.00 |
| Manufacture of non-metallic mineral products | 0.13 |
| Chemical industry | 0.38 |
| Production of man-made fibres | 0.20 |
| Manufacture of metal goods not elsewhere specified | 0.19 |
| Mechanical engineering | 0.28 |
| Manufacture of office machinery and data processing equipment | 0.68 |
| Electrical and electronic engineering | 0.31 |
| Manufacture of motor vehicles and parts thereof | 0.48 |
| Manufacture of other transport equipment | 0.11 |
| Instrumental engineering | 0.29 |
| Food and drink manufacturing industries[1] | 0.09 |
| Food and drink and tobacco manufacturing industries[2] | 0.25 |
| Textile industry | 0.08 |
| Manufacture of leather and leather goods | 0.00 |
| Footwear and clothing industries | 0.06 |
| Timber and wooden furniture industries | 0.06 |
| Manufacture of paper and paper products; printing and publishing | 0.22 |
| Processing of rubber and plastics | 0.28 |
| Other manufacturing industries | 0.13 |

[1] Oils, margarines, milk products; freezing, processing and preserving of meat, fish, fruit and vegetables; grain milling, bread and flour confectionery.
[2] Sugar and sugar confectionery, cocoa, coffee, tea, animal feeds and pet foods, and all others
Source: Haskel, Pereira and Slaughter (2004).

**Table 2: Share of foreign employment, by industry; United States, 1996**

| | |
|---|---|
| Food and kindred products | 0.10 |
| Textile mill products | 0.07 |
| Apparel and other textile | 0.05 |
| Wood and furniture | 0.02 |
| Paper | 0.09 |
| Printing and publishing | 0.07 |
| Chemicals | 0.31 |
| Rubber and plastic | 0.15 |
| Stone, glass and mineral | 0.22 |
| Primary metals | 0.14 |
| Fabricated metals | 0.09 |
| Industrial Machines | 0.11 |
| Electronics | 0.19 |
| Motor vehicles | 0.15 |
| Other transport | 0.04 |
| Instruments | 0.13 |

Source: Keller and Yeaple (2003).

**Table 3: Frequency of foreign acquisitions by year**

| Year | Foreign Acquisitions |
|---|---|
| 1988 | 20 |
| 1989 | 40 |
| 1990 | 31 |
| 1991 | 54 |
| 1992 | 52 |
| 1993 | 39 |
| 1994 | 57 |
| 1995 | 56 |
| 1996 | 25 |
| Total | 374 |

**Table 4: Probit Model of Foreign Acquisition**

| | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| | Base | 95th percentile | 90th percentile | Average | Median domestic |
| | *Firm Variables* | | | | |
| *Log(labour productivity)* $_{t-1}$ | 0.007 (3.31)*** | 0.007 (3.32)*** | 0.007 (3.32)*** | 0.007 (3.37)*** | 0.007 (3.35)*** |
| *Log(emp)* $_{t-1}$ | 0.002 (2.81)*** | 0.002 (2.81)*** | 0.002 (2.80)*** | 0.002 (2.78)*** | 0.002 (2.88)*** |
| *Age* $_{t-1}$ | -0.000 (2.38)** | -0.000 (2.38)** | -0.000 (2.38)** | -0.000 (2.36)** | -0.000 (2.30)** |
| *Export Dummy*$_{t-1}$ | 0.000 (0.09) | 0.000 (0.09) | 0.000 (0.11) | 0.000 (0.11) | 0.000 (0.16) |
| | *Industry Variables* | | | | |
| ***Productivity Gap*** $_{t-1}$ | **0.005 (2.36)**** | **0.005 (2.25)**** | **0.005 (2.00)**** | **0.003 (1.23)** | **0.007 (2.34)**** |
| *Foreign Emp. Share* $_{t-1}$ | 0.017 (3.96)*** | 0.017 (3.95)*** | 0.017 (3.93)*** | 0.017 (3.91)*** | 0.016 (3.85)*** |
| *Relative No. Firms* $_{t-1}$ | 15.144 (0.61) | 16.035 (0.64) | 17.399 (0.70) | 20.214 (0.83) | -1.119 (0.08) |
| *Share foreign output exported* | -0.016 (0.72) | -0.017 (0.74) | -0.017 (0.74) | -0.016 (0.71) | -0.019 (0.86) |
| *Share foreign output domestic* | 0.001 (0.07) | 0.001 (0.09) | 0.002 (0.20) | 0.004 (0.41) | -0.000 (0.03) |
| *Total Exports* | -0.000 (2.10)** | -0.000 (2.09)** | -0.000 (2.09)** | -0.000 (1.91)* | -0.000 (2.01)** |
| *Intra-industry Trade* | 0.008 (1.01) | 0.008 (1.06) | 0.009 (1.19) | 0.010 (1.35) | 0.007 (0.89) |
| *Import Penetration* | 0.041 (2.51)** | 0.041 (2.52)** | 0.042 (2.55)** | 0.041 (2.44)** | 0.031 (1.94)* |
| *R&D intensity* | -0.001 (1.54) | -0.001 (1.56) | -0.001 (1.61) | -0.001 (1.66)* | -0.001 (1.15) |
| *Herfindahl Index* | 0.039 (4.41)*** | 0.039 (4.40)*** | 0.038 (4.34)*** | 0.037 (4.27)*** | 0.041 (4.82)*** |
| *Industry Agglomeration* | -0.051 (1.71)* | -0.052 (1.73)* | -0.053 (1.77)* | -0.054 (1.76)* | -0.056 (1.87)* |
| ***Observations*** | 10323 | 10323 | 10323 | 10323 | 10327 |

