Volkswirtschaftliche Diskussionsbeiträge

VWL

A Macroeconomic Growth Model of Competing Regions

Walter Buhr

University of Siegen

Discussion Paper No. 90-00

ISSN 1433-058x

UNIVERSITÄT GESAMTHOCHSCHULE SIEGEN
FACHBEREICH WIRTSCHAFTSWISSENSCHAFTEN

A Macroeconomic Growth Model of Competing Regions

*Walter Buhr**

I. Characteristics of the Model

The Problem. In the growth context, this paper[1] concentrates on the supply-demand determination of regional equilibrium incomes in regional goods markets as a framework for discussing the implications of competition among regions. Prices at the regional and national level are fixed so that all variables are of real magnitudes; there are no money markets. Regional factor stocks (private and public capital, labor force in the form of human capital) and regional demand set up the barriers to economic growth (cf. generally Barro, Sala-i-Martin (1995)). The analysis is restricted to two regions embedded in the State. The supply side of the model is represented by different regional production functions which generate regional factor demand. Demand-side determination of equilibrium regional incomes arises from the definitions of national accounting enriched by basic behavioral relationships. Substantial consideration is given to the equalization of regional supply and demand in diverging cases (e. g., excess demand in one of the two regions). Changes in factor stocks (differential equations) maintain the dynamics of the model. Regional competition is expressed by variations of regional and state parameters. Their numerical influences on growth will be dealt with in Bobzin (2000).

We assume there are two regions R1 and R2 comprising the State.[2] Figure 1 describes essential linkages: ① Public resources F_{iS}^{pu} $(i = 1, 2)$ are transferred from the public sector of region i to the State. ② These resources F^{pu} are redistributed in the form F_{Si}^{pu} to the regions. ③ Total private exports Ex_i^{pr} $(i = 1, 2)$ of region i include goods exports Z_i^{pr} and transfers of private investment F_{ij}^{pr} (e. g., F_{12}^{pr} meaning transfers from R1 to R2). The link ④ correspondingly sets up total private imports of region i, Im_i^{pr}. ⑤ Migration L_{12} from R1 to R2 refers to educated and raw labor, L_{12}^{edu} and L_{12}^{raw}, respectively.

Competition. Economic growth is taken as the result of competing intraregional and interregional activities. Accordingly, the actors of competition are the households, the firms and the public sectors of the regions, on the one hand, and the

* University of Siegen, Siegen/Germany.

[1] The basic idea for the present approach stems from a paper by Buhr (1995), which has been changed in some essential aspects.

[2] For a multi-area approach cf. Treyz, Rickman, Shao (1992).

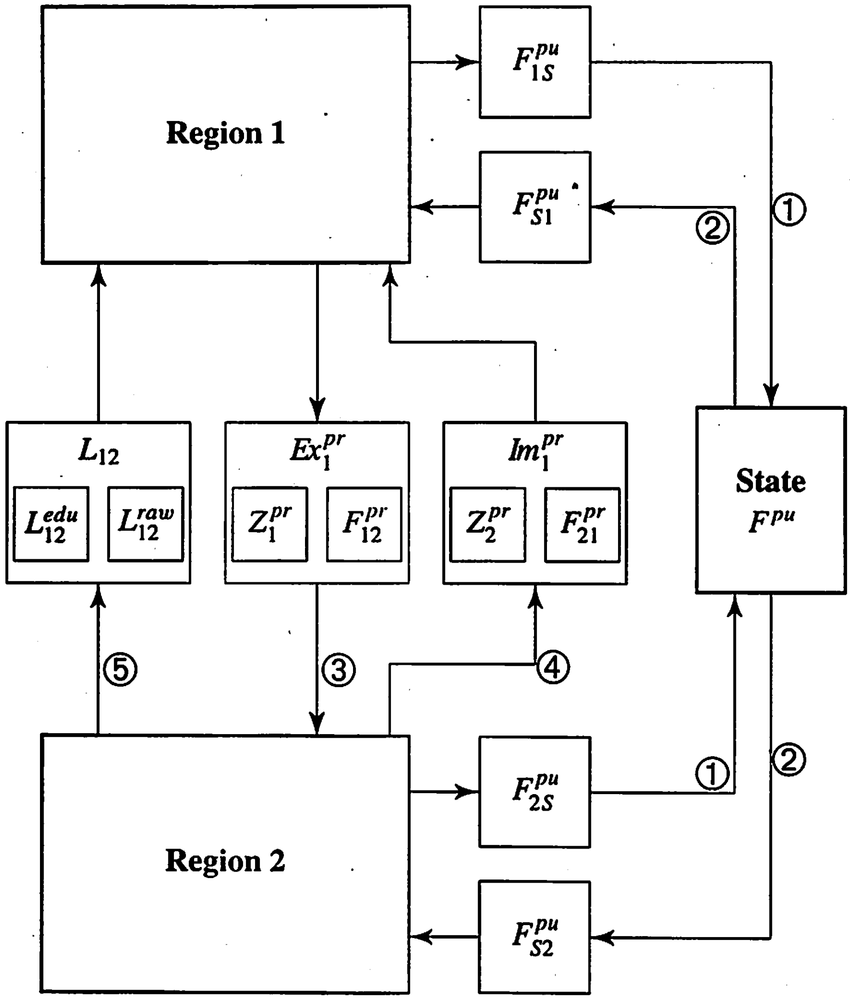

Figure 1: Linkages of the model

State, on the other hand. The instruments of competition appear in the form of parameters under the control of different institutional agents of economic activities. For example:

- the marginal rate of consumption (households of a region),
- production parameters (firms of a region),
- tax rate (public sector of a region)

and

- parameter of distributing state funds among the regions.

