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Trade and the Internationalization of Production

by

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Trade and the Internationalization of Production*

Abstract

Whereas many empirical studies show that the internationalization of production is driven by falling distance costs, theoretical models of the endogenous emergence of multinational enterprises predict the opposite. This paper argues that this dichotomy can be resolved if the production process is modeled more realistically by taking the use of intermediate goods into account. The argument is based on a two-country general equilibrium model set up to study companies' internationalization strategies. Companies use specific intermediate goods in their production and can choose between exports and foreign production. In choosing between these alternatives, they face a trade-off between higher variable distance costs when exporting and additional fixed costs when producing abroad. With falling distance costs, exports increase. Furthermore, the profitability of foreign production increases relative to the profitability of exports if the share of intermediate goods used is not too small. With falling distance costs, it might therefore pay for a company to become a multinational enterprise.

Keywords: Trade, Multinational Enterprise, General Equilibrium

JEL-Classification: F12, F23, L22

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1. Introduction

Globalization is believed to be driven by falling distance costs. Large scale liberalization and deregulation all over the world, drastically declining communication costs, low and further falling barriers to trade in goods and in services, and falling transport costs have impelled a drastic increase of trade, foreign direct investment (FDI) and transfers of knowledge and know-how (Frankel 2000). The main actors in this process are multinational enterprises (MNEs), which account for a bulk of the knowledge transfer (of which 80% is intra-firm) and by definition for all FDI. About 80% of world trade is related to MNEs, a third takes place within MNEs (UNCTAD 1997). The internationalization of production gained importance. Output of foreign affiliates of MNEs overtook exports in the late nineteen seventies and stays twice as high today (UNCTAD 2000).

Economic theory has made great progress in explaining the regional pattern of trade and foreign production (Markusen and Venables 1998) but did not so much focus on their development over time. However, for an understanding of the progress of globalization, an analytical framework, which deals with trade and internationalization of production and accounts for the role of falling distance costs in globalization, might be helpful. Therefore, a general equilibrium model is put forward in this paper to analyze the endogenous emergences of MNEs. Changing incentives of companies to internationalize production are induced by exogenously changing conditions of competition which are due to falling distance costs. In the initial (pre-globalization) situation, distance costs are assumed to be high. Distance costs can be thought of as border effects (McCallum 1995). They separate the two markets in this two-country model but do not apply to domestic transactions. This border effects have fallen over the last two decades (Nitsch 1998). By assumption, distance costs do only occur in the imperfect competitive manufacturing sector but not in the perfect competitive agricultural sector.

The model stands in the tradition of Brainard (1993). A perfect competitive agricultural sector producing a homogenous good and an imperfect competitive manufacturing sector are modeled. In the manufacturing sector, there are two types of companies: final goods producers and intermediate goods producers. Both groups produce a bundle of differentiated goods, which consists of many varieties. The manufacturing sector is characterized by monopolistic competition among the many producers within their group. It is profitable to produce a single variety of the bundle of differentiated goods in a single company because companies in the manufacturing sector use fixed input factors in production which leads to decreasing average costs. The final goods producers in the manufacturing sector produce in a multi-stage process, which include fixed inputs at the corporate level (R&D, marketing, financing) and at the plant level (equipment). They choose between exports and production abroad to serve the foreign market. Exporting saves on additional fixed costs at the plant level, while production abroad saves on distance costs. All goods in both economies are produced by using labor, the only production factor.

The model goes beyond Brainard (1993) in modeling the usage of intermediate goods in the production process of the final good. Recent work (Feenstra 1998, Campa and Goldberg 1997) has called attention to the increasing use of imported intermediate goods in various developed economies and has related this to rising activities of MNEs (Hummels et al. 1998). Intermediate goods companies in the model presented here are assumed to produce in a single stage using fixed input factors like plant equipment. Intermediate goods are considered to be specific either to the final good or to the production process, or to both. Final goods producers use, therefore, intermediate goods exclusively from their home country, even if they produce abroad. Intermediate good producers and final good producers of the same country compose a network. That is, of course, not true for all intermediates but might be an important aspect in the internationalization of production as empirical studies on an aggregated level (METI 2001) and on micro level (Head and Ries 2001) show. The non-specific intermediate goods could be modeled as an additional production factor similar to labor, which is taken from the host country. For simplicity, non-specific intermediate goods are excluded. Table 1 gives a short summary of the model structure.

Table 1: Model Structure

	Agricultural Good	Intermediate Goods	Final Manufacturing Good
Product characteristic	homogeneous	differentiated	differentiated
Competition	perfect competition	monopolistic competition	monopolistic competition
Input factors	labor	labor	labor, intermediate goods
Production stages	one stage	one stage fixed costs at plant level	headquarter service and production stage using fixed costs at plant level
Foreign market service	trade without distance costs incurring	exports to foreign affil. of home-based MNE, incurring distance costs	exports with incurring distance costs or foreign production
Number of companies	high	endogenous	endogenous

The specific modeling of the production process with intermediate goods alters the results regarding the effect of changing distance cost in this model in comparison to other models of endogenous emergences of MNEs (Brainard 1993, Markusen and Venables 1998). Whereas in models without intermediate goods falling distance costs always reduce the profitability of foreign production relative to exports, this is not true in the model proposed here. Because intermediate good used in the foreign affiliate incur distance costs too, prices and quantities of foreign affiliate's goods are affected by falling distance costs as well. Although the one-unit profit increase induced by a distance costs reduction is larger for exports than for affiliate's goods, the total effect of distance costs reductions on relative profits of foreign production and exports is ambiguous a priori, because export markets are smaller than foreign affiliates' markets, and the larger per unit decrease of costs of exports applies to less sales. The analysis reveals that the change in relative profits depends on the level of distance costs. For high distance costs, exports and foreign production are low. Profits of the foreign affiliate would not be high enough to cover the additional fixed cost at the plant level. The company serves the foreign market through exports, because exports do not require fixed costs and are therefore also profitable with low sales. But a small reduction in distance costs increases profits of production abroad more than profits of exports. For intermediate distance cost levels, profits of foreign affiliates might be or might not be sufficient to cover the additional fixed costs at the plant level. Hence, MNEs may arise depending on industry characteristics (fixed costs levels, degree of product differentiation, share of intermediate goods in production). For small distance cost levels, savings of distance cost are not large enough to make up for the additional fixed cost at the plant level. Companies always prefer exports to production abroad.

In the following part, the two country two-sector one factor general equilibrium model is described. The two countries are assumed to be symmetric to make an analytic solution possible. This static model can be solved for given conditions. For any state of conditions there might be an equilibrium of national companies, of MNEs or of a mix of both kinds of companies. Part three introduces the trigger curve which is used to analyze whether a deviation from the equilibrium, by changing the mode of serving the foreign market, is profitable., The equilibrium assumed in part three is one of only national companies. This could be thought of as the situation prior to globalization. It is then checked how falling distance costs alter the incentives of a company to become a MNE (deviate from the pure national company equilibrium). The forth part concludes.

2. The Model

There are two symmetric countries, home H and foreign F, 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 output of the final goods in the manufacturing sector is Q_M. An individual final good producer's 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 produced by intermediate good companies also in the manufacturing sector. The aggregate output of the intermediate goods Z is used as input exclusively by the final goods producer headquartered in the same country. That does not assume non-tradable intermediates, since foreign affiliates of MNEs import them from the home country, but intermediates which cannot be used by foreign companies. An individual intermediate firm's output is denoted z_i. Because of the symmetry of the two countries, it is sufficient to describe the economy of the home country H. All definitions, conditions and derivations apply to the foreign country F in the same way.