Notes:

(i) Effects are estimated marginal effects at the industry mean

(ii) Heteroskedasticity and serial correlation robust t-statistics in parentheses

(iii) * significant at 10%; ** significant at 5%; *** significant at1%

(iv) All specifications include year dummies

(v) All regressions use firm clustered standard errors.

**Table 5: Probit Model of Foreign Acquisition: Robustness**

| | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| | Gap to Frontier | Frontier foreign – frontier domestic | Domestic acquisitions | Standard deviation | Skew |
| | *Firm* | *Variables* | | | |
| *Log(labour productivity)* $_{t-1}$ | 0.009 | 0.007 | 0.003 | 0.009 | 0.009 |
| | (4.04)*** | (3.30)*** | (2.56)** | (3.73)*** | (3.74)*** |
| *Log(emp)* $_{t-1}$ | 0.002 | 0.002 | -0.002 | 0.002 | 0.002 |
| | (2.73)*** | (2.90)*** | (3.59)*** | (2.64)*** | (2.66)*** |
| *Age* $_{t-1}$ | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (2.14)** | (2.37)** | (2.41)** | (2.12)** | (2.12)** |
| *Export Dummy*$_{t-1}$ | 0.002 | 0.000 | -0.002 | 0.001 | 0.001 |
| | (0.85) | (0.16) | (1.12) | (0.19) | (0.23) |
| | *Industry* | *Variables* | | | |
| ***Productivity Gap*** $_{t-1}$ | **0.004** | **0.009** | **-0.000** | | |
| | **(1.38)** | **(2.98)*** ** | **(0.04)** | | |
| *Foreign Max - Domestic Max* | | -0.005 | | | |
| | | (1.91)+ | | | |
| *Standard Deviation LP* | | | | -0.005 | |
| | | | | (1.17) | |
| *Skew LP* | | | | | 0.000 |
| | | | | | (0.13) |
| *Foreign Emp. Share* $_{t-1}$ | 0.021 | 0.016 | 0.018 | 0.021 | 0.021 |
| | (4.27)*** | (3.93)*** | (3.27)*** | (4.70)*** | (4.68)*** |
| *Relative No. Firms* $_{t-1}$ | -6.366 | 12.175 | -8.376 | 54.749 | 60.310 |
| | (0.20) | (0.49) | (0.34) | (1.55) | (1.72)* |
| *Share foreign output exported* | -0.030 | -0.021 | 0.007 | 0.003 | 0.002 |
| | (1.21) | (0.93) | (0.35) | (0.11) | (0.07) |
| *Share foreign output domestic* | 0.001 | 0.003 | -0.015 | 0.009 | 0.008 |
| | (0.05) | (0.27) | (1.64) | (0.75) | (0.68) |
| *Total Exports* | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (2.35)** | (2.39)** | (0.23) | (0.97) | (1.07) |
| *Intra-industry Trade* | 0.002 | 0.007 | 0.001 | 0.013 | 0.014 |
| | (0.29) | (0.98) | (0.24) | (1.59) | (1.60) |
| *Import Penetration* | 0.059 | 0.046 | -0.010 | 0.037 | 0.035 |
| | (3.10)*** | (2.70)*** | (0.84) | (1.79)* | (1.72)* |
| *R&D intensity* | -0.001 | -0.001 | 0.000 | -0.001 | -0.001 |
| | (1.63) | (1.60) | (0.93) | (2.03)** | (1.93)* |
| *Herfindahl Index* | 0.045 | 0.042 | 0.013 | 0.019 | 0.019 |
| | (4.49)*** | (4.67)*** | (1.87)* | (1.70)* | (1.67)* |
| *Industry Agglomeration* | -0.070 | -0.061 | -0.040 | -0.052 | -0.053 |
| | (2.16)** | (2.06)** | (1.99)** | (1.65)* | (1.66)* |
| ***Observations*** | 10649 | 10323 | 10322 | 8582 | 8582 |

