

A Structural Model of Export versus Affiliates Production

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Abstract: We develop and econometrically estimate a model of export versus foreign production using firm-level data on foreign activities of German multinationals. The theoretical model shows that firms face a trade-off between concentrating their production at home to save on plant set-up costs and producing abroad to save on distance costs. Firms face a trade-off and choose between export and foreign production according to their expected profits. The model is brought to the data using a pooled-probit analysis over the period 1996-1999. We find support for the proximity-concentration trade-off. In particular, market size and distance affects positively the probability of foreign production whereas the fixed costs have a negative impact on FDI occurrence.

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1. Introduction

Companies increasingly operate on a multinational scale, acquiring affiliates abroad and shifting production to take advantage of markets and cost differentials. The internationalization of production allows firms to benefit from the international division of labor. This has caught attention in political debate and academic research. From a political point of view, firms might shift a part of their production process in developing countries in order to exploit inexpensive labor. This would create increased unemployment in developed countries. In other words, firms that domestically produced and exported goods might increasingly produce abroad and export jobs. The different modes of firms' entry into foreign markets has received a lot of attention.

From a theoretical point of view, the decision to reach arm-length markets arises as a trade-off. Exports augment the relative price of goods sold in the foreign countries by distance costs, which add to variable costs. Producing abroad is cheaper than exporting with regards to variable costs because no distance costs incur. But producing abroad requires an additional fixed cost because a second plant is necessary. Firms face thus a so-called *proximity-concentration trade-off* (Brainard, 1997). Concentration of production (at home) and exporting saves on additional fixed costs, proximity to the customers abroad saves on distance costs. Firms choose between the two alternatives to serve the foreign market by comparing the associated profits. The result of the comparison is revealed by the existence of a production unit abroad or the non-existence of such a unit.

The empirical literature related to the proximity-concentration trade-off relies so far on aggregated data (Brainard 1997, Carr et al. 2001, Buch et al. 2004). This paper uses firm-level data to estimate a structural model that provides microeconomic foundations for the decision between export and FDI. The dataset has been kindly provided by the *Deutsche Bundesbank* and provides detailed information about foreign affiliates of German firms. This enables us to test a structural model of firms' strategic decision how to serve foreign markets.

The paper falls into six main sections. The following section develops a stylized model of export versus foreign direct investment. Section three gives detailed information on the data while section four presents the estimation strategy. Section five presents the empirical estimates. Section six concludes.

2. A stylized model of the exports versus affiliate production

The model derived in this section is based on Kleinert (2004). We assume a two-country, two-sector one-factor general equilibrium model which explains companies'

internationalization strategies. The only factor of production is labor. All individuals are identical in offering one unit of labor. There are two sectors: (i) a perfect competition sector producing a homogenous good is called agriculture and (ii) a differentiated goods sector, called manufacturing, where monopolistic competition prevails. The production process in the manufacturing sector requires fixed costs at the company level (to generate the ownership advantage), fixed costs at the plant level (to produce the good), and the input of final good specific intermediate goods. Consumers are assumed to love variety. Aggregated, their decisions are reflected in those of the representative consumer who buys an average amount of each variety depending on its price.

Markets are segmented by distance costs. Imported goods sell for a higher price, because they incur these distance costs. Distance costs include costs of information, transport, communication and doing business in a foreign environment. Distance costs in the model take Samuelson's "iceberg" form: a fraction of a good shipped melts away in transit. Relative profitability of the two alternative strategies changes with distance costs. For high distance costs, exporting is the optimal strategy, since sales of an affiliate in the foreign country are too small to generate enough variable profits to pay the additional fixed costs. The small sales are due to high costs in production in the affiliate which stems from fact that the intermediate goods used in production are expensive. In the model it is assumed that intermediate inputs are specific to the final good. Thus, they must be imported from the home country and this trade incurs distance costs. The distances costs add to the variable costs of the good. The affiliates good is, therefore, too expensive to allow for larger sales.

