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The emergence of multinational enterprises: Simulation results

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**The Emergence of Multinational Enterprises: Simulation
Results**

by

Jörn Kleinert



Institut für Weltwirtschaft an der Universität Kiel
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Abstract

In the last decades, foreign direct investment (FDI) has increased strongly among industrialised countries. U.S. companies were the first to set up foreign affiliates followed later by companies from smaller industrialised countries. This paper develops a general equilibrium model of bi-directional intra-industry FDI between industrialised countries, in which this specific time pattern emerges. In contrast to the existing literature on FDI, this paper shows that falling transport costs first lead to increased FDI activities and only later to decreased FDI. Additionally, FDI is more likely to occur in industries with differentiated products, higher scale economies on company relative to plant level, smaller inputs of intermediate goods and more differentiated intermediate goods.

JEL F12, F21, F23

Jörn Kleinert

The Kiel Institute of World Economics

Düsternbrooker Weg 120

24100 Kiel

1. Introduction

Multinational enterprises (MNE) stand at the centre of the new wave of globalisation. They are a dominant part in each of the different aspects of globalisation. First, the turnover of foreign affiliates in 1995 was at US\$ 7 trillion, exceeding world trade in that year for the first time (*The Economist*, 1998). Second, 40% of world trade takes place within multinational companies (Panić, 1997). Third, a high percentage of world wide R&D activities is carried out by multinationals. The global payments of fees and royalties for technology quadrupled to about US\$ 48 billion from 1983 to 1995. In 1995, 80% of these payments flew between parent companies and their foreign affiliates (World Investment Report, 1997). Forth, foreign direct investment (FDI) set a new record in 1996. World wide FDI outflows increased to US\$ 347 billion (World Investment Report, 1997).

FDI is increasingly intra-OECD investment. According to de la Mothe (1996), in 1991 70%, compared to 51% in 1967 of world wide FDI stock is cross industrial country investment. A high and increasing share of these investment are intra industry cross investment (Cantwell and Sanna

Randaccio, 1992). Factor price arbitrage does not seem to be the crucial reason behind this development. A large share of FDI is probably better explained by proximity-concentration theories. That is also supported by the more than 90% of the output of US affiliates in Europe, Canada and Japan which are sold within the region (de la Mothe, 1996).

Despite their importance, multinational corporations are still not well understood in theory. The OLI (Ownership, Location, Internalisation) paradigm (Dunning 1977, 1988) is dominant in the management literature on MNE. It has proved to be a useful way of organising almost all known factors which cause a firm to invest abroad, but it lacks rigorous theoretical formulation. Literature on the economic theory of multinational companies is rather new. It started with Markusen (1984) and Helpman (1984). More recent studies include Brainard (1993), Markusen and Venables (1995) and Koop (1997).

Markusen and Venables (1995) and Koop (1997) analyse trade, investment and MNE in a general equilibrium framework using simulation techniques. "The key idea is that in each of the two countries a homogenous good which is produced with economies of scale at the plant and at the firm

level can be produced by exporters and/or multinational firms" (Koop, 1997: 5)

This paper keeps to the tradition of Brainard (1993) in that, a homogenous and a differentiated goods sector are modelled. That makes the results directly comparable to the findings of new trade theory. The differentiated goods sector is made up of companies producing final goods and companies producing intermediate goods. These companies engage in monopolistic competition within their groups. Since intermediate goods are often very specific to a production process or final goods, it is assumed that final product firms exclusively use intermediate goods from their home country. The final goods producer in the differentiated goods sector produces in a multi-stage process that includes fixed inputs at the corporate level (R&D, marketing, financing) and at the plant level. The variable costs incurred in production include the costs for the input of intermediate goods and factor costs of skilled and unskilled labour. Final goods producing companies in the differentiated goods sector choose between exports and production abroad to serve the foreign market. Export saves on additional fixed costs at the plant level, while production abroad saves on transport costs.

Only economies with identical relative factor endowments are examined, although the examination could be extended to different relative factor endowments. This is intended to exclude effects which result from factor price differentials, because these are not the driving force behind developed countries' cross foreign direct investment. The paper goes beyond Brainard (1993) in (i) that it allows for differences in absolute factor endowments of both countries, which make numerical simulation necessary but gives richer insight in the complexity of the investment decision; (ii) the introduction of an intermediate goods sector; (iii) that conditions of competition are changed by letting transport costs decrease throughout the simulation.

In models of FDI so far, FDI increases if transport costs increase. But this theoretical prediction is at odd with the facts. In the last decades transport and communication costs fell and FDI increased. Moreover, existing models are hardly able to explain the time pattern of FDI with investment first by U.S. companies, later by companies from other industrial countries and recently also from industrialising countries.

It is the central aim of this paper to present a model of bi-directional intra industry FDI which is able to reproduce these basic stylized facts of FDI development in past decades.

In addition to political factors, globalisation is driven by falling transport and communication costs. The simulations in this paper mimic reality by letting transport costs decrease. Transport costs affect the profitability of a company's foreign direct investment. Through variation of different model parameter simulations identify determinants of a company's investment decision. A trigger curve is introduced to present the profitability change of FDI. If the trigger curve exceeds zero, investment in the foreign market is profitable.

The major results of the simulation runs can be summarised as follows: The profitability of FDI differs between industries. It is more profitable to invest abroad for a highly differentiated industry than for industries producing less differentiated goods. Further, the emergence of multinational companies is accelerated by a higher share of fixed costs at the company level relative to the plant level and slowed down by an increasing amount of intermediate goods used in production. The

investment decision is also influenced by the type of intermediate goods. Highly differentiated intermediate goods accelerate investment in the foreign country.

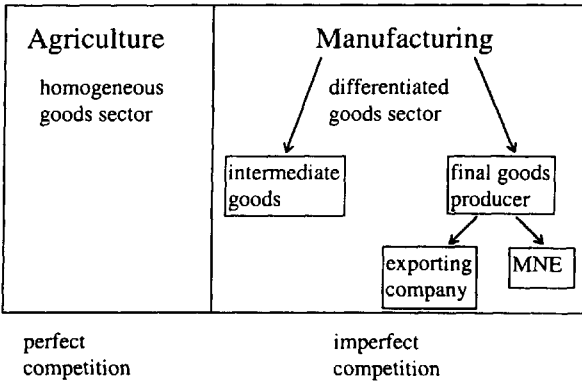
If economies differ in size, the companies in the larger country invest abroad first. For companies in the smaller country investment only becomes profitable, if transport costs are falling further. It may also be the case that it is never profitable for those firms although they produce with the same technology as the companies in the larger country.

2. The Model

Consider two countries, G and K , each with two sectors of production. One sector, agriculture, produces a homogenous product Q_A with constant returns to scale under perfect competition. The other sector, manufacturing, produces a variety of final goods and a variety of intermediate goods under imperfect competition. The aggregate amount of output of the final goods in the manufacturing sector is Q_M . Each firm produces only a single variety i ; output is denoted q_i . The final goods producer, which can serve the foreign market through exports or production abroad, uses intermediate goods, which are also produced in the

manufacturing sector. The aggregate amount of output of the intermediate goods Z is used as input exclusively by the final goods producer headquartered in the same country. An individual intermediate firm's output is denoted z_i . The structure of the production side of the economy is shown in Figure 1.

Figure 1: The Structure of the Production Side of the Economy



It is assumed that every individual is either endowed with one unit of unskilled labour L or one unit of skilled labour H . Labour is perfectly mobile within national economies. However, there is no cross-border mobility of labour. The labour market equilibria give wage levels for

unskilled and skilled labour w_j, v_j in country j . Full employment is assumed.

Consumption

N_j inhabitants live in each country j . They have identical preferences. Their utility function is increasing in the agricultural product and the aggregate manufacturing product.

$$U_j = Q_{A,j}^{1-\mu} Q_{M,j}^{\mu} \quad \mu \in (0,1); j = G, K \quad (1)$$

μ gives the income share spent on manufacturing goods. The aggregate Q_M is a CES-function with λ different products.

$$Q_{M,j} = \left[\sum_{i=1}^{\lambda} q_{i,j}^{\rho} \right]^{1/\rho} \quad \rho \in (0,1); j = G, K \quad (2)$$

ρ defines the degree of differentiation of the manufacturing goods. The products are poor substitutes for each other if ρ is small, leaving the companies with more market power. If ρ increases, it is easier for consumers to substitute one good for the other, therefore market power decreases.