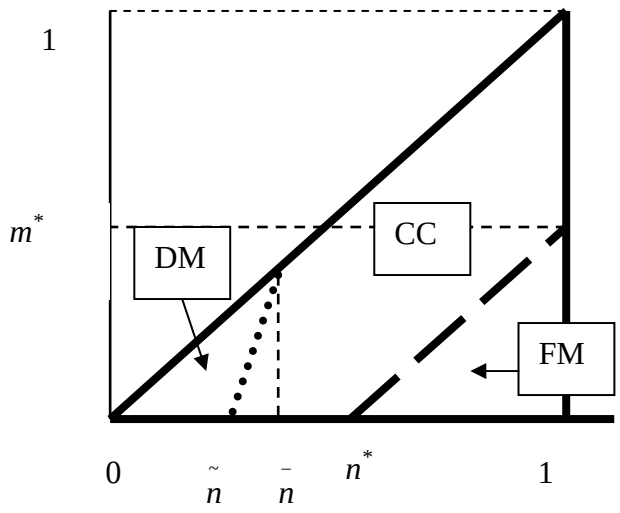
**Table 6: Probit Model of Foreign Acquisition: Measures of TFP**

| | *1* | *2* | *3* |
|---|---|---|---|
| | TFP index | C-D TFP | Translog TFP |
| | *Firm* | *Variables* | |
| *Log(labour productivity)* $_{t-1}$ | 0.003 | 0.002 | 0.004 |
| | (0.42) | (0.22) | (0.45) |
| *Log(emp)* $_{t-1}$ | 0.003 | 0.003 | 0.003 |
| | (2.70)** | (2.31)* | (2.31)* |
| *Age* $_{t-1}$ | -0.000 | -0.000 | -0.000 |
| | (3.92)** | (3.62)** | (3.63)** |
| *Export Dummy*$_{t-1}$ | 0.001 | 0.002 | 0.002 |
| | (0.25) | (0.65) | (0.64) |
| | *Industry* | *Variables* | |
| ***Productivity Gap*** $_{t-1}$ | **0.022** | **0.032** | **0.031** |
| | **(2.49)*** | **(3.29)**** | **(2.92)**** |
| *Foreign Emp. Share* $_{t-1}$ | 0.023 | 0.022 | 0.022 |
| | (4.13)** | (4.10)** | (4.04)** |
| *Relative No. Firms* $_{t-1}$ | 16.928 | 25.391 | 29.201 |
| | (0.40) | (0.77) | (0.90) |
| *Share foreign output exported* | -0.020 | -0.040 | -0.033 |
| | (0.67) | (1.32) | (1.12) |
| *Share foreign output domestic* | 0.006 | 0.004 | 0.007 |
| | (0.45) | (0.29) | (0.46) |
| *Total Exports* | -0.000 | -0.000 | -0.000 |
| | (1.28) | (1.34) | (1.35) |
| *Intra-industry Trade* | 0.005 | 0.004 | 0.005 |
| | (0.46) | (0.38) | (0.46) |
| *Import Penetration* | 0.044 | 0.056 | 0.047 |
| | (2.05)* | (2.41)* | (2.17)* |
| *R&D intensity* | -0.001 | -0.001 | -0.001 |
| | (1.67)+ | (1.49) | (1.67)+ |
| *Herfindahl Index* | 0.044 | 0.045 | 0.045 |
| | (3.34)** | (3.81)** | (3.80)** |
| *Industry Agglomeration* | -0.040 | -0.068 | -0.067 |
| | (1.09) | (1.84)+ | (1.79)+ |
| ***Observations*** | 7463 | 7826 | 7826 |

