VOLKSWIRTSCHAFTLICHE DISKUSSIONSBEITRÄGE

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Regional Economic Growth by Policy-Induced Capital Flows: I. Theoretical Approach

Walter Buhr

Department of Economics
University of Siegen, Germany

Discussion Paper No. 33-92

ABSTRACT

In view of regional income disparities this paper discusses alternative allocation strategies of regional economic growth policy: "movement of the workers to the jobs" (passive factor stocks adjustment) versus "jobs to the workers" (active factor stocks adjustment). For policy evaluation of this classical question a dynamic two-regions model is presented (Part I) whose implications will be analyzed on the basis of selected parameters to give an example of possible model application (Part II).

In Part I, with respect to the model, the analysis will start with general remarks on model construction (stressing the relevance of supply-side growth barriers), then describe the relationships of the model and finally refer to some selected aspects of possible extensions to the model (introduction of a third region as the outside world of the two regions, consideration of the size of regions, and incorporation of independent regional investment functions). The concluding remarks will focus on the essential policy parameters of the model whose variation will allow analysis of the problem at hand.

The author wishes to thank Reiner Wolff, Georg Zink, Siegen, and Norbert Matthes, Bonn, for their permanent readiness to discuss earlier drafts of both parts of this paper. Also the author gratefully acknowledges the useful comments of an anonymous referee.

1. Alternative Allocation Strategies of Regional Growth Policy

One central issue of regional economic policy arises from the question of how to allocate the national resources among the regions of an economy so that the growth of the nation's social product will be maximized (Giersch 1963). Basically, there are two strategies of regional growth applied in practical regional economic policy: active and passive government policy of regional factor stocks adjustment.[1] As far as the passive policy of factor mobility is concerned, migration of mostly unemployed labor from the backward areas into the prosperous regions of agglomeration ("movement of the workers to the jobs" or "flow of labor to capital") is supported or accepted in order to increase national economic growth. This strategy, particularly as regards the criterion of efficiency, assumes that the unemployed or underemployed resources of the retarded regions can be used more effectively in the agglomeration centers. The problems of these centers - if any problems exist at all - form the sole crucial object of regional economic policy (predominantly position of conservative Western European governments).

In contrast, the active policy of factor mobility aims at the transfer of private and public capital into the underdeveloped regions ("movement of the jobs to the workers" or "flow of capital to labor"), at least initially pursuing the criterion of equity. In the longer run, an interregional convergence of per capita incomes and infrastructure provision will only be achieved if self-sustaining growth spreads in the backward areas. Although economic growth in the regions of agglomeration will become relatively slower due to

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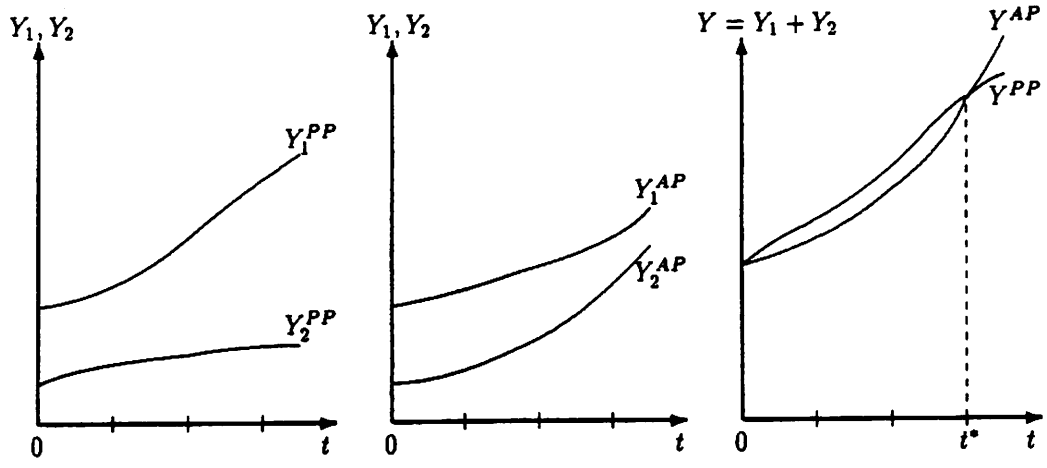
[1] Early verbal discussions are given by Richardson and West 1964 and by Dietrichs 1965.

the transfer of capital - this result will possibly be desired in view of the negative aspects of agglomeration -, the growth of the national economy is assumed finally to be greater than in the case of the passive strategy of factor stocks adjustment (predominantly position of socialist Western European governments, especially in the form of the growth center concept).

The decision between these two growth strategies remains to the present day a classical issue of regional economic policy, even though new problems of regional economic growth have arisen in the meantime (e.g. spatial concentration of the production and application of new technical skills and devices).



(a) Passive Policy (PP)

(b) Active Policy (AP)

(c) National Result

Figure 1: Hypothetical Real Income Time Paths for Region 1, Region 2 and the Nation under Passive and Active Policy of Regional Factor Stocks Adjustment

The different basic positions of the political advocates of the two growth strategies may be characterized by their respective expected

future income time paths for two selected regions and the nation, as shown in Figure 1. With reference to section (c) of this figure the followers of the passive policy argue that the date t*, at which the time paths of total income originating under the different political settings will intersect, will lie far ahead in the future, whereas the advocates of the active policy are convinced that the point t* will occur in the next few years to come.

In the Federal Republic of Germany since at least 1972 clear commitments have been made to an active policy of capital mobility in favor of the backward areas; these commitments have however varied in their degree of realization and have been pursued under differing global policy objectives. The main emphasis has focused on measures to influence industrial location such as investment allowances and subsidies on the cost of loans. Expenditures on production-oriented infrastructure, for example, for the development of general purpose plant sites, the construction of water and sewage facilities and the extension of vocational training colleges have played a secondary role (Dietrichs 1983). Interregional labor mobility, to a large extent, has been left to be governed by market forces.

In the model to be discussed the active policy of regional capital adjustment will concern the following instruments of regional growth policy, rank-ordered by their general importance: (a) the underdeveloped regions' varying participation in national public savings leaving it to these regions to decide how to distribute these means for alternative purposes; in this model, these purposes are assumed to be infrastructure investment, on the one hand, and public means to attract private capital from the outside, that is public

funds to be spent for capital subsidies, on the other hand, thus referring to the two essential sets of instruments of regional development policy (cf. Funck 1990); (b) the volume of the backward areas' public resources designated for capital subsidies and the percentage of capital subsidies of the developing regions in relation to matching private capital attracted from outside areas.

A review of the literature indicates that there exists a number of publications aiming at the solution of different problems more or less related to the quantitative evaluation of the two regional growth strategies. These contributions may be grouped as follows.

