

Walz, Uwe

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## Transport costs, intermediate goods, and localized growth

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**Wirtschaftswissenschaftliche Fakultät  
der Eberhard-Karls-Universität Tübingen**

**Transport costs, intermediate goods,  
and localized growth**

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### **Abstract\***

This paper constructs a dynamic two-regional general equilibrium model, in which the interregional production and trade patterns are endogenously determined. By embedding an endogenous growth mechanism in this approach, it becomes possible to show why and how localized growth with different regional growth rates may emerge without any locational limitations of technological spillovers and despite labor mobility. Geographical concentration of intermediate goods results from the interaction between transport costs and imperfect competition in the intermediate goods production process. Since growth stems from this sector, this also opens up the possibility of localized growth. Furthermore, the analysis sheds some light on the relation between the location of final goods and the geographical distribution of the intermediate inputs in the final goods.

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# 1 Introduction

In the recent past, issues related to regional specialization, concentration and development have become more and more important not least because of the increasing regional integration in various parts of the world. In contrast to nation states which are separated by a more or less pronounced immobility of factors of production (especially labor), between regions interregional migration flows as well as interregional trade can be observed.

These developments call for an analysis which is able to provide answers for decisive questions in this context. These questions include, among others: why are industrial activities more concentrated in one area than in the other? Is it possible that regions grow with different rates despite a rather high degree of factor mobility?<sup>1</sup> International trade theory is only to a limited extent capable to deal with issues of interregional specialization and trade since it abstracts most of the time from two essential inputs in an analysis of regional specialization and development: transport costs and factor mobility. The two other branches which are concerned with locational decisions of firms and industries, namely regional economics [cf. e.g. *Greenhut et al.* (1987)] and industrial organization [cf. e.g. *Tirole* (1988, chapter 7)] are mainly of static nature and restricted to partial equilibrium analysis.

The present paper follows a line of research proposed by *Paul Krugman* (1991a, b). He suggested the extension of the idea of increasing returns and imperfect competition in a general equilibrium framework - as it is pursued in the "new" trade and growth theory - towards regional phenomena. In the following approach a dynamic general equilibrium model for two regions will be constructed, in which the interregional production and specialization patterns are endogenously determined. Geographical concentration does not arise as a result of geographically limited pure externalities (agglomeration economies [cf. *Myrdal* (1957)]) but rather stems from the interaction of transport costs and increasing returns to scale at the firm level. Thereby, the paper also sheds light on some developments which can be expected if regional integration proceeds further.

The analysis differs in various aspects entirely from the work of *Krugman*. First of all, in this paper there is no nontraded good which keeps at least some production and demand for the mobile factor in every region. Here, the existence

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<sup>1</sup>See for a recent survey of the development of regions in the U.S.A. *Blanchard/Katz* (1992).

of an immobile factor leads to the incomplete geographical concentration of the final goods production process. Hence, indirectly, the immobile factor hinders the mobile factor from leaving the region entirely. Furthermore, an intermediate goods sector is introduced, creating a backward linkage [*Hirschman* (1958)] between the final goods and a number of intermediate goods, which are used in the final goods process. The intermediate goods are costly to trade interregional. This notion follows *Marshall's* suggestion that the availability of specialized inputs and services are responsible for locational concentration processes of industrial activity. However, by assuming that transport costs arise in the trade of intermediate goods, rather than using the concept of a nontraded good, a less extreme form of geographical availability is chosen. The existence of increasing returns to scale in the intermediate goods sector takes the argument of *Kaldor* (1970) into account that increasing returns to scale must be included in any explanation of polarisation phenomena.

Since the increasing returns are internal to the firm rather than to the industry as a whole, perfect competition is not suitable anymore and a concept of imperfect competition has to be used. The interaction of transport cost and increasing returns in the intermediate goods sector provides in the present model the basis for the possibility of industrial concentration despite perfect labor mobility.