Equation (2) implies that consumers love variety. If they are indifferent to two products, they prefer a mix of half a unit of each good. The CES-function (2) implies a constant elasticity of substitution σ , with $\sigma = \frac{1}{1-\rho}$, between any two varieties of the manufacturing products.

Individuals maximise their utility (1) subject to budget constraints

$$Y_j = p_{A,j} Q_{A,j} + \sum_{i=1}^{\lambda} q_{i,j} p_{i,j} \quad j = G, K \quad (3)$$

to obtain the optimum quantities of agricultural and manufacturing goods.

$$Q_{A,j} = (1-\mu) Y_j / p_{A,j} \quad j = G, K \quad (4)$$

$$Q_{M,j} = \mu Y_j / p_{M,j} \quad j = G, K \quad (5)$$

$p_{A,j}$ is the price of agricultural goods, $p_{M,j}$ is the price-index of the varieties of manufacturing goods. It depends on the price of every individual product.

Since agriculture stands for the perfectly competitive sector of economy and the agricultural good can be traded without costs, the price of the agricultural product will be the same in both economies and set to 1. The

agricultural good Q_A will therefore be used as numeraire throughout this paper.

Production

The agricultural good is assumed to be produced under constant returns.

$$Q_{A,j} = L_{A,j}^{\theta_1} H_{A,j}^{1-\theta_1} \quad (6)$$

Since agriculture is a perfect competition sector wages w_j and salaries v_j are paid according to the marginal products of the production factors unskilled and skilled labour, respectively.

$$\frac{\partial Q_{A,j}}{\partial L_{A,j}} = w_j \quad \frac{\partial Q_{A,j}}{\partial H_{A,j}} = v_j \quad (7)$$

Perfect mobility of workers across sectors, assures that wages and salaries are identical in every sector of the economy.

For a Cobb-Douglas technology the production function can be transformed into a cost function. For the remainder of this paper, technology is described by the cost function.

Production costs in agriculture are given by

$$C_{A,j} = \left(\frac{w_j}{\theta_1} \right)^{\theta_1} \left(\frac{v_j}{1-\theta_1} \right)^{1-\theta_1} Q_{A,j}, \quad j = K, G; \theta_1 \in (0,1) \quad (8)$$

In the manufacturing sector, companies are engaged in monopolistic competition. Consumers view the differentiated products as imperfect substitutes. Each company produces a single variety. Hence, the number of differentiated goods equals the number of firms in the two countries.

There are two groups of firms in the manufacturing sector, intermediate goods producers and final goods producers. The final goods producers use a bundle of intermediate goods as input in their production. Since intermediate goods are often very specific to a production process or final good, the production of this final good in a foreign market depends on the supply of intermediate goods from the home market. For the sake of simplicity, it is assumed that MNEs exclusively use intermediate goods produced in their home market irrespective of whether production of the final good occurs in the home or in the foreign market.

The intermediate goods are not perfect substitutes for each other. The bundle of intermediate goods used by any firm in the manufacturing sector contains all varieties of intermediate goods.

$$Z_j = \left[\sum_{i=1}^{s_j} z_i^\varepsilon \right]^{-\frac{1}{\varepsilon}} \quad j = G, K; \varepsilon \in (0,1) \quad (9)$$

Aggregation is again assumed to be a CES function. The intermediate goods' degree of differentiation depends on ε . s_j is the number of intermediate goods produced in country j .

The price-index p_{z_j} for intermediate goods can be calculated from (9)¹.

$$p_{z_j} = \left[s_j p_{Z,i,j}^{-\phi} \right]^{-\frac{1}{\phi}} \quad j = G, K \quad (10)$$

where $\phi = \frac{\varepsilon}{1-\varepsilon}$. s_j is the number of varieties of the intermediate goods in

the bundle Z_j , $p_{Z,i,j}$ is the price of any of these varieties.

The costs of production of an intermediate good variety follow the cost function

¹ For a derivation of the price index and the demand for any variety see the appendix.

$$c_{i,j}^Z = \left(\frac{w_j}{\theta_2}\right)^{\theta_2} \left(\frac{v_j}{1-\theta_2}\right)^{1-\theta_2} f_{Z,j} + \left(\frac{w_j}{\theta_3}\right)^{\theta_3} \left(\frac{v_j}{1-\theta_3}\right)^{1-\theta_3} z_{i,j} \quad (11)$$

$$j = G, K \text{ and } \theta_2, \theta_3 \in (0,1)$$

The first term of the right hand side gives the fixed costs. $f_{Z,j}$ is the level of fixed costs given by the production technology. The second term describes the marginal costs $c_{Z,j}$ multiplied by the output $z_{i,j}$. Because all producers of intermediate goods face the same factor costs and use the same technology, their marginal costs and their fixed costs are identical.

The amount spent on intermediate goods of country j by the final goods producer is denoted I_j . From the composition of the aggregate intermediate good (9), the demand of any of the varieties can be derived.

$$z_{i,j} = \frac{p_{Z,i,j}^{-(1+\phi)}}{p_{z,j}^{-\phi}} I_j \quad j = G, K \quad (12)$$

In an equilibrium, demand for the intermediate good equals its production. The output of an intermediate goods producer decreases, therefore, in its own price $p_{Z,i,j}$, and increases in the price-index of intermediate goods

p_{z_j} and the demand for intermediate goods from the final goods producer l_j .

Maximising the profit function of an intermediate goods producer

$$\Pi_{i,j}^Z = [p_{Z,i,j} - c_{Z,j}]z_i(p_{Z,i,j}) - C_{ZF,j} \quad j = G, K \quad (13)$$

yields the optimal price of his intermediate good

$$p_{Z,i,j} = c_{Z,j} / \varepsilon. \quad j = G, K \quad (14)$$

The producers of intermediate goods set their prices $\frac{1}{\varepsilon}$ over their marginal costs $c_{Z,j}$. These prices are identical, because their marginal costs are identical as well as the outputs z_j .

The number of intermediate goods firms s_j is determined by the zero-profit-condition.

$$\Pi_j^Z = (1 - \varepsilon)p_{Z,j}z_j - C_{ZF,j} = 0 \quad (15)$$

Since there is free market entry and exit in both countries in this model, new companies will enter profitable markets until profits fall to 0. New

entrants influence the profit of existing firms by increasing competition: the price index (11) decreases as a result. In equilibrium, the zero-profit condition holds.

Equation (10) gives the price-index for a home based plant of a final good producer. The price-index of affiliates in the foreign country pz_j^M must take the transport costs ($\tau_M D$) into account.

$$pz_j^M = \left[s_j \left(p_{Z,j} e^{\tau_M D} \right)^{-\phi} \right]^{-\frac{1}{\phi}} \quad j = G, K \quad (16)$$

Transport costs are modelled according to Samuelson's 'iceberg' form: a part of the value of every product must be paid for transportation. This value increases with the distance D between the two markets (which is set to 1 for the remainder of this paper). To buy one unit of an imported intermediate good, e^{τ_M} (> 1) units have to be paid by the producer of the final good in the foreign country, $(e^{\tau_M} - 1)$ units being transport costs.

There are two possible types of final goods producers in every country: (i) national firms producing in their home market and serving the foreign country through exports and (ii) multinational companies producing

domestically and abroad. For the sake of simplicity, exports of the multinational companies affiliates to the home country are excluded.

The final goods producers manufacture their products in a multi-stage process. In the first stage, headquarter services are produced in each firm. The headquarter service has the character of public goods within the company. In the second stage, actual production takes place at the plant. Therefore headquarter services and intermediate goods are used as inputs in the second stage.