It is assumed that every individual in H is endowed with one unit of labor, L. The individual is free to choose any job in his/her country. There is no cross-border mobility of labor. The labor market equilibrium gives wage level w_H in country H. Full employment is assumed.

2.1 Consumption

L_H inhabitants live in H. They have identical preferences. Their utility function is increasing in the agricultural product and the aggregate manufacturing product.

$$U_H = Q_{A,H}{}^{1-\mu} Q_{M,H}{}^{\mu} \qquad (1)$$

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

$$Q_{M,H} = \left[\sum_{i=1}^{\lambda} q_{i,H}{}^{\rho} \right]^{1/\rho} \qquad \rho \in (0,1), \qquad (2)$$

where ρ defines the degree of differentiation among 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 becomes easier for consumers to substitute one good for the other. Therefore, companies' market power decreases. Equation (2) implies that consumers love variety. If they are indifferent between 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 $\sigma=1/(1-\rho)$, between any two varieties of the final goods in the manufacturing sector.

Individuals maximize their utility (1) subject to budget constraints

$$Y_H = P_{A,H} Q_{A,H} + \sum_{i=1}^{\lambda} q_{i,H} p_{i,H} \tag{3}$$

to obtain the optimum quantities of agricultural and manufacturing goods

$$Q_{A,H} = (1-\mu) Y_H / P_{A,H}\,, \tag{4}$$

$$Q_{M,H} = \mu Y_H / P_{M,H}\,. \tag{5}$$

$P_{A,H}$ is the price of agricultural goods, $P_{M,H}$ is the price index of the varieties of manufacturing goods. The price index, $P_{M,H}$, depends on the price, $p_{i,H}$, of each individual product.

Since agriculture is the perfectly competitive sector of the economy and since the agricultural good can be traded without incurring costs, the price of the agricultural product will be the same in the two economies and will be set equal to one ($p_A=1$). The agricultural good Q_A will, therefore, be used as a numeraire throughout the paper.

2.2 Production

2.2.1 The Agricultural Good Producer

The agricultural good is assumed to be produced under constant returns to scale. Since agriculture is a perfectly competitive sector, the wage, w_H, is paid according to the marginal products of the production factor labor.

$$\frac{\partial Q_{A,H}}{\partial L_{A,H}} = w_H \tag{6}$$

Perfect mobility of workers across sectors assures that the wage is identical in every sector of the economy.

Production costs in agriculture are given by

$$C_{A,H} = w_H Q_{A,H} . \tag{7}$$

2.2.2 The Manufacturing Goods Producer

In the manufacturing sector, companies engage in monopolistic competition. Consumers view the differentiated products as imperfect substitutes for one another. 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 producer uses a bundle of intermediate goods as input in the final good's production. Since intermediate goods are often very specific to a production process or a final good, the production of this final good in a foreign market depends on the supply of intermediate goods from the home country. For the sake of simplicity, it is assumed that MNEs exclusively use intermediate goods produced in their home country, irrespective of whether production of the final good occurs in the home or in the foreign country.

Intermediate Goods Producers

Intermediate goods are not perfect substitutes for each other. The bundle of intermediate goods used by any final good producing company in the manufacturing sector contains all varieties of intermediate goods.

$$Z_H = \left[\sum_{i=1}^{s_H} z_i^{\varepsilon} \right]^{\frac{1}{\varepsilon}} \qquad \varepsilon \in (0,1) \qquad (8)$$

Aggregate output is also assumed to follow a CES function. The intermediates' degree of differentiation is given by ε. s_H is the number of intermediate goods produced in country *H*. The price index, Pz_H, for intermediate goods can be calculated from (8).

$$Pz_H = \left[s_H pz_{i,H}^{-\phi} \right]^{-\frac{1}{\phi}} \qquad (9)$$

with $\phi=\varepsilon/(1-\varepsilon)$. s_H is the number of varieties of intermediate goods in the bundle Z_H. $pz_{i,H}$ is the price of any of these varieties. Pz_H increases in the prices of a single variety of the intermediate $pz_{i,H}$ ($\delta Pz_H/\delta pz_{i,H}=Pz_H/pz_{i,H}>0$) and decreases in the number of varieties, s_H ($\delta Pz_H/\delta s_H=-Pz_H/\phi s_H<0$).

The costs of production of an intermediate good variety are

$$C^Z_{i,H} = fz_H w_H + z_{i,H} w_H \,. \qquad (10)$$

The first term on the right hand side shows the fixed costs. fz_H is the amount of fixed input which is determined by the production technology. The second term describes the marginal costs cz_H $(=w_H)$ multiplied by the output $z_{i,H}$. 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.

Final goods producer of country H spent an amount of I_H on intermediate goods. From the composition of the aggregate intermediate good (8), the demand for any of the varieties can be derived (see appendix).

$$z_{i,H} = \frac{{pz_{i,H}}^{-(1+\phi)}}{{Pz_H}^{-\phi}} I_H \qquad (11)$$

In equilibrium, the demand for the intermediate good equals its production. Therefore, the output of an intermediate goods producer decreases in its own price, $pz_{i,H}$, and increases in the price index of intermediate goods, Pz_H, as well as in the amount spent on intermediate goods by the final goods producer, I_H.

Maximizing the profit function of an intermediate goods producer yields the optimal price for his intermediate good

$$pz_{i,H} = cz_H / \varepsilon \,. \tag{12}$$

The producers of intermediate goods set their prices equal to a fixed mark-up $1/\varepsilon$ over their marginal costs cz_H. These prices are identical among all intermediate goods, because their marginal costs are identical, as are their outputs z_H. Variable profits in the market for intermediate goods are proportional to sales. They add up to $(1-\varepsilon)I_H$. These variable profits, however, are (at least partly) necessary to cover the aggregated fixed costs $s_H f_H w_H$.

The number of companies producing the intermediate goods, s_H, in country H is determined by the zero-profit-condition.

$$\Pi_j^Z = (1-\varepsilon)pz_H z_H - fz_H w_H = 0\,. \tag{13}$$

Since there is free market entry and exit in both countries of this model, new companies enter profitable markets until profits fall to zero. New entrants influence the profit of existing firms by increasing competition: the price index ($\delta Pz_H/\delta s_H<0$) decreases as a result. Sales and profits of the incumbent companies fall, the average size of companies falls, and the sum of fixed costs used in the production of the intermediate good increases. In equilibrium, the zero-profit condition holds. The sum of the fixed costs must equal the sum of variable profits. The number of intermediate goods producers is therefore given by

$$s_H = \frac{(1-\varepsilon)I_H}{w_H f_H} \tag{14}$$

Equation (9) gives the price index of intermediate goods without distance costs. The price index of affiliates in the foreign country, Pz_H^M, however, must take distance costs $(\tau_M D)$ into account. Foreign affiliates of *H*-bases MNEs have to pay c.i.f. prices for the intermediate goods which include distance costs.

$$Pz_H^M = \left[s_H \left(pz_H e^{\tau_M D} \right)^{-\phi} \right]^{-\frac{1}{\phi}} \tag{15}$$

Distance costs are modeled in Samuelson's 'iceberg' form: a part of the value of every product must be paid for “transportation“. This fraction increases with the distance *D* between the two markets (*D* is set equal to one for the remainder of this paper). To buy one unit of an imported intermediate good, $e^{\tau_M} (> 1)$ units have to be paid by the producer of the final good in the foreign country, $\left(e^{\tau_M} - 1\right)$ units being distance costs. For very high distance costs τ_M the price index for intermediate goods used in the foreign country, Pz_H^M, goes to infinity, for very small distance costs to Pz_H.