Furthermore, an endogenous growth mechanism is added to the regional approach. This mechanism, borrowed from *Romer* (1990) and *Grossman/Helpman* (1990, 1991a) models endogenous technological change as a consequence of permanent product innovations. Technological spill-overs on an interregional scale are responsible for the accumulation of knowledge and allows for constant returns to R&D investments. Hence, these knowledge spill-overs are at the core of the ongoing growth process but do not contribute anything to the geographical concentration process.

In contrast to the "old" regional growth theory [cf. *Siebert* (1969), *Richardson* (1973), and *Faini* (1984)] growth does not peter out in the long-run and interregional differences in the rate of technological change are not exogenously imposed but rather a possible result of the interregional specialization patterns.

Taken together, this provides for a model in which knowledge spill-overs create endogenous growth and the possible geographical concentration of industrial activity in the intermediate goods sector arise from the interaction of increasing returns, imperfect competition and transport costs, which makes it more costly

to spread demand in space. Thereby, it is possible to show that a certain core-periphery pattern may emerge despite perfect labor mobility, but that under a certain different parameter constellation, a stable, inner solution exists, in which intermediate goods are developed in both regions. In this context, an interesting interrelation between the locational decisions of intermediate and final goods producer is developed. Furthermore, it can be revealed that the possibility of locational growth with different steady-state growth rates between the two regions exists.

The paper is structured as follows. In the next section, the basic model will be derived. The third section describes the long-run equilibria and the adjustment process. In the last section a brief summary is given.

## 2 The model

The economy consists of two regions, A and B. They can be regarded as points in space between which transport of intermediate goods is costly. The delivery of intermediate goods in each region is costless. Each region is endowed with a given stock of an immobile factor  $M^i$  ( $i = A, B$ ). This immobile factor shall stand here for land, but might also be considered as immobile labor. The second factor of production is mobile labor. There is no population growth, i.e. the total stock of labor,  $\bar{L}$ , is given. Since workers are perfectly mobile (no migration costs), they migrate towards the region where they get the highest real wage.

The only final good  $Y$  is produced by means of  $M$ ,  $L$  and a set of intermediate products. Employing the production technology, proposed by *Ethier* (1982), the production function of  $Y$  can be written as:<sup>2</sup>

$$Y^i = (M^i)^\alpha (L_Y^i)^\beta \left[ \int_0^n x^i(j)^\sigma \right]^{\frac{1-\beta-\alpha}{\sigma}}, \quad (1)$$

where  $n$  delineates the number of known intermediate goods and  $x^i(j)$  represents the amount of the  $j$ -th intermediate good which is used in the production of  $Y^i$ . With a constant number of intermediate goods (1) is linear-homogenous. However, with variable  $n$ , (1) exhibits increasing returns to scale. New intermediate products are developed through R&D investments. This process will be described

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<sup>2</sup>In the following, superscripts denote the respective region.

in more detail later on. Since the producer of  $Y$  take the number of intermediate goods as given, perfect competition prevails in the final goods sector.

Before addressing the production process in more depth, the consumers' decisions will be analyzed. All consumers economywide share the same intertemporal utility function at time  $t$ :

$$U_t = \int_t^\infty e^{-\rho(\Gamma-t)} \ln C_Y^i(\Gamma) d\Gamma, \quad (2)$$

with  $C_Y^i(\Gamma)$  representing the consumption level of the final good of the consumer in region  $i$  at time  $\Gamma$  and  $\rho$ , the subjective discount rate. Consumers maximize (2) subject to the intertemporal budget constraint:

$$\int_t^\infty e^{-[R(\Gamma)-R(t)]} p_Y^i(\Gamma) C_Y^i(\Gamma) d\Gamma \leq \int_t^\infty e^{-[R(\Gamma)-R(t)]} w^i(\Gamma) d\Gamma + V(t), \quad (3)$$

where  $p_Y^i(\Gamma)$  is the price of the final good in region  $i$  at time  $\Gamma$ ,  $w^i$  is the nominal wage rate in the respective region. The expression  $R(t) = \int_0^t r(a) da$  denotes the accumulated rate of interest at time  $t$  with  $r$  being the instantaneous rate of interest. Since capital is interregional mobile, the same rate of interest prevails in both regions. The identical share of consumers in the value of a typical interregional portfolios of mobile and immobile assets is expressed by  $V(\Gamma)$ .

