

PROXIMITY-CONCENTRATION VERSUS FACTOR PROPORTION
EXPLANATION: THE CASE OF SWEDISH MULTINATIONALS IN THE EU*

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ABSTRACT:

Both proximity-concentration trade-off and factor proportions explanations have been forwarded to explain the existence of multinational enterprises. This paper analyses to what extent these different explanations are supported empirically, in making a first attempt to distinguish explicitly between horizontally and vertically integrated multinationals. The affiliate production share of horizontally integrated multinationals is mainly explained by low plant-level economies of scale, large host country size and similarities in relative factor endowments. Differences for vertical multinationals appear with regard to firm- and plant-level economies of scale, country size, trade costs and relative factor endowments at the national and sectoral level.

Keywords: *Trade Costs, Country Size, Factor Endowments, Horizontal & Vertical Multinationals*

JEL Classification: *F12, F21, F23*

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I. INTRODUCTION

On both a regional and a global scale, the importance of multinational enterprises and Foreign Direct Investment have grown dramatically in recent decades. Against this background, it is thus not surprising that ‘new’ trade theory is now deemed to be an inappropriate reflection of reality, as multinationals are excluded from the analysis.

Starting with the early approaches of Helpman (1984) and Markusen (1984), new literature has emerged which takes account of the increasing importance of multinational production in servicing foreign markets. Most of the newer models concentrate on horizontally integrated multinationals (e.g. Brainard, 1993a; Horstmann & Markusen, 1992; Motta, 1992; Markusen & Venables, 1996a,b, 1998).

Indeed, stylised facts point towards horizontal multinationals being far more important empirically than vertically integrated multinationals. In the context of Sweden, however, it has been argued that the relationship between Swedish parents and their European affiliates is to a significant extent of a vertical nature (Andersson *et al.* 1996).

This distinction is important both on theoretical and empirical grounds, as horizontal multinationals tend to arise if countries are similar in relative and absolute factor endowments, and if trade costs are medium to high, while vertical multinationals arise mainly if countries are very different with respect to their relative factor endowments and if trade costs between countries are low (Markusen *et al.*, 1996).

Recent empirical tests of both proximity-concentration trade-off hypothesis (Brainard, 1997; Ekholm, 1998) and the factor proportions explanation of multinational sales (Brainard, 1993b; Ekholm, 1995, 1997) failed to explicitly distinguish the type of integration between parent and affiliate. Brainard (1993b) distinguished between multinational sales destined for local sales and multinational sales destined for exports to the home country, i.e. between horizontally and vertically backward integrated multinationals. She did this in an attempt to shed light on the poor performance of the factor proportions explanation of multinationals sales.

The main objective of this paper is thus to make an explicit attempt to analyse whether these different theoretical predictions in relation to horizontal vs. vertical multinationals are supported by the data for EU countries. Secondly, separating horizontally integrated multinationals from vertically integrated multinationals also allows us to test the proximity-concentration trade-off hypothesis. As only very few empirical tests have been conducted to test these general propositions, this paper will help to show whether previous empirical

findings are robust. This is particularly important as the countries in Brainard (1997) were chosen to “maximise diversity in geographical coverage, income, production structure, and data coverage” (Brainard, 1997, p. 525). In choosing a relatively homogenous group of countries, as is the case for EU member states, it will be important to see whether her empirical results are still supported.

In the empirical analysis, we use plant and firm level data from Swedish multinationals in the manufacturing industry, collected on a quadrennial basis at the Research Institute of Industrial Economics in Stockholm. In doing so, we restrict ourselves to multinationals already in existence.¹

The remainder of this paper is organised as follows: Section 2 explores the theoretical background. This will lead to the formulation of testable hypotheses. Section 3 presents the data and sources, while section 4 derives the econometric specification. Section 5 discusses the empirical results, and the final section concludes.

II. THEORETICAL ASPECTS

Horizontal multinationals have received more attention in the theoretical literature than vertical multinationals. This may be in line with stylised facts, which point towards horizontal multinationals being more relevant empirically than vertical multinationals (Markusen, 1995). In the case of Sweden, such a general statement may however be misleading. As table 1 shows, the relationship between Swedish parents and their EU affiliates shows considerable signs of vertical integration.

Table 1

Vertical integration between Swedish parent and EC affiliates^a

	Avg. share of parents' exports of intermediates to parents' exports to EC affiliates	Avg. share of parents' exports of intermediates to total parent exports to the EC	Avg. share of parents' exports of intermediates to EC affiliates sales	Avg. share of affiliate exports to Sweden to EC affiliate sales
1974	52.4%	19.8%	9.4%	12.5%
1978	53.4%	15.5%	10.5%	15.7%
1986	44.0%	12.9%	9.6%	9.2%
1990	46.0%	11.4%	8.1%	10.3%
1994	43.4%	15.0%	9.5%	10.3%

^a refers to EC-12 with Ireland and Luxembourg being excluded.

