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TESTING THE KNOWLEDGE-CAPITAL MODEL OF THE MULTINATIONAL ENTERPRISE

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ABSTRACT

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What we term the "knowledge-capital model" of the multinational firm includes three principal assumptions. (1) the services of knowledge-based and knowledge-generating activities such as R&D, can be geographically separated from production and supplied to production facilities at low cost. (2) these knowledge-intensive activities are skilled-labor intensive relative to production. These characteristics give rise to vertical multinationals, which fragment production and locate activities according to factor prices and market size. (3) The services of knowledge-based and knowledge-generating activities have a (partial) joint-input characteristic, in that they can be supplied to additional production facilities at low or zero cost. This characteristic give rise to horizontal multinationals, which produce the same goods or services in multiple locations. In this paper, we note how this model predicts relationships between affiliate sales and country characteristics. We then subject these predictions to empirical tests.

Key words: Knowledge capital; multinational firm; trade costs; investment costs

JEL Codes: F12, F21, F23

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NON-TECHNICAL SUMMARY

The knowledge-capital model of the multinational enterprise (MNE) relies on insights from new trade theory about joint inputs, increasing returns to scale, and international costs of investing and exporting. The model includes three main assumptions. First, the services of knowledge-based and knowledge-generating activities, such as R&D, may be geographically separated from production and supplied to production activities at low cost. Second, these knowledge-intensive activities are skilled-labor intensive relative to production. These characteristics give rise to vertical MNEs, which fragment production and locate activities according to factor prices and market size. Third, the services of knowledge-based and knowledge-generating activities have a partial joint-input characteristic, in that they may be supplied to additional production facilities at low or zero cost. This characteristic gives rise to horizontal MNEs, which produce the same goods or services in multiple locations.

The model underlying the theoretical work in this paper was developed by Markusen (1998). We capture the characteristics of MNEs noted above by a series of assumptions about factor intensities of six firm types in two countries (home and foreign). These firm types include two strictly national firms, which maintain a single plant and headquarters in one country, two horizontal MNEs, which maintain plants in both countries and headquarters in a parent country, and two vertical MNEs, which maintain headquarters in the parent and a single plant in an affiliate nation. Vertical MNEs sell in affiliate markets and also export back to the parent country.

The general-equilibrium model assumes that one sector is perfectly competitive, while the other is subject to increasing returns associated with the joint-input characteristic of headquarters services. The model supports numerical computations that make theoretical predictions about the industrial regimes that will be active in two countries at various combinations of country sizes, differences in factor endowments, and costs of investing abroad and exporting between markets. These predictions are rich and complex, but may be summarized as follows. First, national firms are the dominant type active in a market if the country is both large and skilled-labor abundant: if home and foreign are similar in size and relative endowments, and transport costs are low; or if foreign investment barriers are high. Second, horizontal

MNEs tend to be dominant if home and foreign are similar in size and relative endowments but transport costs are higher, in which case firms prefer to penetrate markets through FDI rather than trade. Finally, vertical MNEs tend to be dominant if the parent country is small and skilled-labor-abundant, while transport costs are fairly low. In this case the firm takes advantage of low wage costs abroad and exports back to the parent country.

These predictions have not been subjected to systematic econometric study in the literature. We do so here by using extensive data on operations of foreign manufacturing affiliates of U.S. firms and on operations of U.S. affiliates of foreign firms. The dependent variable in our specifications is the real volume of affiliate sales, as suggested by the theory, rather than FDI levels or employment. Data on sales are combined with information on real GDP levels, relative skill endowments, measures of investment costs and protectionism in each country, and distance from the United States. The data comprise a panel of observations for 36 countries and the United States over the period 1986-1994.

We specify the econometric model in a way that captures some of the complex non-linearities that emerge in the simulation analysis. For example, the impact of trade costs in the affiliate country depends on the extent of endowment differences, so we interact trade costs with squared differences in skill ratios. Similarly, the effect of skill differences depends on the relative sizes of the parent and host countries.

Results from the panel estimation (corrected for heteroskedasticity) provide strong support for the theoretical model. Coefficients on all variables have the hypothesized signs and all are significant except the trade-cost measures. However, when we introduce distance into the model, trade costs in the affiliate country become significantly positive, consistent with our notion of horizontal investment. We also estimate a Tobit specification, accounting for the absence of affiliate sales in or from small developing countries. The Tobit results are even stronger and indicate that trade costs in the parent country do limit vertical investment and exports. We then estimate a panel specification with country fixed effects. Here it becomes difficult to identify the separate contributions of investment and trade costs because the country dummies account for some portion of the idiosyncratic country impacts of economic frictions on investment behavior. Nonetheless, the signs of the coefficients are robust to all specifications.

We use the econometric results to characterize some of the economic processes driving output decisions of affiliates. We find that differences in relative endowments (skill ratios) must be fairly large for an increase in trade costs to lead to a fall in affiliate sales. Thus, the model is capable indirectly of discriminating between horizontal investment (among countries with skill ratios similar to the United States) and vertical investment (among countries with considerably lower skill ratios). We also find that an increase in a country's GDP will raise its affiliate sales abroad only if it is small and/or skilled-labor scarce. Convergence in GDP levels between the United States and an affiliate country, holding the sum of their GDPs constant, increases affiliate sales in both directions, as predicted by the model. Finally, positive trade costs in larger countries tend to weak the effects of rising skilled-labor-abundance on outward affiliate sales.

In summary, we test hypotheses regarding the importance of multinational activity between countries as a function of size, size differences, relative endowment differences, trade and investment costs, and certain interactions among these variables as predicted by the theory. The model fits well and provides considerable support for the theory. Affiliate sales increase in the sum of economic size of parent and host countries, in size similarity, and in the relative skilled-labor abundance of the parent. Coefficients on interaction terms have the hypothesized signs and are significant in the panel estimation. Our measures of trade costs and investment costs (based on surveys of multinational enterprise managers) are capable of supporting the model in basic specifications, but lose significance in the estimation with fixed effects.

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1. Introduction

The industrial-organization approach to international trade ("new trade theory") has, during the last decade, incorporated features of increasing returns to scale, imperfect competition, and product differentiation into traditional general-equilibrium trade models. These new models offer rich predictions about the direction and volume of trade between two countries as functions of industry characteristics (factor intensities, scale economies, product differentiation) interacting with country characteristics (relative size differences, relative endowment differences, and trade costs).

However, there is one awkward empirical problem, in that most of the firms and industries motivating by the IO approach to trade are multinational firms, while most of the theory has been about single-plant national firms. More recent theoretical developments have allowed multinational firms to arise, firms which maintain facilities in more than one country. These multinationals are often broken down into "horizontal" firms, which produce the same goods and services in multiple countries, and "vertical" firms which geographically fragment production by stages. An early example of a model with "vertical" multinationals is Helpman (1984) while an early model of horizontal multinationals is by Markusen (1984).

Subsequent theoretical work has focussed much more on horizontal firms because they seem to be far more important empirically. Examples include Horstmann and Markusen (1987, 1992), Brainard (1993a), and Markusen and Venables (1996, 1997, 1998). These models have since been subjected to empirical tests, especially Brainard (1993b, 1997) and Ekholm (1995, 1997a,b, 1998). Results give good support to the theoretical predictions of the "horizontal" models: multinational activity should be concentrated among countries that are relatively similar in both size and in relative endowments (or per capita incomes).

Theoretical models which combine both horizontal and vertical motives for direct investment are analytically difficult. Helpman's original model of vertical multinationals relied on the assumption of no trade costs, but in such a case there is no motive for horizontal multinationals (given plant-level scale economies). For analytical tractability, the early models of horizontal firms assumed that different activities (e.g., headquarters and plant) used factors in the same proportion or that there is only one factor, but then there is no factor-price motive for vertical fragmentation across countries. There are now a couple of models in which vertical and horizontal firms can both arise endogenously due to the simultaneous existence of trade costs and different factor intensities across industries. Analytical difficulties, however, imply that most results are derived from numerical simulations (Markusen (1998), Markusen, Venables, Konan, and Zhang (1996)). These simulations generate a number of testable implications, relating direct investment to country characteristics.

The purpose of this paper is therefore to take the theoretical predictions of recent theory and subject them to econometric test. We begin by reviewing this newer theory and discussing its theoretical predictions. The focus will be on explaining the volume of production of foreign affiliates of country i firms in country j, as a function of the characteristics of countries i and j. For example, the production by affiliates of country i firms in country j will be high if either i and j are similar and trade costs are high (affiliates are horizontal), or country i is small and skilled-labor abundant relative to j and trade costs are low (affiliates are vertical). We will not consider nor attempt to explain differences among firms and industries in their propensities to choose multinational production.

Then we turn to the task of translating these predictions into a tractable empirical specification. This is a difficult task, because the theory predicts many relationships are interactive or non-linear. For example, (A) an increase in trade costs will increase production by affiliates of country i firm in country j if the countries are very similar (direct investment is horizontal) but may decrease investment if the countries are very different in relative endowments (direct investment is vertical). (B) The effect of an increase in country i's GNP level on production by affiliates of country i firms in j is non-monotonic, at first increasing when country i is very small and then decreasing when country i's size exceeds that of country j. (C) The effect of an increase in country i's relative endowment of skilled labor on production by affiliates of country i firms in j, may be positive and large if trade costs are small (vertical investment is encouraged) but much smaller if trade costs are large. (D) The volume of affiliate production by country i firms in country j should be highest when country i is both skilled-labor abundant and small relative to country j.