In the first stage, a headquarter-service is produced with unskilled and skilled labour. The cost function of any final good producer is given by

$$C_{Hq,i,j} = \left(\frac{w_j}{\theta_4} \right)^{\theta_4} \left(\frac{v_j}{1-\theta_4} \right)^{1-\theta_4} r_j \quad j = G, K; \theta_4 \in (0,1) \quad (17)$$

r_j is the level of headquarter-services produced by the companies in country j . In the second stage, at the plant level, the companies produce with fixed and variable input factors. The cost function of the fixed inputs $C_{PF,i,j}$ are

$$C_{PF,i,j} = \left(\frac{w_j}{\theta_2} \right)^{\theta_2} \left(\frac{v_j}{1-\theta_2} \right)^{1-\theta_2} f_j \quad j = G, K; \theta_2 \in (0,1) \quad (18)$$

f_j is the level of fixed input necessary for the production of final good. r_j and f_j are determined by the production technology and, therefore, exogenous to the company.

The costs of variable inputs $C_{PV,i,j}^N$ of a plant of a national company in j is given by

$$C_{PV,i,j}^N = \left(\frac{w_j}{\theta_5} \right)^{\theta_5} \left(\frac{v_j}{\theta_6} \right)^{\theta_6} \left(\frac{pz_j}{1-\theta_5-\theta_6} \right)^{1-\theta_5-\theta_6} q_{i,j}^N \quad (19)$$

$$j = G, K \text{ and } \theta_5, \theta_6 \in (0,1)$$

Variable costs $C_{PV,i,j}^N$, increase in the factor prices of unskilled and skilled labour w_j, v_j in country j , the price-index of the intermediate goods pz_j in country j and the output level $q_{i,j}^N$.

Different plants of multinational companies have different variable costs $C_{PV,i,j,h}^M$ in each country because of different wages ($w_j \neq w_h, v_j \neq v_h$) and different prices of the intermediate goods ($pz_j^M \neq pz_j$) in both

markets. A multinational company's variable costs of production in the home-country j , $C_{PV,i,j,j}^M$, are

$$C_{PV,i,j,j}^M = \left(\frac{w_j}{\theta_5}\right)^{\theta_5} \left(\frac{v_j}{\theta_6}\right)^{\theta_6} \left(\frac{pz_j}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} q_{i,j,j}^M \quad (20)$$

$$j = G, K \text{ and } \theta_5, \theta_6 \in (0,1)$$

The variable costs of production in h of a multinational firm headquartered in j $C_{PV,i,j,h}^M$ are

$$C_{PV,i,j,h}^M = \left(\frac{w_h}{\theta_5}\right)^{\theta_5} \left(\frac{v_h}{\theta_6}\right)^{\theta_6} \left(\frac{pz_j^M}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} q_{i,j,h}^M \quad (21)$$

$$j = G, K; h = G, K \text{ and } \theta_5, \theta_6 \in (0,1); j \neq h$$

A multinational company's variable costs abroad depend on the wage rates of unskilled and skilled labour w_h, v_h in the foreign country h , the elasticities of production θ_5, θ_6 (technology used) and the costs of the intermediate goods pz_j^M (including transport costs from the home country). The output $q_{i,j}^k$ ($k = N, M; j = G, K$) differs between domestic

suppliers and MNE in the same country as well as between MNE affiliates in the MNE's home country and the affiliates in the foreign country.

In equilibrium, companies produce the amount of goods they can sell for the optimal price. Given the utility function (1) and the composition of the aggregated manufacturing good (2), equation (22) gives the demand for one single product $q_{i,j}^N$ for a national firm, which serves the foreign country through exports:

$$q_{i,j} = \frac{p_{i,j}^{-(1+\gamma)}}{p_{M,j}^{-\gamma}} \mu Y_j + \frac{p_{i,j}^{-(1+\gamma)} e^{-(1+\gamma)\tau_M}}{p_{M,h}^{-\gamma}} \mu Y_h \quad (22)$$

$$j = G, K; h = G, K \text{ and } h \neq j; \gamma = \frac{\rho}{1-\rho}$$

The optimal quantity of a good i produced in j depends on: its price $p_{i,j}$, the price-indices $p_{M,j}, p_{M,h}$ in both final goods markets and the transport costs τ_M . The lower the price of good i relative to the price-index in both countries, the higher the optimal output. High transport costs decrease the optimal output by increasing the sales price in the foreign market. Consumers in the importing country h must pay the transport costs and react therefore by partially substituting imported goods for goods produced in their country h .

A multinational firm headquartered in j produces in both countries. It supplies goods which are produced within each country. The optimal output from the domestic plant

$$q_{i,j,j}^M = \frac{P_{i,j,j}^M^{-(1+\gamma)}}{P_{M,j}^{-\gamma}} \mu Y_j \quad j = G, K \quad (23)$$

equals the demand in the home country, since re-export is excluded.

The price of a multinational company's goods in the foreign market h are lower than prices for imported goods, since consumers do not have to pay transport costs.

$$q_{i,j,h}^M = \frac{P_{i,j,h}^M^{-(1+\gamma)}}{P_{M,h}^{-\gamma}} \mu Y_h \quad j = G, K; h = G, K \quad (24)$$

$q_{i,j,h}^M$ is the output in h of a multinational company i with Headquarters in j . It is positively related to the price-index and the market size μY_h in country h and negatively related to its own price.

The quantity of the intermediate goods-bundle used by a single final goods producer can be calculated from the variable cost functions (19) – (21) by

taking the partial derivative with respect to the price-index p_{z_j} (Shephards lemma).

$$\begin{aligned} qz_{i,j}^N &= \frac{\partial C_{PV,i,j}}{\partial p_{z_j}} \\ &= (1-\theta_5-\theta_6) \left(\frac{w_j}{\theta_5}\right)^{\theta_5} \left(\frac{v_j}{\theta_6}\right)^{\theta_6} \left(\frac{1-\theta_5-\theta_6}{p_{z_j}}\right)^{\theta_5+\theta_6} q_{i,j}^N \end{aligned} \quad (25)$$

$$\begin{aligned} qz_{i,j}^M &= \frac{\partial C_{PV,i,j,j}^M}{\partial p_{z_j}} + \frac{\partial C_{PV,i,j,h}^M}{\partial p_{z_j}^M} = qz_{i,j,j}^M + qz_{i,j,h}^M \\ &= (1-\theta_5-\theta_6) \left(\frac{w_j}{\theta_5}\right)^{\theta_5} \left(\frac{v_j}{\theta_6}\right)^{\theta_6} \left(\frac{1-\theta_5-\theta_6}{p_{z_j}}\right)^{\theta_5+\theta_6} q_{i,j,j}^M \\ &\quad + (1-\theta_5-\theta_6) \left(\frac{w_h}{\theta_5}\right)^{\theta_5} \left(\frac{v_h}{\theta_6}\right)^{\theta_6} \left(\frac{1-\theta_5-\theta_6}{p_{z_j}^M}\right)^{\theta_5+\theta_6} q_{i,j,h}^M \end{aligned} \quad (26)$$

In equilibrium the aggregate demand for intermediate goods

$\left(\sum_{i=1}^{m_j} qz_{i,j}^M + \sum_{i=1}^{n_j} qz_{i,j} \right)$ equals the aggregate supply (Z_j) . The total costs for

intermediate goods $\left(\sum_{i=1}^{m_j} p_{z_j} qz_{i,j}^M + \sum_{i=1}^{n_j} p_{z_j} qz_{i,j} \right)$ equal the demand I_j .

The final goods producers set their prices to maximise their profits.

$$\Pi_{i,j}^N = [p_{i,j}^N - c_{PV,i,j}^N] q_i(p_{i,j}^N) - C_{Hq,i,j} - C_{PF,i,j} \quad j = G, K \quad (27)$$

$$\begin{aligned} \Pi_{i,j}^M = & [p_{i,j}^M - c_{PV,i,j}^M] q_i^M(p_{i,j}^M) + [p_{i,h}^M - c_{PV,i,h}^M] q_{i,h}^M(p_{i,h}^M) \\ & - C_{Hq,i,j} - C_{PF,i,j} - C_{PF,i,h} \end{aligned} \quad (28)$$

The solution to this maximisation-problem is always a fixed mark-up factor over marginal costs $c_{PV,i,j}^k$.

$$p_{i,j}^k = c_{PV,j}^k / \rho \quad j = G, K; k = N, M \quad (29)$$

The price of a single final good depends only on the good's marginal costs $c_{PV,j}^k$ and ρ , the parameter of differentiation. Marginal costs can easily be obtained from the variable costs (17) – (21). Since all companies use the same technology, the marginal costs differ only if factor prices differ. But factor prices can not differ within one country, because there is intersectoral mobility ($p_{j,j} = p_{i,j,j}$).