¹ Firms in the sample may service individual countries in the EU either through exporting or through multinational production, or both simultaneously. However, a sample selection problem emerges in so far as the database does not contain purely national firms.

Hence, it is important to distinguish between horizontally and vertically integrated multinationals, especially as some of the forces leading to the emergence of horizontal multinationals are in sharp contrast to the forces leading to the presence of vertical multinationals. In trying to identify testable hypotheses for the empirical section, I will draw mainly on the results of Markusen *et al.* (1996), which to the best of my knowledge, provide the only theoretical framework which synthesises the emergence of both horizontal and vertical multinationals.²

Their model assumes that there are two countries producing two homogenous products, with two factors of production: skilled and unskilled labour. Both factors of production are mobile between sectors but immobile between countries. Sector one is characterised by skilled labour being used in the firm-specific fixed costs, while a combination of both production factors is used for the fixed plant set up costs. Unskilled labour is only used in variable costs and transport costs between countries. In the second sector, perfect competition is assumed to prevail. This sector is taken as the numéraire.

Further assumptions for sector one are, firstly, that skilled labour requirements for the generation of multi-plant and plant-level economies of scale are identical for national exporting firms and vertical multinationals. The only difference is that vertical multinationals draw part of the skilled labour requirement from the host country. Thus, the nature of the vertical MNE is similar to the treatment in Helpman (1984), i.e. production and trade in intermediates are not considered.

Secondly, the skilled labour requirements in fixed costs are larger for horizontal multinationals than those for vertical multinationals or national firms. This is due to the fact that horizontal multinationals are assumed to operate two manufacturing plants, as opposed to vertical multinationals or national firms, which operate just one. However, the skilled labour requirements in fixed costs by horizontal multinationals are less than twice the requirement of vertical multinationals or national firms. This reflects the joint-input characteristic of firm-specific assets.

Thirdly, unskilled labour requirements are assumed to be identical for all plants and are drawn entirely from the country where the plant is located. Lastly, it is assumed that there is some small cost to separate headquarters from production.³

² Some readers may regard it as weakness to review the Markusen *et al.* (1996) paper without referring to mathematical expressions. We feel that, due to the requirements of brevity, we would not be able to do justice to the complexity and richness of the paper. Rather, we would like to appeal to the economic intuition behind the results and hope that the reader finds this acceptable.

³ This is to avoid degeneracy of the model.

Table 2

Dominant Production Regime and Country Characteristics

Regime	Hypothesis ⁴	Characteristics
Horizontal multinationals	(1)	• firm-level economies of scale are large,
	(2)	• plant level economies of scale are low,
	(3)	• countries are large,
	(4)	• trade costs are moderate to high,
	(5)	• countries are similar in their relative factor endowments,
	(6)	• countries are similar in size.
Vertical multinationals	(7)	• trade costs are moderate to low,
	(8)	• countries differ significantly in their relative factor endowments.
National exporting firms	(9)	• trade costs are low and countries are similar in their relative factor endowments and size,
	(10)	• trade costs are moderate and countries are very different in size.

Source: Markusen *et al.* (1996)

The simulated theoretical propositions, summarised in table 2 above, suggest firstly, that horizontal multinationals tend to exist if firm-level economies of scale and trade costs are large relative to plant-level economies of scale. This result appears in numerous horizontal models (Brainard, 1993a; Horstmann & Markusen (1992); Markusen & Venables (1996a,b, 1998) and has also been confirmed in recent empirical studies by Brainard (1997), Ekholm (1998).

The idea is that firms have to trade off the benefits of proximity to customers with the concentration of production at a single plant. Proximity to customers saves transport costs, while concentration of production allows the firm to reap the benefits of plant-level economies of scale. It is clear, however, that horizontal multinationals cannot arise if transport costs are assumed to be negligible. This is due to the fact that, by establishing a manufacturing plant abroad, the horizontal multinational has to incur fixed plant set up costs without being able to save on transport costs from doing so.

Secondly, horizontal multinationals are associated with similar relative and absolute factor endowments. Again, these results are consistent with horizontal models of Brainard (1993a) and Markusen & Venables (1996a,b, 1998). These predictions are also supported by recent empirical evidence which reaches the conclusion that multinational activity is mainly promoted by country size and factor endowment similarities (e.g. Brainard, 1997; Ekholm, 1998).

⁴ Hypothesis 6 is not testable as the data only contains Swedish outward multinationality. Hypotheses 9 and 10 are not testable either, as the database does not contain purely national firms.

If countries become dissimilar with respect to relative factor endowments, the skilled labour abundant country will have a comparative advantage in producing goods in sector one. In this case, single plant firms have an advantage over two-plant firms, as horizontal multinationals locate production in the high cost factor market.