The mobile assets are due to the abstentions of workers from consumption. Instead, these resources are used to finance the R&D investments in either region. Hence, the value of the mobile assets is equal to the discounted gross value of investment in R&D. The value of the immobile assets is equal to the discounted remuneration of the immobile factor of production. In order to get more pronounced results with regard to industrial concentration, it is assumed that every worker-consumer owns a typical portfolio of these assets. Consumption from these assets can take place in the region in which the worker actually resides and not where the immobile factor is located. This avoids the existence of "immobile demand", which is the underlying reason of industrial concentration in *Krugman* (1991a, b).

The restricted maximization problem of the consumer yield the dynamic optimal consumption path:

$$\frac{\dot{E}^i}{E^i} = r - \rho, \quad (4)$$



where  $E^i$  are the consumption expenditures in region  $i$ . Since all consumers are identical it is legitimate to interpret  $E^i$  and  $E = E^A + E^B$  as the aggregate consumption expenditures in each region and the economy as a whole. The static demand function is simply:

$$E^i = p_Y^i Y^i. \quad (5)$$

Final goods are traded interregionally without any transport costs. This, together with perfect competition in the  $Y$ -sector implies that prices of the final good are the same in both regions.

Let's turn now to the production process of the intermediate good and the development of new goods. Both, the intermediate good as well as the R&D sector use only the mobile factor  $L$ . Choosing units such that the input coefficient in the intermediate goods sector equals unity, the production function of each intermediate goods producer can be expressed by

$$x(j) = L_x(j). \quad (6)$$

The production of each version of intermediate products requires specific knowledge which is acquired through R&D investments. Monopolistic profits are never smaller than oligopolistic profits. Hence, it is never worthwhile to develop already existing product types. Only one producer for every product variety exists. Every intermediate goods producer in region  $i$  faces the following demand function for his product in each region  $j$ :

$$x^{i,j} = \frac{(\tilde{p}_x^{i,j})^{-\epsilon}}{\int_0^n (\tilde{p}_x^j)^{1-\epsilon}} \beta p_Y Y^i \quad \text{with } i, j = A, B. \quad (7)$$

The "consumer" prices of the intermediate good for the final goods producers are characterized by  $\tilde{p}_x$ , whereas  $p_x$  denotes the respective producer price<sup>3</sup>. The demand function in (6) has the constant elasticity of demand  $\epsilon = 1/(1 - \alpha) > 1$ . The function results from profit maximization of the final goods producer.<sup>4</sup> If production and consumption of intermediate goods take place in different regions, proportional transport costs arise. Choosing the iceberg type formulation [cf. *Helpman/Krugman* (1985)], it is assumed that the proportion  $g$  ( $0 < g < 1$ )

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<sup>3</sup>The superscript  $i$  represents the source region of the good, the index  $j$  the region where the good is used as an input.

<sup>4</sup>For a derivation see *Grossman/Helpman* (1991a, chapter 3).

of each unit of the respective intermediate good gets lost during transport and  $1 - g$  units arrive. This formulation implies that the resources for transport stem from the region of origin. Hence, producer and consumer prices are related in the following manner:

$$\tilde{p}_x^{i,j} = \begin{cases} p_x^i & \text{if } i = j \\ p_x^i/g & \text{if } i \neq j. \end{cases} \quad (8)$$