Results of our estimations are closely consistent with the theory. The volume of affiliate sales from country i to country j follows the theoretical predictions in relationship to the characteristics of both country i and country j. Both vertical and horizontal investments seem to be important, and their importance is related to country characteristics as predicted by the theoretical model.

2. The Theoretical Model

We now present a theoretical model which is drawn from Markusen (1998) and Markusen, Venables, Konan and Zhang (1996). First, we present a broad outline of the model, and then discuss crucial assumptions about the level and composition of fixed costs.

1. There are two homogeneous goods, X and Y;
   There are two countries, h and f.
   There are two factors, unskilled labor: L skilled labor: S.

2. Y - competitive, constant returns to scale, L intensive

3. X - imperfectly competitive, increasing returns to scale, S intensive overall.

"headquarters and "plant" may be geographically separated.
a firm may have plants in one or both countries.

4. There are six firm types, with free entry and exit into and out of firm types. Regime denotes a set of firm types active in equilibrium.

Type m_h - horizontal multinationals which maintain plants in both countries, headquarters are located in country h.

Type m_f - horizontal multinationals which maintain plants in both countries, headquarters are located in country f.

Type n_h - national firms that maintain a single plant and headquarters in country h. Type h firms may or may not export to country f.

Type n_f - national firms that maintain a single plant and headquarters in country f. Type f firms may or may not export to country h.

Type v_h - vertical multinationals that maintain a single plant in country f, headquarters in country h. Type v_h firms may or may not export to country h.

Type v_f - vertical multinationals that maintain a single plant in country h, headquarters in country f. Type v_f firms may or may not export to country f.

5. Transport costs for X use unskilled labor
Factors of production are immobile between countries
X firms are Cournot competitors, there is free entry and exit
Markets are segmented
Type-v firms incur a small cost penalty relative to type-n firms as a "transactions cost" of geographically separating plant and headquarters.

Assumptions relating to the size and composition of fixed costs are crucial to the predictions of the model.[1] First of all, we assume the existence of multi-plant economies of scale (relevant to type-m firms) due to a joint-input property of knowledge capital. Headquarters service (blueprints, manuals, formulae, procedures, etc.) can be supplied to additional plants at very low marginal cost.

[1]The following assumptions draw empirical support from a large number of studies. These include but are not limited too: Aiken et. al. (1995), Blomstrom et. al. (1997), Caves (1996), Ekholm (1995, 1997a,b), Feenstra and Hanson (1997), Lipsey et. al. (1995), Slaughter (1995), UNCTAD (1993). Data drawn from some of these sources is presented in Markusen (1998).

6. There are multi-plant economies of scale in X production: the total fixed costs of headquarters and two plants is less than the double the total fixed costs of a single-plant firm.
(the joint-input property of knowledge capital)

Second, it is assumed that headquarters services are more skilled-labor intensive than production. Somewhat more controversial, we assume that plant-level production is more skilled-labor intensive than the composite rest of the economy.

7. Skilled- Labor intensity of activities
[headquarters only] > [integrated X] > [plant only] > [Y]

Finally, we assume that two-plant type-m firms are more skilled-labor intensive than either type-n or type-v firms. The hypothesis is that type-m firms use additional skilled labor both at home and in the host country in managing and operating the second plant. Type-n and type-v firms use additional unskilled labor in transport costs in serving the foreign market. This particular assumption does not play much of a role in this paper, but does lead to interesting factor market effects from investment liberalization (e.g., the relative wage of skilled labor can rise in both countries, Markusen, 1998).

8. Skilled-labor intensity of firm types
[type-m firms] > [type-v and type-n firms]

The full set of equations and inequalities characterizing equilibrium in the model is given in Markusen (1998) and in Markusen, Venables, Konan, and Zhang (1996) and we will not repeat that exercise here. In the next section, we link the assumptions about technology to country characteristics in order to generate predictions about multinational actively as a function of those country characteristics.

3. Active Firm Types and Country Characteristics

One way to approach this question is to ask what country characteristics favor various firm types producing or maintaining headquarters in country h. Consider first the factors that might favor type-n_h national firms headquartering and producing in country h. Assumptions of the model developed above suggest the following.

(1) Type n_h firms will be the dominant type active in h if:

h is both large and skilled-labor abundant
h and f are similar in size and relative endowments, and transport
costs are low (type n_f will sell in h).
foreign investment barriers in f are high (type n_f may sell in h).

A large h favors production in country h while skilled-labor abundance favors headquartering in h. Thus an integrated type-n_h firm has an advantage over a type-v_h or v_f firm. A type-n_h firm also has an advantage over a type-m firm which must locate costly capacity in the small f market unless trade costs are high. Type-n firms should also be the dominant firm type when the countries are similar and trade costs are small. With countries perfectly symmetric, for example, there is no motive for type-v firms given the assumption of a small cost penalty to separating activities. Small trade costs favor type-n firms over two-plant type-m firms.

(2) Type-m_h firms will be the dominant type active in h if:

h and f are similar in size and relative endowments, and transport costs are higher (type m_f will also produce in h).

Type-m_h firms should be associated with similarities between countries in both size and in relative factor endowments. The intuition behind this lies in noting that if countries are dissimilar in either size or relative endowments then one country will be "favored" as a site of production and/or headquarters. For example, if the countries are similar in relative endowments but of very different sizes, then type-n firms located in the large country will be favored (they avoid costly capacity in the small market). If the countries are very different in relative endowments but of similar size, then there is a motive to concentrate headquarters in the skilled-labor-abundant country and production in the skilled-labor-scarce country. Thus type-v firms headquartered in the skilled-labor-abundant countries should be favored, unless trade costs are high. Then next two predictions follow directly.

(3) Type-v_h firms will be the dominant type active in h if:

h is small, skilled-labor abundant, and transport costs are not too high.

(4) Type-v_f firms will be the dominant type active in h if:

h is large, skilled-labor scarce, and transport costs are not too high.

4. Simulation Results

Data does not exist on the number of firms of various types. Data does exist however, on the volume of production by affiliates of country i owned firms in country j. Thus we want our predictions not on the numbers of firms of various types, but on affiliate production. In this section, we solve the model numerically in order to generate such predictions on the relationship between affiliate sales and country characteristics. The full model, consisting of 41 non-linear inequalities, is solved as a complementarity problem using Rutherford's (1995) solver MPS/GE, a subsystem of GAMS (again, see Markusen (1998) and Markusen, Venables, Konan and Zhang (1996) for the full set of equations and inequalities).

A preliminary question is how do we define "affiliate production" in the context of the model in a way which relates in a sensible way to data on affiliate sales. Parents and affiliates in the data are basically defined in terms of ownership location. In the context of our model, we simply assume that the country in which a firm's headquarters are located is the parent country. Given that assumption, the production of affiliates of country h firms in country f is then the output of plants in country f "owned" by type-m_h and type-v_h firms. Similarly, the volume of production by country h affiliates of country f firms is the production in country-h plants owned by type-m_f and type-v_f firms.

Figure 1 shows simulation results at high trade costs, with affiliate production being the sum of the outputs of both countries' affiliated plants. Figure 2 plots the contours of these same results. Figure 1 is a classic saddle. Each figure is a world Edgeworth box, with the total world endowment of skilled labor on the "Y" axis and the total world endowment of unskilled labor on the "X" axis. The origin for country h is at the southwest (SW) corner of the box and the origin for country f is at the northeast (NE) corner. A diagonal line in Figure 2 gives the approximate locus of points at which the two countries have equal GNP levels. Country h is relatively smaller than f to the left of this locus and relatively larger to the right. We can envision of series of these loci, each one for some constant difference (GNP_h - GNP_f). This will be important insofar as our data give these differences along with differences in relative endowments (roughly a series of lines parallel to the SW-NE diagonal, with that diagonal having a value of zero).

Affiliate sales are at a minimum when the two countries are similar in relative endowments, but are very different in size, in which case national firms headquartered in the large country dominate X production. Moving along the SW-NE diagonal (relative endowments identical), total affiliate sales reach a maximum at the mid-point where the countries are identical. At this point, all firms are type-m and exactly half of all world production of X is affiliate production. The other half is output of the domestic plants of type-m firms.

A somewhat surprising result in Figure 1 and 2 is that total affiliate production is the highest when one country is both small (but not too small!) and skilled-labor abundant. In such a situation, type-v firms located in that country are the dominant firm type. Note that if only type-v firms were active in equilibrium, then all of the world production of X is affiliate sales. Conversely, affiliate activity is lowest when the skilled-labor-abundant country is very large, in which case all production of X is by national firms headquartered in that country.

The non-linearities in Figures 1 and 2 present a challenge for testing. For example, the effect of differences in country size on affiliate sales depends on whether the countries are similar in relative endowments and if they are quite different, on whether or not the small country is the skilled-labor abundant country.