If countries become dissimilar with respect to country size, the larger country will have an advantage of producing goods in sector one due to the home market effect. Moreover, the larger country will have a higher real price of skilled labour, which is due to the general equilibrium constraint. This is assuming that production of the product in sector one is relatively skilled labour intensive. In this case, multinational production has two cost advantages over exporting; saving on transport costs and lower prices of skilled labour. Allowing multinationals to enter, raises the demand and price for skilled labour in the smaller country. In this sense, multinationals reduce factor price differences. If country size differences become too pronounced, however, production in the smaller country can no longer be sustained as output levels are too small to recoup fixed plant set up costs. This explains the association of horizontal multinationals with similarity of absolute and relative factor endowments.

If factor endowments and transport costs are such that two plant, i.e. horizontal multinationals, cannot be sustained, the question as to whether the equilibrium is dominated by vertical multinationals or national firms hinges on the fact of whether factor prices are equalised internationally. If factor prices are virtually equalised, vertical multinationals cannot be supported due to the cost disadvantage of splitting headquarter services and production. If factor prices fail to equalise, vertical multinationals can enter, as they fragment headquarter services and production, such that headquarter services are located in the skilled labour abundant country, while production takes place in the unskilled labour abundant country. These results are consistent with the work by Helpman (1984), Helpman & Krugman (1985) and Zhang & Markusen (1996).

There is only limited evidence for the factor proportions explanation of multinational sales. Brainard's (1993b) results reject the pure factor proportions explanation. In an attempt to separate horizontally and vertically integrated multinationals, she finds that affiliate production destined for exports back to the US differs from that destined for local sales. The factor proportions hypothesis is generally supported in explaining the share exported back to the US. To be more precise, the share of affiliate sales accounted for by exports back to the

US increases with differences in per capita endowments of capital, and illiterate labour, and decreases with differences in unskilled, literate labour, and transport costs.

Ekholm (1998) also finds some support for the factor proportions explanation in that the share of the net outward foreign production to total foreign production is positively increasing in absolute capital per capita differences, and particularly in human capital differences. Her results are consistent with earlier obtained results, which indicated that outward foreign production is positively affected by the home country's relative endowment in overall and human capital (Ekholm, 1995, 1997).

Another important issue to be considered is the effect of both horizontal and vertical multinationals on trade volumes. Horizontal multinationals have the tendency of reducing trade volumes between countries. This was suggested in models by Brainard (1993a), Markusen & Venables (1996a,b, 1998).

For vertical multinationals, such a clear prediction is not possible. Firstly, investment liberalisation, followed by entry of vertical multinationals, may lead to the reversal of trade flows. The reason is the geographical separation of the production stages, which results in the home country importing the final product rather than exporting it, as would be the case with purely national firms.

Secondly, investment liberalisation may lead to increases in trade flows. There has been a considerable debate in the literature as to whether exports and multinational production are substitutes or complements. In the case of Sweden, empirical evidence demonstrates some complementarity between exports and multinational sales (Swedenborg, 1979, 1982; Blomström *et al.*, 1988). In contrast to these studies Svensson (1996) finds some evidence of substitutability, which is especially pronounced for EU countries.

In theory, increases in trade flows are especially likely if one country is small and skilled labour abundant, whilst the other country is large and unskilled labour abundant. Indeed, it may be argued that this scenario reflects the case of Sweden. In such a case, investment liberalisation has the effect of relaxing constraints in both the small and large country. In the small country, production of the final product is constrained due to unskilled labour scarcity and a small domestic market, while in the large country, production of headquarter services is constrained due to the high price of skilled labour. Thus, investment liberalisation may lead to relocation of headquarter services to the small skilled labour abundant country. Production would take place in the larger country, which exports the final

product to the small country, while the small country exports headquarter services to the large country. As a result the volume of exports may increase.

One can detect many stylised Swedish facts as presented by Andersson *et al.* (1996) in this scenario. Firstly, Sweden is the home country of many multinationals in relation to its country size. Secondly, the internationalisation process of Swedish multinationals was characterised by expansion through foreign affiliates between 1970 and 1990. Thirdly, the relationship between parent and EU affiliate is to a significant extent of a vertical rather than horizontal nature.

III. DATA

The data is taken from the database at the Research Institute of Industrial Economics (IUI) in Stockholm. This database contains information on the foreign operations of individual Swedish multinationals with more than 50 employees in the manufacturing industry.⁵ We shall consider the operations of Swedish multinationals in ten individual EU member states. Ireland and Luxembourg had to be excluded. This is because industrial variables were taken mainly from OECD's STAN database, which includes neither of these countries. Data for Germany refers to West Germany prior to 1990 and to united Germany from 1991 onwards. The variables are defined in million SEK and 1990 prices. The analysis covers the years 1974, 1978, 1986, 1990 and 1994. Earlier years had to be excluded, as the questionnaire prior to 1974 only covered firms' exports for countries where foreign production was established. No survey was conducted in 1982. The data set is pooled over these years. Interaction variables are used to test for structural differences between horizontal and vertical multinationals.