Processes of regional competition such as interactions between economic agents of the same region or of other regions are not discussed in this model. Here the basis is laid to follow up numerically the immediate effects and the final results or regional competition.

II. Supply Side of the Model

Regional Production. The analysis is based on nested CES production functions, e. g. for R1 output X_1 is a function of the stock of human capital H_1, the private capital stock K_1 and the stock of infrastructure capital B_1.

$$\begin{aligned} X_1 &= f_1(H_1, K_1, B_1) \\ &= A_1 \left[\alpha_1^H (a_1 H_1)^{\rho_1} + \alpha_1^K (k_1 K_1)^{\rho_1} + \alpha_1^B (b_1 B_1)^{\rho_1}\right]^{1/\rho_1} \end{aligned}$$

with $\alpha_1^H + \alpha_1^K + \alpha_1^B = 1$ and $0 \leq \alpha_1^H, \alpha_1^K, \alpha_1^B \leq 1$.
We assume[3]

$$\begin{aligned} a_1 &= a_{10} + a_{11} t + a_{12} B_1^S + a_{13} K_1^S \\ k_1 &= k_{10} + k_{11} t + k_{12} B_1^S + k_{13} K_1^S \\ b_1 &= b_{10} + b_{11} t, \end{aligned}$$

all parameters being positive, except $k_{13} < 0$.
For $\rho_1 \to 0$ (i. e., the elasticity of substitution $\sigma_1 = 1/(1-\rho_1) = 1$), the CES function becomes a linear-homogeneous Cobb-Douglas production function

$$X_1 = A_1 (a_1 H_1)^{\alpha_1^H} (k_1 K_1)^{\alpha_1^K} (b_1 B_1)^{\alpha_1^B}$$

The constants $\alpha_1^H, \alpha_1^K, \alpha_1^B$ here are the factor shares in output.
For $\rho_1 \to -\infty$ (i. e., $\sigma_1 = 0$) the CES function approaches a linear-limitational production function

$$X_1 = A_1 \, min\{a_1 H_1, k_1 K_1, b_1 B_1\}$$

In this case the coefficients a_1, k_1, b_1 are the average productivities of the inputs. Human capital H_i is aggregated by a linear-homogeneous CES function of educated and raw labor, L_i^{edu} and L_i^{raw}, respectively ($i = 1, 2$). For R1 we get

$$\begin{aligned} H_1 &= g_1(L_1^{edu}, L_1^{raw}) \\ &= A_1^H \left[\varphi_1 (a_1^{edu} L_1^{edu})^{\omega_1} + (1-\varphi_1)(a_1^{raw} L_1^{raw})^{\omega_1}\right]^{1/\omega_1}, \end{aligned}$$

[3] Index S refers to supply, index D to demand.

where $0 \leq \varphi_1 \leq 1$.
As long as L_1^{edu} and L_1^{raw} are not perfect substitutes, $\omega_1 < 1$ must apply.
In addition

$$a_1^{edu} = a_{10}^{edu} + a_{11}^{edu} B_1^{edu} + a_{12}^{edu} K_1^{dev}$$
$$a_1^{raw} = a_{10}^{raw} + a_{11}^{raw} B_1^{edu},$$

where B_i^{edu} represents the level of education of region i and K_i^{dev} the pool of knowledge for research and development (R&D) of region i ($i = 1, 2$). It is assumed that the outputs X_i of the regions will be produced at minimum cost at every point of time. Let us turn to the general production case.
Taking again R1 as the reference region, the cost minimum rental rate of human capital is given by

$$w_1 := (w_1^{edu} + \zeta_1 w_1^{raw})/\psi_1$$

where

$$\zeta_1 := \left(\frac{w_1^{raw} \varphi_1 (a_1^{edu})^{\omega_1}}{w_1^{edu}(1 - \varphi_1)(a_1^{raw})^{\omega_1}} \right)^{\frac{1}{\omega_1 - 1}}$$
$$\psi_1 := A_1^H \left[\varphi_1 (a_1^{edu})^{\omega_1} + (1 - \varphi_1)(a_1^{raw})^{\omega_1} \zeta_1{}^{\omega_1} \right]^{1/\omega_1}.$$

Thus w_1 is linear-homogeneous in the two wage rates w_1^{edu} and w_1^{raw} (the function ζ_1 and therefore ψ_1 are homogeneous of degree 0 in the wage rates).