Final Good Producer

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) MNE producing domestically and abroad. Given the symmetry of both countries in this model, exports of the multinational companies' affiliates to the home country cannot be profitable.

Final good producers manufacture their products in a multi-stage process. In the first stage, headquarter services are produced in each company. Headquarter services, like R&D or marketing, have the character of public goods within the company. In the second stage, production takes place at the plant level. Headquarter services and intermediates are used as inputs. The cost function of any national final good producer is given by

$$C_{i,H}^{N} = w_H r_H + w_H f_H + \left(\frac{w_H}{\theta}\right)^{\theta}\left(\frac{Pz_H}{1-\theta}\right)^{1-\theta} q_{i,H}^{N} \qquad \theta \in (0,1) \qquad (16)$$

The first term represents fixed costs at the company level, the second term the fixed costs at the plant level. Fixed costs increase in wages, w_H, and in r_H and f_H. r_H is the level of headquarter-services produced by the companies in the home country. f_H is the amount of fixed input necessary for the production of the final good. r_H and f_H are given by the production technology and, therefore, exogenous to the company.

Variable costs, the third term in equation (16), increase in the factor price of labor, w_H, at home, the price index of the intermediates, Pz_H, and the output level $q^N_{i,H}$. The marginal costs $(w_H/\theta)^\theta(Pz_H(1-\theta))^{1-\theta}$ are denoted by $c_H{}^N$.

A multinational company's production costs in its home-country, $C^M_{i,H,H}$, are

$$C^M_{i,H,H} = w_H r_H + w_H f_H + \left(\frac{w_H}{\theta}\right)^\theta \left(\frac{Pz_H}{1-\theta}\right)^{1-\theta} q^M_{i,H,H} \qquad \theta \in (0,1). \qquad (17)$$

Costs differ for MNEs from the costs of a national producer only in the third term, the variable costs. Factor prices and technologies used are the same, but MNEs produce at their home country plant only for the home market and not for export. The quantities produced by a H-based national and a multinational company in country H differ $\left(q^N_{i,H} \neq q^M_{i,H,H}\right)$. Marginal costs are the same ($c_H{}^N = c_H{}^M$), but variable costs differ because the quantities differ.

Different plants of a MNE have different variable costs in each country because of differences in the prices of the intermediates $\left(Pz^M_H \neq Pz_H\right)$ they use in both countries. In the foreign country affiliates pay c.i.f. prices. An affiliate's costs in the foreign country F, $C^M_{P,i,H,F}$, are

$$C^M_{P,i,H,F} = w_F f_F + \left(\frac{w_F}{\theta}\right)^\theta \left(\frac{Pz^M_H}{1-\theta}\right)^{1-\theta} q^M_{i,H,F} \qquad \theta \in (0,1). \qquad (18)$$

The costs of production in the foreign country do not include costs at the corporate level due to the public goods character of the headquarter service. Headquarter services are produced at home and are used on a non-rivalry basis in both plants, at home in *H* and in the foreign country *F*.

MNE's production costs abroad depend on the wage rate of labor, w_F, in *F,* the amount of fixed inputs used in production, f_F, the elasticity of production, θ, (technology used) and the costs of the intermediate goods, ${Pz_H}^M$, (including their distance costs from the home country). Production costs of the MNE in the affiliate abroad increase in distance costs, because the price index of intermediate goods increases in distance costs. For very high distance costs, MNE's production costs in the foreign country approach infinity.

The output, $q^k_{i,H}$, ($k=N, M$) differs between domestic suppliers and MNEs in the same country, as well as between the MNE's home country plant and the affiliate in the foreign country. In equilibrium, companies produce the amount of goods they can sell at an optimal price. Given the utility function (1) and the composition of the aggregated manufacturing good (2), equation (19) gives the demand for a single product ${q_{i,H}}^N$ of a national firm, which serves the foreign country through exports.

$$q_{i,H} = \frac{{p_{i,H}}^{-(1+\gamma)}}{{P_{M,H}}^{-\gamma}}\mu Y_H + \frac{{p_{i,H}}^{-(1+\gamma)} e^{-(1+\gamma)\tau_M}}{{P_{M,F}}^{-\gamma}}\mu Y_F \qquad \gamma=\rho/(1-\rho) \qquad (19)$$

The optimal quantity of good i produced in H depends on: its price, $p_{i,H}$, the price-indices, $P_{M,H}$ and $P_{M,F}$, in both final goods markets, the size of the markets μY, and distance costs, τ_M. The lower the price of good i relative to the price index in both countries, the higher the optimal output of this good. High distance costs decrease the optimal output by increasing the good's price in the foreign market. Consumers in the importing country F must pay the distance costs and, therefore, react by partially substituting imported goods by goods produced in their country F. For very high distance costs, exports approach zero. Given the symmetry for both countries exported quantities equal home sold quantities for distance costs of zero.

A multinational company headquartered in H produces in both countries. It supplies goods which are produced in both countries. The optimal output from the domestic plant

$$q^M_{i,H,H} = \frac{{p^M_{i,H,H}}^{-(1+\gamma)}}{{P_{M,H}}^{-\gamma}} \mu Y_H \tag{20}$$

equals the demand in the home country, since re-export is excluded. The price of a good of a multinational company from country H in the foreign market F is lower than the price for an imported good, since consumers do not have to pay distance costs. The output is higher:

$$q_{i,H,F}^{M} = \frac{p_{i,H,F}^{M}{}^{-(1+\gamma)}}{P_{M,F}{}^{-\gamma}} \mu Y_F \qquad (21)$$

$q_{i,H,F}^{M}$ is the output in F of a MNE i with headquarters in H. It is positively related to the price index, $P_{M,F}$, and the market size μY_F in country F, and negatively related to its own price, $p_{i,H,F}^{M}$.

The quantity of the intermediate goods-bundle used by a single final goods producer can be calculated from the cost functions (16-18) by taking the partial derivatives with respect to the price index Pz_H (Shephards lemma).

$$qz_{i,H}^{N} = \frac{\partial C_{i,H}}{\partial Pz_H} = \left(\frac{w_H}{\theta}\right)^{\theta} \left(\frac{1-\theta}{Pz_H}\right)^{\theta} q_{i,H}^{N} \qquad (22)$$

$$\begin{aligned} qz_{i,H}^{M} &= \frac{\partial C_{i,H,H}^{M}}{\partial Pz_H} + \frac{\partial C_{P,i,H,F}^{M}}{\partial Pz_H^{M}} = qz_{i,H,H}^{M} + qz_{i,H,F}^{M} \\ &= \left(\frac{w_H}{\theta}\right)^{\theta} \left(\frac{1-\theta}{Pz_H}\right)^{\theta} q_{i,H,H}^{M} + \left(\frac{w_F}{\theta}\right)^{\theta} \left(\frac{1-\theta}{Pz_H^{M}}\right)^{\theta} q_{i,H,F}^{M} \end{aligned} \qquad (23)$$

In equilibrium, the aggregate demand for intermediate goods $\left(\sum_{i=1}^{m_H} qz_{i,H}^{M} + \sum_{i=1}^{n_H} qz_{i,H} \right)$ equals aggregate supply, Z_H. The amount spent on intermediate goods, I_H, equals their total costs $\left(\sum_{i=1}^{m_H} \left(pz_{i,H} e^{\tau_M} \right) qz_{i,H}^{M} + \sum_{i=1}^{n_H} pz_{i,H} qz_{i,H} \right)$.