With falling distance costs, exports rise. However, at high and intermediate distance costs, the profitability of production abroad increases even more with falling distance costs than the profitability of exports. For intermediate distance cost levels, it might therefore pay for a company to produce abroad and to become an MNE. For very low distance costs, exporting is again the more profitable strategy to supply the foreign market. International activities of companies follow, therefore, a pattern in which exports increase over time (because of falling distance cost over time). A change of the internationalization strategy from exports to production abroad is possible when distance costs have fallen below a certain threshold. Finally, companies return to exports when distance costs have fallen even further.

Equilibrium in this model requires that utility $u(Q^A, Q^M)$ of the representative consumer is maximized, that all goods and the factor market are cleared in both countries, that the current account is balanced and that firms' profits Π_i in both countries are maximized. Maximization of firms' profits includes that no firm can increase its profit by changing the strategy to the supply the foreign market, i.e. to

switch from exporting to producing abroad or vices versa. Therefore, firms compare the profits of the different modes:

$$\Pi_i = (1 - \rho) [p_{i,H}^M q_{i,H}^M + p_{i,F}^M q_{i,F}^M - p_{i,H}^N q_{i,H}^N] - F_{i,F} \quad (1)$$

The superscripts M and N stand for multinational and national firms. The subscripts H and F denote home and foreign as location of production. Prices of goods are denote by p , quantities by q . The markup $1/\rho$ over variable costs reflects the market power of a single firm and has an important effect on variable profits. The lower ρ , the larger the market power and, hence, the larger the variable profits. The first term (in parenthesis) on the right hand side gives the fraction of the revenue which becomes variable profits. The second term [in brackets] gives the difference in the revenues for the two strategies to supply the foreign market. The third term, $F_{i,F}$, denotes the fixed costs which incur if a firm uses an additional plant in the foreign country.

In (1), it is easy to see, that the lower are the fixed costs at the plant level, $F_{i,F}$, the more likely is it that a national company will decide to build a plant abroad. Furthermore, the internationalization decision depends only on the profits earned in the foreign market since prices, quantities and mark ups, and therefore profits, of national and multinational companies at home are the same. But foreign profits differ. Rewriting (1) yields

$$\Pi_i = (p_{i,F}^M - c_{i,F}^M) D(p_{i,F}^M) - (p_{i,H}^N - c_{i,H}^N) D(p_{i,H}^N e^\tau) - F_{i,F} \quad (2)$$

$$\text{with } D(p_{i,F}^k) = \frac{(p_{i,F}^k)^{-1/(1-\rho)}}{(P_F)^{-\rho/(1-\rho)}} \mu Y_F, \quad k=M,N, \text{ and } p_{i,F}^N = p_{i,H}^N e^\tau.$$

The price index in the foreign country is denoted by P_F . Variable costs are given by $c_{i,j}$ with $j=H,F$. Equation (2) can also be written as

$$\Pi_i = (1 - \rho) (Sales_{Affiliate} - Sales_{Exports}) - F_{i,F}. \quad (2')$$

If Π_i smaller than zero, firms prefer to export their goods. If Π_i larger than zero, they decide to establish a foreign affiliate in the host country. The decision depends on the sales in the foreign market under the different regimes, the fixed costs and the inverse of the markup. The sales depend on the market size a company can capture which is a function of its own price p_i , the foreign market's price index P_F and the total size of the market μY_F .

3. The data

We use a new and comprehensive data set on the foreign activities of German firms at the individual level of the foreign affiliate¹. The data have been kindly provided by the *Deutsche Bundesbank*.

German firms' foreign activities is measured by affiliate sales, and not by FDI stocks of the foreign affiliates, because affiliates sales are the right match to exports. Moreover, we believe that affiliate sales link the empirical specification more closely with the theory developed above since the stylized model gives predictions on real activity by multinational firms rather than financial flows or stock.

One feature of our data is that we can distinguish between the foreign activities of firms that set up affiliates in the same sector where they are active at home from firms that set up affiliates in different sectors. We use information for 65 different sectors to identify the sector of the reporting firm and the foreign affiliate.