Factor Demand. The demand for the factors of production in R1 may be expressed as

$$\begin{pmatrix} H_1^D \\ K_1^D \\ B_1^D \end{pmatrix} = \begin{pmatrix} a_1{}^{-\beta_1} (w_1/\alpha_1^H)^{\beta_1 - 1} \\ k_1{}^{-\beta_1} (r_1/\alpha_1^K)^{\beta_1 - 1} \\ b_1{}^{-\beta_1} (r_1^*/\alpha_1^B)^{\beta_1 - 1} \end{pmatrix} \frac{X_1}{A_1} Z_1{}^{-1/\rho_1}.$$

where (r_1 = rental rate of private capital in R1, r_1^* = rental rate of infrastructure capital in R1)

$$\beta_1 := \rho_1/(\rho_1 - 1)$$
$$Z_1 := (\alpha_1^H)^{1-\beta_1} \left(\frac{w_1}{a_1}\right)^{\beta_1} + (\alpha_1^K)^{1-\beta_1} \left(\frac{r_1}{k_1}\right)^{\beta_1} + (\alpha_1^B)^{1-\beta_1} \left(\frac{r_1^*}{b_1}\right)^{\beta_1}$$

Moreover,

$$L_1^{edu,D} = H_1^D/\psi_1$$
$$L_1^{raw,D} = \zeta_1 H_1^D/\psi_1$$

Provided both kinds of labor are payed by their monetary marginal productivity, total payment to human capital in R1 amounts to (P_1 = price level of R1)

$$w_1 H_1^D = P_1 \frac{\partial X_1}{\partial H_1} \frac{\partial H_1}{\partial L_1^{edu.}} L_1^{edu,D} + P_1 \frac{\partial X_1}{\partial H_1} \frac{\partial H_1}{\partial L_1^{raw}} L_1^{raw,D}$$
$$= w_1^{edu} L_1^{edu,D} + w_1^{raw} L_1^{raw,D}$$

The consideration of the linear-homogeneous formation of human capital, the adding up theorem and the regional price level lead to the cost function of R1

$$c_1(w_1, r_1, r_1^*, X_1) = \frac{X_1}{A_1} Z_1^{1/\beta_1} = P_1 X_1$$
$$\text{or} \quad Z_1{}^{1/\beta_1}/A_1 = P_1$$

Factor Prices. The implied rental rate of human capital turns out to be

$$w_1 = a_1 (\alpha_1^H)^{\frac{\beta_1 - 1}{\beta_1}} \left[(P_1 A_1)^{\beta_1} - (\alpha_1^K)^{1-\beta_1} \left(\frac{r_1}{k_1}\right)^{\beta_1} - (\alpha_1^B)^{1-\beta_1} \left(\frac{r_1^*}{b_1}\right)^{\beta_1} \right]^{1/\beta_1}$$

Wage rate of educated labor is defined as w_1^{edu}:

(a) Suppose that the time path of w_1^{raw} is determined by

$$w_1^{raw}(t) = w_1^{raw}(0) + \delta_1^{raw} t,$$

then the calculation of w_1^{edu} from w_1^{raw} and w_1 amounts to

$$w_1^{edu} = \left(\frac{\pi_1{}^{\frac{\omega_1}{1-\omega_1}} \varphi_1 (a_1^{edu})^{\omega_1}}{1 - \pi_1{}^{\frac{\omega_1}{1-\omega_1}} (1 - \varphi_1)(a_1^{raw})^{\omega_1} \pi_2{}^{\omega_1}} \right)^{\frac{1-\omega_1}{\omega_1}}$$

$$\text{where} \quad \pi_1 := w_1 A_1^H \varphi_1 (a_1^{edu})^{\omega_1}$$

$$\text{and} \quad \pi_2 := \left(\frac{w_1^{raw} \varphi_1 (a_1^{edu})^{\omega_1}}{(1 - \varphi_1)(a_1^{raw})^{\omega_1}} \right)^{\frac{1}{\omega_1 - 1}}$$

(b) If we assume that the labor market perfectly adjusts the wage rates of educated and raw labor so that

$$\frac{w_1^{edu}}{w_1^{raw}} = \frac{\varphi_1 (a_1^{edu})^{\omega_1} (L_1^{edu,S})^{\omega_1 - 1}}{(1 - \varphi_1)(a_1^{raw})^{\omega_1} (L_1^{raw,S})^{\omega_1 - 1}}.$$