In each country j there are four different potential supplier of final manufacturing goods. (i) National firms of country j producing for their home market. (ii) Foreign firms serving country j through exports. (iii)

MNEs with their headquarters in country j producing at their plant in j and
 (iv) MNEs with the headquarter in country h producing at their affiliate in
 country j .

Prices set by companies located in G and K differ as result of different
 marginal costs caused by different factor costs. Prices set by national and
 multinational enterprises also differ in the foreign market but not at home.

There are therefore up to three different prices $p_{j,h}^k$
 ($j = G, K; h = G, K; j \neq h$ and $k = N, M$) in each country h : price of goods
 produced by j based firms (nationals and multinationals), imported goods
 and goods produced by an h -headquartered multinational firm's plant in j .

The price of a national firm's good in the foreign market $p_{j,h}^N$ equals the
 home-market price multiplied by the transportation costs

$$p_{j,h}^N = p_{j,j}^N e^{\tau M}.$$

From the utility functions (1) and (2) the price index for each market can
 be calculated.

$$P_{M,j} = \frac{\mu Y_j}{Q_{M,j}} = \left[\sum_{i=1}^{\lambda} p_i^{-\gamma} \right]^{-\frac{1}{\gamma}} \quad j = G, K \quad (30)$$

Using the different product prices of the different companies, the price index can be written as

$$p_{M,j} = \frac{\mu Y_j}{Q_{M,j}} = \left[\sum_{i=1}^{n_j} (p_{j,j}^N)^{-\gamma} + \sum_{i=1}^{n_h} (p_{h,j}^N)^{-\gamma} + \sum_{i=1}^{m_j} (p_{j,j}^M)^{-\gamma} + \sum_{i=1}^{m_h} (p_{h,j}^M)^{-\gamma} \right]^{-\frac{1}{\gamma}} \quad (31)$$

$$j = G, K$$

n_j is the number of national companies, located in j , n_h the number of nationals located in h , m_j and m_h are the numbers of multinationals headquartered in j and h , respectively. n_j , n_h , m_j and m_h add up to λ .

Since there is free market entry and exit, in equilibrium the zero-profit condition holds for national and multinational companies.

$$\Pi_j^N = (1 - \rho) p_j^N q_j^N - C_{Hq,j} - C_{PF,j} = 0 \quad (32)$$

$$j = G, K; h = G, K; j \neq h$$

and

$$\Pi_j^M = (1 - \rho) \left(p_{j,j}^M q_{j,j}^M + p_{j,h}^M q_{j,h}^M \right) - C_{Hq,j} - C_{PF,j} - C_{PF,h} = 0 \quad (33)$$

The zero-profit-conditions (32) and (33) are sufficient to determine the number of national firms n_j and multinational firms m_j .²

Investment Decision

All final goods producers can decide whether to serve the foreign market through exports or to become a MNE and to produce abroad. If there are no restrictions to FDI, a company will invest in the foreign market if it is profitable to do so.

The price of the good drops in the foreign market, when an exporting company becomes a multinational, since there are only transport costs on the intermediate good but not on the final good. The quantity sold rises as do variable profits.

² In general, there is no simple solution to the number of companies in both countries. But there are some special cases where an expression for the number of companies can be derived (see Brainard, 1993).

A national final goods producer decides to invest in a foreign country if the gains in variable profits are at least as high as the additional fixed costs at the plant level.

$$C_{PF,h} \leq (1-\rho) \left(p_{j,j}^M q_{j,j}^M + p_{j,h}^M q_{j,h}^M - p_j^N q_j^N \right) \quad (34)$$

$$j = G, K; H = G, K \quad j \neq h$$

The lower the fixed costs at the plant level $C_{PF,h}$, the sooner a national firm will decide to build a plant abroad. Not clear is the influence of the transport costs. The last term of the right hand side increases with lower transport costs, because q_j^N increases. But the second term from the right increases as well. The net effect depends on the parameters. The influence of ρ is also ambiguous. The first factor on the right hand side of equation (34) will increase, as product differentiation increases (falling ρ). That accelerates investment. But $\Delta q = q_{j,j}^M + q_{j,h}^M - q_j^N$ is influenced by ρ , as well. A smaller ρ implies a smaller Δq , and therefore a smaller increase in variable profits. Therefore, the influence of ρ on the investment decision depends on the specific value of the parameters.

One company's investment in the foreign market intensifies competition for all companies in this market. It produces the same effect as the entry of a new firm, the price index decreases.

Multinational companies are free to divest in the foreign country and serve consumers there instead through exports. Fixed costs at the plant-level are sunk-costs, but if the revenue of a MNE is smaller than the revenue of a national company,

$$p_{j,j}^M q_{j,j}^M + p_{j,h}^M q_{j,h}^M < p_j^N q_j^N \quad j = G, K; h = G, K; j \neq h \quad (35)$$

it is profitable for a company to divest. Factor prices for labour and skilled labour must be much cheaper in country j compared to country h to make up for the additional transport costs.

Factor Demand

Factor demand is derived by Shepards Lemma. The cost functions (8), (11) and (17) through (21) are differentiated with respect to the factor price. The derivation of the unskilled and skilled labour demand is shown in the appendix.

Market Equilibrium

Full employment of all resources is assumed in both economies. For a given endowment of unskilled labour, L_j , the labour market condition is

$$\begin{aligned}
 L_j = & L_{A,j} + n_j \left(L_{Hq,j} + L_{PF,j} + L_{PV,j}^N + L_{t,j}^N \right) \\
 & + m_j \left(L_{Hq,j} + L_{PF,j} + L_{PV,j,j}^M \right) \\
 & + m_h \left(L_{PF,j} + L_{PV,h,j}^M \right) + s_j \left(L_{Z,j} + L_{tZ,j}^Z \right)
 \end{aligned} \tag{36}$$

Then, the market clearing condition for skilled labour is

$$\begin{aligned}
 H_j = & H_{A,j} + n_j \left(H_{Hq,j} + H_{PF,j} + H_{PV,j}^N + H_{t,j}^N \right) \\
 & + s_j \left(H_{Z,j} + H_{tZ,j}^Z \right) + m_j \left(H_{Hq,j} + H_{PF,j} + H_{PV,j,j}^M \right) \\
 & + m_h \left(H_{PF,j} + H_{PV,h,j}^M \right)
 \end{aligned} \tag{37}$$

Wages and salaries are set as to clear factor markets in each country. The wage level determines the size of the agricultural sector because this is a perfectly competitive industry. In both countries the price of agricultural goods is equal to marginal costs.

$$p_{A,j} = c_{A,j} \qquad j = G, K \tag{38}$$

The income Y_j in each country is given by the sum of the income of each individual.

$$Y_j = w_j L_j + v_j H_j \quad j = G, K \quad (39)$$

The demand functions (4) and (5), the income equation (39) and the budget constraint (3) ensure that goods markets clear. The factor market clearance is given by (36) and (37). The value of the marginal products of unskilled and skilled labour (7) determines the wages in each economy.

The pricing rule (29) and the equations (22) to (24), (32) and (33), define the output of the national and multinational firms and their number in each country. The number of intermediate goods firms and their production levels are given by (14), (12) and (15).

The pricing rule (38) sets the agricultural goods output in each economy and therefore the level of inter-industry trade. The costless one-way trade of the homogenous good leads to price equality of this good in both economies.