Figure 3 plots only the production by h-owned plants in country f. Here again, we see the inverted u-shaped curve of production along the SW-NE diagonal, but that affiliate production is highest when country h is moderately small and very skilled-labor abundant. The latter situation is especially reminiscent of Sweden, Switzerland, and The Netherlands which are small, skilled-labor-abundant countries and important home countries for multinationals.

Figures 4-6 present results concerning the effects of trade costs, assumed here to be symmetric in both directions, on production by h-owned plants in country f. On the vertical axes of these diagrams is affiliate sales assuming 25% trade costs minus affiliate sales with 5% trade costs. Again, we see that the results are highly non-linear. Looking first at Figure 4, what we are seeing is that higher trade costs increase total affiliate sales if the countries are relatively similar in size and in relative endowments. Similarity favors horizontal type-m firms and, as we noted earlier, horizontal production is encouraged by higher trade costs. Higher trade costs, however, reduce total affiliate sales when there is a moderate difference in relative endowments with the skilled-labor-abundant country moderately smaller. These are regions with type-v firms headquartered in the skilled-labor-abundant country and with a correspondingly large volume of X trade. Higher trade costs "bring some plants back home" to the skilled-labor abundant country. So in the NW region of negative change in Figures 4, for example, higher trade costs lead to a substitution of some type-n_h firms for some type-v_h firms thereby reducing the volume of affiliate production. Parenthetically, these are regions in which trade and affiliate sales are complements: higher trade costs reduce both.

The results in Figure 4 are derived for an equal increase in trade costs in both directions. This is not a very useful experiment to take to the data. Fortunately, the results break down nicely into the effects of trade costs in the host country j and the trade costs to enter the home country i. These results are shown in Figures 5 and 6. Figure 5 shows the comparative statics effects of trade costs in country f, the host country, and results indicate that this will increase production of affiliates of country h firms in f if the countries are relatively similar (horizontal investments). Figure 6 shows the comparative statics effects of increased trade costs into the source-country h. These trade costs discourage vertical investments in which the output of the plant in country f is shipped back to country h. This effect occurs when h is relatively small and skilled-labor abundant.

These results will be used in subsequent sections in order to help specify estimating equations for empirical analysis.

4. Data Sources and Variable Construction

To implement the model, we define the following variables, which are listed in Table 1, and discuss their construction. The data form a panel of cross-country observations over the period 1986-92. First, we take sales volume of non-bank manufacturing affiliates in each country to indicate production activity. The U.S. Department of Commerce provides annual data on sales of foreign affiliates of American parent firms and on sales of U.S. affiliates of foreign parent firms. Thus, for each year the United States serves as both the headquarters country for its firms producing abroad and the affiliate country for foreign firms producing there. There are 36 countries in addition to the US for which we have at least one year of complete data. Annual sales values abroad are converted into millions of 1990 U.S. dollars using an exchange-rate adjusted local wholesale price index, with exchange rates and price indexes taken from the *International Financial Statistics* of the International Monetary Fund.

Real gross domestic product is measured in billions of 1990 U.S. dollars for each country. For this purpose, annual real GDP figures in local currencies were converted into dollars using the market exchange rate. These data are also from the IFS.

Skilled labor abundance is defined as the sum of occupational categories 0/1 (professional, technical, and kindred workers) and 2 (administrative workers) in employment in each country, divided by total employment. These figures are compiled from annual surveys reported in the *Yearbook of Labor Statistics* published by the International Labor Organization. In cases where some annual figures were missing, the skilled-labor ratios were taken to equal the period averages for each country. The variable SKDIFF is then simply the difference between the relative skill endowment of the parent country and that of the affiliate country.

The cost of investing in the affiliate country is a simple average of several indexes of impediments to investment in 1992, reported in the *World Competitiveness Report* of the World Economic Forum.[2] The indexes include restrictions on ability to acquire control in a domestic company, limitations on the ability to employ foreign skilled labor, restraints on negotiating joint ventures, strict controls on hiring and firing practices, market dominance by a small number of enterprises, an absence of fair administration of justice, difficulties in acquiring local bank credit, restrictions on access to local and foreign capital markets, and inadequate protection of intellectual property. These indexes are computed on a scale from 0 to 100, with a higher number indicating higher investment costs.

A trade cost index is taken from the same source and is defined as a measure of national protectionism, or efforts to prevent importation of competitive products. It also runs from 0 to 100, with 100 being the highest trade costs. All of these indexes are based on extensive surveys of multinational enterprises. Note that neither the investment cost index nor the trade cost index varies over time.

As alternative measures of trade costs we compute the average tariff rate, or the ratio of import duties to total merchandise imports in each country, with the data taken from the IFS and the *Government Finance Statistics Yearbook* of the IMF. This measure does vary over time but suffers from well-known problems of interpretation. This variable performed poorly in regression equations, so we do not report them here (but include them as available supplemental tables). We also incorporate a measure of distance, which is simply the number of kilometers of each country's capital city from Washington, DC. It is unclear whether this variable captures trade costs or investment costs, since both should rise with distance.

[2] A small number of observations are from 1993 or 1996. These data were kindly provided by staff of the United States International Trade Commission, who used them in their report on trade liberalization (USITC, 1997).

The Appendix lists the countries for which we have at least one complete yearly observations. The final data set, after eliminating any row with missing variables, is 328 observations.

5. Results

As noted above, the theoretical model is characterized by many non-linear relationships and interactions among the variable. Table 1 gives the variables used in the "central-case" regressions and were discussed in the previous section. Table 1 then presents this central-case regression specification. We specify the regression as linear in levels, with quadratic and interaction terms included.

The dependent variable is the real production (sales to all markets) of affiliates of country i firms in country j (RSALES). The first dependent variables is SUMGDP (an intercept is included but ignored here), which we expect to have a positive sign. There is indeed a stronger hypothesis, which is that the elasticity of affiliate sales with respect to SUMGDP is greater than one. The second variable is SKDIFF, which we expect to be positive: firms tend to be headquartered in the skilled-labor-abundant country. The third variable is GDPDIFSQ, which we expect to be negative: RSALES has an inverted u-shaped relationship to differences in country size.

The fourth and fifth variables are the investment-cost and trade-cost measures from the World Competitiveness Report respectively for the <u>host</u> country j. We expect the investment-cost coefficient B4 to be negative and the trade-cost coefficient B5 to be positive. The first interaction term (B6) is designed to capture the fact that trade costs may encourage horizontal investment but discourage vertical investment.

B7 and B8 correspond to B5 and B6, except that they include trade costs for the <u>home</u> or <u>source</u> country i. B7 should be negative (trade costs diminish the incentive to locate plants abroad for shipment back to the home market) and B8 should be positive (this effect diminishes as the source country becomes very skilled-labor abundant as in Figure 6).

The last interaction term (B9) is designed to capture the result in several of our earlier diagrams that outward investment is highest when the country is skilled-labor abundant and (moderately) small.

Table 2 considers these interactive terms in more detail by writing the implied partial derivatives. The derivative of RSALES with respect to TCJ (1) has two terms. We expect the sum of the two effects to be positive if the countries are similar (horizontal investment) but negative if country i is skilled-labor-abundant (vertical investment). This in turn implies that the coefficient B6 should be negative.

The derivative of RSALES with respect to the GDPDIFF (2) has two terms. This should be an inverted U as noted above, reaching a maximum when the countries are very similar in relative endowments, which is the first term. But as we showed in our theoretical results, investment may fall almost continuously with increases in country i's size if country i is skilled-labor abundant, which is reflected in the second term.

Finally, the derivative of RSALES with respect to SKDIFF (3) then has four terms. The first is a direct effect that should be positive (vertical direct investment and headquarters of horizontal firms). But this effect is weakened if trade costs are higher (discouraging vertical investments). This is the second term. The direct effect is also weakened as country i gets larger, since vertical firms are replaced by national firms headquartered in country i serving country j by exports. The coefficients B6 and B7 each show up twice in the three derivatives, and are predicted to be negative in each case.