First, although embedded in specific contexts not directly applicable to our research purposes, valuable building blocks of various kinds for modeling are available in economic theory (e.g. Rahman 1963, Borts and Stein 1964, Sakashita 1967, Casetti 1968, Borts and Stein 1969, Holzheu 1969, Nicoletti, Pezzella and Raiconi 1976, McCulloch and Yellen 1977, Carlberg 1983, Thoss 1983, Bennett and Hordijk 1986, Parr 1988).

Among these studies Mera's neoclassical contribution (1973, 1975) on income distribution in the process of regional economic development deserves special attention, since it deals with many important regional growth issues and has stimulated research up to present times (e.g. Merriman 1990). Nevertheless, Mera's work remains controversial due to basic theoretical objections, quite apart from the often unsatisfactory quality of the data he refers to. Social overhead (public, infrastructure) capital cannot meaningfully be incorporated into a Cobb-Douglas production function, since the substitution between public and private capital is usually not an economic, but an

institutional problem (cf. Buhr 1975 on the role of material infrastructure in regional economic growth). State-ownership and privatization are issues of the economic order of an economy, not primarily a matter of relative factor prices. Cannot the relationship of social capital to private resources be expected to be complementary (Mera 1975, p. 165)? Moreover, public capital is often characterized by substantial excess capacities which Mera did not take into account. And finally, to end this list of critical issues, it is difficult to accept, as the result of a model, the non-specific statement that "... the growth of regional economic activities is determined primarily by the growth of social capital and technical progress in the region" (Mera 1975, p. 61).

Second, the discussion of the relevant policy aspects of our topic is mostly of a general and non-technical nature (e.g. Groenman and Turcan 1968, Thirlwall 1974, MacLennan and Parr 1979, Vanhove and Klaassen 1980, Mawson et al. 1985, Armstrong and Taylor 1986, Klemmer 1986, Molle 1988). Recently intensive research has also been concerned with generating alternative approaches aiming at establishing a new foundation of regional economic policy (e.g. Stöhr 1984, Bothe et al. 1987).

Third, we should consider two reference bases in the regional science literature in order to present the broader context for the intended essentially macroeconomic research approach. Although the links to this frame will not be pursued in this paper, it is important to stress their relevance for future work. One of these reference bases is concerned with the possible microeconomic foundation of our investigation which would result from merging urban economics with regional price, trade and growth theory (as an example cf. Henderson

1988). The other reference basis is computable general equilibrium models with came into existence in the field of microeconomics (e.g. Scarf and Shoven 1984, Shoven and Whalley 1984, Borges 1986, Piggott and Whalley 1991, Wolff 1992) and which may now also be encountered in regional science research, posing specific practical problems of implementation on the regional scale (e.g. Higgs, Parmenter and Rimmer 1988, Hirte and Genosko 1988/89, Batten and Westin 1990, Jones and Whalley 1990). Basically, the model to be presented belongs to this group of approaches, although in terms of its size and its empirical characteristics it must be considered as a first formal attempt.

In the following a dynamic model of interregional factor stocks adjustment will be presented for the two-regions case. We shall start the discussion with some general remarks on model construction, then describe the relationships of the model, and finally refer to some selected aspects of possible extensions to the model (introduction of a third region as the outside world of the two regions, consideration of the size of regions, and incorporation of independent regional investment functions). The concluding remarks will focus on the essential policy parameters of the model whose variation will alow analysis of the problem at hand.

2. A Dynamic Model of Interregional Factor Stocks Adjustment: The Two-Regions Case

2.1 General Considerations on Model Contruction

The proposed model, as a first approach, is designed to demonstrate the dynamic structure of the problem and the interrelationships of

important variables, thus representing the groundwork for quantitative policy analysis with respect to the two growth strategies. The model may be taken as a pilot study for more comprehensive analytical work in support of decision-making in regional economic policy. We stress that the model has been developed in view of the problem described above. There is no primary interest in introducing a new model of a multiregional economy. In addition, the model will be simulated with reference to its policy implications to improve our insight into the dynamics and characteristics of regional economies. No role was played either by any intention to make generalizations concerning passive or active regional economic policy or give specific generally valid policy prescriptions or by any aim of assessing regional economic policy in its many facets.

Now let us demonstrate the power of computer simulation. Since the model to be introduced generates, leaving aside other variables, the future real income time paths of the regions and thus the future real income time path of the nation, the projected impact of policy measures, linked to specific model parameters, may be derived in the framework of both policy strategies of regional economic growth. To give an example: The introduction of modern technologies in the underdeveloped areas reinforced by government financial assistance will increase the productivity of private capital in these regions. This influence may be captured by a change in the corresponding parameter of capital productivity so that the effects of this parameter variation on other model variables can be studied against the background of each of the two growth strategies.

In this context it must be stressed that it has been the aim of model

construction to keep the model as simple as possible, the reason being the dynamic nature of the problem at hand. Since the core of the model is formed by a system of differential equations, these equations have basically been given a linear form so that the general properties of specific solutions of the model in a reduced version, omitting the interregional wealth aspects, may still be analyzed, at least numerically. However, linearity of the equations is restricted to a single iteration of the applied solution method (Zonneveld fifth order Runge-Kutta method; Stroud 1974, pp. 243-254), because factor productivities have to be assumed to be dependent on technical progress and, more importantly, labor productivities in this model are strongly correlated with per capita incomes of the regions. In modelling factor productivities in this way we must accept the overall nonlinearity of the model, being rewarded by greater proximity to reality.

The key idea behind the structuring of the present model, that is the implementation of growth limiting demand-side and supply-side barriers, was first introduced by Vogt (1964) into the theory of economic growth, thus criticizing the assumption of smoothly exponential growth paths and integrating the different approaches to the theory of economic growth. According to Vogt - who uses a linear-limitational approach - at any period of time real output may be determined either by the demand side (Keynesian growth theory) or by the supply side (classical growth theory). Then in a Leontief production function supply-side output is taken to depend on capital, labor, intermediate products and financial means. For the period 1950-1960 Vogt successfully tested his approach on the basis of macroeconomic data for the Federal Republic of Germany, demonstrating

sequentially the effectiveness of individual growth barriers. Basically, this view of the growth process is supported by the first two studies prepared for the Club of Rome (Meadows et al. 1972, Mesarovic and Pestel 1974), stressing the empirical relevance of non-constant growth rates (first increasing, then decreasing in the sense of logistic growth) and considering also other binding constraints on growth such as the availability of natural resources on the world scale. Having recognized the significance of growth barriers for the world and for nations there is no reason to assume that regions grow according to a fundamentally different mechanism. On the contrary, the present day economic situation of the five new German states in the east gives ample evidence on the empirical dynamics of substitution between alternative factor bottlenecks in the regional growth context (for instance, consider the important role of material infrastructure as a regional growth limiting factor in eastern Germany).