Taking this relation and (7) into account, the total demand function a producer in region  $i$  faces, can be written as:

$$x^i = (p_x^i)^{-\epsilon} \beta p_Y \left[ \frac{Y^j g^{-\epsilon}}{\int_0^n (\tilde{p}_x^j)^{1-\epsilon}} + \frac{Y^i}{\int_0^n (\tilde{p}_x^i)^{1-\epsilon}} \right]. \quad (9)$$

The intermediate goods producer maximize their profits

$$G^i = (p_x^i - c^i)x^i. \quad (10)$$

From the first order condition results, if markets are segmented as well as if the integrated market hypothesis [see *Horstman/Markusen* (1986)] is employed:

$$p_x^i = \frac{w^i}{\sigma}. \quad (11)$$

Equation (11) reveals that producer prices of each intermediate goods variety are the same, irrespective of the region of consumption. Consumer prices differ between the region by the transport cost ration  $g^{-1}$ .

The R&D sector which develops the production knowledge of the intermediate goods sector is at the center of the growth mechanism. Forward looking firms invest in R&D and are compensated by means of future profits. The formulation of the R&D sector and the endogenous growth mechanism is borrowed from *Grossman/Helpman* (1990, 1991) and *Romer* (1990). For matters of concreteness let R&D investments and production of intermediate products take place in the same firm. But nothing would be changed if the innovator would license the acquired production knowledge to another firm.

Suppose an entrepreneur in region  $i$  employs  $L_n^i$  units of labor for a certain time interval. This enables him to invent

$$\dot{n}^i = \frac{L_n^i}{a_n} W^i \quad (12)$$

new intermediate goods per unit of time<sup>5</sup>.  $W^i$  is the stock of knowledge in the respective region and represents the spill-overs of knowledge which stem from the innovation process. A decisive point in the present analysis is the assumption of international spill-overs ( $W^A = W^B = W$ ), i.e. ideas spread evenly in and between regions. In this way, knowledge spill-overs contribute to the permanent growth process but not to the geographical concentration of industrial activity.<sup>6</sup> In accord with the endogenous growth literature, constant returns to knowledge accumulation, i.e.  $W = n$ , is assumed.

Hence, the production in the R&D sector amount to  $c_n^i = a_n w^i / n$ . Entrepreneurs invest in R&D if and only if the value of the acquired knowledge (that is the discounted future profits)

$$v_t^i = \int_t^\infty e^{-[R(\Gamma) - R(t)]} G^i(\Gamma) d\Gamma \quad (13)$$

is equal or larger than the respective costs  $c_n^i$ . Free market entry prevails in this sector  $\Rightarrow v^i = c^i$  if  $\dot{n}^i > 0$ . Differentiating (13) with respect to time gives the intertemporal no-arbitrage condition

$$\dot{v}^i + \frac{G^i}{v^i} = r. \quad (14)$$

This equation constitutes capital market equilibrium. Two final elements complete the structure of the model. First, the relation  $C_Y^A + C_Y^B = Y^A + Y^B$  describes the goods market clearing condition. Second, since the present model lacks any monetary sector, a numeraire variable can be freely chosen. Here, this is done by setting  $E = 1$ . From this,  $r = \rho$  follows.

Now, the interregional distribution of the final goods production and the migration decisions of workers can be studied. Let us first address the geographical distribution of the final good production. It is rather obvious that a situation in which  $Y$  is produced in one region only does not constitute an equilibrium. This can be seen as follows. Marginal cost pricing and cost minimization with respect to  $Y$  yields

$$p_Y^i = B(w^i)^\alpha (l_x^i)^\beta [(\tilde{p}_x)^{1-\epsilon}]^{\frac{1-\alpha-\beta}{1-\epsilon}} \quad (15)$$

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<sup>5</sup>Dots denote time rates, hats stand for growth rates.