Table 1

Variables

RSALES	Volume of production by affiliates of i parents in country
SUMGPD	Sum if country i's plus country j's GDP
SKDIFF	Measure of skilled labor abundance of country i relative to j.
GPDDIFF	Difference between country i and country j's GPD.
GDPDIFSQ	Squared difference between country i and country j's GDP.
INVCJ	Cost of investing in country j
TCJ	Cost of exporting to country j
INTER1	(TCJ)(SKDIFF)
TCI	Cost of exporting to country i
INTER4	(TCI)(SKDIFF)
INTER2	(GDPDIFF)(SKDIFF)

RSALES =	B1(SUMGDP)	(+)	
	B2(SKDIFF)	(+)	
	B3(GDPDIFSQ)	(-)	
	B4(INVJ)	(-)	
	B5(TCJ)	(+)	
	B6(TCJ)(SKDIFF)	(-)	(INTER1)
	B7(TCI)	(-)	
	B8(TCI)(SKDIFF)	(+)	(INTER4)
	B9(GDPDIFF)(SKDIFF)	(-)	(INTER2)

Other Variables

DIST Distance from i to j

Table 2: Explanation of Hypothesized Interactions

RSALES =	B1(SUMGDP)	(+)	
	B2(SKDIFF)	(+)	
	B3(GDPDIFSQ)	(-)	
	B4(INVJ)	(-)	
	B5(TCJ)	(+)	
	B6(TCJ)(SKDIFF)	(-)	(INTER1)
	B7(TCI)	(-)	
	B8(TCI)(SKDIFF)	(+)	(INTER4)
	B9(GDPDIFF)(SKDIFF)	(-)	(INTER2)

$$\frac{\partial VOLIJ}{\partial TCJ} = B5 + B6(SKDIFF) \qquad 1$$

This derivative is expected to be positive when relative endowments are similar (trade costs encourage horizontal direct investment) but negative when country i is skilled labor abundant (trade costs discourage vertical direct investment). This implies that the expected sign of B6 is negative.

$$\frac{\partial VOLIJ}{\partial GDPDIFF} = 2B3(GDPDIFF) + B9(SKDIFF) \qquad 2$$

If countries are similar in relative endowments, this derivative is positive when country i is small, and negative when country i is large. If country i is very skilled-labor abundant, and increase in country i's size can reduce outward investment even if i is small. This implies that the expected sign of B9 is negative.

$$\frac{\partial VOLIJ}{\partial SKDIFF} = B2 + B6(TCJ) + B9(GDPDIFF) + B8(TCI) \qquad 3$$

This derivative is expected to be positive but (a) smaller if TCJ is large, (b) larger if country i is small, again implying that B6 and B9 should be negative.

(We won't take time with the derivative with respect to TCI, since it turns out in the data that INTER4 = TCI*SKDIFF is almost perfect collinear with SKDIFF, so INTER4 is dropped.)

Results for the central-case regression are shown in Table 3. All signs are as predicted, although the t-statistics on the two trade-cost and investment-cost variables are weak. Later, we will consider the numerical values of these coefficients in relationship to the partial derivative just discussed in Table 2. The lower panel of Table 3 adds the distance variable to central-case regression at the top of the Table.. It is not clear theoretically what sign this variable should have since distance may lead to a "substitution" effect toward investment and away from exports, but could also lead to a "scale" effect of decreasing both trade and investment. The significant negative sign duplicates the findings of Brainard (1997), and the explanatory power of the regression rises as measured by the R^2 or adjusted R^2. No signs of the other variables are changed, although some t-statistics are smaller.[3]

A problem with the results in Table 3 is that SKDIFF and TCI*SKDIFF have a correlation of 0.97 (the US is the source country in about 60% of the observations, so in 60% of the observations TCI*SKDIFF is just a multiple of SKDIFF). In Table 4, we drop TCI*SKDIFF. This greatly increases the numerical value of the coefficient on SKDIFF and similarly greatly increases its statistical significance. The t-value on TCI is still small in Table 4, so we drop this variable as well in Table 5. There is almost no effect on the numerical magnitudes or statistical significance of the other variables.

Overall, the results strongly support the theoretical model. Evidence is consistent with both horizontal and vertical investments depending on the country characteristics (except for weak results with respect to trade costs back into the source country).

[3] The addition of distance (DIST) reduces t-statistics on the three variables involving SKDIFF. DIST has a rather low correlation with both SKDIFF and TCJ of about .14 each, but virtually no correlation with any other variable other than the dependent variable RSALES. Thus adding DIST takes some explanatory power away from SKDIFF and TCJ*SKDIFF, cutting those coefficients in half.

Table 3

Model: COMP (PG heteroscedasticity correction)
Dependent Variable: RSALES

Total Obs 323
R-square 0.4756
Adj R-sq 0.4589

Parameter Estimates

Variable	Parameter Estimate	Sign as Predicted?	T for H0: Parameter=0	Prob > |T|
SUMGDP	14.391498	Yes	7.927	0.0001
SKDIFF	43755	Yes	0.937	0.3497
GDPDIFSQ	-0.001081	Yes	-5.219	0.0001
INVCJ	-146.914776	Yes	-1.112	0.2668
TCJ	203.701360	Yes	1.380	0.1687
TCJ*SKDIFF	-1429.825405	Yes	-1.648	0.1003
TCI	-48.837549	Yes	-0.319	0.7502
TCI*SKDIFF	534.258310	Yes	0.394	0.6935
GDPDIFF*SKDIFF	-5.729543	Yes	-3.370	0.0008
INTDUM	-41015		-2.736	0.0066

Table 3 continued

Model: COMP + DIST (PG heteroscedasticity correction)
Dependent Variable: RSALES

Total Obs 323
R-square 0.5241
Adj R-sq 0.5074

Parameter Estimates

Variable	**Parameter Estimate**	**Sign as Predicted?**	**T for H0: Parameter=0**	**Prob > |T|**
SUMGDP	12.306543	Yes	6.561	0.0001
SKDIFF	33189	Yes	0.698	0.4857
GDPDIFSQ	-0.001001	Yes	-4.765	0.0001
INVCJ	-389.032025	Yes	-2.699	0.0073
TCJ	292.323011	Yes	1.937	0.0537
TCJ*SKDIFF	-862.901645	Yes	-0.966	0.3350
TCI	-79.110099	Yes	-0.514	0.6076
TCI*SKDIFF	454.027375	Yes	0.331	0.7412
GDPDIFF*SKIDFF	-2.755985	Yes	-1.491	0.1371
DIST	-1.119013	Yes	-5.426	0.0001
INTDUM	-16167		-0.985	0.3254

Correlation coefficient between SKDIFF and TCI*SKDIFF is 0.97, so in the next regressions we drop INTER4 = TCI*SKDIFF.

Table 4

Model: COMP-INTER4 (PG heteroscedasticity correction)
Dependent Variable: RSALES

Total Obs 323
R-square 0.4753
Adj R-sq 0.4603

Parameter Estimates

Variable	Parameter Estimate	Sign as Predicted?	T for H0: Parameter=0	Prob > |T|
SUMGDP	14.390744	Yes	7.957	0.0001
SKDIFF	58913	Yes	2.281	0.0232
GDPDIFSQ	-0.001074	Yes	-5.227	0.0001
INVCJ	-146.997526	Yes	-1.118	0.2646
TCJ	203.502779	Yes	1.383	0.1677
TCJ*SKIDFF	-1424.637238	Yes	-1.647	0.1005
TCI	-94.282765	Yes	-0.935	0.3507
GDPDIFF*SKDIFF	-5.815444	Yes	-3.471	0.0006
INTDUM	-39960		-2.728	0.0067

Table 4 continued

Model: COMP-INTER4+DIST (PG heteroscedasticity correction)
Dependent Variable: RSALES

Total Obs 323
R-square 0.5240
Adj R-sq 0.5088

Parameter Estimates

Variable	**Parameter Estimate**	**Sign as Predicted?**	**T for H0: Parameter=0**	**Prob > |T|**
SUMGDP	12.286953	Yes	6.562	0.0001
SKDIFF	46216	Yes	1.739	0.0830
GDPDIFSQ	-0.000993	Yes	-4.763	0.0001
INVCJ	-389.890656	Yes	-2.709	0.0071
TCJ	293.211318	Yes	1.945	0.0526
TCJ*SKDIFF	-862.391667	Yes	-0.966	0.3346
TCI	-117.264597	Yes	-1.154	0.2495
GDPDIFF*SKIDFF	-2.837918	Yes	-1.551	0.1220
DIST	-1.120826	Yes	-5.443	0.0001
INTDUM	-15180		-0.941	0.3472

Table 5

Model: COMP-INTER4-TCI (PG heteroscedasticity correction)
Dependent Variable: RSALES

Total Obs 327
R-square 0.4731
Adj R-sq 0.4599

Parameter Estimates

Parameter Variable	Sign as Estimate	T for H0: Predicted?	Parameter=0	Prob > |T|
SUMGDP	14.149017	Yes	7.965	0.0001
SKDIFF	58017	Yes	2.266	0.0241
GDPDIFSQ	-0.001042	Yes	-5.181	0.0001
INVCJ	-150.798906	Yes	-1.156	0.2487
TCJ	208.128385	Yes	1.425	0.1552
TCJ*SKDIFF	-1421.701341	Yes	-1.656	0.0988
GDPDIFF*SKIDFF	-5.750744	Yes	-3.489	0.0006
INTDUM	-42019		-2.949	0.0034

Model: COMP-INTER4-TCI+DIST (PG heteroscedasticity correction)
Dependent Variable: RSALES
Total Obs 327
R-square 0.5218
Adj R-sq 0.5083

Parameter Estimates

Variable	Parameter Estimate	Sign as Predicted?	T for H0: Parameter=0	Prob > |T|
SUMGDP	12.167117	Yes	6.604	0.0001
SKDIFF	48040	Yes	1.823	0.0692
GDPDIFSQ	-0.000969	Yes	-4.733	0.0001
INVCJ	-385.490565	Yes	-2.701	0.0073
TCJ	295.205896	Yes	1.971	0.0496
TCJ*SKIDFF	-887.458527	Yes	-1.000	0.3180
GDPDIFF*SKDIFF	-3.184311	Yes	-1.786	0.0751
DIST	-1.087163	Yes	-5.445	0.0001
INTDUM	-18882		-1.203	0.2300

0.2300

6. Interpreting the coefficients

In this section, we interpret the magnitude of the coefficient and then interpret the partial derivatives (1)-(3) in Table 2. We will do this for the "COMP - INTER4" regression in Table 4 and for the same regression with DIST added in Table 4. 1991 observations are used.