IV. ECONOMETRIC SPECIFICATION

The share of foreign production: $AFFSH_{i,k,t}$

The dependent variable takes account of exports and multinational production being simultaneously determined. It is defined as:

$$AFFSH_{i,k,t} = \frac{Production_{i,k,t}}{Production_{i,k,t} + Exports_{i,k,t}}$$

The production volume of a multinational i in country k at time t is defined as the sum of all affiliates' total sales in country k at time t minus the sum of their total imports from their parent company in Sweden at time t . Thus, we make an attempt to disentangle affiliates'

⁵ For a complete documentation of the database see Andersson *et al.* (1996).

production from pure resale activities of imported products. Exports are defined as firm i 's total exports to country k at time t . Exports include both exports of finished products, which may be sold by the affiliate in country k , and intermediate products, which are used by the affiliate for further processing. We distinguish between horizontal and vertical multinationals in employing interaction variables, which take account of the extent of vertical integration between parent and its EU affiliates.

Econometric Estimation Method

It is immediately apparent that the dependent variable may be censored. Censoring of the dependent variable usually refers to a sample where some observations of the dependent variable are not observed, while the independent variables are observed (e.g. Maddala, 1983; Greene, 1993). In this case estimation of the dependent variable by Ordinary Least Squares will result in biased coefficient estimates. To avoid this problem we formulate a Tobit regression model, which accounts for censoring at both the lower and upper tail.

AFFSH is censored at both tails, as firms export to EU countries, but are not necessarily engaged in multinational production in these countries. Additionally, there are cases where the Swedish parent supplies the foreign market entirely via multinational production, but not via exports from Sweden.⁶ The specification for *AFFSH* takes the following form:

$$y_i^* = \beta'x_i + \mu_i \quad , \text{ where } y_i^* \text{ is the underlying latent variable and}$$

$$y_i = y_i^* \quad \text{if } 0 < y_i^* < 1$$

$$y_i = 0 \quad \text{if } y_i^* \leq 0$$

$$y_i = 1 \quad \text{if } y_i^* \geq 1$$

Explanatory Variables

This section briefly presents the proxies and variables that are used in the econometric analysis. The exact definitions and the data source are shown in table 3. As the proxy for firm-level economies of scale, we use the R&D to sales ratio (*R&D*) of individual firms.⁷ The importance of plant-level economies of scale is captured by the ratio of the average industry

⁶ Unfortunately, we cannot account for any relationship between affiliates within the EU.

⁷ It would have been worth while to include firms' marketing or advertising expenditures. However, such data is only available for 1994, and could therefore not be included in the estimations.

plant size to the firm size in Sweden (*LSCALE*).⁸ In doing so, we attempt to ensure that the firms operate at the minimum efficient scale of production.

Table 3

Table with Variables and Data Sources

Proxy	Variable Definition	Data Source
$R\&D_{i,t}$	The ratio of total R&D expenditure to world-wide sales	IUI database
$LSCALE_{i,k,t}$	The log of the ratio of the average plant size in terms of employees to the firm size in the Swedish market	Firm size taken form IUI database. Swedish industry census of production at the 3 and 4 digit level of the ISIC classification. Years refer to 1975, 1978, 1987, 1990, 1993.
$LTRADE_{i,t}$	The log of industry specific trade and packaging costs expressed as share of industry sales	Swedish industry census of production at the 3 and 4 digit level of the ISIC classification. Years refer to 1975, 1978, 1987, 1990, 1993.
$LGDP_{k,t}$	Country size expressed as log of GDP	OECD National Accounts
$LINCDIF_{k,t}$	$\log\left(\frac{Per\ Capita\ GDP_{k,t}}{Per\ Capita\ GDP_{SWE,t}}\right)$	OECD National Accounts
$LVADIF_{j,k,t}$	$\log\left(\frac{Value\ Added\ Per\ Employee_{j,k,t}}{Value\ Added\ Per\ Employee_{j,SWE,t}}\right)$	OECD STAN database, at the 3 digit level of the ISIC classification.
$LWAGEDIF_{j,k,t}$	$\log\left(\frac{Compensation\ Per\ Employee_{j,k,t}}{Compensation\ Per\ Employee_{j,SWE,t}}\right)$	OECD STAN database, at the 3 digit level of the ISIC classification.
$LUNITDIF_{j,k,t}$	$\log\left(\frac{Unit\ Labour\ Cost_{j,k,t}}{Unit\ Labour\ Cost_{j,SWE,t}}\right)$	OECD STAN database, at the 3 digit level of the ISIC classification.

Interaction terms indicated by suffix -*V*

$VFEU_{i,t}$	$\frac{\sum_k Export\ of\ Intermediates\ to\ Affiliates_{i,k,t}}{\sum_k Affiliate\ Production_{i,k,t}}$	
$VBEU_{i,t}$	$\frac{\sum_k Affiliate\ Exports\ to\ Sweden_{i,k,t}}{\sum_k Affiliate\ Production_{i,k,t}}$	IUI Database
$VFBEU_{i,t}$	$VFBEU_{i,t} = VFEU_{i,t} + VBEU_{i,t}$	

Note: The subscript *i, j, k, and t* denotes the firm, industry, country, and time specific component, respectively. The prefix *L* denotes that the variable is expressed in logarithmic form to reduce heteroscedasticity. This was not possible for *R&D* as some values contain zeros.