There is always intra-industry trade in final products, because the final goods are not perfect substitutes for one another. The quantities $q_{j,h}^N$ sold

fall with rising transport costs, they can be very small for almost prohibitive transport costs.

$$Ex_j^M = n_j p_{j,h}^N q_{j,h}^N \quad j = G, K; h = G, K; j \neq h \quad (40)$$

The existence of multinational enterprises and, therefore, the trade of services, depends on fixed costs on both the company and the plant levels, market size and transport costs. Trade in services equals

$$Ex_j^S = m_j C_{Hq,j} \frac{q_{j,h}^M}{q_{j,j}^M + q_{j,h}^M} \quad j = G, K \quad (41)$$

Since this is a static model, trade must be balanced, otherwise one country would be giving away goods for free.

$$Ex_j^A + Ex_j^M + Ex_j^S = Ex_h^M + Ex_h^S \quad j = G, K; h = G, K; j \neq h \quad (42)$$

Ex^A can be positive or negative, depending on whether j is an exporter or an importer of the agricultural good. Ex^M must be positive for both economies except in the case of prohibitive high transport costs τ_M . Ex^S

can be 0 or positive for both countries depending on the existence of multinational companies.

3. Simulation Results: When Do National Companies Invest in a Foreign Market?

To analyse the determinants on bi-directional intra-industry foreign direct investment in industrialised countries the model described in section 2 is simulated for different scenarios. Since the influence of relative factor endowment differences is not the focus of this paper, a constant unskilled-skilled labour endowment ratio of 3:1 across countries is assumed.

To make the changes in profitability of FDI visible a trigger curve of investment is derived from the investment decision (34).

$$\Phi = (1 - \rho) \left(p_{j,j}^M q_{j,j}^M + p_{j,h}^M q_{j,h}^M - p_j^N q_j^N \right) - C_{PF,h} \quad (43)$$

The first two terms describe the change in variable profits resulting from investment, the last term describes fixed costs. Φ is positive if profits are increased by FDI. The company invests abroad if Φ is greater than 0, since

companies are assumed to maximise profit. Φ shows the incentive for a company from j to invest in the foreign country h .

Φ in (43) is derived using a price index with national companies only. Hence, the trigger curve (43) is only valid before the investment of any company has occurred. One company's FDI changes the price index (30), the optimal output conditions (22) through (26) and, therefore, the investment decision (34) and the trigger curve (43).

The focus of this paper is the point where international investment becomes profitable. That is the point where the trigger curve crosses the zero line. It is examined how this point is influenced by the variation of the different parameters. If the value of the trigger curve is positive and at least one company decides to invest in the foreign market the trigger curve (43) is not valid any more, because its derivation used a price index with only national companies. The consequences of one company's investment in the foreign market is beyond the scope of this paper. Here, the determinants of initial investment are considered. To separate the different influences, equilibria with only national companies are employed.

The following simulations begin at very high transport cost levels. There is no inter-industry trade, since the two countries have the same relative factor endowments. Due to high transport costs, there is no trade in differentiated final goods. The countries are autarkic. Factor prices are identical in both countries. There is no incentive to invest in the foreign country, because high transport costs leads to high intermediate goods prices.

Scenario 1: The Influence of Transport Costs

Transport costs fall in this scenario. As a result, intra-industry trade rises between the two countries. Transport costs prevent price equalisation. Hence factor prices differ in both countries and inter-industry trade arises. Falling transport costs raise profit from FDI because home-supplied intermediate goods become cheaper abroad.

Figure 3.1: The Influence of Transport Costs

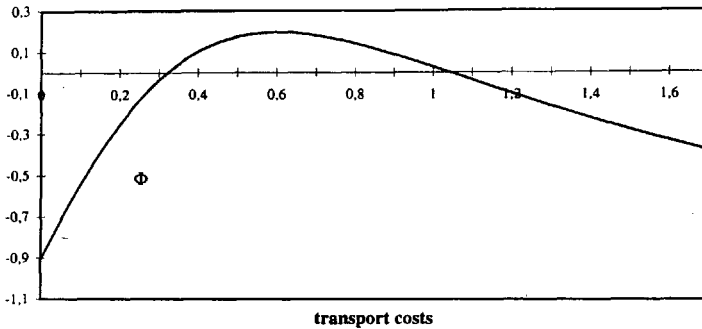


Figure 3.1 shows the trigger curve for equilibria with two identical countries 1 and 2³. It is profitable for companies in both countries to invest in the foreign market if the transport costs are not too high, but not too low, either. In the case of high transport costs intermediate goods from the home country are very expensive and production abroad, therefore, is not profitable. If transport costs are very low, the company does not save enough on transport costs which would make up for the additional fixed costs for the second plant. Hence it is not profitable to invest.

³ The parameters which are used to derive the trigger curves in scenario 1 to 6 are given in the Appendix.

Scenario 2: The Influence of Transport Costs when Countries Differ in Size

To allow for differences in absolute, but not in relative factor endowments, the size of country 2 is reduced to two third of the size of country 1. This changes the investment decision for both countries. Now, Φ differs between the two economies.

$$\Phi_1 = (1 - \rho) \left(p_{1,1}^M q_{1,1}^M + p_{1,2}^M q_{1,2}^M - p_1^N q_1^N \right) - C_{PF,2} \quad (44)$$

$$\Phi_2 = (1 - \rho) \left(p_{2,2}^M q_{2,2}^M + p_{2,1}^M q_{2,1}^M - p_2^N q_2^N \right) - C_{PF,1} \quad (45)$$

Figure 3.2: The Influence of Transport Costs when Countries Differ in Size

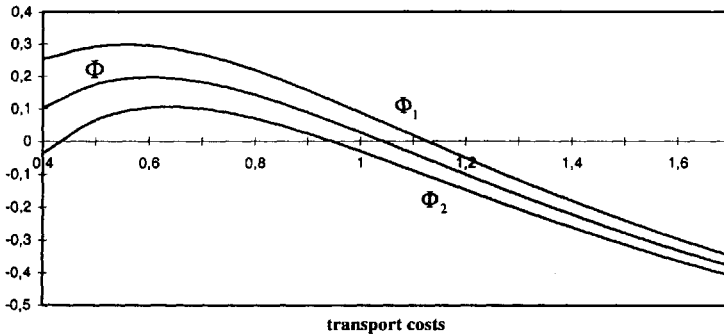
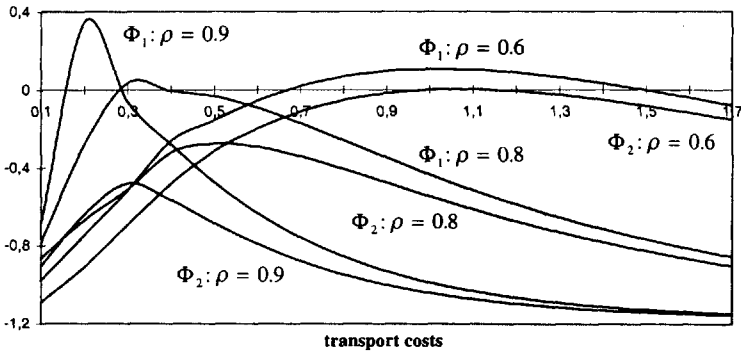


Figure 3.2 shows the new trigger-curves Φ_1 and Φ_2 in comparison to the trigger curve Φ of 3.1. All trigger curves increase with falling transport costs until transport costs fall below a certain point ($\tau_M = 0.6$) and decrease thereafter. Φ_1 , the larger country's trigger curve lies above Φ . FDI is profitable at a higher level of transport costs for companies based in the larger country 1 ($\tau_M = 1.1$), compared to those in the smaller country 2 ($\tau_M = 0.94$), because they enjoy a cost advantage that stems from higher economies of scale in their larger home market. The actually valid part of these trigger curves is only the part of the right of the point where the trigger curve of the larger country 1 crosses the zero line. At this point, country 1's companies investment in the smaller country 2 becomes profitable. MNE emerge since profit maximisation is assumed. That changes the price index (30) and, therefore, the trigger curve (43). The rest of the trigger curve stays valid only if the companies of country 1 do not invest.

Scenario 3: The Influence of Transport Costs on Various Industries in Economies of Different Size

If industries are characterised by different degrees of product differentiation ρ , the trigger curve differs by industry. The degree of differentiation determines the economies of scale enjoyed by the companies. Figure 3.3 shows trigger curves for the larger and the smaller country for different parameters ρ .