First, consider increases in trade costs as measured by the index TCJ. It is clear from the estimation that trade costs increase affiliate production when countries have identical relative endowments of skilled labor (SKDIFF = 0). This is consistent with horizontal investment. How large does the difference in relative endowments of skilled labor have to be in order to reverse the sign of the derivative, so that an increase in TCJ leads to a fall in affiliate production (vertical investment)? Recall that the SKDIFF is the difference between the proportion of the labor force that is skilled in country i minus the proportion that is skilled in country j. So a value of SKDIFF = 0.20, for example, could occur if country i has 0.30 skilled and country j has 0.10 skilled. Results from Table 4 (TCI*SKDIFF) give us the following result.

$$(1) \qquad \frac{\partial RSALES}{\partial TCJ} = B5 + B6(SKDIFF)_4$$

> 0 if SKDIFF	< 0.143	(COMP - INTER4)
< 0 " "	> 0.143	
> 0 if SKDIFF	< 0.340	(COMP - INTER4 + DIST)
< 0 " "	> 0.340	

These results indicate that the difference in relative endowments must be modest to large (DIST added) for an increase in trade costs to lead to a fall in affiliate sale, although with DIST included, the necessary value of SKDIFF is at the extreme end of *observed* values for SKDIFF on active investment links.[4] In order to add some concreteness (using the regression without distance), affiliates of US firms increase/decrease their sales in response to an increase in country j's trade costs:

Increase			Decrease	
	Australia	Norway		Chile
	Austria	Panama		Costa Rica
	Belgium	Sweden		Egypt
	Canada	Switzerland		Hong Kong

[4]The standard deviation of SKDIFF in the data is 0.12. The maximum value of SKI in the data is 0.48 (Sweden) and the minimum value is 0.06 (Philippines). But the maximum value of SKDIFF between any two countries in which some affiliate sales are actually observed is only 0.23. This is due to the fact that we have only bilateral observations with the US so, for example, no sales by Swedish firms in the Philippines can be observed. The maximum value of SKDIFF for the US is 0.29, so we cannot observe values of SKDIFF greater than 0.23.

Denmark	Korea
Finland	Mexico
France	Philippines
Germany	Portugal
Ireland	Singapore
Israel	South Africa
Italy	Spain
Japan	Turkey
Holland	Venezuela

This suggests that trade cost into country j contribute positively to investment if j is a developed country (horizontal investment) and negatively if j is a developing country (vertical investment). Adding DIST, derivative (1) is always positive for active links, but trade costs reduce the magnitude of the effect. This is consistent with the theory.

Second, consider an increase in country i's GDP, holding total world GPD constant (i.e, country j's GPD change is the negative of country i's change). When countries have identical relative endowments, this derivative is positive with GDPDIFF < 0, zero at GDPDIFF = 0, and negative with GDPDIFF > 0. With country i more skilled-labor intensive than country j, the theory and simulations predicted that this derivative switches sign (+) to (-) at a lower value of GDPDIFF. Results from Table 4 give us the following results, again using the regressions of Table 4.

(2) $$\frac{\partial RSALES}{\partial GDPDIFF} = 2B3(GDPDIFF) + B7(SKDIFF)$$ [5]

$$= - 0.02148(GDPDIFF) - 5.8(SKDIFF) \qquad (COMP - INTER4)$$

$$= - 0.01986(GDPDIFF) - 2.8(SKDIFF) \qquad (COMP - INTER4 + DIST)$$

An increase in a country's GPD will increase its affiliate sales abroad only if it is small and/or skilled-labor scarce.[5]

One interesting interpretation of these results involves the converegence in income between the US and trading partners, holding total "world" income constant (SUMGDP is constant). Using values of SKDIFF from the data, it turns out that the contribution of this term is small and is always dominated by the first term. Note that GDPDIFF is always positive if the US is country i and negative if the US is country j. Accordingly, we can say that a convergence in income (GDP) between the US and country j increases affiliate sales in both directions.

[5]There are 66 country pairs (i,j observations) with positive affiliate sales from i to j in 1991. 52 of these have complete data for this exercise (i.e, TCJ, GDPDIFF, SKDIFF). 30 of the 52 are affiliate sales of US firms in some country j and 22 are country j affiliate sales in the US.

Third, consider an increase in the skilled-labor abundance of country i relative to country j. Our results in Table 4 indicate that this derivative is generally negative, but its (absolute) value is reduced by higher trade costs or a larger GPD difference.

$$(3) \quad \frac{\partial RSALES}{\partial SKDIFF} = B2 + B6(TCJ) + B7(GDPDIFF)$$ [6]

$= \quad 58913 - 1425(TCJ) - 5.8(GDPDIFF) \qquad$ (COMP - INTER4)

$= \quad 46216 - 862(TCJ) - 2.8(GDPDIFF) \qquad$ (COMP - INTER4 + DIST)

Positive trade costs and being a larger country weaken the effects of an increase in skilled-labor abundance on outward affiliate sales.[6]

Inserting values for TCJ and GDPDIFF for the 1991 data, these results imply the following. Using Table 4, an increase in the skilled-labor abundance of country j relative to the US increases country j's affiliate production in the US in all cases where production is observed in 1991. The effect of such a change on US affiliate production abroad is however mixed, increasing in some cases and decreasing in others. But for many country pairs, the increase in the skilled-labor abundance of country j relative to the US increases affiliate production in both direction.

As a final point, we note that the theory suggests a sharper hypothesis on the coefficient of SUMGDP than that it is simply positive. Higher total income should lead to some shifting from national firms, which are high marginal-cost suppliers to foreign markets, to horizontal multinationals which are high fixed-cost suppliers (Markusen and Venables, 1998). In regions of parameter space in which regime shifting does not occur, affiliate production should rise in proportion to total world income. Overall, this suggests that affiliate sales should be elastic with respect to world income. We therefore used the results to calculate the implied elasticity of total affiliate sales (RSALES) with respect to total income (SUMGDP) for 1991 in the data. The result is an elasticity of 3.88: an increase of world real income of 1% results in an estimates 3.88% increase in affiliate sales, other things equal. This adds further support to the underlying theory.

7. Further Econometrics

Econometric work is still in progress, but Tables 6 and 7 show some further results. Table 6 uses the full panel, reporting results without TCI and TCI*SKDIFF (corresponding to the top panel of Table 5). The top panel of Table 6 shows ordinary least squares for a comparison to the Park-Glejser corrected regressions in the second panel (reproduced from Table 5). It is clear that this heteroscedasticity correction significantly improves the fit of the overall regression and the statistical significance of key coefficients (without changing any signs).

[6] In this case there are 60 observations which have complete data for this exercise (i.e, TCJ, GDPDIFF). 37 of the 60 are affiliate sales of US firms in some country j and 23 are country j affiliate sales in the US.

For many country pairs, there is no reported data for production of affiliates of country i firms in country j. This could be because there isn't any, the data is missing, or because of small-numbers confidentiality situations. In most of these cases, country i is a relatively small, poor country with no listed production in the US. Therefore, we assume that the true value of these observations are zero, and add them into the data set. This adds an additional 107 observations to the regression. We then do a Tobit estimation, with results reported in the bottom panel of Table 6. These results are quite consistent with the other regressions, although the trade and investment-cost variables are not significant (they are noisy in all of the regressions).

The purpose of Table 7 is to decompose results into cross-section and time-series effects. The full-panel results (using PG) from Table 5 are once again reproduced in the top panel of Table 7 for easy comparison. The middle panel of Table 7 averages the years into a single observation on every ij pair. There are only 63 observations. Signs of the coefficients are preserved except for that on TCJ. The magnitudes of other coefficients change significantly, but are not wildly different. Standard errors are very large, and t-values are accordingly very small.

The bottom panel adds country pair dummies, in order to isolate time-series effects in the central coefficients. The first three coefficients (SUMGDP, SKDIFF, GDPDIFSQ) are not that different from the full-panel and cross-section estimations. The trade and investment-cost variables have the wrong signs, and the interactive term GDPDIFF*SKDIFF is essentially zero both quantitatively and statistically.