⁸ In the Industrial Organisation literature it is commonplace to relate absolute measures of economies of scale to industry or market size. As we seek to explain individual firms' behaviour, it is more appropriate to relate economies of scale to firm size.

The measure of trade costs (*LTRADE*) is also taken from Swedish industry statistics. It has neither a distance nor a country specific component, but varies over time. The country size (*LGDP*) is measured by the Gross Domestic Product. We follow Brainard (1997) and use the absolute difference in relative per capita incomes (*LINCDIF*) as a proxy for differences in relative factor endowments. Additionally, we introduce the absolute difference in the relative labour productivity (*LVADIF*), wages (*LWAGEDIF*), and unit labour costs (*LUNITDIF*) at the industry level as proxies for differences in human capital, skills, and technologies.^{9 10}

Lastly, vertical interaction variables are employed to analyse the structural differences between horizontal and vertical multinationals. The aggregate extent of vertical forward integration and backward integration between the parent and its EU affiliates, labelled *VFEU* and *VBEU* respectively, are multiplied with the respective explanatory variables. We also include the sum of the two measures, labelled *VFBEU*. In using the actual values of these terms and not just dummy variables, we are able to avoid analysing the sensitivity of the obtained results to different ad hoc threshold values.

V. ECONOMETRIC RESULTS

Specification (I) does not distinguish between horizontal and vertical multinationals, but merely replicates some of the most robust findings in recent empirical studies. The results, presented in table 4, demonstrate that the share of affiliate production of Swedish multinationals is primarily explained by the determinants associated with horizontal multinationals (Hypotheses 2,3,4,5). The share of foreign production to total foreign sales, *AFFSH*, is decreasing in plant-level economies of scale relative to firms size, and increasing in trade costs, host country size, and in similarities in per capita income, labour productivity, wages and unit labour costs. The coefficients of these variables are highly significant. Only the coefficient of the R&D intensity does not have the expected sign. It is negative and significantly so. This result will be further discussed at a later point.

⁹ Data on the capital labour ratio at the sectoral level is available in the STAN database. We did not to use this measure as the data availability is much poorer than for the other measures. Its inclusion would have resulted in too many missing observations.

¹⁰ Technological differences between countries and industries do not explicitly appear in the theoretical model by Markusen *et al.* (1996). In a similar model, Markusen & Venables (1996a) have, however, shown that horizontal multinationals are promoted if countries converge with regard to relative technologies. Therefore, we expect absolute human capital and technology differences to have a negative impact on horizontal multinationals.

Table 4

Tobit Estimates for the Affiliate Production Share

Specification	(Ia)	(Ib)	(Ic)	(Id)
Interaction variable	NO	NO	NO	NO
Dep. Var.	AFFSH	AFFSH	AFFSH	AFFSH
No. of obs.	1698	1698	1698	1698
Threshold value	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1
Log likelihood	-1252.4	-1258.3	-1256.6	-1260.2
<i>CONSTANT</i>	-5.134 (-9.172)	-5.766 (-10.047)	-5.581 (-9.828)	-6.062 (-10.245)
<i>R&D</i>	-2.352 (-3.151)	-2.537 (-3.417)	-2.556 (-3.472)	-2.303 (-3.089)
<i>LSCALE</i>	-0.341 (-12.808)	-0.339 (-12.787)	-0.343 (-12.845)	-0.338 (-12.705)
<i>LTRADE</i>	0.246 (5.679)	0.244 (5.706)	0.254 (5.889)	0.252 (5.829)
<i>LGDP</i>	0.228 (6.851)	0.265 (7.795)	0.251 (7.435)	0.283 (8.081)
<i>LINCDIF</i>	-0.375 (-3.853)			
<i>LVADIF</i>		-0.228 (-2.625)		
<i>LWAGEDIF</i>			-0.275 (-3.076)	
<i>LUNITDIF</i>				-0.273 (-1.857)

T-statistic in brackets. Time fixed effects are included. Estimates are heteroscedasticity consistent.

The results in specifications (II), (III) and (IV), shown in tables 5, 6, and 7, demonstrate clearly the presence of significant differences between horizontal and vertical multinationals. The log-likelihood ratio test statistic strongly rejects the restriction of parameter equality of horizontally and vertically multinationals.¹¹

Firstly, the results for horizontal multinationals are essentially those obtained in specification (I). Horizontal multinationals are strongly associated with the proximity-concentration trade-off explanation of multinational sales and with similarities in relative factor endowments, and thus with similarities in technologies, skills and human capital. Thus, these results adequately confirm the theoretical predictions for the emergence of horizontal multinationals (Hypotheses 2,3,4,5).