<sup>6</sup>See for the implications of national or regional spill-overs *Grossman/Helpman* (1991b).

with

$$B = \left(\frac{\alpha}{\beta}\right)^{\beta} \left(\frac{\alpha}{1-\alpha-\beta}\right)^{1-\alpha-\beta} + \left(\frac{\beta}{\alpha}\right)^{\alpha} \left(\frac{\beta}{1-\alpha-\beta}\right)^{1-\alpha-\beta} \\ + \left(\frac{1-\alpha-\beta}{\alpha}\right)^{\alpha} \left(\frac{1-\alpha-\beta}{\beta}\right)^{\beta}.$$

The price of the immobile factor of production is characterized by  $l_x^i$ . Because of profit maximization of the  $Y$ -producers and perfect competition in the factor markets, the immobile factor is remunerated according to its marginal product:

$$l_x^i = \frac{p_Y Y^i}{M^i}. \quad (16)$$

If, for example,  $Y$  would not be produced in region A,  $l_x^i$  would be zero and the same is true for  $p_Y^A$ . But this does not constitute an equilibrium, since there remains always an incentive to produce a small amount of  $Y$  in region A at lower costs than in region B. Hence, one can conclude that  $Y$  is produced in both regions. The relative degree of specialization depends, as can be seen from (15), on the relative endowment of each region with the immobile factor and on the location of the intermediate goods. By assumption workers migrate according to real wage differentials. As a consequence of the equality of final goods prices, this is the equivalent to nominal wage differentials. Therefore, workers migrate until nominal wages are the same in both regions. A corner solution, in which all workers reside in one region, does not exist, as has been argued above. In equilibrium, nominal wages are the same in both regions and do not play any role in the interregional equilibrium distribution of  $Y$ -production. The equality of  $Y$ -production costs, requires, taking (15), (16), (8), and (11) into account, that in equilibrium

$$\frac{Y^A}{Y^B} = \left(\frac{g^{\epsilon-1} + \mu}{1 + \mu g^{\epsilon-1}}\right)^{\frac{1-\alpha-\beta}{\beta(1-\epsilon)}} \frac{M^A}{M^B} \quad (17)$$

holds, with  $\mu = n^B/n^A$ , the number of intermediate products assembled in region B relative to the respective number in region A. This equation determines the equilibrium distribution of  $Y$ -production between the two regions in the presence of perfect labor mobility.

In the absence of transport costs ( $g = 1$ ), (17) would read as  $Y^A/Y^B = M^A/M^B$ , i.e. the interregional distribution of  $Y$ -production is precisely equal to the regions' relative endowment with the immobile factor. This follows simply from the fact that the marginal product of the immobile factor must be equal in both regions in the absence of any other causes for cost differentials. The same is true for  $n^A = n^B \Rightarrow \mu = 1$ . In this case each  $Y$ -producer has to bear the same transport costs per unit of  $Y$ . If, however,  $\mu \neq 1$  and  $g < 1$ , the one-to-one correspondance between  $Y^A/Y^B = \mathcal{F}$  and  $M^A/M^B$  is distorted.

Since  $\partial \mathcal{F} / \partial \mu = (1 - \alpha - \beta) / (\beta(1 - \epsilon)) < 0$ , one receives an intuitively appealing pattern. In a world with positive transport costs of intermediate goods, the production of final goods has to be relatively more concentrated in the region where more intermediate goods are assembled in order to minimize transport costs. In equilibrium, the lower transport costs are just compensated by a lower price to be paid for the immobile factor.

Up to now, nothing has been said about the location of the intermediate goods and the place where new intermediate goods are developed in the long-run. In this respect various interesting issues should be dealt with. Besides the question where intermediate goods production takes place and where new product development occurs, it is necessary to study the interaction between final and intermediate good production in the full equilibrium. Furthermore, the determinants of the locational decisions and therefore of the interregional growth paths must be looked upon. As it is often the case with various forms of increasing returns, the possibility of multiple equilibria exists. This will be analyzed in the next section which is concerned with the long-run equilibrium with steady-state growth.