then the two wage rates may be calculated as follows. Setting

$$\zeta_1 = \frac{L_1^{raw,S}}{L_1^{edu,S}}$$

we have, considering that $w_1 = P_1 \partial X_1 / \partial H_1$

$$
\begin{aligned}
w_1^{edu} &= w_1 \frac{\partial H_1^D}{\partial L_1^{edu}} \\
&= w_1 A_1^H \left[\varphi_1 (a_1^{edu})^{\omega_1} + (1-\varphi_1)(a_1^{raw}\zeta_1)^{\omega_1}\right]^{\frac{1-\omega_1}{\omega_1}} \varphi_1 (a_1^{edu})^{\omega_1} \\
w_1^{raw} &= w_1 \frac{\partial H_1^D}{\partial L_1^{raw}} \\
&= w_1 A_1^H \left[\varphi_1 (a_1^{edu})^{\omega_1} + (1-\varphi_1)(a_1^{raw}\zeta_1)^{\omega_1}\right]^{\frac{1-\omega_1}{\omega_1}} (1-\varphi_1)(a_1^{raw})^{\omega_1} \zeta_1{}^{\omega_1 - 1}
\end{aligned}
$$

where all terms are known. This procedure implies that educated and raw labor will always have the same rate of unemployment as human capital.
The rental rates r_1 and r_1^* are constants. Starting with an initial value of P_1 the rental rate of human capital is determined. It will be changed by technical progress, i. e. a_1, k_1, and b_1 will vary over time.

Special Aspects of Production. Under modified production conditions factor demand and factor prices will change.

- Linear-homogeneous Cobb-Douglas production function:
  In this case factor demand is

$$
\begin{pmatrix} H_1^D \\ K_1^D \\ B_1^D \end{pmatrix} = \begin{pmatrix} \alpha_1^H / w_1 \\ \alpha_1^K / r_1 \\ \alpha_1^B / r_1^* \end{pmatrix} \frac{X_1}{A_1} Z_1,
$$

  where the factor shares sum up to one: $\alpha_1^H + \alpha_1^K + \alpha_1^B = 1$. The rental rate of human capital is obtained as

$$
w_1 = \alpha_1^H a_1 \left[P_1 A_1 \left(\frac{r_1}{\alpha_1^K k_1}\right)^{-\alpha_1^K} \left(\frac{r_1^*}{\alpha_1^B b_1}\right)^{-\alpha_1^B} \right]^{1/\alpha_1^H} .
$$

  The wage rate w_1^{edu} must be calculated according to case a) of the CES function for a given wage rate w_1^{raw}.

- Linear-limitational production function:
  Here factor demand is

$$
\begin{pmatrix} H_1^D \\ K_1^D \\ B_1^D \end{pmatrix} = \begin{pmatrix} 1/a_1 \\ 1/k_1 \\ 1/b_1 \end{pmatrix} \frac{X_1}{A_1}.
$$

  The rental rate of human capital turns out to be

$$
w_1 = a_1 \left(1 - \frac{r_1}{k_1} - \frac{r_1^*}{b_1}\right) P_1 A_1
$$

with factor shares $w_1/a_1, r_1/k_1, r_1^*/b_1$.
The wage rate w_1^{edu} must again be determined according to case a) of the CES function for a given wage rate w_1^{raw}.

Restricted Factor Supply. The labor supply barriers are introduced by

$$L_1^{edu,D} \leq L_1^{edu,S}, \; L_1^{raw,D} \leq L_1^{raw,S}.$$

Maximum supply of human capital then is

$$H_1^S = \psi_1 \, min\{L_1^{edu,S}, \, L_1^{raw,S}/\zeta_1\},$$

since, as given above, $L_1^{edu} = H_1/\psi_1$ and $L_1^{raw} = \zeta_1 H_1/\psi_1$.
The demand for human, private, and public capital is also restricted by supply.

$$H_1^D \leq H_1^S, \; K_1^D \leq K_1^S, \; B_1^D \leq B_1^S$$

Potential output (Z_1 and w_1 appropriately determined):

- CES case:

$$X_1^{pot} = A_1 \, Z_1{}^{1/\rho_1} \, min \left\{ \frac{H_1^S \, a_1{}^{\beta_1}}{(w_1/\alpha_1^H)^{\beta_1 - 1}}, \; \frac{K_1^S \, k_1{}^{\beta_1}}{(r_1/\alpha_1^K)^{\beta_1 - 1}}, \; \frac{B_1^S \, b_1{}^{\beta_1}}{(r_1^*/\alpha_1^B)^{\beta_1 - 1}} \right\}$$

- Cobb-Douglas case:

$$X_1^{pot} = \frac{A_1}{Z_1} \, min \left\{ \frac{w_1 H_1^S}{\alpha_1^H}, \; \frac{r_1 K_1^S}{\alpha_1^K}, \; \frac{r_1^* B_1^S}{\alpha_1^B} \right\}$$

- Linear-limitational production case:

$$X_1^{pot} = A_1 \, min \, \{a_1 H_1^S, \; k_1 K_1^S, \; b_1 B_1^S\}$$

Demand Barriers. Introducing the Hahn-Negishi rule of transactions (cf. Hahn, Negishi (1962)) we get

$$X_1^{eq} \leq min \, \{X_1^D, X_1^{pot}\}$$

Factor demand with respect to realized X_1^{eq} results from the above-mentioned relationships.
With reference to the given factor supply and the derived factor demand, we are now able to calculate the rates of factor stock idleness.