Figure 3.3: The Influence of Transport Costs on Various Industries of Economies of Different Size



The point where the trigger curve Φ crosses the τ_M -axis differs from industry to industry. FDI is profitable at higher levels of transport costs for

industries that are characterised by higher product differentiation (lower ρ) because this translates to greater economies of scale. To make FDI of an industry with very low economies of scale profitable, transport costs have to fall to a very low level. It is not profitable for a company in a less differentiated sector ($\rho = 0.8$ and $\rho = 0.9$) from the smaller country to invest in the larger country at any transportation costs level.

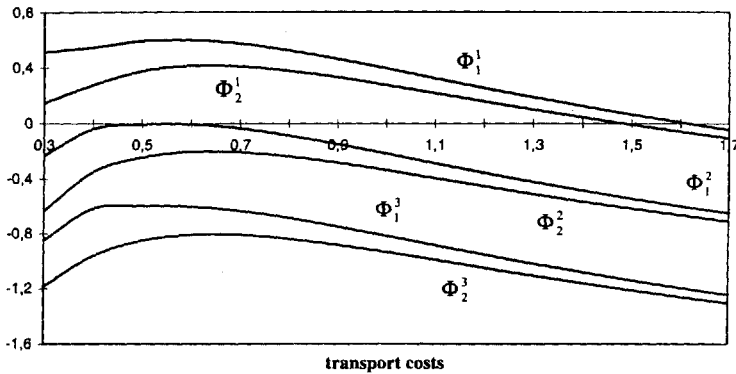
Scenario 4: The Influence of Transport Costs when Fixed Costs Vary

In this scenario the ratio of fixed costs at the company level to plant level is varied while the absolute level of fixed costs is kept constant. High (total) fixed costs are a barrier to entry, because of the zero-profit-function (32), but in the trigger curve function (43) only the plant fixed costs are included. Equation (32) does not change but the trigger function shifts outward with a higher share of fixed costs at the company level. Company level services are public goods within the company. The profitability of an investment increases with the level of services which can be used at no additional costs by the second plant.

The total fixed costs in all three cases shown in Figure 3.4 are identical. The variation in the distribution of plant and company fixed costs strongly

effects the profitability to invest in a foreign country. Increasing returns resulting from high fixed costs at the plant level favour exports since the concentration advantage of production is large compared to transport costs.

Figure 3.4: The Influence of Transport Costs when Fixed Costs Vary



$$\Phi_1^1: r = 15, f = 0.5; \Phi_2^1: r = 15, f = 0.5; \Phi_1^2: r = 1, f = 1; \Phi_2^2: r = 1, f = 1;$$

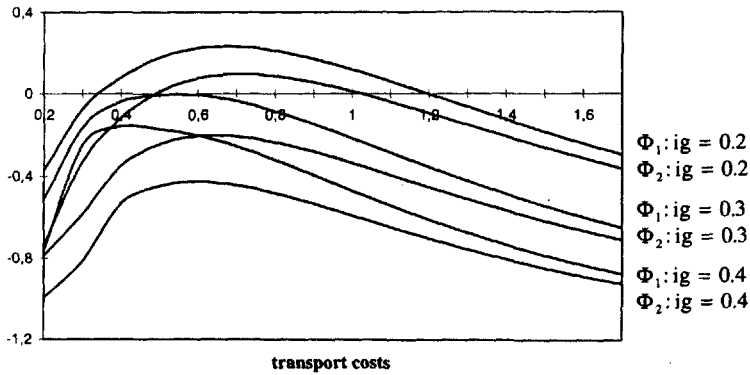
$$\Phi_1^3: r = 0.5, f = 1.5; \Phi_2^3: r = 0.5, f = 1.5;$$

High fixed costs at the company level favour foreign direct investment since the exploitation of the headquarter-service is not restricted to one production site. The ability to split the production process is an important requirement for investment abroad.

Scenario 5: The Influence of Transport Costs on Various Industries with Different Cost Share Spent on Intermediate Goods

The complexity of the production process influences the decision between investment and export, too. The amount of intermediate goods used in the production of the final good characterises the complexity of the production process in this model. The cost share spent on intermediate goods ($ig = 1 - \theta_5 - \theta_6$) varies in Figure 3.5.

Figure 3.5: The Influence of Transport Costs on Industries with Different Cost Shares Sent on Mediate Goods



($ig = 0.2: \theta_4 = 0.55; \theta_5 = 0.25$, $ig = 0.3: \theta_4 = 0.5; \theta_5 = 0.2$

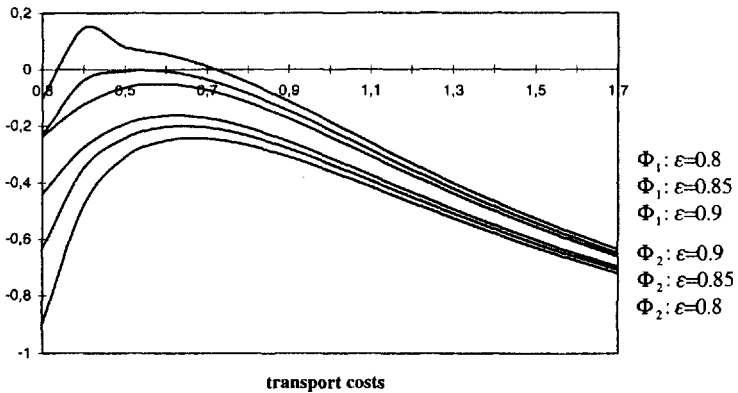
and $ig = 0.4: \theta_4 = 0.4; \theta_5 = 0.2$)

ig stands for the intermediate goods cost share of a company's variable costs. The higher the cost share of intermediate goods the less likely is an investment in the foreign market. As in the scenarios above, there is an advantage for companies from the larger country.

Scenario 6: The Influence of Transport Costs when the Intermediate Goods' Differentiation Varies

The kind of intermediate goods is understood in this scenario as their degree of differentiation. In Figure 3.6, the differentiation parameter ε of intermediate goods is varied.

Figure 3.6: The Influence of Transport Costs when the Intermediate Goods' Differentiation Varies



The variation of ε , the degree of differentiation of the intermediate good, has influence on the investment decision in both countries. Investment in the smaller country by firms from larger countries is eased by more differentiated intermediate inputs (smaller ε). The trigger curve Φ_1 crosses the zero-line only for $\varepsilon = 0.8$. For the foreign investment of companies from the smaller country the opposite is true. The trigger curve Φ_2 lies lower for $\varepsilon = 0.8$ than $\varepsilon = 0.9$.

4. Conclusion

Determinants of FDI and the emergence of MNEs have been analysed in a general equilibrium framework that was solved by simulations. The profitability of investment in the foreign market and, therefore, the possible emergence of multinational companies increases with decreasing transport costs up to a certain point and decreases thereafter. However, it depends on several factors, whether the investment in a foreign country actually is profitable.

Firstly, the profitability is influenced by the size of its home market relative to that of the foreign market. Companies in the larger country

invest at higher transport costs than countries headquartered in the smaller country. That matches the history of FDI after World War II. U.S. companies took the initiative in the internationalisation process in most industries, followed with a time lag by European, Japanese and Canadian companies.

Secondly, product differentiation influences the investment decision. Companies which produce highly differentiated goods are more likely to become multinational. It can be observed, that FDI and multinational companies are dominant in few industries such as chemicals, pharmaceuticals, electronics and motor vehicles, which are industries with imperfect competition and differentiated goods.

Thirdly, product differentiation is necessary but not sufficient. The ability to split the fixed costs from the production process is important for the emergence of multinational corporations. In this model, all fixed costs that can be separated from production process are headquarter-fixed costs. If these are high compared to the fixed costs at the plant level, investment in the foreign market is more likely. The relatively moderate FDI in machinery in spite of highly differentiated goods in this industry is due to

its high content of tacit knowledge. Fixed costs that can not be separated from production process (fixed costs at the plant level) are high compared to fixed costs at the corporate level. In other industries, high fixed costs at the plant level relative to transport costs result in a high concentration advantage. That seems to be the case in the shipbuilding industry, as a very extreme case, since the transport costs of the final product are close to zero. In the steel industry, transport costs are high, but are outweighed by the high concentration advantage resulting from high fixed costs at the plant level.