The final goods producer sets his/her price to maximize profits. The solution to this maximization problem is a fixed mark-up factor over marginal costs $c_{PV,i,H}^{k}$.

$$p^k_{i,H} = c^k_H / \rho \qquad k=N, M \qquad (24)$$

The price of a single final good depends only on the good's marginal costs ${c_H}^k$ and ρ, the parameters of differentiation. Marginal costs can be obtained from variable costs (16–18). Since all companies use the same technology, the marginal costs differ only if the factor prices differ. But factor prices cannot differ ($p_{H,H}=p_{i,H,H}$) within one country, because of inter-sectoral mobility.

In each country *j*, there are four different potential suppliers of final manufacturing goods, (i) country *j*'s national firms producing for their home market, (ii) foreign national firms serving country *H* through exports, (iii) MNEs, with their headquarters in country *H* producing at their plant in *H*, and (iv) country *F*-based MNEs producing at their affiliate in country *F*.

F.o.b. prices (net of distance costs) set by companies located in *H* and *F* do not differ. By assumption the economies are symmetric. Thus, companies do not differ in their ability to use economies of scale. They operate at the same scale in their home market. However, prices set by national and multinational enterprises differ in their foreign market but not at home. There are, therefore, up to three different prices $p^k_{j,H}$ ($j=H, F$ and $k=N, M$) for different varieties of the manufacturing good in each market *H* depending on the mode the market is serviced: the price of goods produced by *H*-based firms (nationals and multinationals), the one of imported goods and that of goods produced by a *F*-headquartered multinational affiliate's plant in *H.* The price of a national firm's good in the foreign market $p^N_{H,F}$ equals the home-market price multiplied by distance costs $p^N_{H,F} = p^N_{H,H} e^{\tau_M}$.

From the utility functions (1) and (2), the price index, $P_{M,H}$, for each market *H* can be calculated:

$$P_{M,H} = \frac{\mu Y_H}{Q_{M,H}} = \left[\sum_{i=1}^{\lambda} p_i^{-\gamma} \right]^{-\frac{1}{\gamma}} . \qquad (25)$$

Using the different product prices of the different companies, equation (25) changes to

$$P_{M,H} = \frac{\mu Y_H}{Q_{M,H}} = \left[\sum_{i=1}^{n_H} \left(p^N_{H,H}\right)^{-\gamma} + \sum_{i=1}^{n_F} \left(p^N_{F,H}\right)^{-\gamma} + \sum_{i=1}^{m_H} \left(p^M_{H,H}\right)^{-\gamma} + \sum_{i=1}^{m_F} \left(p^M_{F,H}\right)^{-\gamma} \right]^{-\frac{1}{\gamma}} \qquad (26)$$

where n_H is the number of national companies located in *H*, n_F the number of nationals located in *F*, and m_H and m_F are the numbers of MNEs headquartered in *H* and *F*, respectively. n_H, n_F, m_H, and m_F, added together equal λ. The price index, $P_{M,H}$, increases in the prices of each kind of company and therefore in distance costs, since distance costs increase the prices of national, exporting companies and MNE's in the foreign markets.

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

$$\Pi_H^N = (1-\rho) p_H^N q_H^N - w_H (r_H + f_H) = 0 \qquad (27)$$

$$\Pi_H^M = (1-\rho)\left(p_{H,H}^M q_{H,H}^M + p_{H,F}^M q_{H,F}^M\right) - w_H (r_H + f_H) + w_F f_F = 0 \qquad (28)$$

The zero-profit-conditions (27) and (28) are sufficient to determine the number of national companies, n_H, and multinational companies, m_H, in country *H* in equilibrium. The number depends on the market share of the total market $\mu(Y_H+Y_F)$ the group holds, which is endogenous. For the special cases of only national companies or only MNEs in equilibrium and zero distance costs, the number of companies is given by

$$n_H = \frac{(1-\rho)\mu Y_H}{r_H w_H + f_H w_H} \qquad (29)$$

$$m_H = \frac{(1-\rho)\mu Y_H}{r_H w_H + f_H w_H + f_F w_F} \qquad (30)$$

It is easy to see, that the number of companies in that case in equilibrium with only national companies is larger than in a MNE equilibrium. For positive distance cost levels, from the gross variable profits, $(1-\rho)\mu Y_H$, of all companies in country *H* the sum of the distance costs of all has to be subtracted. As discussed above, this distance costs are larger for national (exporting) companies than for MNEs which's foreign affiliates only import a fraction, the intermediate goods.

2.3 Distance Costs and Factor Demand

Due to the iceberg-form of distance costs, a share t_H of final goods is lost in the case of export. tz_H represents the loss of intermediate goods due to distance costs.

$$t_H = \left(e^{\tau_M} - 1\right) \frac{\left(p_H e^{\tau_M}\right)^{-(1+\gamma)}}{P_{M,F}^{\ \ -\gamma}} \mu Y_F \tag{31}$$

$$tz_H = \left(e^{\tau_M} - 1\right) \frac{\left(pz_H e^{\tau_M}\right)^{-(1+\gamma)}}{Pz_H^{M^{-\gamma}}} m_H qz_{H,F}^M pz_H^M \tag{32}$$

Factor demand is derived by using Shepard's Lemma. The cost functions (7), (10), (16) through (18) and the distance costs equations (31) and (32) are differentiated with respect to factor prices.

2.4 Market Equilibrium

Full employment of all resources is assumed in both economies. For a given endowment of labor in H, L_H, the labor market condition is given by

$$\begin{aligned} L_H = L_{A,H} + n_H\left(r_H + f_H + L_H^N + L_{t,H}^N\right) + s_H\left(fz_H + z_H + L_{tz,H}\right) \\ + m_H\left(r_H + f_H + L_{H,H}^M\right) + m_F\left(f_H + L_{F,H}^M\right) \end{aligned} \tag{33}$$

with

$L_H{}^N=(\theta/(1-\theta))^{1-\theta}(Pz_H/w_H)^{1-\theta}q_H{}^N$, $L_{t,H}{}^N=(\theta/(1-\theta))^{1-\theta}(Pz_H/w_H)^{1-\theta}t_H$,

$L_{tz,H}=(\theta/(1-\theta))^{1-\theta}(Pz_H/w_H)^{1-\theta}\,tz_H$, $L_{H,H}{}^M=(\theta/(1-\theta))^{1-\theta}(Pz_H/w_H)^{1-\theta}q_{H,H}{}^M$, *and*

$L_{F,H}{}^M=(\theta/(1-\theta))^{1-\theta}(Pz_F{}^M/w_H)^{1-\theta}q_{F,H}{}^M$.

The labor market clears if the fix labor supply, L_H, in country *H* equals the sum of the labor demand of the agricultural sector, of all stages of production of *H*'s national and multinational companies, of the intermediate good producers in *H*, of the affiliates in *H* of MNE's headquartered in *F*, and of the transport of final and intermediate goods.