III. Demand-Side Determination of Equilibrium Regional Incomes

Regional Accounting. In order to be able to determine equilibrium regional incomes on the demand side we apply the principles of national accounting to the regions and the State. Each region is characterized by a private sector and a public sector (cf. Figure 2) whose retained incomes are $Y_i^{pr,r}$ and $Y_i^{pu,r}$, respectively ($i = 1, 2$). The outputs X_i of the private sectors are equal to total factor payments, that is, $w_i H_i^D + r_i K_i^D + r_i^* B_i^D$. The private sectors must raise direct taxes T_i and interest payments for the use of infrastructure capital supplied by the public

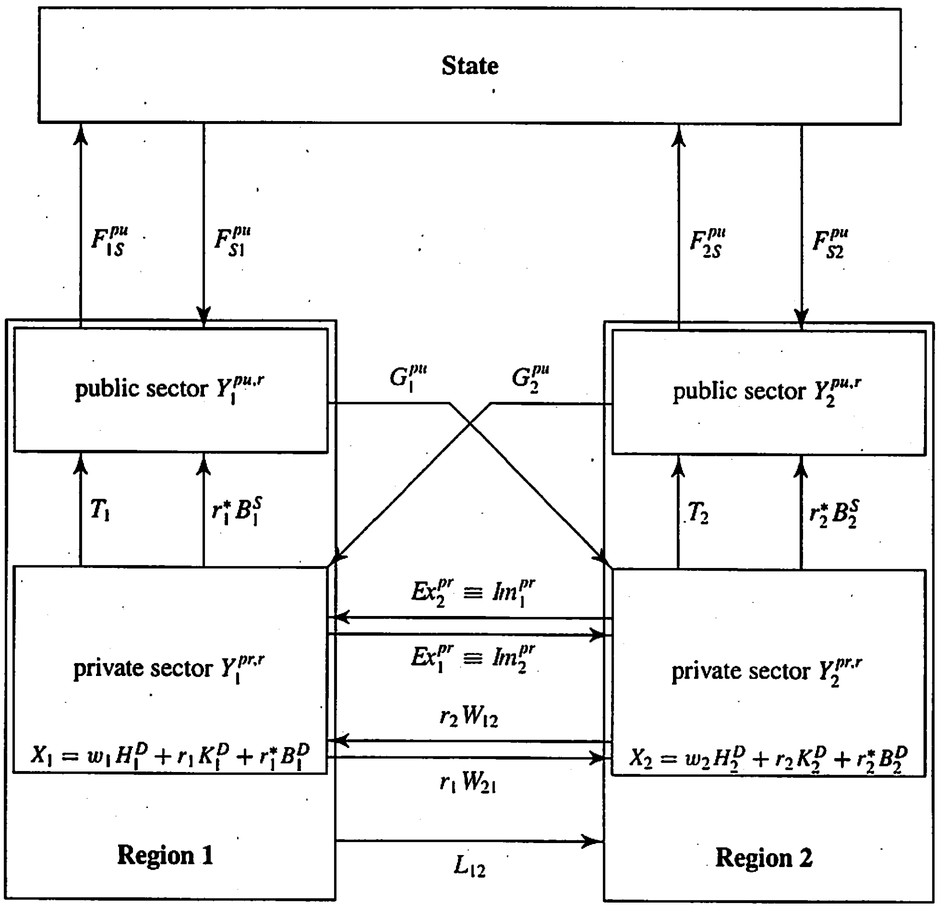

Figure 2: Private and public sectors of R1 and R2 and State

sectors, $r_i^* B_i^S$. Observe that there is no capital depreciation in both sectors of the regions. In addition, we assume balanced budgets for the public sectors of the regions and the State. An important interrelationship between the regions is formed by interregional interest payments on private assets held in the other region, for example $r_1 W_{21}$ refers to the interest payments of R1 on assets owned by R2 in R1 (r_i= rate of interest in region i). The symbol G_i^{pu} indicates public investment subsidies of region i granted to investors of the other region. All other relationships shown in Figure 2 have been discussed before.

For example, for R1 we get the following basic relationships of accounting.

R1's income:

$$Y_1 := X_1 + r_2 W_{12} - r_1 W_{21}$$

and factor distribution of R1's output:

$$X_1 := w_1 H_1^D + r_1 K_1^D + r_1^* B_1^D$$

where

$$w_1 H_1^D = w_1^{edu} L_1^{edu,D} + w_1^{raw} L_1^{raw,D} \quad \text{(total payment to R1's human capital)}$$

R1's retained private income:

$$\begin{aligned} Y_1^{pr,r} &:= Y_1 - r_1^* B_1^S - T_1 = (1 - t_1)(Y_1 - r_1^* B_1^S) \\ &= C_1^{pr} + I_1^{pr,dev} + S_1^{pr} \end{aligned}$$

R1's retained public income:

$$\begin{aligned} Y_1^{pu,r} &:= T_1 + r_1^* B_1^S + F_{S1}^{pu} - F_{1S}^{pu} = (1 - \tau_1)(T_1 + r_1^* B_1^S) + F_{S1}^{pu} \\ &= C_1^{pu} + S_1^{pu} + G_1^{pu} \end{aligned}$$

Behavioral Relationships. For R1 we introduce the following important behavioral relationships. Note that the variables and parameters of R1 not yet explained are C_1^{pr} for private consumption, C_1^{pu} for public consumption, S_1^{pr} for private savings, S_1^{pu} for public savings, $I_1^{pr,dev}$ for private expenditures on research and development (R&D), t_1 for the tax rate, τ_1 for the state share in the revenue of R1's public sector.