The set of sectoral exogenous variables is classified according to NACE and taken from the OECD STAN database. In order to match our dependent variable to a set of sectoral exogenous variable, we aggregate the sales of 65 non-service industries to 26 NACE 3-digit sectors. Wages and sectoral output, which we chose to proxy market size, are deflated and converted into US\$ at 1995 prices using the 1995 purchasing power parity.

Distance is taken from CEPII (2004). The geodesic distances are calculated following the great circle formula, which uses latitudes and longitudes of the most important cities or agglomerations (in terms of population). The sales weighted distance costs are computed from the database "International Capital Links" of the *Deutsche Bundesbank*.

Although we have, in principle, information on the foreign activities of German firms in more than 200 host countries, we lack information on some important explanatory variables for quite a few of these countries, mostly overseas countries or low-income countries. Therefore, the effective sample size is restricted to affiliates set up in a little over 100 countries, including a large number of developing countries and emerging markets. While the information that we lose seems large in terms of the absolute *number* of observations for sales of foreign affiliates, the unconsidered countries account for only 2-3% of the foreign activities of German multinational firms. Moreover, summary statistics for sales of the affiliates for the full and for the restricted sample are very similar. Therefore, the data limitations are unlikely to limit the representativeness of our study.

¹ See Lipponer (2002) for a detailed description of the data and of the definition of FDI underlying German statistics

4. Estimation strategy

The database covers the whole population of German firms' foreign affiliates. These affiliates and the parent firms are classified according to the sector they are dominantly engaged in. Descriptive analysis reveals that the affiliates of manufacturing multinational firms are strongly concentrated in the same sector as the parent firm and in the wholesale sector.

In our test of the theory, we restrict the analysis to the set of affiliates for which the parent company is active in one of the manufacturing industries. In fact, the stylized model gives prediction for manufacturing firms. In order to distinguish between export and production abroad, we use the information on the sector in which a particular affiliate is active.

An exporting firm is a manufacturing parent firm that has affiliates active *only* in the wholesale sector of a particular country. Production abroad takes place when the manufacturing parent company holds affiliates that are only active in manufacturing.

In our multi-country multi-sector database, a particular parent company may export in one country and produce abroad in another one.

Having first classified the firms, we analyze systematic differences between both groups using a probit model. The equation to estimate is the comparison of the variable profits of exporting and producing abroad (π_i^M and π_i^N), keeping in mind the additional fixed costs at the plant level F_i needed for producing abroad. We derive the comparison from the theoretical proximity-concentration approach. According to theory, firms solve the program

$$\Pi_i = [\pi_i^M - \pi_i^N] - F_i. \quad (3)$$

If Π_i is larger than zero production abroad is more profitable for firm i than exporting. If Π_i is smaller than zero the firm decides to export its goods to serve the foreign market, because exporting is more profitable. Thus, firms produce abroad if $F_i < \pi_i^M - \pi_i^N$ and export if $F_i > \pi_i^M - \pi_i^N$. The comparison can also be expressed in terms of the relative (variable) profitability of both alternatives (π_i^N / π_i^M).

$$1 - \frac{F_i}{\pi_i^M} \begin{cases} \geq \frac{\pi_i^N}{\pi_i^M} & \text{if } \Pi_i \geq 0 \\ < \frac{\pi_i^N}{\pi_i^M} & \text{if } \Pi_i < 0 \end{cases} \quad (3')$$

We define $\phi_i \equiv \pi_i^N / \pi_i^M$ and express the profits as fraction of sales. In monopolistic competition models, the fixed mark-up over variable costs $1/\rho$ yields $\pi_i = (1-\rho)p_i q_i$. Because the price p_i is a function of production costs c^N or c^M , distance

costs τ and the mark-up ρ , and output q_i is a function of the former three and the (negatively) weighted overall price index in the industry P , ϕ_i is given by

$$\phi_i = \frac{(1-\rho)/\rho}{(1-\rho)/\rho} \frac{(c_i^N)^{-\rho/(1-\rho)} (e^\tau)^{-1/(1-\rho)} P_{jk} \mu_j Y_k}{(c_i^M)^{-\rho/(1-\rho)} P_{jk} (\mu_j Y_k)^\gamma}. \quad (4)$$