Tab

Table 6

Model: Full Panel, OLS
Dependent Variable: RSALES

Total Obs	327
R-square	0.3322
Adj R-sq	0.3130

Variable	**Parameter Estimate**	**Sign as Predicted?**	**T for H0: Parameter=0**	**Prob > |T|**
SUMGDP	10.395467	Yes	4.627	0.0001
SKDIFF	72945	Yes	2.225	0.0268
GDPDIFSQ	-0.000761	Yes	-2.989	0.0030
INVCJ	-136.036355	Yes	-0.780	0.4359
TCJ	254.696033	Yes	1.367	0.1725
TCJ*SKDIFF	-1947.169094	Yes	-1.772	0.0773
GDPDIFF*SKIDFF	-8.470638	Yes	-3.986	0.0001
INTERCEPT	-27931		-1.356	0.1759

Model: Full Panel, PG heteroscedasticity correction
Dependent Variable: RSALES

Total Obs	327
R-square	0.4731
Adj R-sq	0.4599

Variable	**Parameter Estimate**	**Sign as Predicted?**	**T for H0: Parameter=0**	**Prob > |T|**
SUMGDP	14.149017	Yes	7.965	0.0001
SKDIFF	58017	Yes	2.266	0.0241
GDPDIFSQ	-0.001042	Yes	-5.181	0.0001
INVCJ	-150.798906	Yes	-1.156	0.2487
TCJ	208.128385	Yes	1.425	0.1552
TCJ*SKDIFF	-1421.701341	Yes	-1.656	0.0988
GDPDIFF*SKDIFF	-5.750744	Yes	-3.489	0.0006
INTDUM	-42019		-2.949	0.0034

Table 6 continued

Model: Full Panel, Tobit estimation
Dependent Variable: RSALES
Noncensored Values = 327
Left Censored Values = 107
Log Likelihood for NORMAL -3691.335443

Variable	Parameter Estimate	Sign as Predicted?	ChiSquare	Pr/Chi
SUMGDP	15.174671	Yes	54 .81125	0.0001
SKDIFF	83635	Yes	6.875366	0.0087
GDPDIFSQ	-0.000519	Yes	4.907158	0.0267
INVCJ	-3.614492	Yes	0.000432	0.9834
TCJ	35.113890	Yes	0.037572	0.8463
TCJ*SKDIFF	-1179.420900	Yes	1.208903	0.2715
GDPDIFF*SKDIFF	-13.037638	Yes	44.38517	0.0001
INTERCPT	-63350		11.45254	0.0007
SCALE	16562			

Table 7

Model: Full Panel (no country dummies), PG heteroscedasticity correction
Dependent Variable: RSALES
Total Obs 327
R-square 0.4731
Adj R-sq 0.4599

Variable	Parameter Estimate	Sign as Predicted?	T for H0: Parameter=0	Prob > |T|
SUMGDP	14.149017	Yes	7.965	0.0001
SKDIFF	58017	Yes	2.266	0.0241
GDPDIFSQ	-0.001042	Yes	-5.181	0.0001
INVCJ	-150.798906	Yes	-1.156	0.2487
TCJ	208.128385	Yes	1.425	0.1552
TCJ*SKDIFF	-1421.701341	Yes	-1.656	0.0988
GDPDIFF*SKDIFF	-5.750744	Yes	-3.489	0.0006
INTDUM	-42019		-2.949	0.0034

Table 7 continued

Model: Cross section (years averaged), PG heteroscedasticity correction
Dependent Variable: RSALES
Total Obs 63
R-square 0.5487
Adj R-sq 0.4830

Variable	**Parameter Estimate**	**Sign as Predicted?**	**T for H0: Parameter=0**	**Prob > |T|**
SUMGDP	25.175711	Yes	1.769	0.0824
SKDIFF	22809	Yes	0.329	0.7436
GDPDIFSQ	-0.000512	Yes	-0.332	0.7413
INVCJ	-103.311337	Yes	-0.302	0.7641
TCJ	-27.922529	No	-0.072	0.9430
TCJ*SKDIFF	-297.279166	Yes	-0.126	0.9000
GDPDIFF*SKDIFF	-5.520963	Yes	-1.338	0.1864
INTDUM	-116019		-0.910	0.3666

Model: Panel with country pair dummies, PG heteroscedasticity correction
Dependent Variable: RSALES
Total Obs 327
R-square 0.8986
Adj R-sq 0.8833

Variable	**Parameter Estimate**	**Sign as Predicted?**	**T for H0: Parameter=0**	**Prob > |T|**
SUMGDP	20.822176	Yes	3.946	0.0001
SKDIFF	66184	Yes	3.468	0.0006
GDPDIFSQ	-0.001907	Yes	-3.535	0.0005
INVCJ	394.058451	No	3.202	0.0015
TCJ	-42.883504	No	-0.424	0.6721
TCJ*SKDIFF	-1861.031596	Yes	-2.810	0.0053
GDPDIFF*SKDIFF	0.868037	No	0.291	0.7715
INTDUM	-76109		-4.992	0.0001

8. Summary

The knowledge-capital approach to the multinational enterprise as outlined in this paper is operational, and yields clear, testable hypotheses. It this sense, it is more useful that some other "theories", such as the "transactions cost" approach to the MNE.

In this paper, we test hypotheses regarding the importance of multinationals activity between countries as a function of certain characteristics of those countries, particularly size, size differences, relative endowment differences, trade and investment costs, and certain interactions among theses predicted by the theory. In our view, the model fits well, and gives considerable support to the theory.

Outward investment from country i to country j is increasing in the sum of their economic sizes, their similarity in size, and the relative skilled-labor abundance of country i. The these results are not particularly novel, and some can be found in the papers of Brainard and Ekholm in particular. But the precise formulations here are a bit different and carfully tied to one particular theoretical model. The interactive terms, TCJ*SKDIFF and GDPDIFF*SKDIFF are considerably more novel, and the theoretical predictions on them are clearly demanding of the data. Although "noisy", these coefficients have the correct signs, and GDPDIFF*SKDIFF is highly significant when distance is excluded, weakly significant when it is included (exception: the panel estimation with country-pair dummies). Consistent with the model, small, skilled-labor-abundant countries are significant outward investors.

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APPENDIX: Countries plus the US (Figures for 1990)

COUNTRIES (countries for which at least one year is included)

Argentina	Hong Kong	Norway
Australia	India	Panama
Belgium	Indonesia	Philippines
Brazil	Ireland	Portugal
Canada	Israel	Singapore
Chile	Italy	
Colombia	Japan	Spain
Denmark	Korea	Sweden
Finland	Malaysia	Switzerland
France	Mexico	Turkey
Germany*	Netherlands	UK
Greece	New Zealand	Venezuela

Variable	N	Mean	Std Dev	Minimum	Maximum
YEAR	328	1989.22	1.8997788	1986.00	1992.00
RSALES	328	11384.60	19779.72	0	106861.97
KSTOCKI	328	4624462.47	3403984.37	7910.64	8936213.73
KSTOCKJ	327	3090702.90	3480848.38	37593.42	8936213.73
SKLI	328	0.2614387	0.0628014	0.0637300	0.4855800
SKLJ	328	0.2259352	0.0857400	0.0637300	0.4855800
GDPI	328	3604.02	2561.57	4.8400000	5842.70
GDPJ	328	2350.37	2634.72	23.4300000	5842.70
INVCJ	328	35.0164634	8.9715130	19.5000000	62.4000000
TCJ	328	29.8600610	12.0639056	10.7000000	79.4000000
ATRJ	328	5.0627726	7.8571217	0	62.7632361
DIST	328	8577.08	3993.15	734.0000000	16370.00
TCAVG	324	29.0885802	7.1422321	19.3000000	53.6000000
TCI	324	28.3629630	7.7499297	10.7000000	67.5000000
SUMGDP	328	5954.38	631.3472223	5210.23	8957.42
SKDIFF	328	0.0355035	0.1203055	-0.2207900	0.2283500
GDPDIFF	328	1253.65	5158.32	-5836.41	5806.61
INTER1	328	1.3778507	4.2470091	-6.1379620	15.4822060
GDPDIFSQ	328	28098751.00	5546274.81	6786077.10	34063681.69
INTER2	328	464.7367727	475.9393927	-1064.21	1324.08
INTER3	324	1.1901784	3.8083217	-8.0146770	10.8484110
INTER4	324	0.9410540	3.6223448	-9.8693130	6.34813001

Notes: *German data are for West Germany before unification and for an estimate of Western Germany since unification.