Private consumption function:

$$C_1^{pr} = c_1^{pr} Y_1^{pr,r}, \quad 0 < c_1^{pr} < 1$$

function of private expenditures on investment and research and development (R&D):

$$\tilde{I}_1^{pr} = I_1^{pr} + I_1^{pr,dev} = \frac{u_1}{r_1} Y_1^{pr,r} + u_1^{aut} K_1^S, \quad u_1 > 0, u_1^{aut} > 0$$

$$\text{where} \quad I_1^{pr,dev} = \varepsilon_1^{dev} \tilde{I}_1^{pr} \quad \text{with} \quad \varepsilon_1^{dev} = \varepsilon_{10}^{dev} + \varepsilon_{11}^{dev} H_1^S < 1$$

private investment function: $I_1^{pr} = (1 - \varepsilon_1^{dev})\tilde{I}_1^{pr}$

export function:

$$Ex_1^{pr} = Z_1^{pr} + F_{12}^{pr} \quad \text{with} \quad Z_1^{pr} = i_{12} \frac{r_2}{r_1} Y_2^{pr,r}, \quad i_{12} > 0$$

import function:

$$Im_1^{pr} = Z_2^{pr} + F_{21}^{pr} \quad \text{with} \quad Z_2^{pr} = i_{21} \frac{r_1}{r_2} Y_1^{pr,r}, \quad i_{21} > 0$$

public consumption function:

$$C_1^{pu} = c_1^{pu} Y_1^{pu,r}, \quad 0 < c_1^{pu} < 1$$

tax function:

$$T_1 = t_1(Y_1 - r_1^* B_1^S), \quad 0 < t_1 < 1$$

It is assumed that the public sector requires the payment of $r_1^* B_1^S$ instead of $r_1^* B_1^D$ (provided $B_1^D < B_1^S$), so that the difference $r_1^*(B_1^S - B_1^D)$ has the effect of an additional tax.
Public investment is residually determined.
Public investment:

$$I_1^{pu} = (1 - c_1^{pu}) Y_1^{pu,r} + F_{1S}^{pu} - F_{S1}^{pu}$$

public expenditure on education:

$$I_1^{pu,edu} = \varepsilon_1^{edu} I_1^{pu} \quad \text{with} \quad \varepsilon_1^{edu} = \varepsilon_{10}^{edu} + \varepsilon_{11}^{edu} Y_1^{pr,r} + \varepsilon_{12}^{edu} K_1^{dev} + \varepsilon_{13}^{edu} H_1^S < 1$$

public investment subsidies:

$$G_1^{pu} = h_1 I_1^{pu} \quad (h_1 > 0 \text{ small enough to guarantee } S_1^{pu} \geq 0\,).$$

Investments interregionally initiated by public investment subsidies are

$$F_{21}^{pr} = v_{21} G_1^{pu}, \quad v_{21} \geq 0,$$
$$F_{12}^{pr} = v_{12} G_2^{pu}, \quad v_{12} \geq 0.$$

State revenue is by definition

$$F^{pu} := F^{pu}_{1S} + F^{pu}_{2S}$$

$$\text{with} \quad F^{pu}_{1S} = \tau_1(T_1 + r_1^* B_1^S), \quad 0 < \tau_1 < 1, \text{ for R1, for example.}$$

State expenditures amount to

$$F^{pu}_{S1} = \nu F^{pu} \quad \text{and} \quad F^{pu}_{S2} = (1-\nu)F^{pu}, \quad 0 \leq \nu \leq 1.$$

Regional Equilibrium Incomes. By combining the above given relationships we obtain a system of simultaneous equations to calculate the goods market equilibrium incomes Y_1 and Y_2 of the regions:

$$I_1^{pr} = S_1^{pr} - Z_1^{pr} - F_{12}^{pr} + Z_2^{pr} + r_1 W_{21} - r_2 W_{12} - G_2^{pu}$$
$$I_2^{pr} = S_2^{pr} - Z_2^{pr} - F_{21}^{pr} + Z_1^{pr} + r_2 W_{12} - r_1 W_{21} - G_1^{pu}$$

or

$$Y_1 = \mathrm{f}_1(Y_2)$$
$$Y_2 = \mathrm{f}_2(Y_1)$$

as regional demand functions which intersect at (Y_1^D, Y_2^D), cf. Figure 3, for example.