Where ρ is a measure of the degree of differentiation in the industry, c_i stands for the marginal costs of production, with the superscript M denoting a multinational firm and N denoting a national exporting firm, τ stands for the distance costs, and P_{jk} for the price index in the industry j in the foreign country k . The market size of industry j in country k is given by $\mu_j Y_k$. This market size might have different effects on profits of firms which produce abroad than on profits of exporting firms, in which case is γ different from one.

The first term in equation (4) cancels. Certainly, the degree of differentiation differs between firms and the differences systematically affect the profits of the firms and the profit comparison between the two modes of supplying the foreign market. From the theoretical model, we stick to the assumption of the same degree of differentiation for all goods, because we do not have any information on goods produced or exported by firms. The third term cancels as well. In a model of monopolistic competition à la Helpman and Krugman, firms are assumed to be too small to affect the price index. In other words, they do not take into account the effect of changes in the price index which result from their action. The size of the market should also not affect the decision between production abroad and export according to the model, i.e. γ equals one. However, $\gamma=1$ follows only from the use of a CES utility function in the model. The CES implies that all changes in market size are met by entrance of additional firms. In oligopolistic competition models (which do not rely on the CES function), in contrast, firms' size also changes with changing market size (Markusen 2002). Empirical evidence points to adjustment to changing market size through both: entrance and size adjustment of existing firms, which would translate into a γ larger than one (Buch et al. 2003). We therefore estimate γ and do not assume it to be one.

$$\phi_i = \frac{(c_i^N)^{-\rho/(1-\rho)} (e^\tau)^{-1/(1-\rho)} \mu_j Y_k}{(c_i^M)^{-\rho/(1-\rho)} (\mu_j Y_k)^\gamma} \quad (4')$$

Log linearizing of equation (4') yields

$$\ln(\phi_i) = \frac{\rho}{1-\rho} [\ln(c_i^M) - \ln c_i^N] - \frac{1}{1-\rho} \tau + (1-\gamma) \ln(\mu_j Y_k). \quad (5)$$

We define the left hand side of equation (3') $\psi_i \equiv 1 - (F_i/\pi_i^M)$. Log-linearizing, we have a non-linear term which is some function of profit scaled fixed costs at the plant level.

$$\ln(\psi_i) = \ln\left(1 - \frac{F_i}{\pi_i^M}\right). \quad (6)$$

Equation (3') changes to

$$\ln\left(1 - \frac{F_i}{\pi_i^M}\right) \begin{cases} \geq \frac{\rho}{1-\rho} [\ln(c_i^M) - \ln c_i^N] - \frac{1}{1-\rho} \tau + (1-\gamma) \ln(\mu Y_k) & \text{if } \Pi_i \geq 0 \\ < \frac{\rho}{1-\rho} [\ln(c_i^M) - \ln c_i^N] - \frac{1}{1-\rho} \tau + (1-\gamma) \ln(\mu Y_k) & \text{if } \Pi_i < 0 \end{cases}$$

We observe when Π_i is larger zero by the observation that a foreign affiliate exists. If no affiliate in manufacturing exists the firm revealed that exporting is more profitable, i.e. Π_i smaller zero. We indicate firms which produce abroad ($\Pi_i > 0$) by one, exporting firms ($\Pi_i < 0$) by zero. Bringing ψ_i to the other side and defining the difference positively, the decision I with $I=0$ for exporting firms and $I=1$ for firms producing abroad is explained by

$$I = \beta_1 [\ln(c_i^N) - \ln(c_i^M)] + \beta_2 \tau + \beta_3 \ln(\mu Y_k) + \ln\left(1 - \frac{F_i}{\pi_i^M}\right). \quad (7)$$