Since the factor stocks as growth barriers refer to the supply side of production, there remains the question of how to model factor demands, that is which type of production function to use in the model. This question has been decided in favor of a Leontief function, simply because there are the following arguments against the neoclassical substitutional production function. (a) Substitution of factors of production in response to changes of relative factor prices takes a certain amount of time so that using an iterative solution procedure to run the model with empirical data implies a substantial increase in the number of model relationships; this section of the model would then be out of proportion to other parts of the model. (b) Material infrastructure or public capital is understood as a precondition of

private production and capital formation; thus it is assumed that there does not exist any substitution between private and public capital governed by economic forces. (c) The model has been formulated in such a way as to allow the substitution of the factors of production to be simulated by the variation of input dependent productivity parameters.

In more detail, the model has the following major characteristics.

(a) With respect to the general assumptions of the model we shall group all spatial subsections of the nation into two regions R1 und R2. Region R1 includes areas of agglomeration showing a high level of income and infrastructure provision (absolute and per head), a tendency towards inmigration and a shortage of either private capital, labor, or material infrastructure. R2 refers to areas with an insufficient degree of development which are typified by a low level of income and infrastructure provision (absolute and per head), a tendency towards outmigration, and above all a lack of private capital.[2] These two polar groups of spatial units called region R1 and region R2 are characterized by averages with respect to important economic indicators and are thus, strictly speaking, artificial entities. However, this kind of aggregation corresponds well with the basically macroeconomic approach to the problem. Analytical parallels may easily be found in macroeconomic theory; take, for instance, the macroeconomic theory of income distribution that often distinguishes grossly between labor incomes on the one hand and profits on the other hand.

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[2] Depressed areas often suffer from an abundance of unused private capital in the form of excess capacities. Therefore here the term "private capital" is restricted to capital that serves actual market demand.

We shall be concerned with a real and non-monetary two-regions model of a closed economy which considers the production of the national product in the regions. There are neither indirect taxes paid by enterprises to the state nor directly production-related subsidies paid to them by the state. Regional output is a function of the regionally available factors of production labor, private capital, and public capital (material infrastructure).[3] Interregional mobility of labor is taken to be imperfect and the labor markets are assumed to incorporate regionally different monopolistic elements so that diverging wage rates can exist in R1 and R2. (Observe that the macroeconomic model chosen shall not be disaggregated according to the distinction between traded and non-traded goods so that, for instance, we will not discuss the influence of diverging wage rates on the prices of non-traded goods.) Regionally differing interest rates for private and public capital are due to the imperfections of capital markets, whereas the mobility of investments is supposed to be perfect. Finally, we postulate infinite life spans of capital stocks so that depreciation can be neglected in the model[4].

The restriction to two regions has been imposed in order to simplify the analysis. In view of the given experiences with handling the model there is no reason to assume - neither from the angle of theory, nor

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[3] It is implicitly assumed - realistically - that the availability of land does not decisively influence output growth.

[4] This simplifying assumption is made in order to avoid construction of a more complicated type of growth model, for example, a vintage model, whose successively formed increments of capital stocks are subject to depreciation. In view of the research period stated later in the paper (fifteen years) the present approach anyway corresponds to the practice of estimating and handling empirical data on public capital stocks.

from the angle of the calculations made on the basis of the model - that any specific problems, for instance problems of stability, would arise if more than two regions were taken into account. What is certainly true is that for the case of more than two regions the model would be more complicated and the description of its results more sophisticated and lengthy, without generating any additional fundamental insights (cf. Buhr 1984). Most probably the analysis as such remains valid, irrespective of the number of regions considered. In order to create, in the present context, a limited theoretical and numerical basis for these statements we shall introduce, under specific circumstances, the rest of the world as a third region, thus dropping the closed-economy assumption within the context of model extensions.

(b) Factor supplies are assumed to limit satisfiable factor demands in the growth process. Due to the underlying linear-limitational production functions the demand for a particular factor is equal to the corresponding input coefficient (= reciprocal value of factor productivity) multiplied by the output level. Thus, in each region, the barrier input determines regional output; for all other inputs, realized factor demand remains, in general, smaller than factor supply, so that we have factor unemployment. Since the supply of each of the three production inputs may be restrictive in both regions R1 and R2 - there are no demand barriers in the model - we obtain in all nine possible combinations of growth limiting factors of production, one restrictive input for each region. Now regional output growth interrelated between the two regions depends on the processes of accumulation with respect to the growth constraining factor supplies in the regions which can be described by systems of interdependent differential equations. Consequently, there are, in total, nine

alternative systems of differential equations of which, in the normal case, only one will be relevant at any one small interval of time.

The switch from one combination of growth restricting factor supplies to another may be imagined in the following way. Once the input barrier in each region has been determined, the solution of the corresponding system of differential equations will specify the time paths of supply and demand of the factors which have acted restrictively so far. Then we may calculate: on the one hand, the time paths of the regional outputs and of the demand for the remaining non-restrictive regional inputs and, on the other hand - by numerical integration - the time paths of the supply of the non-restrictive regional factors. By equalizing the demand for and the supply of each non-restrictive regional input we may state the time span elapsing until the demand-supply equilibrium for each input will occur. The determination of the minimum time interval among these time spans will indicate the new combination of growth limiting regional factor supplies.

According to the statements made above, the decision criterion applied to a situation in which more than one factor supply becomes effective as a growth barrier in a region is minimum regional output. If, in an unlikely case, two identical minimum values should come up, we apply the criterion of the lowest growth rate of factor productivity, because we may expect the corresponding input to be a restrictive factor in the next iteration.

(c) Interregional linkages refer to trade flows, interest payments and migration. In the given development context, private exports of a

region are assumed to be made up of two components. The first export element, independent of government incentives, will depend on the level of regional production (supply-side oriented export push or economic base hypothesis). This assumption implies the relationship of exports to regional production, taken as a specific rate of investment, to be constant. The second export component is determined by interregional private investments induced by government policy, especially by capital subsidies (Richardson 1978, pp. 26-28, Armstrong and Taylor 1986, pp. 195-205). These interregional investments are not transfers in the sense of the current accounts of the interregional balances of payment, since they reduce private investment in the donor region, correspondingly increase private investment in the receiving region, and create assets for the donor region or, equivalently, generate liabilities for the beneficiary region. Private interest payments arise from the interregional private wealth relationships. To model migration an approach is used in which net migration is a function of interregional differences in wage rates and rates of unemployment.

As far as public revenues and expenditures are concerned, we take the state as an independent institution related to the two regions. Transfers of public resources (direct taxes plus interest payments minus public consumption) of both regions - forming the public component of regional exports - are pooled by the state who decides on the use of these resources for regional public investment (including capital subsidies). These investments are allocated by the state between the regions. Public consumption is determined by regional governments. Thus, in all, the state decides on the budget situation (surplus or deficit) of each region under the constraint that the

state budget is balanced.