### 3 The long-run equilibrium

At the center of this section will be the analysis of the equilibrium distribution of intermediate goods. Thereby, the steady-state equilibrium with constant factor allocations of the two regional model will be deduced. The long-run analysis will be undertaken against the background of an equilibrium distribution of workers and final goods production at every moment in time. This implies that nominal wage rates are always the same in both regions. The long-run equilibrium distribution of intermediate products determines the interregional steady-state growth

rate.

Entrepreneurs willing to invest in the R&D have to decide where they locate their development activities and their production plants. By assumption, international licensing and multinational firms are excluded, i.e. the production of a good developed in A in region B, or vice versa is not feasible. Nor is the shift of established production plants for intermediate goods possible. That is, entrepreneurs must commit themselves definitively for a specific region. A glance at the no-arbitrage condition in (14) reveals that, besides the profit function, all other factors are identical. Entrepreneurs invest only in region A (B) if  $G^A$  ( $G^B$ ) is not strictly smaller than  $G^B$  ( $G^A$ ).

New goods will be developed in both regions simultaneously only if  $G^A = G^B$  holds. Therefore, it is necessary to take a closer look at the profit differential. Inserting (9), (11), and (17) in (10) yields after some calculations:

$$\begin{aligned} G^A - G^B &= p_Y Y_2 (1 - \sigma) (1 - g^\epsilon) \left[ \frac{\frac{M^A}{M^B} \left( \frac{g^{\epsilon-1} + \mu}{1 + \mu g^{\epsilon-1}} \right)^\theta}{n^A + n^B g^{\epsilon-1}} - \frac{1}{g^{\epsilon-1} n^A + n^B} \right] \\ &= \frac{p_Y Y_2 (1 - \sigma) (1 - g^\epsilon)}{n^A g^{\epsilon-1} + n^B} \left[ \frac{M^A}{M^B} \left( \frac{g^{\epsilon-1} + \mu}{1 + \mu g^{\epsilon-1}} \right)^{\theta+1} - 1 \right], \end{aligned} \quad (18)$$

with  $\theta = \frac{1-\alpha-\beta}{\beta(1-\epsilon)} < 0$ .

Since net profits per unit are the same in both regions, the sign of (18) is determined exclusively by total sales of every producer in each region. In order to analyze the long-run dynamics of the model and to determine where innovation and growth occur, it proves to proceed in two steps. First, it is assumed that an inner equilibrium with  $G^A = G^B$  exist. It will be asked whether this solution is a stable steady-state equilibrium. In a second step, conditions will be derived under which such an equilibrium solution exists and under what conditions corner solutions with localized growth in only one region take place. Giving priority to the stability analysis and proceeding thereby in a somewhat unconventional manner, has the advantage that this yields a condition which greatly simplifies the selection of existing equilibria.

The inner solution represents a stable solution if small perturbations lead to locational decisions of new innovators which reestablish the initial equilibrium.

This is the case if, for  $G^A > G^B$  ( $G^B > G^A$ ), i.e. with incentives to innovate only in region A (B), the profit differential in (18) gets smaller in absolute terms if  $\mu$  decreases (increases). Differentiating (18) with respect to  $\mu$  and evaluating at  $G^A = G^B$  yields

$$\text{sign} \frac{\partial(G^A - G^B)}{\partial\mu} = \text{sign} \left[ \frac{M^A}{M^B} \frac{g^{\epsilon-1} + \mu}{1 + \mu g^{\epsilon-1}} (1 - g^{\epsilon-1}) \right] (\theta + 1) = \text{sign}(\theta + 1). \quad (19)$$

Given that  $\theta + 1$  is positive, the inner solution with  $G^A = G^B$  is stable. In this case, product development is undertaken in both regions. In the steady-state the growth rates in both regions are equal to each other. Hence, the economy as a whole grows at this rate as well.

In the case of  $\theta + 1 < 0$ , the solution with positive R&D investments is unstable. Small perturbations create incentives to innovate which lead permanently to a still further drift apart of the respective profits in A and B.