¹¹ The Log-Likelihood statistic for testing restrictions is $\lambda = -2(\ln L^* - \ln L)$, where L^* and L refer to the restricted and unrestricted estimation, respectively. This statistic is asymptotically distributed as Chi-squared with J degrees of freedom (e.g. Greene, 1993).

Table 5

Tobit Estimates for the Affiliate Production Share and the differences between horizontally and vertically forward integrated multinationals

Specification	(IIa)	(IIb)	(IIc)	(IId)
Interaction variable	VFEU	VFEU	VFEU	VFEU
Dep. Var.	AFFSH	AFFSH	AFFSH	AFFSH
No. of obs.	1698	1698	1698	1698
Threshold value	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1
Log likelihood	-1219.2	-1224.0	-1222.2	-1226.5
<i>CONSTANT</i>	-4.982 (-9.069)	-5.579 (-9.999)	-5.380 (-9.750)	-5.908 (-10.269)
<i>R&D</i>	-2.109 (-2.181)	-2.395 (-2.454)	-2.327 (-2.412)	-2.062 (-2.109)
<i>LSCALE</i>	-0.351 (-12.278)	-0.350 (-12.320)	-0.354 (-12.331)	-0.351 (-12.342)
<i>LTRADE</i>	0.141 (3.150)	0.144 (3.268)	0.154 (3.486)	0.149 (3.344)
<i>LGDP</i>	0.228 (6.974)	0.262 (7.960)	0.248 (7.559)	0.282 (8.298)
<i>LINCDIF</i>	-0.382 (-3.822)			
<i>LVADIF</i>		-0.284 (-3.111)		
<i>LWAGEDIF</i>			-0.327 (-3.480)	
<i>LUNITDIF</i>				-0.365 (-2.252)
<i>R&D-V</i>	7.053 (2.448)	7.535 (2.638)	7.352 (2.533)	7.209 (2.483)
<i>LSCALE-V</i>	0.455 (3.996)	0.471 (4.092)	0.475 (4.086)	0.472 (4.151)
<i>LTRADE-V</i>	-0.306 (-1.580)	-0.347 (-1.890)	-0.360 (-1.925)	-0.330 (-1.785)
<i>LGDP-V</i>	0.086 (2.481)	0.083 (2.366)	0.088 (2.465)	0.083 (2.386)
<i>LINCDIF-V</i>	-0.013 (-0.047)			
<i>LVADIF-V</i>		0.508 (1.655)		
<i>LWAGEDIF-V</i>			0.390 (1.505)	
<i>LUNITDIF-V</i>				0.713 (1.158)

T-statistic in brackets. Time fixed effects are included. Estimates are heteroscedasticity consistent. The suffix -V indicates the inclusion of a vertical interaction term.

One very interesting result is that the coefficient of the R&D intensity is negatively significant in almost all specifications, which is contrary to expectation. The negative coefficient may be related to technology transfer costs between parents and affiliates. As Norbäck (1998) has demonstrated in the case of horizontal multinationals, the expectation of a positive R&D coefficient hinges on the assumption of technology transfer costs between

parent and affiliates being unrelated to the magnitude of the R&D intensity. Allowing instead that technology transfer costs and the R&D intensity are positively related, as technical personnel, scientists and other managerial staff have to be sent to foreign affiliates to supervise implementation of the firm-specific assets, is consistent with the expectation of a negative coefficient of the R&D intensity.

Table 6

Tobit Estimates for the Affiliate Production Share and the differences between horizontally and vertically backward integrated multinationals

Specification	(IIIa)	(IIIb)	(IIIc)	(IIId)
Interaction variable	VBEU	VBEU	VBEU	VBEU
Dep. Var.	AFFSH	AFFSH	AFFSH	AFFSH
No. of obs.	1655	1655	1655	1655
Threshold value	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1
Log likelihood	-1205.0	-1205.9	-1205.0	-1221.7
<i>CONSTANT</i>	-5.017 (-9.076)	-5.508 (-9.959)	-5.347 (-9.636)	-6.158 (-10.481)
<i>R&D</i>	-1.955 (-2.207)	-2.371 (-2.729)	-2.510 (-2.871)	-1.816 (-2.078)
<i>LSCALE</i>	-0.341 (-12.285)	-0.343 (-12.432)	-0.347 (-12.367)	-0.338 (-12.374)
<i>LTRADE</i>	0.214 (4.433)	0.219 (4.587)	0.231 (4.800)	0.217 (4.536)
<i>LGDP</i>	0.232 (6.972)	0.257 (7.794)	0.245 (7.359)	0.295 (8.405)
<i>LINCDIF</i>	-0.551 (-5.166)			
<i>LVADIF</i>		-0.460 (-4.712)		
<i>LWAGEDIF</i>			-0.480 (-4.739)	
<i>LUNITDIF</i>				-0.353 (-1.993)
<i>R&D-V</i>	1.231 (0.233)	4.066 (0.778)	5.883 (1.078)	-1.943 (-0.363)
<i>LSCALE-V</i>	0.224 (1.379)	0.172 (1.041)	0.174 (1.064)	0.074 (0.450)
<i>LTRADE-V</i>	-0.414 (-1.140)	-0.450 (-1.217)	-0.486 (-1.311)	-0.277 (-0.758)
<i>LGDP-V</i>	-0.025 (-0.480)	-0.035 (-0.666)	-0.035 (-0.676)	-0.010 (-0.195)
<i>LINCDIF-V</i>	2.113 (4.317)			
<i>LVADIF-V</i>		2.124 (3.955)		
<i>LWAGEDIF-V</i>			1.933 (3.788)	
<i>LUNITDIF-V</i>				0.279 (0.165)