Figure 1: Volume of Affliate Production: 25% trade costs

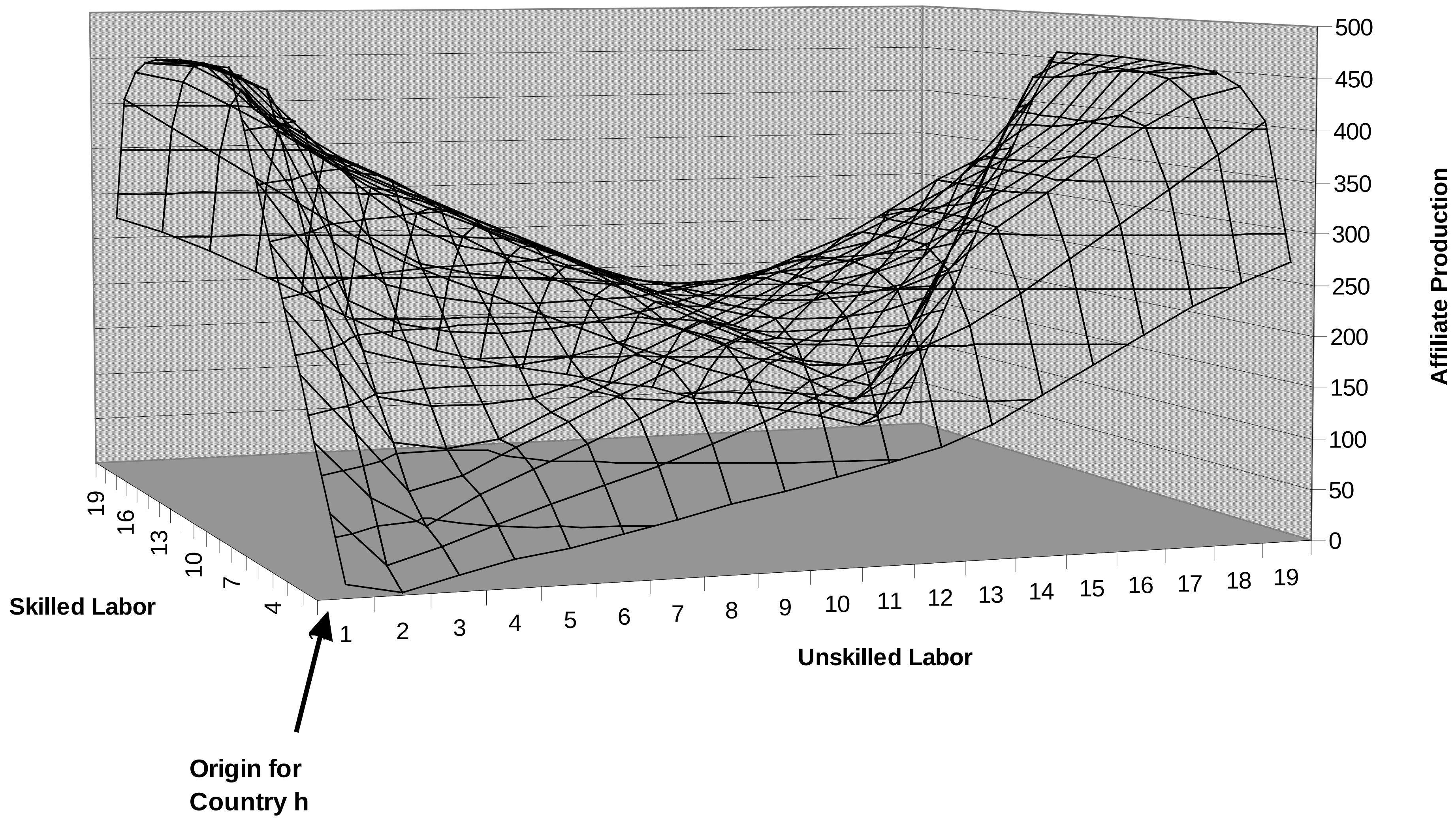

Figure 2: Volume of Affiliate Production: 25% trade costs

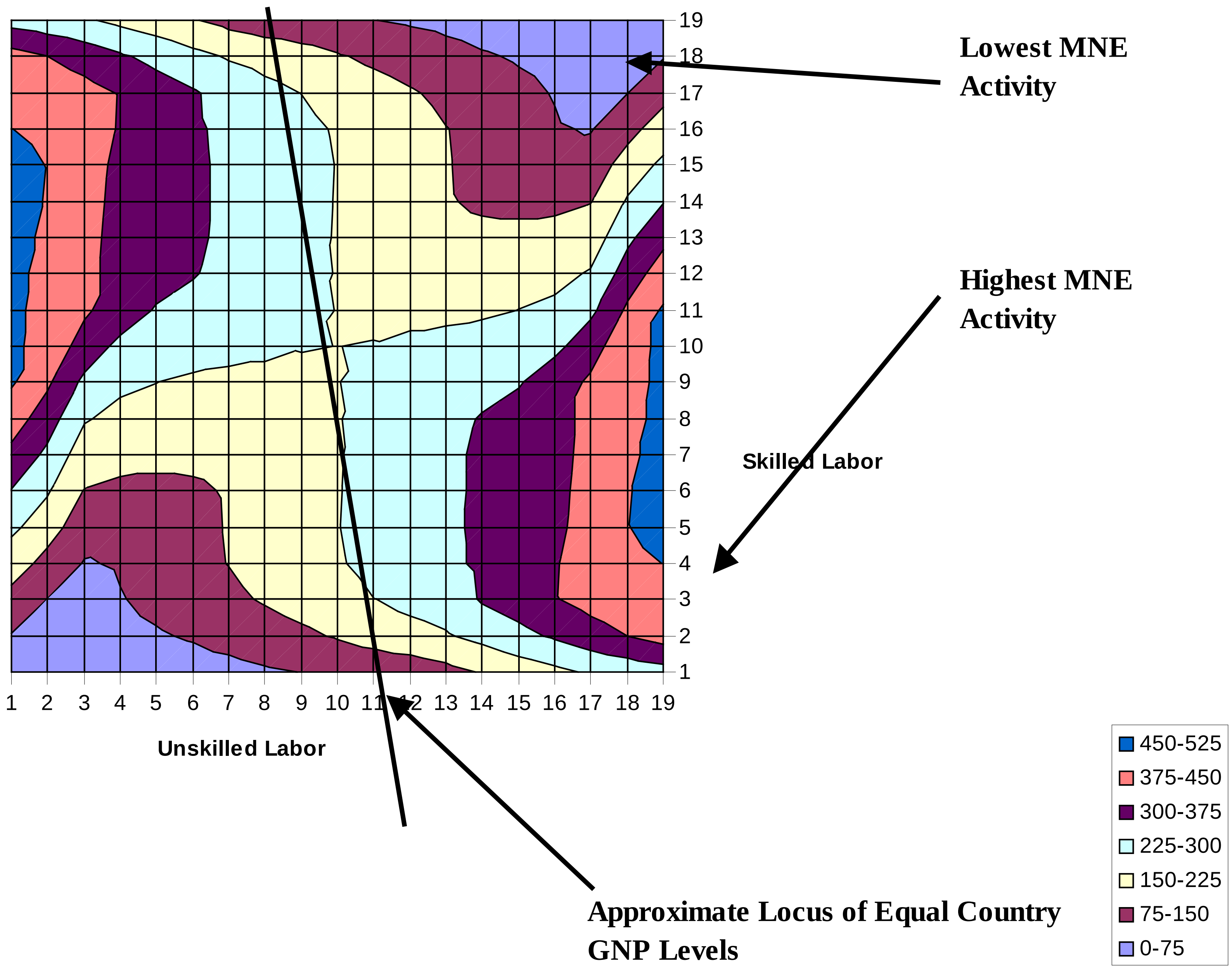

Figure 3: Affiliate Production by h-owned plants in country f

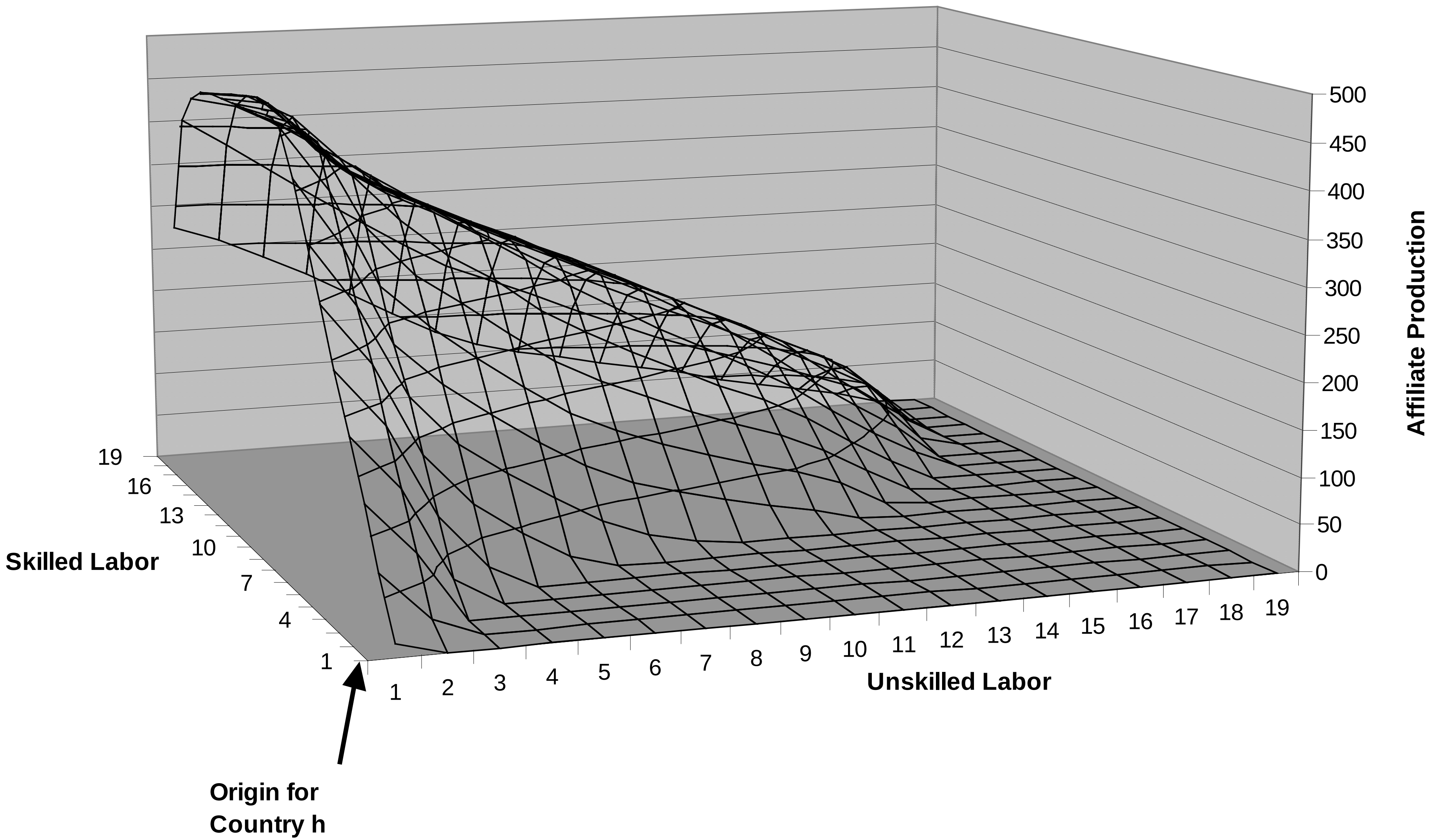

Figure 4: Change in Affiliate Production, h plants in f:
25% trade costs minus 5% trade costs in both directions