Wages are set in order 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 equals marginal costs:

$$P_{A,H} = c_{A,H} = w_H \qquad (34)$$

The income Y_H in each country is given by the sum of the incomes of all individuals:

$$Y_H = w_H L_H \qquad (35)$$

The demand functions (4) and (5), the income equation (35) and the budget constraint (3) ensure that goods markets clear. The factor market clearance is given by (33). The value of the marginal product of labor (6) determines wages in each economy.

The pricing rule (24) and the equations (19) to (21), (27) and (28) determine the output of the national and multinational companies and their number in each country. The number of intermediate goods producers and their production levels and prices are given by (13), (11) and (12).

The pricing rule (34) determines the agricultural goods output in each economy and, therefore, with demand equation (4), the level of inter-industry trade. The costless one-way trade of the homogenous good Ex_H^A leads to price equality of this good in both economies. Since symmetry between the two countries is assumed, there is only intra-industry trade; Ex_H^A is zero in any equilibrium. If the countries are symmetric, there is no trade in agricultural goods, since each country satisfies its own demand for theses goods.

There is always intra-industry trade of final manufacturing products, Ex_H^M, in this model, because final goods are not perfect substitutes for one another.

$$Ex_H^M = n_H p_{H,F}^N q_{H,F}^N \tag{36}$$

The final goods export sales Ex_H^M rise with the number of exporting companies, the price of the exported good and its quantity. $q_{H,F}{}^N = p_H{}^{-(1+\gamma)} e^{-(1+\gamma)\tau} / P_{M,F}{}^{-\gamma} \mu Y_F$, the exported quantity, falls with rising distance costs and rises with the price index in the foreign market, and the market size. If distance costs are almost prohibitive, exported quantities can be very small.

Trade in services depends on the existence of MNEs, since trade in services in this model is trade in headquarter services. It rises with the number of MNEs, the level of headquarter services, which is necessary for production, and with the quantities produced by the MNE abroad. It is assumed that the fixed costs for the production of the headquarter service is shared among the plants according to their sales. Hence, trade in services equals the share of the foreign affiliate:

$$Ex_H^S = m_H w_H r_H \frac{q_{H,F}^M}{q_{H,H}^M + q_{H,F}^M}. \qquad (37)$$

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

$$Ex_H^A + Ex_H^M + Ex_H^S = Ex_F^M + Ex_F^S \qquad (38)$$

Ex_H^A can be positive or negative, depending on whether H is an exporter or an importer of the agricultural good, for the symmetric case Ex_H^A equals zero. Ex^M must be positive for both economies except in the case of prohibitively high distance costs $(\tau_M \rightarrow \infty)$. Ex_H^S can be zero or positive for both countries depending on the existence of MNEs.

3. The Trade or Production Abroad Decision

All final goods producers can decide whether to serve the foreign market through exports or to become a MNE and produce abroad. If there are no restrictions to FDI, a company will invest in the foreign market if it is profitable to do so. Profitability of internationalization of production depends on technical parameters which enter the production function (fixed costs on plant and company level, f and r, the share on intermediate goods used in production, $1-\theta$), on the degree of differentiation, ρ, on the degree of competition, Γ, which is affected by the type of companies in equilibrium, and on the exogenously given distance cost levels, τ_M, which separate the two markets. In the following analysis, the effect of exogenously falling distance costs on the internationalization strategies of the companies is examined.

In the initial situation, it is assumed that all companies are national companies which serve the foreign market through exports. This is assumed to determine the price index. An investment decision condition helps to determine whether this equilibrium is stable. If, at given competitive structure, foreign production is not profitable relative to exports, an equilibrium with national companies is stable. However for changing conditions of competition due to exogenously falling distance costs, it must be analyzed at every distance cost level whether deviating from the equilibrium with national company only by internationalizing production is a profitable strategy for any company. If one company deviates, the price index changes, and the competitive structure changes. The trigger curves used below apply only until the first company decides to establish an affiliate abroad.

The price of a good in the foreign market drops when the exporting company becomes a MNE, since consumers in the foreign market do not have to pay distance costs on the final good anymore. There are only distance costs on the intermediate goods, which increase the price of a foreign affiliate final good, relative to foreign companies (in their home market), because of more expensive intermediate inputs, but this increase is smaller than an exporting companies' price increase due to distance costs. The quantity of the final good, which is sold in the foreign market, rises with the establishment of an affiliate in the foreign country, and so do variable profits. A national final goods producer decides to produce abroad if the gains in variable profits are at least as high as the additional fixed costs at the plant level.

$$w_F f_F \leq (1-\rho)\left(p_{H,H}^M q_{H,H}^M + p_{H,F}^M q_{H,F}^M - p_H^N q_H^N\right) \qquad (39)$$

Since condition (39) is essential for the resulting equilibrium. The effect of distance cost changes on relative profits of production abroad and exports clarifies the mechanisms which drives this model of globalization. Assuming symmetry is essential in order to continue with an analytical solution, because price indices are the same in both countries and companies are therefore identical. For this special case the effect of distance cost changes on the investment decision can be analyzed without recourse to numerical simulations.

First, however, it is easy to see, that the lower the fixed costs at the plant level $w_F f_F$ are, the more likely is it that a national company will decide to build a plant abroad. Next, the internationalization decision depends only on the profits earned in the foreign market since prices, quantities and mark ups, and therefore profits, of national and multinational companies at home are the same. But foreign profits differ. Rewriting (39) yields

$$\Phi = \left(p^M - c^M\right)D\left(p^M\right) - \left(p^N - c^N\right)D\left(p^N e^{\tau_M}\right) - w_F f_F \text{ or}$$

$$\Phi = \left[\frac{1-\rho}{\rho}c^M \frac{\left(c^M/\rho\right)^{-\frac{1}{1-\rho}}}{\Gamma} - \frac{1-\rho}{\rho}c^N \frac{\left(c^N e^{\tau_M}/\rho\right)^{-\frac{1}{1-\rho}}}{\Gamma}\right]\mu Y_F - w_F f_F \qquad (40)$$

where $\Gamma = n\left(c^N/\rho\right)^{-\frac{\rho}{1-\rho}} + n\left(e^{\tau_M} c^N/\rho\right)^{-\frac{\rho}{1-\rho}}$.

For convenience, p^M and c^M stands for $p_{H,F}{}^M$ $c_{H,F}{}^M$ and p^N and c^N for $p_{H,F}{}^N$ and $c_{H,F}{}^N$, respectively. Companies refrain from establishment of a foreign affiliate if distance costs are very high, since the term in brackets becomes very small although it remains positive, because $c^M > c^N$ and (c^M/ρ)^$(-1/(1-\rho)) > (c^N e^\tau/\rho)$^$(-1/(1-\rho))$ for any $\tau_M > 0$. Demand for home country's goods in the foreign market is too small to generate enough variable profits to make up for the additional fixed costs at the plant level, $w_F f_F$. For very low distance costs foreign production is not a profitable alternative either, since the term in brackets approaches zero. *Φ* is negative. Equation (41) shows the derivative of *Φ* with respect to distance costs, τ_M.

$$\frac{\partial\Phi}{\partial\tau_M}=\frac{c^M\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-(1-\theta)\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]}{\Gamma^2}\mu Y$$
$$\underbrace{-\frac{c^N\left(\frac{c^N e^{\tau_M}}{\rho}\right)^{-\frac{1}{1-\rho}} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-\frac{1}{\rho}\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]}{\Gamma^2}\mu Y}_{>0} \quad (41)$$

The first line of (41) give the effect of changes in distance costs on the (variable) profits of production in the foreign country, the second line of the effect on exports. For convenience, the first line is denoted Φ_M' (for multinational production), the second Φ_N' (for national production). Φ_M' is negative for not too low distance costs levels, τ_M, and a share of intermediate goods $1-\theta$ which is not too low. Then, falling distance costs allow for larger profits through foreign production. For very high distance costs the term in brackets approaches $-(1-\theta)$. For a production function which does not require intermediate goods $(1-\theta=0)$, the first line turns positive. Rising distance costs would then be related to higher profits.