Notes:

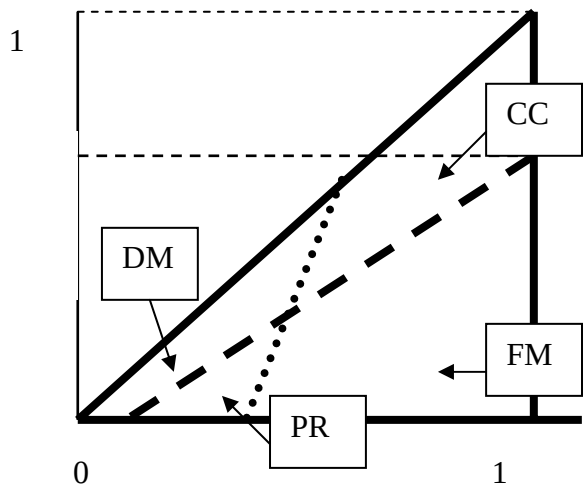
(i) See notes to Table 4

**Figure 1: Equilibria when** $n^* > \tilde{n}$




Note: (DM) Domestic Monopoly; (CC) Cournot Competition; (FM) Foreign Monopoly; ..... $m(n)$ ; _ _ _ _ $n(m)$

**Figure 2: Equilibria when** $n^* < \tilde{n}$




Note: (DM) Domestic Monopoly; (CC) Cournot Competition; (FM) Foreign Monopoly; (PR) Predation; ..... $m(n)$; _ _ _ _ $n(m)$

| *Industry* | *Non-exporters* | *Industry* | *Non-exporters* |
|---|---|---|---|
| Manufacture of food products & beverages | 15 | Manufacture of other non-metalic mineral products | 26 |
| Manufacture of tobacco products | 16 | Manufacture of basic metals | 27 |
| Manufacture of textiles | 17 | Manufacture of fabricated metal products (except machinery) | 28 |
| Manufacture of wearing apparel | 18 | Manufacture of machinery & equipment | 29 |
| Manufacture of leather & leather products | 19 | Manufacture of office machinery | 30 |
| Manufacture of wood & wood products | 20 | Manufacture of electrical machinery | 31 |
| Manufacture of pulp, paper & paper products | 21 | Manufacture of radio, television & communication equipment | 32 |
| Publishing printing & reproduction of recorded media | 22 | Manufacture of medical, precision & optical instruments, watches & clocks | 33 |
| Processing of nuclear fuel | 23 | Manufacture of motor vehicles, trailers & semi-trailers | 34 |
| Manufacture of chemicals & chemical products | 24 | Manufacture of other transport equipment | 35 |
| Manufacture of rubber & plastic products | 25 | Manufacture of furniture & other manufacturing | 36 |

**References**


Aw B., S. Chung and M. Roberts, 2000, Productivity and Turnover in the Export Market: Micro-level Evidence from the Republic of Korea and Taiwan (China), *The World Bank Economic Review*, 14. 65-90.

Blonigen B., 2005, A review of the empirical literature on FDI determinants, *Atlantic Economic Journal*, 33, 383-403.

Buckley P. and M. Casson, 1981, The optimal timing of foreign direct investment," *Economic Journal*, 91, 75-87.

Caves D, L. Christensen and W. Diewert ,1982a, Multilateral Comparisons of Output, Input, and Productivity Using Superlative Index Numbers, *Economic Journal*, 92, 73-86.

Caves D, L. Christensen and W. Diewert, 1982b, The Economic Theory of Index Number and the Measurement of Input, Output and Productivity, *Econometrica*, 50, 1393-1414.

Criscuolo C. and R. Martin 2005, Multinationals and US productivity leadership: evidence from Great Britain, AIM Research Working Paper Series 024

Davies S. and B. Lyons, 1991, Characterizing relative performance: the productivity advantage of foreign owned firms in the UK, *Oxford Economic Papers*, 43, 584-595

Delgado M., J. Farinas and S. Ruano, 2001, Firm productivity and export markets: a non-parametric approach, *Journal of International Economics*, 57, 397-422.