Where $\beta_1 = \rho/(1-\rho)$, $\beta_2 = 1/(1-\rho)$, and $\beta_3 = (\gamma-1)$. The last term in (7) is difficult to implement in an econometric analysis. If in theory, fixed costs have to be covered by per period profits it is hard to judge how many years in real time make one period. Moreover, we decided to use sales as scaling factor rather than profits. In theory that does not change the results because profits are a fixed share of sales. Regarding our data, we believe that sales are less sensitive to accounting standards, profit transfers and other effects which are not related to our export versus production abroad decision. We, therefore, proxy the last term with $\beta_0 + \beta_4 \ln(F_i/p_i^M q_i^M)$ and expect β_4 to be negative. Substituting in (7) yields

$$I = \beta_0 + \beta_1 [\ln(c_i^N) - \ln(c_i^M)] + \beta_2 \ln(\tau) + \beta_3 \ln(\mu Y_k) + \beta_4 \ln\left(\frac{F_i}{p_i^M q_i^M}\right). \quad (7')$$

Adding the error term and plugging in the variables we use to estimate the model, we derive equation (8) which is the empirical model we estimate

$$\begin{aligned} I = & \beta_0 + \beta_1 [\ln(w_j^{Germany}) - \ln(w_j^{Foreign})] + \beta_2 \ln(DC) \\ & + \beta_3 \ln(\text{market size}_{jk}) + \beta_4 \frac{F_j}{Sales_j} + u_{ijk} \end{aligned} \quad (8)$$

w_j^{Ger} denotes wages in sector j in Germany, $w_j^{Foreign}$ denotes wages in sector j in the foreign country. Following Markusen and Maskus (1999), we include a dummy

variable $D1$, which controls for countries that have a higher sectoral wages level compared to Germany. DC is the distance costs. We proxy distance costs by the log of physical distance between Germany and the foreign country. We use output of sector j in the foreign country k as variable for $market\ size_{jk}$. F denotes the fixed costs of the affiliate of firms i in industry j in country k . The fixed costs are taken from the database “*International Capital Links*”. We use the variable fixed assets (*Sachanlagen*) on the level of the affiliate. We use the sectoral average of the fixed assets for each country and scale this variable by the average sectoral sales of foreign affiliates of German multinational firms in this country. We believe that this variable is a good proxy for the ex-ante expectations over the fixed costs of the production unit which might be established. We use this variable in non-logarithmic form because the fixed costs are scales already by the sales. u_{ijk} is the error term.

Before interpreting the results, the specified model raises several issues. First, the model relies crucially on the assumption of homoskedasticity in the underlying latent variable model. We use the Huber-White method to correct for heteroscedasticity. Since the data are pooled over four years, from 1996 to 1999, we include time dummy variables and also correct for serially correlated responses from Affiliates (Wooldridge, 2002).

Finally, the model being non-linear, the marginal effects are not constant and need to be interpreted at some sample point. We choose to use the means of the independent variables to do this evaluation.

5. Results

Table 1 presents the estimates of the marginal effects. Both specifications include sector and time dummy variables, which controls for some unobserved determinants. All coefficients have the expected sign. The coefficient for the relative costs, β_1 , is positive. Production in foreign affiliates is more likely in locations with lower labor cost. The location must have an advantage over production at home to make up for the higher cost an affiliate faces when producing in an unfamiliar environment. The introduction of the control dummy variable D1 does not affect the main results. The difference in wage still significant at one percent level of significance.

Turning to the coefficient of the distance costs variable, β_2 , it is positive as well. Firms prefer exports over production abroad in markets close by. That is in line with the proximity-concentration literature (Brainard 1993, Markusen and Venables 1998, Markusen 2002).

The coefficient for market size, β_3 , is positive, although small. A one percent increase of the market size, increases the probability that a firm decides to set up a production unit by 0.01%. This is in accordance with general equilibrium models of trade which use a CES utility function. In fact, the differences in market size affect the number of firms active in each market but does not influence the decision between export and production abroad. We find that larger markets attract more foreign production but that this effect is quantitatively very small.