The second line of (41) is always positive, since the minus sign in front of the term changes the negative sign of Φ_N'. The term in brackets is always negative, because ρ is defined as $0<\rho<1$. Hence, exports increase with falling distance costs for all distance costs levels. The total effect is determined by the difference of the two effects (Φ_M'- Φ_N'). For most parameter constellation (distance cost levels not too low, intermediate good share not too low) they have the same sign. Hence the sign of the difference depends on the size of the two effects. For very low distance cost levels and intermediate goods shares, however, the total effect must be positive. Φ increases with rising distance costs and decreases with falling. For an intermediate goods share of zero, this applies for all distance cost levels. The model converges to the Brainard (1993) model.

For intermediate goods shares which are higher than zero, the size of both is not easily compared since it depends on various exogenous parameters in a non-linear manner. The absolute size of the terms in brackets is always larger in the second line, since $1-\theta<1/\rho$. This term expresses the effect of distance cost changes on the variable profits of one unit of the final good. These changes are always higher for exported goods because distance costs raise the price for exports more than for goods produced abroad. Foreign affiliate products are only partly, through the imported intermediate goods, affected by distance costs.

For any $\tau_M>0$ holds that $c^M>c^N$ and (c^M/ρ)^$(-1/(1-\rho))>$ $(c^N e^\tau/\rho)$^$(-1/(1-\rho))$. Higher marginal costs of c^M relative to c^N increase the variable profits of production abroad relative to exports, because higher costs translate into higher unit variable profits with a constant and equal-size mark-up ρ. Furthermore demand for goods produced in affiliates of foreign MNEs is larger than for imported final goods, because the c.i.f. prices are lower, as can be seen from (c^M/ρ)^$(-1/(1-\rho))> (c^N e^\tau/\rho)$^$(-1/(1-\rho))$. These terms give the own-price effects on demand. With the price index being equal in both cases, the own-price effect is sufficient for comparison of demand. Demand is always higher for affiliates goods. With falling distance costs, higher increases in one-unit variable profits of exports than for goods produced abroad apply to lower sales in the foreign market. The total effect is parameter-dependent, and especially dependent on the distance cost level, τ_M.

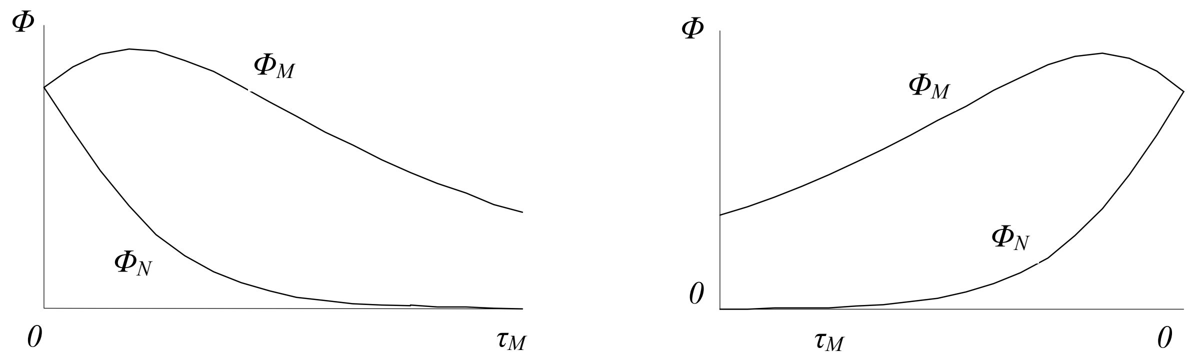
The second derivatives help to determine the curvature of Φ_M' and Φ_N' and therefore of Φ' and Φ. The second derivative of the variable profits of affiliates products with respect to distance costs, Φ_M'', is negative for low distance cost levels and positive for high distance costs. The second derivative of variable export profits with respect to distance costs, Φ_N'', is always positive (see Appendix for derivation). Hence, the negative slope becomes steeper for foreign production and less steep for exports with rising distance costs. Table 2 summarizes the derivative for both functions.

Figure 1 sketches the curvature of the two effects. On the left, the functions are shown in a graph with increasing distance costs (τ_M increasing from zero to higher values). The graph on the right hand side gives the same functions on a x-axis which shows τ_M decreasing from higher values to zero.

Table 2: Level and Curvature of the Profitability Functions

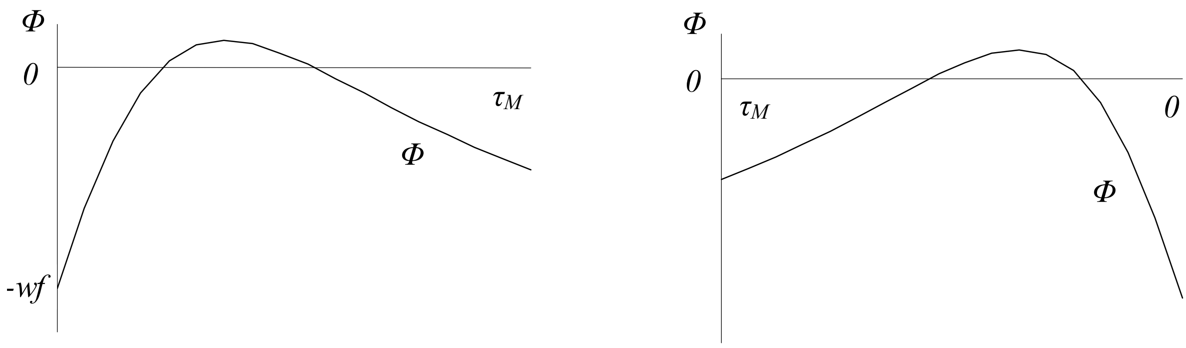
Distance cost level	Foreign Production Φ_M (net of fixed costs)	Exports Φ_N	Total Φ (including fixed costs)
$\tau_M=0$	$\Phi_M=\Phi_N$, $\Phi_M'>0$, $\Phi_M''<0$	$\Phi_N=\Phi_M$, $\Phi_N'<0$, $\Phi_N''>0$	$\Phi=-w_F f_F$, $\Phi'>0$, $\Phi''<0$
$0<\tau_M<1-\theta/\theta > e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}$	Φ_M high, $\Phi_M'>0$, $\Phi_M''<0$	Φ_N medium $\Phi_N'<0$, $\Phi_N''>0$	$\Phi'>0$, $\Phi''<0$
$1-\theta/\theta > e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} < \tau_M<\tau_M^*$	Φ_M medium, $\Phi_M'<0$, $\Phi_M''>0$	Φ_N low $\Phi_N'<0$, $\Phi_N''>0$	
$\tau_M^*<\tau_M$	Φ_M low, $\Phi_M'<0$, $\Phi_M''>0$	Φ_N very low $\Phi_N'<0$, $\Phi_N''>0$	
$\tau_M\rightarrow\infty$	$\Phi_M\rightarrow 0$, positive $\Phi_M'<0$, $\Phi_M''>0$	$\Phi_N\rightarrow 0$, positive $\Phi_N'<0$, $\Phi_N''>0$	$\Phi\rightarrow -w_F f_F$

Figure 1: Variable profits of production abroad Φ_M and exports Φ_N for changing distance cost levels τ_M



The difference of both functions gives the total trigger curve Φ which is relevant for the decision of a company to internationalize production. Fixed costs as the intercept must be added. This trigger curve, Φ, which describes the profitability of production abroad relative to exports, is given in Figure 2. A trigger curve, Φ, exceeding zero indicates a higher profitability of production abroad, a Φ below a higher profitability of exports.