IV. Equalization of Supply and Demand

Lack of Demand. Under regular circumstances regional supply and demand will not be equal, so that we must discuss the problem of adjustment for different cases (cf. Sneesens (1984, p. 190); Ramser, Stadler (1997, pp. 46–49)).
In the case of regional demand shortages, the regional demand functions are simultaneously fulfilled under the condition $Y_i^D \leq Y_i^{pot}$. Excess capacities (looking here only at R1) are eliminated by reducing potential output X_1 to X_1^{eq} so that

$$X_1^{eq} + r_2 W_{12} - r_1 W_{21} = Y_1^D < Y_1^{pot} = X_1 + r_2 W_{12} - r_1 W_{21}$$

Consequently, all three factors of production are unemployed and realized output X_1^{eq} implies

$$Y_1^D = Y_1^{eq} = w_1 H_1^D + r_1 K_1^D + r_1^* B_1^D + r_2 W_{12} - r_1 W_{21}$$
$$\text{where} \quad w_1 H_1^D = w_1^{edu} L_1^{edu,D} + w_1^{raw} L_1^{raw,D}$$

Excess Demand in One of the Two Regions. Let us assume that the regional demand functions generate the following inequalities

$$
\begin{aligned}
&Y_1^D < Y_1^{pot} \\
&Y_2^D > Y_2^{pot} = X_2 + r_1 W_{21} - r_2 W_{12} = Y_2^S = Y_2^{eq}
\end{aligned}
$$

Since Y_2^D cannot be realized, disposable incomes of R2 must be corrected downwards.

$$
\begin{aligned}
Y_2^{pr,r} &= (1 - t_2)(Y_2^{eq} - r_2^* B_2^S) \\
Y_2^{pu,r} &= (1 - \tau_2)[t_2 Y_2^{eq} + (1 - t_2) r_2^* B_2^S] + F_{S2}^{pu}
\end{aligned}
$$

With respect to R1 only exports Z_1^{pr} must be adjusted, since $Y_2^{pr,r}$ of R2 has fallen. The revised Y_1^D can be determined by inserting Y_2^{eq} into $Y_1 = \mathrm{f}_1(Y_2)$. For the lower $Y_1^{eq} = \mathrm{f}_1(Y_2^{eq})$ we get:

$$
\begin{aligned}
Y_1^{pr,r} &= (1 - t_1)(Y_1^{eq} - r_1^* B_1^S) \\
Y_1^{pu,r} &= (1 - \tau_1)[t_1 Y_1^{eq} + (1 - t_1) r_1^* B_1^S] + F_{S1}^{pu}
\end{aligned}
$$

Since Y_1^{eq} continues to indicate a demand-side equilibrium for R1, residually determined private investment I_1^{pr} according to the goods market equilibrium of R1 must be equal to the private investment demand shown in R1's gross savings and investment account.
Now in R2, income Y_2 falls if we introduce a reduced Y_1 ($Y_1^D \rightarrow Y_1^{eq}$) into $Y_2 = \mathrm{f}_2(Y_1)$. Suppose for this revised case $Y_2^{pot} < Y_2^{D,actual} = \mathrm{f}_2(\mathrm{f}_1(Y_2^{eq}))$, then the residually determined private investment I_2^{pr} according to the goods market equilibrium of R2 is smaller by the amount Γ than the private investment demand coming up in R2's gross savings and investment account: $\Gamma = I_2^{pr,D} - I_2^{pr} > 0$.
It can be shown that excess demand is created in the private sector.

$$
Y_2^{pr,r} = C_2^{pr} + \tilde{I}_2^{pr} + F_{12}^{pr} + G_1^{pu} - \Delta F_1^n < C_2^{pr,D} + \tilde{I}_2^{pr,D} + F_{12}^{pr} + G_1^{pu} - \Delta F_1^n
$$

where the sum of $F_{12}^{pr} + G_1^{pu}$ is determined by R1's public sector decision-making. Thus, it seems convincing to eliminate the balance $\Gamma = I_2^{pr,D} - I_2^{pr}$ with reference to private consumption C_2^{pr} and private investment $\tilde{I}_2^{pr} = I_2^{pr} + I_2^{pr,dev}$.

$$
\begin{aligned}
C_2^{pr} &= C_2^{pr,D} - \frac{C_2^{pr,D}}{\tilde{I}_2^{pr,D} + C_2^{pr,D}} \Gamma = C_2^{pr,D} \left(1 - \frac{\Gamma}{\tilde{I}_2^{pr,D} + C_2^{pr,D}} \right) \\
\tilde{I}_2^{pr} &= \tilde{I}_2^{pr,D} - \frac{\tilde{I}_2^{pr,D}}{\tilde{I}_2^{pr,D} + C_2^{pr,D}} \Gamma = \tilde{I}_2^{pr,D} \left(1 - \frac{\Gamma}{\tilde{I}_2^{pr,D} + C_2^{pr,D}} \right)
\end{aligned}
$$