(d) In this model investment is taken to be a residual of resources available from the income stream after other categories of demand have been fixed. Figure 2 shows, in a simplified form of the model, investment I_i of region i (i = 1, 2) to result from real income Y_i^S determined by the supply side[5], given the savings function $S_i = g_i(Y_i)$ (demand equilibrium F). This approach implies that real income of each region, Y_i^S, originating from the supply side is equal to regional real income Y_i^D determined by the demand side. However, the equality of supply-side and demand-side income will

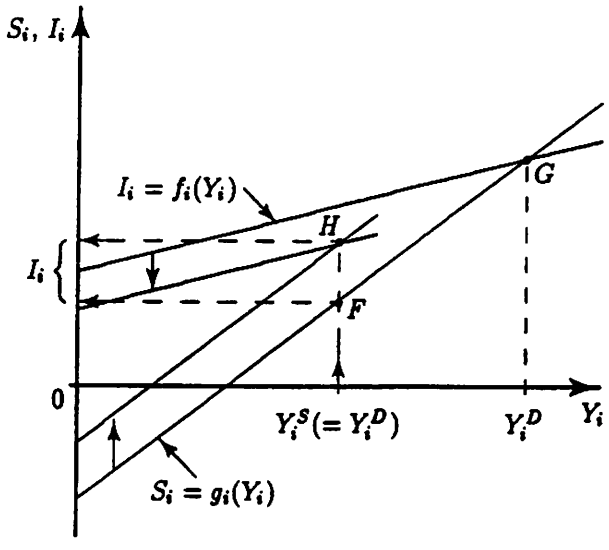

Figure 2: Demand-Supply Equilibria for Region i (i = 1, 2)

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[5] The superscript S refers to the supply side, the superscript D to the demand side.

generally not hold if regional investments have to be explained by independent investment functions $I_i = f_i(Y_i)$, as is certainly more realistic for a market economy (point G for which we assume $Y_i^D > Y_i^S$). In order then to guarantee macroeconomic equilibrium for the regions and the nation, an adjustment procedure as sketched below will have to be applied at each iteration of the solution method (final demand equilibrium at point H).

2.2 The Relationships of the Model

[1] Let us start with the basic definitions of regional real income. For region i (i = 1,2) income Y_i (= net social product at factor prices) allowed for on the demand side is defined as the sum of private consumption (C_i^{pr}), public consumption (C_i^{pu}), private investment (I_i^{pr}), public investment (I_i^{pu}), exports to the other region (Z_i) and interest payments received (r_j = given rate of interest applied to private capital in region j, W_{ij} = private assets held by region i in region j, j = 1,2) minus imports from the other region (M_i) and interest payments to be made (r_i = given rate of interest of region i, W_{ji} = assets owned by region j in region i).

$$Y_i = C_i^{pr} + C_i^{pu} + I_i^{pr} + I_i^{pu} + Z_i - M_i + r_j W_{ij} - r_i W_{ji} \qquad (1)$$

Current account surplus (deficit) of region i is

$$H_i = Z_i - M_i + r_j W_{ij} - r_i W_{ji} - F_i^{Apu} + F_i^{Epu} \qquad (2)$$

where F_i^{Apu} denotes public resources of region i transferred to the state and F_i^{Epu} stands for resources re-transferred to region i from the state in the form of public investment.

Regional income generated on the supply side is defined as

$$Y_i = X_i + r_j W_{ij} - r_i W_{ji} \qquad (3)$$

implying the real output of region i, X_i, to be (compare formula (1) to relationship (3))

$$X_i = C_i^{pr} + C_i^{pu} + I_i^{pr} + I_i^{pu} + Z_i - M_i$$

Regional income is used for private and public consumption (C_i^{pr} and C_i^{pu}), private and public savings (S_i^{pr} and S_i^{pu}) and net public transfers to the state ($F_i^{Apu} - F_i^{Epu}$).[6]

$$Y_i = C_i^{pr} + C_i^{pu} + S_i^{pr} + S_i^{pu} + F_i^{Apu} - F_i^{Epu} \qquad (4)$$

with (T_i = volume of direct taxes and public interest receipts of region i)

$$F_i^{Apu} = T_i - C_i^{pu} \qquad (5)$$

$$F_i^{Epu} = I_i^{pu} \qquad (6)$$

so that the state budget surplus (deficit)

$$B = \sum_i F_i^{Apu} - \sum_i F_i^{Epu} = 0 \qquad (7)$$

Starting from region i's public sector income account relationship

$$T_i = C_i^{pu} + S_i^{pu} + F_i^{Apu} - F_i^{Epu} \qquad (8)$$

we may derive the following implications of the above mentioned formulae. If relationship (8) is combined with (5), we get

$S_i^{pu} = F_i^{Epu}$ and according to (6) $S_i^{pu} = I_i^{pu}$.

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[6] A different approach concerning the transfer payments was used in Buhr 1986.

Then relationship (4) reduces to

$$Y_i = C_i^{pr} + C_i^{pu} + S_i^{pr} + F_i^{Apu} \quad \text{or to}$$

$$Y_i = C_i^{pr} + S_i^{pr} + T_i \qquad (4')$$

meaning that private households' expenditures are made up of consumption, savings, direct taxes and interest payments for the utilization of public capital.

Income distribution is represented by

$$Y_i = r_i(K_i^D - W_{ji}) + r_j W_{ij} + w_i L_i^D + r_i^* B_i^D \qquad (9)$$

with K_i = private capital stock of region i, B_i = public capital stock (material infrastructure) of region i, L_i = labor force of region i, w_i = wage rate of region i, and r_i^* = given rate of interest applied to public capital in region i.[7] Private and public capital is measured in units of real output.

[2] In all there are nine alternative regional production set-ups corresponding to the possible combinations of growth limiting factor supplies in the regions. Let the symbols k_i, b_i and a_i indicate respectively average productivity of private and public capital and labor in region i. Capital productivities have no dimension, labor productivities are of the dimension "real output/labor quantity". We may now give the following example of a system of regional production relationships; it assumes that public and private capital constitute the growth barriers in R1 and R2, respectively, at a certain time.