Figure 2: Relative profitability of production abroad and exports



The analysis reveales that the shape of the trigger curve, Φ, depends on four exogenous parameters. Easiest to see are the fixed costs at the plant level, *fw*, that mark the intercept on the y-axis in the left graph. At $\tau_M=0$ variable profits for exports and affiliate production are equal, only fixed costs determine the level of the trigger curve. Higher fixed costs at the plant level shift the trigger curve downwards. The share of intermediate goods, $1-\theta$, affects level and slope of Φ_M. The level of Φ_M decreases with rising $1-\theta$ for all $\tau_M>0$ if $1-\theta$ is not too small. With increasing $1-\theta$ the slope curvature of Φ is less pronounced. The maximum of Φ is reached at a lower distance cost level. The range of low distance costs shrinks for which the first derivative of Φ_M with respect to τ_M is positive. The influence of ρ is not easily described either. The degree of differentiation, ρ, shapes the trigger curve. For homogeneous goods ($\rho \rightarrow 1$) the trigger curve is a straight line parallel to the x-axis at minus fixed costs ($-wf$). With no product differentiation there is no room for MNEs. Exports in the foreign market would neither be possible with perfect price competition. The fourth exogenous parameter effecting Φ are the fixed costs at company level, r. It enters the decision via Γ. The degree of competition, represented by Γ, increases in the number of companies n in the equilibrium, which depend negatively on r (equation 29). Since Γ is negatively related to Φ, Φ increases in r. The trigger curve shifts up with increasing fixed costs at the company level.

The emergence of MNEs is parameter dependent. For a range of realistic parameter constellations, MNEs may emerge in a process of globalization which is characterized by falling distance costs. In this process companies rely on exports to serve the foreign market until the distance costs have fallen below a particular threshold. Then, internationalization of production is possible. However, parameters are industry or even company specific. This may explain the observed pattern of internationalization of production with strong concentration on some industries and some industries preceding others. The internationalization of production in the discussion above is brought about by falling distance costs only, but other factors, as falling minimum required size of a plant or increasing importance of headquarter services, might have been supportive, too.

4. Conclusions

A general equilibrium model of trade and production in foreign affiliates is set up and analyzed with regard to the effect falling distance costs. The model includes the use of intermediate goods in the production which are not easily substitutable. Foreign affiliates import these intermediate goods from their home country. This raises the price of the affiliate's product relative to the domestic producers because intermediate goods incur the same distance costs as final goods when exported. However, affiliates goods are cheaper than imported ones, their sales (net of distance costs) larger. It may therefore be profitable to save on the distance costs by changing the strategy of service of the foreign market, although this requires additional fixed cost at the plant level. An equilibrium with national companies or MNEs may emerge.

Assuming an equilibrium with only national companies in the initial situation, effects of exogenously falling distance costs on this equilibrium are analyzed. Stability of the market structure with national companies only is given as long no company has an incentive to change its mode of serving the foreign market from exports to production abroad. Since the incentive to internationalize production depends on the level of distance costs, stability of the equilibrium depends on the distance cost level. For high levels of distance costs the establishment of an affiliate is not profitable since its output is too small to generate variable profits large enough to make up for the additional fixed costs at the plant level. With falling distance costs, however, the profitability of foreign production first increases stronger than the profitability of exports, later less. The relative profitability, therefore, describes an inverted U-shape. At intermediate distance costs levels, the emergence of MNEs might be profitable. For low distance cost levels, export is always the preferred mode of serving the foreign market.

This analysis reveals that the observed pattern of increasing intra-industry trade preceding the internationalization of production in globalization can be explained in a trade model which allows for the endogenous emergence of MNEs. The consideration of specific intermediate goods in the production function is essential for deriving the results of the model. Empirical studies also indicate that an essential part is missed in explaining the emergence of MNEs if intermediate goods trade is abstained from. However, although the emergence of a MNE can be explained, no adjustment to a new equilibrium, which might be a pure MNE equilibrium or a mixed equilibrium of national and multinational companies, has been modeled yet. This is beyond the scope of this paper and had to be let to future research.

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Appendix

Profits of affiliates production net of fixed costs are given by

$$\phi_M = \frac{1-\rho}{\rho} c^M \frac{\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}}}{\Gamma} \mu Y = (1-\rho) \frac{\left(\frac{c^M}{\rho}\right)^{-\frac{\rho}{1-\rho}}}{\Gamma} \mu Y \tag{A1}$$

(A2) gives the first derivative of the profits with respect to distance costs.

$$\frac{\partial \phi_M}{\partial \tau_M} = \frac{(1-\rho)\left(-\frac{\rho}{1-\rho}\right)\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} \frac{1}{\rho}\frac{\partial c^M}{\partial \tau_M}\Gamma}{\Gamma^2} \mu Y$$

$$- \frac{\left(\frac{1-\rho}{\rho}\right) c^M \left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} \frac{\partial \Gamma}{\partial \tau_M}}{\Gamma^2} \mu Y$$

$$= \frac{-\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} \frac{\partial c^M}{\partial \tau_M}\Gamma - \left(\frac{1-\rho}{\rho}\right) c^M \left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} \frac{\partial \Gamma}{\partial \tau_M}}{\Gamma^2} \mu Y \tag{A2}$$

The derivatives of affiliate's costs and of the price index with respect to distance costs are given in (A3) and (A4).

$$\frac{\partial c^M}{\partial \tau_M} = \frac{\partial \left[\left(\frac{w_n}{\theta}\right)^{\theta} \left(\frac{P z_j^M}{1-\theta}\right)^{1-\theta}\right]}{\partial \tau_M}$$

$$= \left(\frac{w_n}{\theta}\right)^{\theta} (1-\theta) \left(\frac{P z_j^{\ M}}{1-\theta}\right)^{-\theta} \frac{1}{1-\theta} \left(-\frac{1}{\phi}\right) \left[s_j \left(p z_j e^{\tau_M}\right)^{-\phi}\right]^{-\frac{1}{\phi}-1}$$

$$(-\phi) s_j \left(p z_j e^{\tau_M}\right)^{-(\phi+1)} p z_j e^{\tau_M}$$

$$= \left(\frac{w_n}{\theta}\right)^{\theta}\left(\frac{Pz_j^M}{1-\theta}\right)^{-\theta} Pz_j^M$$
$$= (1-\theta)c^M \tag{A3}$$

$$\frac{\partial\Gamma}{\partial\tau_M} = -\frac{\rho}{1-\rho} n\left(\frac{c^N e^{\tau_M}}{\rho}\right)^{-\frac{\rho}{1-\rho}} = -\frac{\rho}{1-\rho} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} e^{\tau_n\left(-\frac{\rho}{1-\rho}\right)} \tag{A4}$$