The decisive parameter condition  $\theta + 1$  is surprisingly independent from transport costs. There are three forces which influence the equilibrium distribution in the intermediate goods sector and therefore the stability of the equal rate equilibrium. These forces can be seen at best by looking at the terms in brackets at the RHS in (18). First, the endogenous location of final good production and its influence on the profit functions in the intermediate sector is described by the large term in the nominator of the first fraction. The second and third forces, the home market and competition effect are characterized by the denominator of the terms in brackets. In order to demonstrate them more clearly, suppose for a moment that all intermediate goods are produced in A. An entrepreneur who wants to produce in B (at given  $Y_1$  and  $Y_2$ ) has a disadvantage in the A-market since his products are more costly compared to the ones of his competitors located in A, due to transport costs. In the B-market, his home market, he has a cost advantage against his competitors. In addition, by moving to B, another advantage can be exploited. Competition is less fierce in B than in A since all other producers sell for higher prices. Whereas this last effect, the competition effect, is unambiguously positive and calls for a diversification of intermediate goods production, the home market effect is less clear-cut and depends on the size of demand in the respective regions. The first factor, the locational effect of final goods favors the concentration of intermediate products, since final goods production tends to move towards the location with more intermediate products in order to save

transport costs. This effect destabilizes the inner solution ( $\theta < 0$ ). The stability of the inner solution depends whether the home market and competition effect overcompensate this effect or not. The larger (smaller) the share of the intermediate good (labor) in final good production is and the more intensive competition in the intermediate goods sector is (small  $\sigma$ ) the more probable a stable interior solution becomes.

Now, the second step can be approached. Here, the analysis must clarify whether or under which circumstances  $G^A \lesseqgtr G^B$  holds for all  $\mu$ , i.e. when do corner solution happen in any case. In order to do this it is once more useful to distinguish between case i.) with  $\theta + 1 > 0$  and case ii.) with  $\theta + 1 < 0$ . If, in case i.) (18) proves to be negative for  $\mu \rightarrow \infty$  (positive for  $\mu = 0$ ) this is true for all  $\mu$  and concentration in B (A) is the sole equilibrium of the model. Inserting these values in (18) shows that concentration in B occurs if  $\frac{M^A}{M^B} < g^{(\epsilon-1)(\theta+1)}$  and in A if  $\frac{M^A}{M^B} > g^{(1-\epsilon)(\theta+1)}$ . Given that the first (second) inequality is valid, new intermediate products are developed in region B (A) only. In the long-run, the share of intermediate products and output in the intermediate goods sector in the inactive region approaches zero. Steady-state growth<sup>7</sup> takes place in B with  $\frac{\dot{n}^B}{n^B} = w^B = w = \frac{\dot{n}}{n}$  ( $\frac{\dot{n}^A}{n^A} = w^A = w$ ). In the intermediate parameter range with  $g^{(\epsilon-1)(\theta+1)} < \frac{M^A}{M^B} < g^{(1-\epsilon)(\theta+1)}$ , a stable equilibrium with identical growth rates takes place. The equilibrium relation for  $\mu$  deduced from (18) with  $G^A = G^B$  is

$$\mu = \frac{\left(\frac{M^B}{M^A}\right)^{\frac{1}{\theta+1}} - g^{\epsilon-1}}{1 - g^{\epsilon-1} \left(\frac{M^B}{M^A}\right)^{\frac{1}{\theta+1}}}. \quad (20)$$