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[7] The private wealth of region i may be defined as $W_i = W_i^K + W_{ij} - W_{ji}$ with $W_i^K = K_i^S$.

$$X_1 = b_1 B_1 \qquad (10a) \qquad\qquad X_2 = k_2 K_2 \qquad (10b)$$

$$(B_1^D = B_1^S = B_1) \qquad\qquad (K_2^D = K_2^S = K_2)$$

$$K_1^D = \frac{1}{k_1} X_1 \leq K_1^S \qquad (11a) \qquad\qquad B_2^D = \frac{1}{b_2} X_2 \leq B_2^S \qquad (11b)$$

$$L_1^D = \frac{1}{a_1} X_1 \leq L_1^S \qquad (12a) \qquad\qquad L_2^D = \frac{1}{a_2} X_2 \leq L_2^S \qquad (12b)$$

We postulate that the following relationships hold for the factor productivities.

$$k_i = k_{io} + k_{i1} t + k_{i2} \left(B_i^S - \frac{dB_i^S}{dt} dt\right) + k_{i3} K_i^S \qquad (13)$$

$$b_i = b_{io} + b_{i1} t \qquad (14)$$

$$a_i = a_{io} + a_{i1} t + a_{i2} \left(B_i^S - \frac{dB_i^S}{dt} dt\right) + a_{i3} K_i^S \qquad (15)$$

$$\text{with } B_i^S - \frac{dB_i^S}{dt} dt = B_i^S \Big|_{t-dt}$$

All terms in (13) - (15) showing two subscripts are assumed constant and given. While the productivity of public capital depends solely on technical progress (t = time), the productivities of private capital and labor are also a function of the preexisting stock of infrastructure capital and the present stock of private capital. The parameter k_{i2} is positive by assumption meaning that an increase in the public capital stock will improve locational conditions in the regions, and thus taking material infrastructure as a precondition of private production and capital formation[8]. The negative parameter k_{i3}

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[8] In a more disaggregated model the parameter k_{i2} could be taken to be subject to the regional composition of the public capital stocks.

implies that a growing private capital stock will lower private capital productivity. In this way we introduce a neoclassical element into our analysis. Growth of the capital stocks will have a positive effect on labor productivities: $a_{i2} > 0$, $a_{i3} > 0$. The other parameters not discussed shall also be positive.

Assuming given interest rates r_i and r_i^* and productivities k_i, b_i and a_i, production technology implies the following factor price and income share relationships.

$$r_i = k_i g_i = k_i(1 - c_i - q_i) \text{ with } g_i = 1 - c_i - q_i \tag{16}$$

implying

$$g_i = \frac{r_i}{k_i} \tag{17}$$

and

$$r_i^* = b_i c_i \tag{18}$$

implying

$$c_i = \frac{r_i^*}{b_i} \tag{19}$$

According to (16), $q_i = 1 - c_i - g_i$ specifying the wage rate of region i as

$$w_i = a_i q_i \tag{20}$$

The symbols g_i, c_i, and q_i are the shares of private capital, public capital and labor in (real) production, respectively.

[3] Now we shall turn to the assumed demand side income equilibrium for which income is given by the supply side (formula (3)), so that regional investment I_i may be determined as a residual. Equalizing the right-hand sides of relationships (1) and (4) we get

$$I_i = I_i^{pr} + I_i^{pu} = S_i^{pr} + S_i^{pu} + F_i^{Apu} - F_i^{Epu} - Z_i + M_i - r_j W_{ij} + r_i W_{ji} \tag{21}$$

which amounts to $I_i = S_i - H_i$ (S_i = total savings of region i).

In addition we postulate

$$S_i^{pr} = s_i^{pr} Y_i \tag{22}$$

$$T_i = t_i Y_i + r_i^* B_i^D \tag{23}$$

$$C_i^{pu} = c_i^{pu} Y_i . \tag{24}$$

Here the marginal (average) private propensity to save, s_i^{pr}, the marginal (average) tax rate, t_i, the marginal (average) public propensity to consume, c_i^{pu}, and the implied marginal (average) propensity to transfer resources for public purposes, $f_i^{pu} = t_i - c_i^{pu}$, are assumed constant and given.[9]

At this point, some comment should be made on the underlying consumption function. We derive this function by setting out from (4') and considering (22) and (23). It shows a varying average propensity to consume which corresponds to the constant average savings ratio in (22), later used as an important parameter of model simulation. In addition, directly basing our approach on the savings function (22) instead of starting from a consumption function provides the advantage of simplifying the present model.

Adding relationships (21) for the two regions to one another leads to (note that $Z_i = M_j$ as far as private terms are concerned and observe (7), (22), (23), (24))

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[9] For simplicity we assume that private and public savings of region i depend on regional real income Y_i, rather than on the corresponding disposable income.

$$\sum_i (s_i^{pr} + f_i^{pu})\, Y_i + \sum_i r_i^* B_i^D = \sum_i I_i^{pr} + \sum_i I_i^{pu} \qquad (25)$$

which is split up into (I^{pr} = national (total) private investment, I^{pu} = national public investment)

$$\sum_i s_i^{pr} Y_i = \sum_i I_i^{pr} = I^{pr} \qquad (26)$$

$$\sum_i \left(f_i^{pu} Y_i + r_i^* B_i^D\right) = F^{pu} = \sum_i F_i^{Apu} = \sum_i F_i^{Epu} = \sum_i I_i^{pu} =$$

$$= \sum_i S_i^{pu} = S^{pu} = I^{pu} \qquad (27)$$

applying (5) and (8); F^{pu} stands for national (total) public transfers to the state and S^{pu} refers to national public savings.[10]

[4] With respect to investment, we shall at first concentrate on the determinants of private investment, then on those of public investment. According to (21) we obtain private investment of region i, using (5), (6) and (8).

$$I_i^{pr} = S_i^{pr} + F_i^{Apu} - F_i^{Epu} - Z_i + M_i - r_j W_{ij} + r_i W_{ji} \qquad (28)$$

Leaving aside the public F-terms and the interest payments between the regions for a moment, we note that S_i^{pr} is determined by (22).

Focusing on private investment I_1^{pr} of R1, we postulate the exports of this region, with reference to the regionally relevant hypothesis of export push or export base, to be

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[10] In order to be able to discuss the influences of changes in regional demand, the marginal propensity to save in (26) or the marginal propensity to transfer in (27) may be altered.

$$Z_1 = \bar{i}_{12} \frac{r_2}{r_1} X_1 + F_1^{Apr} + F_1^{Apu} \tag{29}$$

and the imports correspondingly to be

$$M_1 = \bar{i}_{21} \frac{r_1}{r_2} X_2 + F_1^{Epr} + F_1^{Epu} \tag{30}$$

The terms $\bar{i}_{12} > 0$ and $\bar{i}_{21} > 0$ are parameters. F_1^{Apr} are exports in the form of private real capital outflow (measured in real output), while F_1^{Epr} are imports in the form of private real capital inflow (measured in units of real output), both flows being induced by public subsidies. Further, F_1^{Apu} and F_1^{Epu} refer to resource transfers between R1 and the state.

If we combine relationships (29) and (30), specified for region i, with (1) and concentrate on the terms which are related to the resource use and the production of public investment, that is on $I_i^{pu} + F_i^{Apu} - F_i^{Epu}$, this expression will reduce to F_i^{Apu}, considering (6). Thus F_i^{Apu} may be interpreted as the state's demand for regional public resources (cf. (5)). In addition, we also find that the current account surplus (deficit) H_i of region i according to (2) relates solely to the other region j. And finally, we may state that private investment of region i according to (28) is exclusively determined by factors originating from the private sectors of the regions.