Finally, companies with complex production processes (high proportion of intermediate goods) tend to stay national longer. The kind of intermediate goods used is of importance, too. Production which uses very differentiated intermediate goods internationalises earlier.

Appendix

I_j is the expenditure on intermediate goods. The optimal quantity of any variety bought by the final good producer is obtained through maximisation under the budget constraints

$$\max \ell = \left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{-\frac{1}{\varepsilon}} + \kappa \left[I_j - \sum_{g=1}^{s_j} p_{Z,g,j} z_{g,j} \right] \quad (\text{A.1})$$

$$\frac{\partial \ell}{\partial z_{h,j}} = \frac{1}{\varepsilon} \left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1-\varepsilon}{\varepsilon}} \varepsilon z_{h,j}^{\varepsilon-1} - \kappa p_{Z,h,j} = 0 \quad (\text{A.2})$$

$$\frac{\partial \ell}{\partial z_{i,j}} = \frac{1}{\varepsilon} \left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1-\varepsilon}{\varepsilon}} \varepsilon z_{i,j}^{\varepsilon-1} - \kappa p_{Z,i,j} = 0 \quad (\text{A.3})$$

$$\frac{\partial \ell}{\partial \kappa} = I_j - \sum_{i=1}^{s_j} p_{Z,g,j} z_{g,j} = 0 \quad (\text{A.4})$$

Transformation of (A.2) and (A.3) yields

$$\left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1}{\varepsilon}} = \kappa^{1-\varepsilon} z_{h,j} p_{Z,h,j}^{\frac{\varepsilon}{1-\varepsilon}} p_{Z,h,j} \quad (\text{A.5})$$

$$\left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1}{\varepsilon}} = \kappa^{1-\varepsilon} z_{i,j} p_{Z,i,j}^{\frac{\varepsilon}{1-\varepsilon}} p_{Z,i,j} \quad (\text{A.6})$$

Taking the sum over all $h=1..s_j$ products gives

$$\left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1}{\varepsilon}} \sum_{h=1}^{s_j} p_{Z,h,j}^{\frac{\varepsilon}{1-\varepsilon}} = \kappa^{1-\varepsilon} I_j \quad (\text{A.7})$$

$$\kappa^{1-\varepsilon} = \left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1}{\varepsilon}} \sum_{h=1}^{s_j} p_{Z,h,j}^{\frac{\varepsilon}{1-\varepsilon}} / I_j$$

Substituting $\kappa^{\frac{1}{1-\varepsilon}}$ in (A.6)

$$\left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1}{\varepsilon}} = \left[\sum_{g=1}^{s_j} z_{g,j}^\varepsilon \right]^{\frac{1}{\varepsilon}} \sum_{h=1}^{s_j} p_{Z,h,j}^{\frac{\varepsilon}{1-\varepsilon}} p_{Z,i,j}^{\frac{\varepsilon}{1-\varepsilon}} p_{Z,i,j} z_{i,j} / I_j \quad (\text{A.8})$$

and transforming (A.8) gives the demand for any variety of the intermediate good

$$z_{i,j} = \frac{\frac{1}{p_{Z,i,j}^{1-\epsilon}}}{\sum_{h=1}^{s_j} \frac{1}{p_{Z,h,j}^{1-\epsilon}}} I_j = \frac{p_{Z,i,j}^{-(1+\phi)}}{p_{Z,j}^{-\phi}} I_j \quad (\text{A.9}) / (\text{12})$$

Equation (A.2) and (A.3) yield

$$\kappa = \left[\sum_{g=1}^{s_j} z_{g,j}^\epsilon \right]^{\frac{1-\epsilon}{\epsilon}} z_{h,j}^{\epsilon-1} / p_{Z,h,j}$$

$$\kappa = \left[\sum_{g=1}^{s_j} z_{g,j}^\epsilon \right]^{\frac{1-\epsilon}{\epsilon}} z_{i,j}^{\epsilon-1} / p_{Z,i,j} \quad \text{or} \quad \frac{p_{Z,i,j}}{p_{Z,h,j}} = \left(\frac{z_{i,j}}{z_{h,j}} \right)^{\epsilon-1} \quad (\text{A.10})$$

The relative demand of any two products depends only on their relative prices.

$$p_{Z,i,j} z_{i,j} = \left(\frac{z_{i,j}}{z_{h,j}} \right)^\epsilon p_{Z,h,j} z_{h,j} \quad i \neq h \quad (\text{A.11})$$

Taking the sum over all $h = 1 \dots s_j$ and substituting into (A.3) gives

$$I_j = \sum_{h=1}^{s_j} \left(\frac{z_{h,j}}{z_{i,j}} \right)^\epsilon p_{Z,i,j} z_{i,j} = \sum_{h=1}^{s_j} z_{h,j}^\epsilon z_{i,j}^{1-\epsilon} p_{Z,i,j} = Z_j^\epsilon z_{i,j}^{1-\epsilon} p_{Z,i,j} \quad (\text{A.12})$$

(A.12) can be solve for the expenditure for one intermediate good

$$z_{i,j} p_{Z,i,j} = Z_j^{-\frac{\epsilon}{1-\epsilon}} p_{Z,i,j}^{-\frac{\epsilon}{1-\epsilon}} I_j^{\frac{1}{1-\epsilon}}$$

Taking the sum of the expenditure for all intermediate goods gives

$$I_j = \sum_{i=1}^{s_j} p_{Z,i,j}^{-\frac{\epsilon}{1-\epsilon}} Z_j^{-\frac{\epsilon}{1-\epsilon}} I_j^{\frac{1}{1-\epsilon}}$$

By solving for the aggregate the price index of the intermediate goods p_{z_j}

can be derived, because $p_{z_j} = I_j / Z_j$.

$$Z_j = \left[\sum_{i=1}^{s_j} p_{Z,i,j}^{-\frac{\epsilon}{1-\epsilon}} \right]^{\frac{1-\epsilon}{\epsilon}} I_j$$

$$p_{z_j} = \frac{I_j}{Z_j} = \left[\sum_{i=1}^{s_j} p_{Z,i,j}^{-\phi} \right]^{\frac{1}{\phi}} = \left[s_j p_{Z,i,j}^{-\phi} \right]^{-\frac{1}{\phi}} \quad (10)$$

Derivation of the labour demand

Unskilled labour is used as follows

$$L_{A,j} = \frac{\partial C_{A,j}}{\partial w_j} = \left(\frac{\theta_1}{1-\theta_1} \right)^{1-\theta_1} \left(\frac{v_j}{w_j} \right)^{1-\theta_1} Q_{A,j} \quad (\text{A.13})$$

$$j = G, K; \theta_1 \in (0,1)$$

$$L_{Hq,j} = \frac{\partial C_{Hq,j}}{\partial w_j} = \left(\frac{\theta_4}{1-\theta_4} \right)^{1-\theta_4} \left(\frac{v_j}{w_j} \right)^{1-\theta_4} r_j \quad (\text{A.14})$$

$$j = G, K; \theta_4 \in (0,1); k = N, M$$

$$L_{PF,j} = \frac{\partial C_{PF,j}}{\partial w_j} = \left(\frac{\theta_2}{1-\theta_2} \right)^{1-\theta_2} \left(\frac{v_j}{w_j} \right)^{1-\theta_2} f_j \quad (\text{A.15})$$

$$j = G, K; \theta_2 \in (0,1)$$

$$L_{PV,j}^k = \frac{\partial C_{PV,j}^k}{\partial w_j} = \left(\frac{\theta_5}{w_j} \right)^{1-\theta_5} \left(\frac{v_j}{\theta_6} \right)^{\theta_6} \left(\frac{pz_j}{1-\theta_5-\theta_6} \right)^{1-\theta_5-\theta_6} q_{j,j}^k \quad (\text{A.16})$$

$$j = G, K; \theta_5, \theta_6 \in (0,1); k = N, M$$

$$L_{PV,j,h}^M = \frac{\partial C_{PV,j,h}^M}{\partial w_h} = \left(\frac{\theta_5}{w_h}\right)^{1-\theta_5} \left(\frac{v_h}{\theta_6}\right)^{\theta_6} \left(\frac{pz_j^M}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} q_{j,h}^M \quad (\text{A.17})$$

$$j = G, K; \theta_5, \theta_6 \in (0,1); h = G, K; j \neq h$$

$$L_{Z,j} = \frac{\partial C_{Z,j}}{\partial w_j} = \left(\frac{\theta_2}{1-\theta_2}\right)^{1-\theta_2} \left(\frac{v_j}{w_j}\right)^{1-\theta_2} f_{Z,j} + \left(\frac{\theta_3}{1-\theta_3}\right)^{1-\theta_3} \left(\frac{v_j}{w_j}\right)^{1-\theta_3} z_j \quad (\text{A.18})$$