The equilibrium for  $\mu$  is determined by the relative endowment with the immobile factor and by transport costs. The growth process and the equilibrium dynamics for case i.) can be summarized by:

$$w = \begin{cases} w^A = \frac{G^A}{a_n w/n} - \rho & \text{for } \frac{M^A}{M^B} > g^{(1-\epsilon)(\theta+1)} \\ w^A = w^B = \frac{G}{a_n w/n} - \rho & \text{for } g^{(\epsilon-1)(\theta+1)} < \frac{M^A}{M^B} < g^{(1-\epsilon)(\theta+1)} \\ w^B = \frac{G^B}{a_n w/n} - \rho & \text{for } \frac{M^A}{M^B} < g^{(\epsilon-1)(\theta+1)} \end{cases} \quad (21)$$

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<sup>7</sup>It is assumed in the entire paper that resource endowments are large enough to sustain growth.



for case i.) In addition, the wage rate is constant in any steady-state, This follows from  $L_Y = \frac{\alpha}{w}$  and the fact that the steady state is described by constant intersectoral factor allocations. Outside the intermediate parameter range, localized steady-state growth emerges from the model. However, individuals in both regions benefit to the same extent from the growth process in the form of permanent price reductions in the final good. Permanent product innovations cause ongoing productivity increases. Using (1) and recalling  $E = 1$  gives  $\hat{Y} = -\hat{p}_Y = (1 - \alpha - \beta)/(\epsilon - 1)$ .

Case ii.) is slightly more complicated. As has been shown above, the intermediate solution is unstable. If, however, parameters are in a certain range, the problem of the interior solution does not arise, because only corner solutions constitute equilibria. If  $G^B > G^A$  for  $\mu \rightarrow \infty$  ( $G^A > G^B$  for  $\mu = 0$ ) this is true for all  $\mu$  and hence, concentration in B (A) is the unique long-run equilibrium. The model economy approaches one of these equilibria from all starting positions. Which one depends on the parameter constellation. The corner solution in B will be reached if  $\frac{M^A}{M^B} < g^{(1-\epsilon)(\theta+1)}$  holds, whereas the concentration takes place in A, given that  $\frac{M^A}{M^B} > g^{(\epsilon-1)(\theta+1)}$ .

As in case i.), with  $M^A/M^B$  being in the intermediate range, the interior solution exists, but here it is unstable. In this subcase, the phenomena of multiplicity of equilibria appears. Besides the unstable solution, two stable corner solution represent two additional long-run equilibria. Which one finally takes place depends in almost all cases on the starting point, i.e. the initial conditions. Only if  $\mu$  is, by coincidence such that  $G^A = G^B$ , the expectations of agents determine the equilibrium being approached.<sup>8</sup> But outside the parameter range  $g^{(1-\epsilon)(\theta+1)} < \frac{M^A}{M^B} < g^{(\epsilon-1)(\theta+1)}$ , with  $\theta + 1 < 0$ , the problem of multiple equilibria does not arise and the discussion whether historical events or expectations determine the final solution [cf. *Krugman* (1991c) and *Matsuyama* (1991)] is not relevant. From the above it becomes obvious that in case ii.) the steady-state equilibrium is characterized in any case by localized growth and complete concentration of intermediate goods development and production.

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<sup>8</sup>See on this point also the analysis of *Grossman/Helpman* (1991b).

## 4 Summary

Without relying on geographically limited technological spill-overs, the present paper developed a simple model of localized growth and industrial concentration. The location of the production and R&D process as well as the immobile workers is endogenously determined. In most situations, only the relative endowment of the regions with the immobile factor and the level of transport costs for intermediate goods have been decisive for the geographical distribution of economic activity.

It could be shown that regional growth rates might very well differ despite perfect labor mobility. Given that regions are rather unequally endowed with the immobile factor, in relation to transport costs, a restricted core-periphery pattern emerged. In the long-run all development and production activities in the intermediate goods sector takes place in the “larger” region. Due to the immobility of one factor of production, final good production is never completely concentrated in one region. Therefore, there are always at least some workers in either region. An interesting interaction between the locational decisions of final and intermediate goods producers was revealed. Despite the simple structure, the model provides a justification and explanations for various important phenomena in regional economics, especially input production clustering and the possibility of growth rate differentials between regions.

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