Observe for the two-regions case that private capital inflow of one region is identical to private capital outflow of the other region and vice versa. With reference to (29) and (30) we thus have

$$F_1^{Apr} = F_2^{Epr} \tag{31a}$$

$$F_2^{Apr} = F_1^{Epr} \tag{31b}$$

Private capital transfers of region i to region j are induced by capital subsidies G_j^{pu} of region j. The coefficients $v_{12} \geq 0$ and $v_{21} \geq 0$ are parameters which indicate the desired relationships of private capital to be attracted from the other region to public funds invested in private projects of the region under consideration. Notice, for example, that $1/v_{12}$ indicates the percentage of R2's capital subsidies in relation to private capital imports from R1. Thus v_{12} will be one decisive active policy parameter.

$$F_1^{Apr} = v_{12} G_2^{pu} \tag{32}$$

$$F_1^{Epr} = v_{21} G_1^{pu} \tag{33}$$

Private investment I_2^{pr} of R2 could be discussed in the same way.

With respect to public investment we take note of (6). Public investment of region i is assumed to be composed of investment in public capital I_i^{puJ} and capital subsidies G_i^{pu} to attract private capital from the other region. Thus we have

$$I_i^{pu} = F_i^{Epu} = I_i^{puJ} + G_i^{pu} \tag{34}$$

The components of public investments are determined in relation to total public transfers (cf. (27)) by applying distribution parameters ν (distribution of resources between the regions), h_1 and h_2 (distribution of regional resources among regional activities, respectively). The parameters ν and h_2 are two other essential access-points of active regional economic policy.

For R1 we get

$$I_1^{puJ} = h_1 \nu F^{pu} \qquad 0 \leq \nu,\ h_1 \leq 1 \tag{35a}$$

$$G_1^{pu} = (1 - h_1) \nu F^{pu} \tag{36a}$$

so that according to (34)

$$I_1^{pu} = F_1^{Epu} = \nu F^{pu} \tag{37a}$$

Analogously, we have for R2

$$I_2^{puJ} = h_2(1 - \nu)F^{pu} \qquad 0 \leq h_2 \leq 1 \tag{35b}$$

$$G_2^{pu} = (1 - h_2)(1 - \nu)F^{pu} \tag{36b}$$

so that according to (34)

$$I_2^{pu} = F_2^{Epu} = (1 - \nu)F^{pu} \tag{37b}$$

[5] The next step is dedicated to the calculation of the F-terms. Observe (31a) and (31b).

$$\left.\begin{aligned} F_1^{Apu} &= f_1^{pu}Y_1 + r_1^*B_1^D \qquad (38a)\\ F_2^{Apu} &= f_2^{pu}Y_2 + r_2^*B_2^D \qquad (38b)\end{aligned}\right\} \text{ according to (5), (23), (24)}$$

$$\left.\begin{aligned} F_1^{Epu} &= \nu \sum_i \left(f_i^{pu}Y_i + r_i^*B_i^D\right) \qquad (39a)\\ F_2^{Epu} &= (1 - \nu) \sum_i \left(f_i^{pu}Y_i + r_i^*B_i^D\right) \qquad (39b)\end{aligned}\right\} \text{ according to (6), (27), (37a), (37b)}$$

$$F_1^{Apr} = v_{12}(1 - h_2)(1 - \nu) \sum_i \left(f_i^{pu}Y_i + r_i^*B_i^D\right) \tag{40}$$

according to (27), (32) and (36b)

$$F_1^{Epr} = v_{21}(1 - h_1)\nu \sum_i \left(f_i^{pu}Y_i + r_i^*B_i^D\right) \tag{41}$$

according to (27), (33) and (36a)

[6] We shall now derive regional investments in explicit form. Starting from (28) and considering (3), (10a), (11b), (22), (29), (30), (40) and (41) we obtain for private investment in R1 (without considering capital subsidies)

$$I_1^{pr} = \left(s_1^{pr} + \varphi\,(f_1^{pu} + \frac{r_1^*}{b_1}) - \bar{i}_{12}\,\frac{r_2}{r_1}\right) X_1 +$$

$$+ \left(\bar{i}_{21}\,\frac{r_1}{r_2} + \varphi\,(f_2^{pu} + \frac{r_2^*}{b_2})\right) X_2 +$$

$$+ r_2\left(s_1^{pr} + \varphi\,(f_1^{pu} - f_2^{pu}) - 1\right) W_{12} +$$

$$+ r_1\left(1 - s_1^{pr} - \varphi\,(f_1^{pu} - f_2^{pu})\right) W_{21} \qquad (42a)$$

with

$$\varphi = v_{21}(1 - h_1)\,\nu - v_{12}(1 - h_2)(1 - \nu)$$

Analogously, we get for private investment in R2, starting from (28) and taking into account (3), (10a), (11b), (22), (29), (30), (31a), (31b), (40) and (41),

$$I_2^{pr} = \left(s_2^{pr} - \varphi\,(f_2^{pu} + \frac{r_2^*}{b_2}) - \bar{i}_{21}\,\frac{r_1}{r_2}\right) X_2 +$$

$$+ \left(\bar{i}_{12}\,\frac{r_2}{r_1} - \varphi\,(f_1^{pu} + \frac{r_1^*}{b_1})\right) X_1 +$$

$$+ r_1\left(s_2^{pr} + \varphi\,(f_1^{pu} - f_2^{pu}) - 1\right) W_{21} +$$

$$+ r_2\left(1 - s_2^{pr} - \varphi\,(f_1^{pu} - f_2^{pu})\right) W_{12}\,. \qquad (42b)$$

Combining (6), (32), (33) and (34) we have

$$I_1^{puJ} = I_1^{pu} - G_1^{pu} = F_1^{Epu} - \frac{1}{v_{21}}\,F_1^{Epr} \qquad (43a)$$

$$I_2^{puJ} = I_2^{pu} - G_2^{pu} = F_2^{Epu} - \frac{1}{v_{12}}\,F_1^{Apr} \qquad (43b)$$

[7] We assume the following relationships for net migration from R1 to R2 (and vice versa).

$$L_{12} = \tilde{L}_{12} + \tilde{\tilde{L}}_{12}, \qquad L_{21} = - L_{12} \tag{44}$$

with

$$\tilde{L}_{12} = \begin{cases} e^1_{12}(w_2 - w_1)L_1, & \text{if } w_1 < w_2 \\ e^2_{12}(w_2 - w_1)L_2, & \text{if } w_1 \geq w_2 \end{cases}$$

$$\tilde{\tilde{L}}_{12} = \begin{cases} d^1_{12} \left[\dfrac{L^S_1 - L^D_1}{L^S_1} - \dfrac{L^S_2 - L^D_2}{L^S_2} \right]_{t-dt}, & \text{if } \dfrac{L^S_1 - L^D_1}{L^S_1} > \dfrac{L^S_2 - L^D_2}{L^S_2} \\ d^2_{12} \left[\dfrac{L^S_1 - L^D_1}{L^S_1} - \dfrac{L^S_2 - L^D_2}{L^S_2} \right]_{t-dt}, & \text{if } \dfrac{L^S_1 - L^D_1}{L^S_1} \leq \dfrac{L^S_2 - L^D_2}{L^S_2} \end{cases}$$

The wage rates w_i $(i,j = 1,2)$ are determined by (20), e^1_{12}, e^2_{12}, d^1_{12}, and d^2_{12} being nonnegative parameters.