Due to the iceberg-form of the transport costs, a share t_j of final goods is lost in the case of export.

$$t_j = \left(e^{\tau_M} - 1\right) \frac{\left(p_j e^{\tau_M}\right)^{-(1+\gamma)}}{p_{M,h}^{-\gamma}} \mu Y_h \quad (\text{A.19})$$

$$j = G, K; h = G, K \text{ and } j \neq h$$

Therefore, the labour input for the transport of final good exports is

$$L_{t,j}^N = \left(\frac{\theta_5}{w_j}\right)^{1-\theta_5} \left(\frac{v_j}{\theta_6}\right)^{\theta_6} \left(\frac{pz_j}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} t_j / \rho \quad (\text{A.20})$$

The export of intermediate goods contains

$$L_{tz,j}^Z = \left(\frac{\theta_3}{1-\theta_3} \right)^{1-\theta_3} \left(\frac{v_j}{w_j} \right)^{1-\theta_3} tz_j / \varepsilon \quad (\text{A.21})$$

units of labour with

$$tz_j = \left(e^{\tau M} - 1 \right) \frac{\left(p_{Z,j} e^{\tau M} \right)^{-(1+\gamma)}}{p_{Z,j}^{M-\gamma}} m_j q_{z,j,h}^M p_{Z,j}^M \quad (\text{A.22})$$

The same differentiation can be made for skilled labour.

$$H_{A,j} = \frac{\partial C_{A,j}}{\partial v_j} = \left(\frac{w_j}{v_j} \right)^{\theta_1} \left(\frac{1-\theta_1}{\theta_1} \right)^{\theta_1} Q_{A,j} \quad j = G, K; \theta_1 \in (0,1) \quad (\text{A.23})$$

$$H_{Hq,j} = \frac{\partial C_{Hq,j}}{\partial v_j} = \left(\frac{w_j}{v_j} \right)^{\theta_4} \left(\frac{1-\theta_4}{\theta_4} \right)^{\theta_4} r_j \quad (\text{A.24})$$

$$j = G, K; \theta_4 \in (0,1); k = N, M$$

$$H_{PF,j} = \frac{\partial C_{PF,j}}{\partial v_j} = \left(\frac{w_j}{v_j} \right)^{\theta_2} \left(\frac{1-\theta_2}{\theta_2} \right)^{\theta_2} f_j \quad (\text{A.25})$$

$$j = G, K; \theta_2 \in (0,1)$$

$$\begin{aligned}
 H_{PV,j}^k &= \frac{\partial C_{PV,j}^k}{\partial v_j} \\
 &= \left(\frac{w_j}{\theta_5}\right)^{\theta_5} \left(\frac{\theta_6}{v_j}\right)^{1-\theta_6} \left(\frac{pz_j}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} q_{j,j}^k
 \end{aligned} \tag{A.26}$$

$$j = G, K; \theta_5, \theta_6 \in (0,1); k = N, M$$

$$\begin{aligned}
 H_{PV,j,h}^M &= \frac{\partial C_{PV,j,h}^M}{\partial v_h} \\
 &= \left(\frac{w_h}{\theta_5}\right)^{\theta_5} \left(\frac{\theta_6}{v_h}\right)^{1-\theta_6} \left(\frac{pz_j^M}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} q_{j,h}^M
 \end{aligned} \tag{A.27}$$

$$j = G, K; \theta_5, \theta_6 \in (0,1); h = G, K; j \neq h$$

$$\begin{aligned}
 H_{Z,j} &= \frac{\partial C_{Z,j}}{\partial v_j} = \left(\frac{w_j}{v_j}\right)^{\theta_2} \left(\frac{1-\theta_2}{\theta_2}\right)^{\theta_2} f_{Z,j} \\
 &\quad + \left(\frac{w_j}{v_j}\right)^{\theta_3} \left(\frac{1-\theta_3}{\theta_3}\right)^{\theta_3} z_j
 \end{aligned} \tag{A.28}$$

$$j = G, K; \theta_2, \theta_3 \in (0,1)$$

$$H_{t,j}^N = \left(\frac{w_j}{\theta_5}\right)^{\theta_5} \left(\frac{\theta_6}{v_j}\right)^{1-\theta_6} \left(\frac{pz_j}{1-\theta_5-\theta_6}\right)^{1-\theta_5-\theta_6} t_j / \rho \tag{A.29}$$

$$j = G, K; \theta_5, \theta_6 \in (0,1)$$

$$H_{tz,j}^Z = \left(\frac{w_j}{v_j} \right)^{\theta_3} \left(\frac{1-\theta_3}{\theta_3} \right)^{\theta_3} tz_j / \varepsilon \quad j = G, K; \theta_3 \in (0,1) \quad (\text{A.30})$$

Table A1: Parameters for the Derivation of the Trigger Curve in the Scenarios 1 to 6

Scenario 1	$\mu = 0.6, \rho = 0.75, \varepsilon = 0.85, \theta_1 = 0.7, \theta_2 = 0.5, \theta_3 = 0.6, \theta_4 = 0.3, \theta_5 = 0.5, \theta_6 = 0.2, L_1 = L_2 = 150, H_1 = H_2 = 50, \eta = r_2 = 1.25, f_1 = f_2 = 0.75, fz_1 = fz_2 = 0.3$
Scenario 2	$\mu = 0.6, \rho = 0.75, \varepsilon = 0.85, \theta_1 = 0.7, \theta_2 = 0.5, \theta_3 = 0.6, \theta_4 = 0.3, \theta_5 = 0.5, \theta_6 = 0.2, L_1 = 150, L_2 = 105, H_1 = 50, H_2 = 35, \eta = r_2 = 1.25, f_1 = f_2 = 0.75, fz_1 = fz_2 = 0.3$
Scenario 3	$\mu = 0.6, \varepsilon = 0.85, \theta_1 = 0.7, \theta_2 = 0.5, \theta_3 = 0.6, \theta_4 = 0.3, \theta_5 = 0.5, \theta_6 = 0.2, L_1 = 150, L_2 = 105, H_1 = 50, H_2 = 35, \eta = r_2 = 1, f_1 = f_2 = 1, fz_1 = fz_2 = 0.3$
Scenario 4	$\mu = 0.6, \rho = 0.75, \varepsilon = 0.85, \theta_1 = 0.7, \theta_2 = 0.5, \theta_3 = 0.6, \theta_4 = 0.3, \theta_5 = 0.5, \theta_6 = 0.2, L_1 = 150, L_2 = 105, H_1 = 50, H_2 = 35, fz_1 = fz_2 = 0.3$
Scenario 5	$\mu = 0.6, \varepsilon = 0.85, \theta_1 = 0.7, \theta_2 = 0.5, \theta_3 = 0.6, \theta_4 = 0.3, L_1 = 150, L_2 = 105, H_1 = 50, H_2 = 35, \eta = r_2 = 1, f_1 = f_2 = 1, fz_1 = fz_2 = 0.3$ $ig=0.2: \theta_5 = 0.55; \theta_6 = 0.25, ig=0.3: \theta_5 = 0.5; \theta_6 = 0.2$ $ig=0.4: \theta_5 = 0.4; \theta_6 = 0.2$
Scenario 6	$\mu = 0.6, \rho = 0.75, \theta_1 = 0.7, \theta_2 = 0.5, \theta_3 = 0.6, \theta_4 = 0.3, \theta_5 = 0.5, \theta_6 = 0.2, L_1 = 150, L_2 = 105, H_1 = 50, H_2 = 35, \eta = r_2 = 1, f_1 = f_2 = 1, fz_1 = fz_2 = 0.3$

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