T-statistic in brackets. Time fixed effects are included. Estimates are heteroscedasticity consistent. The suffix -V indicates the inclusion of a vertical interaction term.

Table 7

Tobit Estimates for the Affiliate Production Share and the differences between horizontally and vertically forward and backward integrated multinationals

Specification	(IVa)	(IVb)	(IVc)	(IVd)
Interaction variable	VFBEU	VFBEU	VFBEU	VFBEU
Dep. Var.	AFFSH	AFFSH	AFFSH	AFFSH
No. of obs.	1655	1655	1655	1655
Threshold value	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1	Lower=0, Upper=1
Log likelihood	-1190.8	-1190.9	-1190.6	-1200.5
<i>CONSTANT</i>	-4.919 (-8.983)	-5.382 (-9.853)	-5.237 (-9.555)	-5.959 (-10.352)
<i>R&D</i>	-1.643 (-1.406)	-2.191 (-1.851)	-1.999 (-1.707)	-1.649 (-1.384)
<i>LSCALE</i>	-0.353 (-11.926)	-0.352 (-11.995)	-0.357 (-11.954)	-0.350 (-11.947)
<i>LTRADE</i>	0.162 (3.293)	0.164 (3.416)	0.181 (3.713)	0.166 (3.369)
<i>LGDP</i>	0.228 (6.921)	0.254 (7.810)	0.242 (7.368)	0.288 (8.409)
<i>LINCDIF</i>	-0.489 (-4.589)			
<i>LVADIF</i>		-0.449 (-4.481)		
<i>LWAGEDIF</i>			-0.472 (-4.526)	
<i>LUNITDIF</i>				-0.378 (-2.152)
<i>R&D-V</i>	4.813 (1.589)	6.214 (2.063)	5.736 (1.889)	5.033 (1.627)
<i>LSCALE-V</i>	0.377 (3.881)	0.381 (3.941)	0.387 (4.008)	0.360 (3.756)
<i>LTRADE-V</i>	-0.462 (-2.559)	-0.471 (-2.719)	-0.509 (-2.886)	-0.449 (-2.453)
<i>LGDP-V</i>	0.065 (2.158)	0.056 (1.895)	0.065 (2.169)	0.066 (2.189)
<i>LINCDIF-V</i>	0.509 (1.821)			
<i>LVADIF-V</i>		1.057 (4.084)		
<i>LWAGEDIF-V</i>			0.931 (3.642)	
<i>LUNITDIF-V</i>				0.383 (0.632)

T-statistic in brackets. Time fixed effects are included. Estimates are heteroscedasticity consistent. The suffix -V indicates the inclusion of a vertical interaction term.

Furthermore, there is a significant structural difference between horizontally and vertically forward integrated multinationals as the coefficient of *R&D-V* is positively significant in specifications (II) and (IVb,c,d). This may indicate that their technology transfer costs are independent of the R&D intensity. This is likely to be the case if vertical multinationals are to embody the technology in the exports of intermediates to their affiliates.

This enables them to reduce opportunistic behaviour and may help to fully appropriate the returns of the undertaken research and the development of new technology. Hence, vertical multinationals are able to embody the technology transfer in the trade costs which have to be incurred, while horizontal multinationals' technology transfer costs may rise with the R&D intensity.

Furthermore, in accordance with hypothesis (2), the achievement of the minimum efficient scale of production is of significantly less importance for vertically integrated multinationals. The coefficient of *LSCALE-V* is positively significant at the 1% level in specifications (II) and (IV). This indicates that, in contrast to horizontal multinationals, vertically integrated multinationals can compensate the cost penalty of producing below minimum efficient scale to some extent, as they are able to fragment the production process geographically, and thereby are able to exploit differences in relative factor endowments, and thus factor prices.

With regard to hypotheses (4) and (7) there is strong evidence to suggest that high trade costs promote horizontal integration between parent and affiliates, while low trade cost favour vertical integration. The coefficient of *LTRADE* is highly significant in all specifications, while the coefficient of *LTRADE-V* is negatively significant in specifications (IIb,c,d) and (IV). Noteworthy is also that the net coefficient is negative.