[8] The relationships indicating the changes in the stocks of capital, labor and wealth form the basis of alternative systems of differential equations. These changes-of-stocks relationships are as follows.

$$\frac{dK^S_i}{dt} = I^{pr}_i + \begin{cases} \dfrac{1}{v_{21}} F^{Epr}_1 & \text{for } i = 1 \\ \dfrac{1}{v_{12}} F^{Apr}_1 & \text{for } i = 2 \end{cases} \tag{45}$$

I^{pr}_i is given by (42a) and (42b) in the case of example (10a) - (12b); the terms on the right-hand side of the bracket in (45) are equal to G^{pu}_i $(i = 1,2)$ according to (32) and (33).

$$\frac{dB^S_i}{dt} = I^{puJ}_i \tag{46}$$

I_i^{puJ} stems from (43a) or (43b).

$$\frac{dL_1^S}{dt} = n_1 L_1^S - \tilde{L}_{12} - \tilde{\tilde{L}}_{12} = n_1 L_1^S - L_{12} \tag{47a}$$

$$\frac{dL_2^S}{dt} = n_2 L_2^S + \tilde{L}_{12} + \tilde{\tilde{L}}_{12} = n_2 L_2^S + L_{12} \tag{47b}$$

For $\tilde{L}_{12}$ and $\tilde{\tilde{L}}_{12}$ see (44); n_i is the given growth rate of the natural labor force of region i.

Changes of interregionally held private assets W_{ij} basically must be taken as

$$\frac{dW_{ij}}{dt} = Z_i + r_j W_{ij} - F_i^{Apu} + G_j^{pu}$$

or, referring to (29), as

$$\frac{dW_{ij}}{dt} = \bar{i}_{ij} \frac{r_j}{r_i} X_i + F_i^{Apr} + r_j W_{ij} + G_j^{pu}$$

The variable G_j^{pu} is explained by (36a) and (36b).

However, considering our specific problem at hand, we base our calculations on the following different approach.

$$\frac{dW_{12}}{dt} = \bar{i}_{12} \frac{r_2}{r_1} X_1 - \bar{i}_{21} \frac{r_1}{r_2} X_2 + r_2 W_{12} - r_1 W_{21} + F_1^{Apr} + G_2^{pu} \tag{48a}$$

and

$$\frac{dW_{21}}{dt} = F_2^{Apr} + G_1^{pu} \tag{48b}$$

The reasons, in view of the economic potential of R1, are as follows (assuming $\bar{i}_{12} \frac{r_2}{r_1} X_1 - \bar{i}_{21} \frac{r_1}{r_2} X_2 + r_2 W_{12} - r_1 W_{21} = U$ and $r_1 > r_2$):

(1) If $U > 0$ in the case of an excess supply of private capital in

R1, it makes sense for R1 to invest the amount of resources U in R2. (2) If $U < 0$, it pays for R1 to reduce W_{12} instead of increasing W_{21} with regard to the interregional difference in interest rates.

Regarding the differential equations (45) - (48) we must observe that the changes in stocks are partly functions of regional incomes Y_i which according to (3) may be substituted by X_i. For this variable we introduce the production relationships corresponding to (10a) and (10b). Then the differential equation system related to a specific situation of growth limiting factor shortages in the regions becomes evident. Due to the model structure, particularly due to the existence of the regional growth barriers, such a system may not be solved analytically but must be treated numerically.

Our example of production approach (10a) and (10b) basically implies a system of the following four differential equations.

$$\begin{aligned}
\frac{dB_1}{dt} &= f_1(B_1,\ K_2,\ W_{12},\ W_{21}) \\
\frac{dK_2^S}{dt} &= f_2(B_1,\ K_2,\ W_{12},\ W_{21}) \\
\frac{dW_{12}}{dt} &= f_3(B_1,\ K_2,\ W_{12},\ W_{21}) \\
\frac{dW_{21}}{dt} &= f_4(B_1,\ K_2,\ W_{12},\ W_{21})
\end{aligned} \tag{49}$$

[9] Finally we shall turn again to income distribution. According to (3) and (9) we have

$$Y_i = X_i + r_j W_{ij} - r_i W_{ji} =$$

$$= r_i\left(K_i^D - W_{ji}\right) + r_j W_{ij} + w_i L_i^D + r_i^* B_i^D \qquad (50a)$$

or, according to (16), (18) and (20),

$$X_i = r_i K_i^D + w_i L_i^D + r_i^* B_i^D = k_i g_i K_i^D + a_i(1 - c_i - g_i)L_i^D + b_i c_i B_i^D \qquad (50b)$$

Observe also that with respect to (3)

$$\sum_i Y_i = \sum_i X_i \qquad (51)$$

Relationships (50b) and (51) are the basis of income distribution according to income shares g_i and c_i. The terms cancelling out in (50a) refer to interregional income distribution due to the regional accumulation of wealth.

2.3 Selected Aspects of Model Extension

[1] We shall now introduce the outside world as a third region, thus dropping here the closed-economy assumption. In particular we shall assume, in order to have a concrete case, the occurance of a foreign non-interest-bearing capital inflow into either of the two regions or the state. (The postulated absence of interest payments to the rest of the world has the advantage of limiting the number of necessary changes to the model.) Depending on which will be the finally beneficiary region, R1 or R2, and on the private or public nature of the foreign credit, relationship (30) for R1 must be extended by adding M_{10}^{pr} or M_{10}^{pu} (private or public means to R1), correspondingly for R2 by adding M_{20}^{pr} or M_{20}^{pu} (private or public resources to R2).

In greater detail, the following cases may be distinguished. (a) If we have to deal with private capital imports, we have to add M_{10}^{pr} and/or M_{20}^{pr} to I_1^{pr} and/or I_2^{pr} in (42a) and/or (42b), respectively. Since we

shall assume that R2 suffers from a lack of private capital, the increase of I_2^{pr} by M_{20}^{pr} and its system-wide effects will be highly interesting. (b1) Public capital imports M_0^{pu} may be donated to the state who distributes these means in the form $M_{10}^{pu} = \nu M_0^{pu}$ to R1 and $M_{20}^{pu} = (1 - \nu)M_0^{pu}$ to R2, correspondingly augmenting F_1^{Epu} and F_2^{Epu} according to (39a) and (39b). The disadvantage of this case is that the development impact, especially for R2, will be relatively low. (b2) Therefore, we may directly concentrate on boosting R2's public investment I_2^{pu} by M_{20}^{pu} that must be added on the right-hand side of (37b) and (39b). Public resources M_{20}^{pu} are distributed to infrastructure investment I_2^{puJ} and attraction means G_2^{pu} according to (35b) and (36b). These two relationships are the starting points, if foreign public capital is dedicated specifically to either R2's infrastructure investment or its attraction resources; in both instances the full amount M_{20}^{pu} must be considered. The disadvantages of these possibilities are, on the one hand, that R2's infrastructure capital may not constitute the decisive growth barrier and, on the other hand, the increase of R2's attraction funds implies the additional transfer of resources from R1 to R2; this brings us back to the zero-sum investment context of the model.