Doms M. and J. Jensen, 1998, Comparing wages, skills and productivity between domestically and foreign-owned manufacturing establishments in the United States, in R. Baldwin J. Richardson (eds.) Geography and Ownership as Bases for Economic Accounting, University of Chicago

Duranton, G. and H. Overmann (2005), Testing for Location Using Micro-geographic Data, *Review of Economic Studies*, 72, 1077-1106..

Eicher T. and J. Kang, 2005, Trade, foreign direct investment or acquisition: optimal entry models for multinationals, *Journal of Development Economics*, 77, 207-228

Ferrett B., 2003, Greenfield investment versus acquisition: positive analysis, GEP research paper 2003/02, University of Nottingham

Flam H. and E. Helpman, 1987, Vertical product differentiation and North-South

trade, *American Economic Review*, 77, 810-822

Gorg H. and Greenaway, D. (2004) Much Ado About Nothing: Do Domestic Firms Really Benefit from Foreign Direct Investment. World Bank Research Observer, 19, 171-198

Girma S., R. Kneller and M. Pisu, 2007a, Do exporters have anything to learn from foreign multinationals?, *European Economic Review*, 51, 993-1010

Girma S., R. Kneller and M. Pisu, 2007b, Acquisition FDI and the export intensity of multinational firms", *Review of International Economics* (forthcoming).

Glass A., 1997, Product cycles and market penetration, *International Economic Review*, 38, 865-891

Glass A. and K. Saggi, 1998, International technology transfer and the technology Gap, *Journal of Development Economics*, 55, 369-398

Good, D., M. Nadiri and R. Sickles, 1997, Index Number and Factor Demand Approaches to the Estimation of Productivity in M. Hashem Pesaran and M. R. Wickens, eds, Handbook of Applied Econometrics, Vol. 2, Blackwell Publishers.

Greenaway, D. and Kneller, R. (2008) 'Exporting, Agglomeration and Productivity'. European Economic Review, 52 (forthcoming)

Griffith R., 1999, Using ARD establishment level data to look for foreign ownership and productivity in the UK, *Economic Journal*, 109, F416-F442

Haskel J., S. Pereira and M. Slaughter, 2004, Does inward foreign direct investment boost the productivity of domestic firms? NBER working paper #8724

Hennart J. and Y. Park, 1993, Greenfield vs. acquisition: the strategic Japanese investors in the United States, *Management Science*, 39, 1954-1970

Horstman I. and J. Markusen, 1992, Endogenous market structures in international trade (natura facit saltum), *Journal of International Economics*, 32, 109-129

Keller W., 2004, "International technology diffusion," *Journal of Economic Literature*, 42, 752-782

Keller W. and S. Yeaple, 2003, "Multinational enterprizes, international trade, and productivity growth: firm-level evidence from the United States," GEP research paper 2003/03, University of Nottingham

Lipsey R. and F. Sjoholm, 2002, Foreign firms and Indonesian manufacturing wages: an analysis with panel data, NBER working paper 9417

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

Motta M. and Norman, G., 1996, Does economic integration cause foreign direct investment? *International Economic Review*, 37, 757-783.

Moulton B., 1990, An illustration of a pitfall in estimating the effects of aggregate variables on micro units, *Review of Economics and Statistics*, 72, 334-338.

Mueller T., 2001, Analyzing models of foreign entry: Greenfield investment versus acquisition, University of Munich, mimeo

Petit M.-L. and F. Sanna-Randaccio, 2000, Endogenous R&D and foreign direct Investment in international oligopolies, *International Journal of Industrial Organization*, 18, 339-367

Rowthorn R., 1992, Intra-industry trade and investment under oligopoly: the role of market size, *Economic Journal*, 102, 402-414

Smarzynska, B., 2000, Technological leadership and the choice of entry mode by foreign investors, World Bank Policy Research working paper 2314

Stokey N., 1991, The volume and composition of trade between rich and poor countries, *Review of Economic Studies*, 58, 63-80

Yeaple, S., 2003, The role of skill endowments in the structure of U.S. outward foreign direct investment, *Review of Economics and Statistics*, 85, 726-734.