The host country size seems to play a more important role for vertically forward integrated multinationals. The coefficient of *LGDP-V* is positively significant at the 5% level in specifications (II) and (IV), which is not in line with hypothesis (3). This hypothesis is however partly the result of the assumption of vertical multinationals operating one plant only. In a different model Zhang & Markusen (1996) have shown that the host country market size is of importance for the emergence of vertical multinationals if they operate two plants and engage in intra-firm trade in intermediates.¹² Small countries have difficulties in attracting vertically integrated multinationals, as transport costs have to be incurred for a large share of finished products when shipping them back to the home country. On the contrary, a large host country market size facilitates the presence of vertical multinationals, as the transport costs have to be incurred for the intermediate product but not for the final product. In specification

¹² Please note that the model by Zhang & Markusen (1996) does not incorporate horizontal multinationals. The model assumes that a necessary intermediate product can only be produced in the skilled labour abundant country. The final product can either be produced by home country firms or by foreign affiliates. The production of the final product uses the intermediate product and unskilled labour in variable costs, whilst a certain amount of local skilled labour is needed in plant-set up fixed costs. The results suggest that the Foreign Direct Investment level falls to zero if the host country has a very scarce skilled labour endowment. Furthermore, the larger the host country size the larger the investment to GDP ratio becomes.

(III), the *LGDP-V* coefficient is negative, albeit insignificantly so. The negative coefficient is intuitively appealing, as the host country size is not as important a location factor if a significant share of the affiliate production is exported back to the home country Sweden.

Concerning relative factor endowments, i.e. hypothesis (8), the results indeed suggest that they are significant determinants for the emergence of vertically integrated multinationals. This is particularly true in the case of multinationals being vertically backward integrated and relative factor endowment differences being analysed at the sectoral level. Firstly, in specifications (IIIa) and (IVa), *LINCDIF-V* is positively significant. Secondly, there is strong evidence at the sectoral level that differences in the labour productivity and wages, and thus technology, skills and human capital are important determinants of the affiliate production share of vertically integrated multinationals. The coefficients of *LVADIF-V* and *LWAGEDIF-V* are positively significant at the 10% level or better in specifications (IIb, IIIb, IVb) and (IIIc, IVc), respectively. This result is in sharp contrast with that obtained for horizontal multinationals. Unfortunately however, it is not completely robust across all three specifications, as only weakly significant effects could be found for vertically forward integrated multinationals. Also, differences in unit labour costs do not seem to be a significant motive for vertical integration.

Taken together, these results suggest, nevertheless, that vertical multinationals fragment production stages geographically in order to take advantage of differences in relative factor endowments and factor prices. The results also suggest that relative factor endowments may be best analysed at the sectoral level as nations are inherently heterogeneous entities.

VI. CONCLUDING REMARKS

Recent developments in the new trade and investment literature suggest that there are fundamental differences between horizontal and vertical multinationals. Horizontal multinationals tend to emerge due to market proximity considerations, which have to be traded off against concentration of production. Other important determinants are a large host country size and similarities in relative factor endowments. On the contrary, vertical multinationals fragment production into geographically separate stages to exploit factor price, and thus relative factor endowment differences or technologies. As a result, vertical multinationals engage in intra-firm trade, and therefore tend to emerge if transport costs are low and relative factor endowment differences are large.

Previous empirical results suggest that foreign production is mainly promoted by the proximity-concentration trade-off considerations and, to a minor extent, by the factor proportions explanation (Brainard, 1993b, 1997; Ekholm, 1995, 1997, 1998). These studies fail, however, to distinguish between horizontal and vertical multinationals. This paper makes a first explicit attempt to distinguish between horizontal and vertical multinationals. The results can be summarised as follows:

Firstly, if horizontal and vertical multinationals are not distinguished, then the aggregate activity of Swedish multinationals in the EU is mainly driven by the proximity-concentration trade-off explanation of multinationals sales and by similarities in relative factor endowments.

Secondly, the affiliate production share of horizontal multinationals is decreasing in firm and plant-level economies of scale, and increasing in large host country size, and similarities in per capita income, labour productivity, wages and unit labour costs. Almost all of these results are consistent with the theoretical predictions, and with earlier results by Brainard (1997) and Ekholm (1998).

Thirdly, there are significant differences between horizontally and vertically integrated multinationals. They emerge with regard to firm and plant-level economies of scale, host country market size, trade costs, and relative factor endowments and factor prices. In contrast to horizontal multinationals, vertically integrated multinationals can compensate the cost penalty of producing below minimum scale of production, as they fragment the production process geographically, and thereby not only are able to exploit differences in relative factor endowments but also relative factor prices.

Summing up, the factor proportions explanation of multinational sales is an important determinant for the explanation of the activities of Swedish multinationals in the EU. At the aggregate level however, multinational activity is primarily explained by the proximity-concentration trade-off explanation. Hence, one may argue that the proximity-concentration hypothesis overshadows the factor proportions explanation. This reinforces previous empirical results.

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