[2] Another possible extension of the model would arise from the disaggregation of variables, allowing structural phenomena to come more strongly into the foreground. Within such a framework we may also discuss the question of the significance of the relative size of the rich region R1 compared to the poor region R2. Size can be represented by the criteria population or area, differentiating the analysis with reference to the level of development expressed by income per capita. Taking population as the decisive size indicator we would need a

different model incorporating mainly per capita variables. While we must admit that our empirical knowledge on the relationships of such a regional model is rather unsatisfactory, the data situation is even worse when taking areal dimension as the criterion of size in order to discuss the effects of its changes or of different levels on model variables and parameters. In addition, we must consider that a differentiating variable such as per capita income does not show up directly in the present model, although it may be derived within the context of the numerical calculations. To give an example of the complexity of the issue at hand, the regional private export and import ratios Z_i^{pr}/X_i and M_i^{pr}/X_j (cf. (29) and (30)) may rise or fall as functions of the regions' areas subject to changes in a number of factors such as spatial distribution of resources, spatial factor intensities, goods composition of production, expenditure pattern of population and quality of transport networks, all of these factors belonging to the realm of a disaggregated analysis.

Let us bear in mind that, in the present basically macroeconomic model, the areas of the regions R1 and R2 are constant and given. Their size effects on, for example, factor productivities, interregional trade, migration and policy decisions are assumed to have been taken into account in the context of the determination of numerical parameters.

[3] In order to adjust demand-side real income to supply-side real income (or vice versa) in the case of given independent regional investment functions the adjustment mechanism must be conceived in such a way as to guarantee simultaneously regional and national

income equilibrium.[11] Let us assume the validity of simple linear private and public investment functions of the type $I_i = f_i(Y_i)$ so that equilibrium regional demand-side real incomes Y_i^D (according to relationship (1)) may be determined. Now if we succeed in equalizing Y_i^D with Y_i^S (the regional supply-side incomes of relationship (3)), then we also establish national income equilibrium.

The economic implications of the adjustment mechanism may be discussed for the case of R1, specifically $Y_1^D > Y_1^S$, as an example (Figure 3).

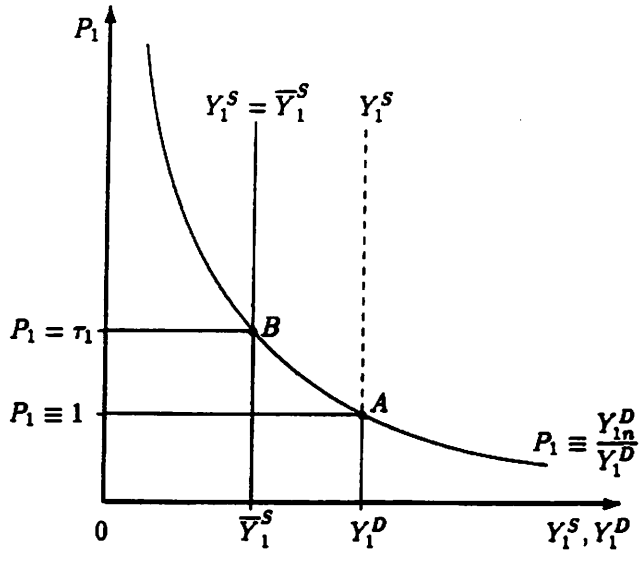

Figure 3: Income Equilibrium of R1

Assume that the unspecified regional price level P_1 is set equal to 1 at the start of the calculations for a certain period (for instance, iteration step or year) so that $Y_1^D = Y_{1n}^D = Y_1^S$ (the subscript n refers to a nominal value) at a given initial equilibrium (point A). The

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[11] An alternative adjustment procedure may be found in Buhr 1984, pp. 152-153.

problem situation (point B) may be thought to have come into existence by a shift of the regional supply curve Y_1^S to the left, to $\bar{Y}_1^S$. Then in the final regional equilibrium B the price level P_1 is equal to the adjustment parameter

$$\tau_1 = \frac{Y_1^D}{Y_1^S} = \frac{Y_{1n}^D}{Y_1^S} = \frac{Y_{1n}^D}{Y_1^D} \equiv P_1 > 1$$

by which we must divide Y_1^D (case of demand reduction) or multiply Y_1^S (case of supply increase).

The case of demand reduction is also demonstrated in Figure 2 where the demand equilibrium at point G is to be substituted by the demand-supply equilibrium at H. In Figure 2, for instance, autonomous investment and consumption of region i are cut by the factor τ_i.

Now looking at the two regions and assuming $Y_i^D > Y_i^S$ the national price level P is equal to

$$\tau = \frac{\sum_i \tau_i Y_i^S}{\sum_i Y_i^S} = \frac{\sum_i Y_i^D}{\sum_i \frac{1}{\tau_i} Y_i^D}$$

The price levels for the period under consideration may be calculated for alternative periods and then linked in a chain over time so that we obtain them in a continuous form. For instance, the national price level at time t is

$$P_t = \frac{\tau_t}{\tau_{t-1}}$$

If $Y_i^D < Y_i^S$ for a specific region i and additionally Y_i^S has to be reduced then demand of region i is a growth barrier. Modelling the adaptability of the supply side is beyond the scope of this paper.

3. Concluding remarks

We have discussed above two alternative allocation strategies of regional economic growth policy, namely passive factor stocks adjustment in favor of the advanced regions ("movement of the workers to the jobs") and active factor stocks adjustment in favor of the backward regions ("movement of the jobs to the workers"). The model - designed to analyze the economic implications of these strategies for two polarized groups of regions (developed regions vs. backward areas) - is essentially characterized by the existence of regional supply-side growth barriers determined by the availability of the regional factor stocks private capital, material infrastructure and labor. Moreover, the model guarantees regional demand-supply equilibrium by a simplified approach whose possible extensions have been referred to.

Two tasks remain to be addressed. The first of these concerns study of the properties of the model on the basis of parameters representative for the case of passive adjustment policy. Then the second task involves the step towards active regional economic policy, varying essentially three policy parameters in order to deepen our insight into the workings of the model: the underdeveloped regions' share in national public savings, the volume of the backward areas' public funds for capital subsidies competing with public expenditures on infrastructure investments and the percentage of these capital subsidies in relation to matching private capital attracted from the prosperous regions.

The policy simulation results will be described in the second part of this paper.

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