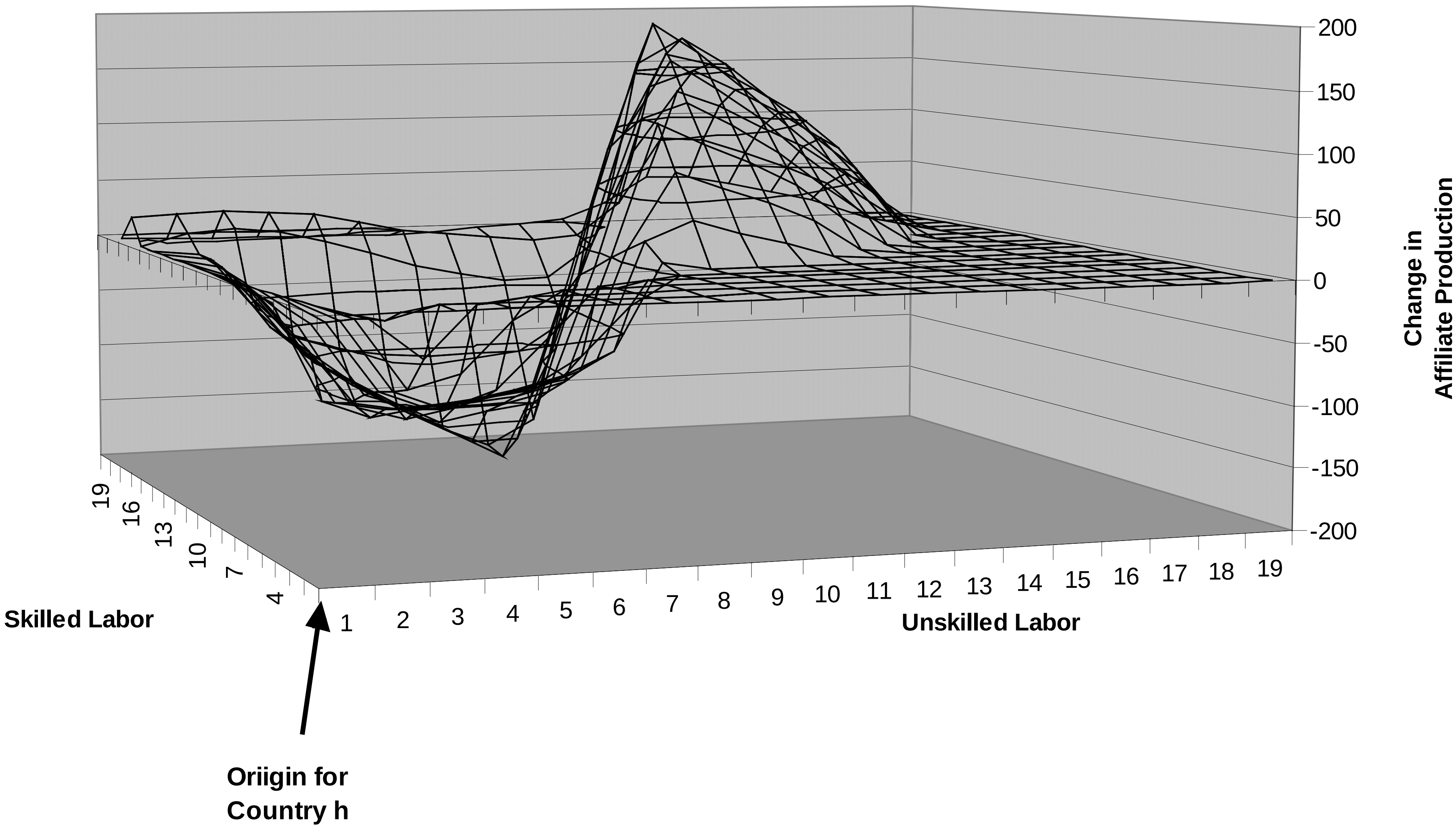

Figure 5: Change in Affiliate Production by h firms in f: increase in f's trade costs

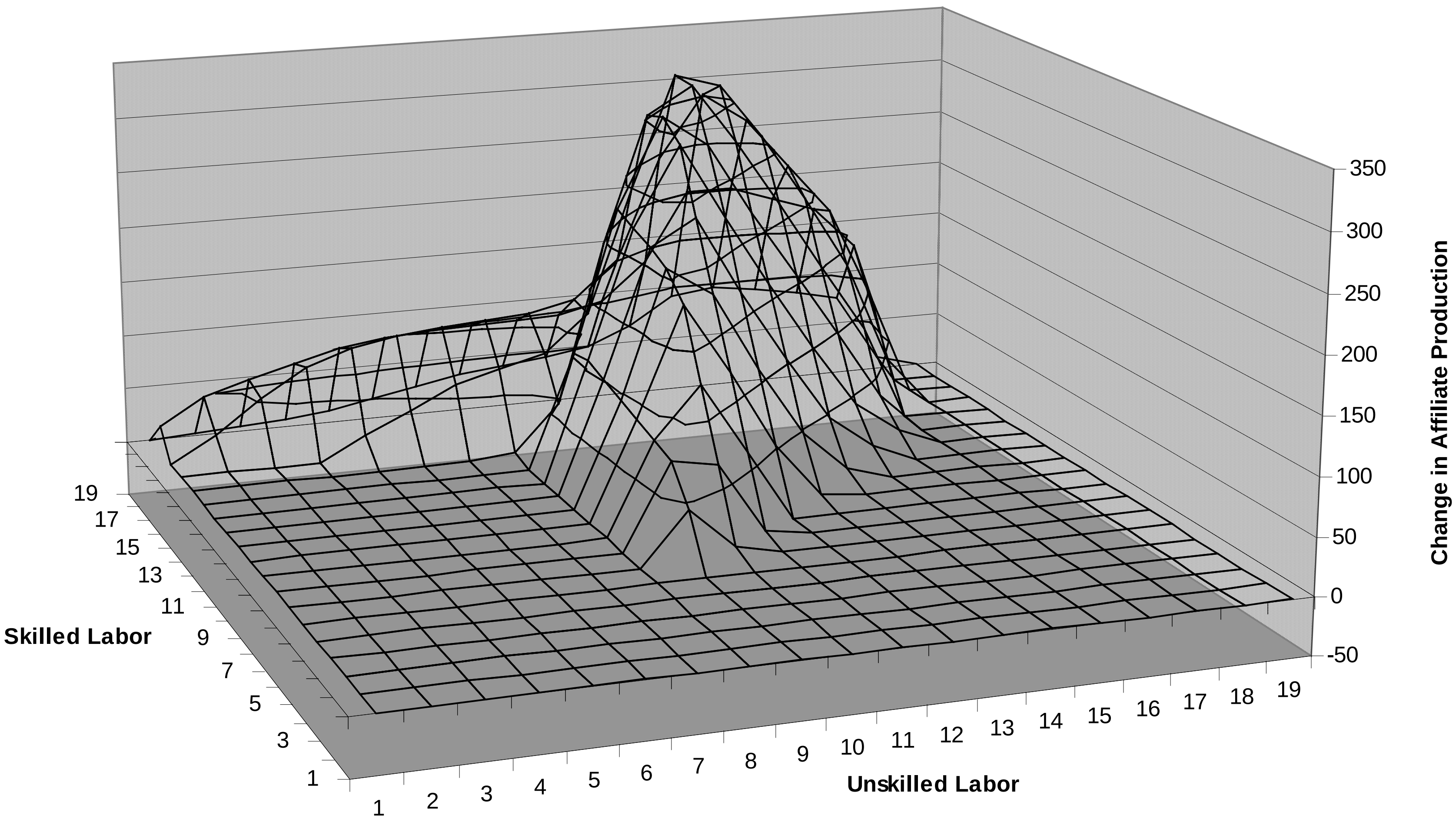

Figure 6: Change in Affiliate Production by h firms in f: increase in h's trade cost