(A3) and (A4) plugged into (A2), yields

$$\frac{\partial\phi_M}{\partial\tau_M} = \frac{-\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}}(1-\theta)c^M n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left(1+e^{\tau_M}\right)}{\Gamma^2}\mu Y$$
$$-\frac{\frac{1-\rho}{\rho}c^M\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}}\left(-\frac{\rho}{1-\rho}\right)n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}}{\Gamma^2}\mu Y$$

$$= \frac{c^M\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - (1-\theta)\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]}{\Gamma^2}\mu Y \tag{A5}$$

Profits of exports are given by

$$\Phi_N = \frac{1-\rho}{\rho}c^N \frac{\left(\frac{c^N}{\rho}e^{\tau_M}\right)^{-\frac{1}{1-\rho}}}{\Gamma}\mu Y \tag{A6}$$

the first derivative with respect to distance costs τ_M by

$$\frac{\partial \Phi_N}{\partial \tau_n} = \frac{\frac{1-\rho}{\rho} c^N \left(-\frac{1}{1-\rho}\right)\left(\frac{c^N}{\rho} e^{\tau_M}\right)^{-\frac{1}{1-\rho}} n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right]}{\Gamma^2} \mu Y \qquad \text{(A7)}$$
$$- \frac{-\frac{1-\rho}{\rho} c^N \left(\frac{c^N}{\rho} e^{\tau_M}\right)^{-\frac{1}{1-\rho}} n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left(-\frac{\rho}{1-\rho}\right) e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}}{\Gamma^2} \mu Y$$

$$= \frac{c^N \left(\frac{c^N}{\rho} e^{\tau_M}\right)^{-\frac{1}{1-\rho}} n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - \frac{1}{\rho}\left(1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]}{\Gamma^2} \mu Y \qquad \text{(A8)}$$

Second derivatives

$$\frac{\partial \phi'_M}{\partial \tau_M} = \frac{-\frac{\rho}{1-\rho}\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} (1-\theta) c^M n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - (1-\theta)\left(1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]\Gamma^2}{\Gamma^4} \mu Y$$
$$+ \frac{\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} c^M n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[-\frac{\rho}{1-\rho} e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - (1-\theta)\left(-\frac{\rho}{1-\rho}\right) e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right]}{\Gamma^4} \mu Y$$
$$- \frac{\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} c^M n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - (1-\theta)\left(1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right] 2\Gamma}{\Gamma^4} \mu Y$$

$$\frac{\partial \phi'_M}{\partial \tau_M} = -\frac{\frac{\rho}{1-\rho}\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} c^M n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - (1-\theta)^2 \left(1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]\Gamma^2}{\Gamma^4}\mu Y$$

$$-\frac{\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} c^M n \left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}} \left[\theta e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} - (1-\theta)\right] 2\Gamma}{\Gamma^4}\mu Y$$

(A9)

The second derivative is negative for low τ_M and positive for high τ_M. Both terms are negative at low distance costs τ_M. The second term changes sign to positive at lower τ_M than the first term as can be seen by a comparison of (A10) and (A11). "High" and "low" depend on the share of intermediate goods *(1-θ)* and on the price index *Γ*. The profits of foreign production increase at falling rates up to a certain point and decrease thereafter first at an increasing then at an decreasing rate with distance costs τ_M. That implies, that the function must change sign from positive to negative at lower distance costs then its slope changes sign from negative to positive. From (A5) the point at which $\partial\Phi_M/\partial\tau_M=0$ can be calculated. That is at

$$e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} = (1-\theta)\left(1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right) \Leftrightarrow (1-\theta) = \theta e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}. \qquad \text{(A10)}$$

At this point the second derivate is negative, what can be seen using (A9). The second term is zero at this point. Hence, the sign of the first is decisive. The first term equals zero at

$$e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} = (1-\theta)^2\left(1 + e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right) \Leftrightarrow (1-\theta)^2 = \left(2\theta - \theta^2\right) e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)} \qquad \text{(A11)}$$

what requires higher distance costs τ_M. At lower distance costs the term in brackets is positive, the whole term negative. Since the slope of Φ_M is change signs at lower distance costs, at the point where the first derivative is zero the second is negative. The function changes from being concave to being convex at

$$\frac{-\frac{\rho}{1-\rho}\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} c^M n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-(1-\theta)^2\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]\Gamma^2}{\Gamma^4}\mu Y$$

$$=\frac{\left(\frac{c^M}{\rho}\right)^{-\frac{1}{1-\rho}} c^M n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[\theta e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-(1-\theta)\right]2\Gamma}{\Gamma^4}\mu Y$$

$$\Leftrightarrow$$

$$-\frac{\rho}{1-\rho}\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\left[(1-\theta)^2-\left(2\theta-\theta^2\right)e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right]$$

$$=2\left[\theta e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-(1-\theta)\right]$$

The two differences in brackets must have different signs. (A10) and (A11) showed, that the term on the right hand side turns positive first. Hence, the turning point lies in the interval with borders describes by (A10) and (A11), let $\tau_M{}^*$ denotes the distance costs with equalize the condition above.

(A12) gives the second derivative of export profits with respect to distance costs τ_M.

$$\frac{\partial\Phi'_N}{\partial\tau_n}=\frac{-\frac{1}{1-\rho}c^N\left(\frac{c^N}{\rho}e^{\tau_M}\right)^{-\frac{1}{1-\rho}} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-\frac{1}{\rho}\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]\Gamma^2}{\Gamma^4}\mu Y$$

$$+\frac{c^N\left(\frac{c^N}{\rho}e^{\tau_M}\right)^{-\frac{1}{1-\rho}} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[\left(-\frac{\rho}{1-\rho}\right)e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-\frac{1}{\rho}\left(-\frac{\rho}{1-\rho}\right)e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right]\Gamma^2}{\Gamma^2}\mu Y$$

$$-\frac{c^N\left(\frac{c^N}{\rho}e^{\tau_M}\right)^{-\frac{1}{1-\rho}} n\left(\frac{c^N}{\rho}\right)^{-\frac{\rho}{1-\rho}}\left[e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}-\frac{1}{\rho}\left(1+e^{\tau_M\left(-\frac{\rho}{1-\rho}\right)}\right)\right]2\Gamma}{\Gamma^4}\mu Y$$

$$\frac{\partial \Phi'_N}{\partial \tau_n} = \frac{-\frac{1}{1-\rho} c^N \left(\frac{c^N}{\rho} e^{\tau_M} \right)^{-\frac{1}{1-\rho}} n \left(\frac{c^N}{\rho} \right)^{-\frac{\rho}{1-\rho}} \left[e^{\tau_M \left(-\frac{\rho}{1-\rho} \right)} \left(\rho - \frac{1}{\rho} \right) - \frac{1}{\rho} \right] \Gamma^2}{\Gamma^4} \mu Y - \frac{c^N \left(\frac{c^N}{\rho} e^{\tau_M} \right)^{-\frac{1}{1-\rho}} n \left(\frac{c^N}{\rho} \right)^{-\frac{\rho}{1-\rho}} \left[-\frac{1-\rho}{\rho} e^{\tau_M \left(-\frac{\rho}{1-\rho} \right)} - \frac{1}{\rho} \right] 2\Gamma}{\Gamma^4} \mu Y \tag{A12}$$

The second derivative of export profits with respect to distance costs τ_M is always positive. The negative slope becomes less and less steep.