The fixed cost variable is at the heart of the proximity-concentration trade-off. Higher fixed costs of the additional plant in the foreign country reduce the probability that a production unit is set up abroad. Instead, production is concentrated in existing plants and goods are exported to foreign markets. Our analysis supports the proximity-concentration trade-off. The coefficient for the fixed costs, β_4 is negative and significant on the one percent level. Lower fixed costs by 100 percentage points increases the probability to establish a production unit abroad by 0.05 per cent.

Estimations of the coefficients β_1 and β_2 allows to compute the average degree of differentiation among the products of the firms. The degree of differentiation ρ defines the substitutability of the products. We can solve for it dividing β_1 by β_2 . For our estimation, the computed ρ equals 0.98, which is very closed to 1. A low ρ represents a high degree of differentiation and low substitution.

6. Conclusion

We analyze manufacturers decision to serve foreign markets through export or FDI. Our theoretical model shows that the decision to reach arm-length markets arises as a trade-off. Exports raises the relative price of goods sold in the foreign countries by distance costs while producing abroad requires an additional fixed cost related to the new branch plant.

The model is estimated using firm-level data that allows to distinguish between export and FDI. We find strong evidence for the proximity concentration trade-off. In particular, set-up costs reduce the incentive to engage in FDI. Sectoral wages and the fixed-costs share have a negative impact on the probability of foreign production. However, firms prefer to produce in distant country and to export in nearby markets. We find also that market size influences the internationalization decision between export and affiliate production but the impact of market size on the probability of investment remains low.

Table 1: Estimation Results (Pooled-Probit Analysis: 1996-1999)

	Affiliate Production Marginal Effects	
Wage Difference	0.0510*** (6.76)	0.0516*** (6.62)
Distance	0.0522*** (10.57)	0.0514*** (9.41)
Market Size	0.0120* (1.68)	0.0116 (1.62)
Fixed-costs Share	-0.0006* (-1.83)	-0.0006* (-1.84)
D1		0.0088 (0.44)
Sectoral Dummy	Yes	Yes
Year Dummy	Yes	Yes
Observations	33010	33010
Log pseudo-likelihood	-21924.038	-21923.769
McFadden's Adj R2	0.0068	0.0068
Robust z statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%		

REFERENCES

- Brainard, S.L., 1997. An empirical assessment of the proximity-concentration trade-off between multinational sales and trade. *American Economic Review* 87 (4), 520–544.
- Brainard, S.L., 1993. An Empirical Assessment of the Factor Proportions Explanation of Multinational Sales, NBER Working Paper No. 4583.
- Buch, C.M., Kleinert, J., Toubal, F., 2004. Determinants and Effects of Foreign Direct Investment: Evidence from German Firm-Level Data. Kiel Mimeo.
- Carr, D.L., Markusen, J.R., Maskus, K.E., 2001. Estimating the knowledge-capital model of the multinational enterprise. *American Economic Review* 91 (3), 693–708.
- CEPII, distance on the web. www.cepii.fr.
- Kleinert, J., 2004. The role of multinational enterprises in globalization. *Kiel Studies* 326. Berlin: Springer.
- Lipponer, A. (2002). ‘A „new“ microdata base for German FDI’, in H. Herrmann and R. Lipsey (eds), *Foreign Direct Investment in the Real and Financial Sector of Industrial Countries*, Berlin: Springer.
- Markusen, J.R., 2002. *Multinational Firms and the Theory of International Trade*, MIT Press, Cambridge.
- Markusen, J.R., Maskus, K.E., 2002. General-equilibrium approaches to the multinational firm: a review of theory and evidence. In: Harrigan, J. (Ed.), *Handbook of Empirical International Trade*, London: Blackwell, also NBER working paper 8334.
- Markusen, J.R., Venables, A.J., 1998. Multinational firms and new trade theory. *Journal of International Economics* 46 (2), 183–203.
- Wooldridge J.M. 2002. *Econometric Analysis of Cross-section and panel data*. MIT Press, Cambridge.