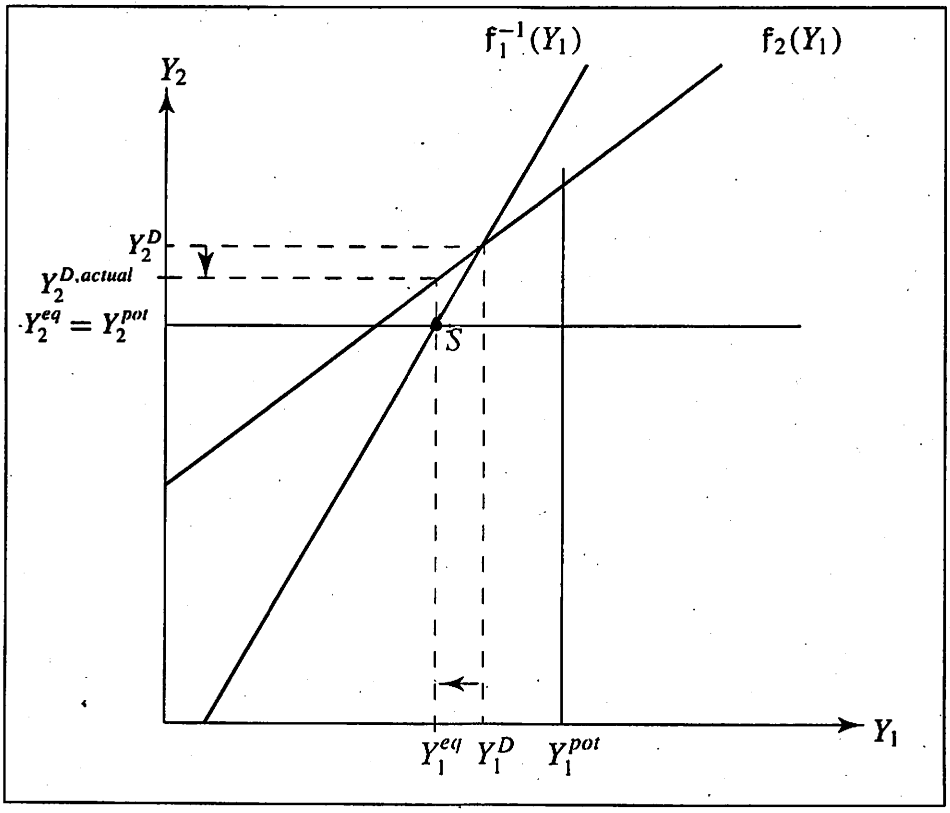

Figure 3: Excess demand in R2

By dividing both relationships we see that the proportion of private disposable income dedicated to C_2^{pr} and $\tilde{I}_2^{pr}$ will be spent in such a way that $C_2^{pr}/\tilde{I}_2^{pr}$ remains constant.
Then again

$$I_2^{pr} = \varepsilon_2^{dev}\tilde{I}_2^{pr} \quad \text{and} \quad I_2^{pr,dev} = (1 - \varepsilon_2^{dev})\tilde{I}_2^{pr}$$

The solution (point S in Figure 3) is:

$$Y_1^{eq} < Y_1^{pot}; \quad Y_2^{eq} = Y_2^{pot}$$

meaning for R1: all three factors of production are unemployed,
for R2: at least one factor is fully employed
in the framework of regional demand-supply equilibria.
Observe:

1. The described approach can only be applied, if the slope of the line $f_2(Y_1)$ is smaller than that of $f_1^{-1}(Y_1)$.

2. The corresponding problem $Y_1^D > Y_1^{pot}$, $Y_2^D < Y_2^{pot}$ can be solved analogously.

Excess Demand in Both Regions. If $Y_1^D > Y_1^{pot}$, $Y_2^D > Y_2^{pot}$, then calculate

$$Y_1^D > Y_1^{D,actual} = \mathfrak{f}_1(Y_2^{pot})$$
$$Y_2^D > Y_2^{D,actual} = \mathfrak{f}_2(Y_1^{pot})$$

according to the goods market equilibrium relationships of R1 and R2.
Now three cases are possible, subject to $Y_i^{D,actual} \gtreqless Y_i^{pot}$ $(i = 1, 2)$ (The slopes of the curves exclude the possibility that $Y_i^{D,actual} < Y_i^{pot}$ in both regions at the same time.).
Case 1: In both regions we have $Y_i^{D,actual} \geq Y_i^{pot}$ (cf. Figure 4) so that each region produces at full capacity. The resulting balances $\Gamma_i = I_i^{pr,D} - I_i^{pr}$ will be eliminated as described before.
The solution (point S in Figure 4) is:

$$Y_i^{eq} = Y_i^{pot}$$

meaning that in both regions at least one factor of production is fully employed in the framework of regional demand-supply equilibria.
Case 2: Given $Y_1^{D,actual} \geq Y_1^{pot}$ and $Y_2^{D,actual} < Y_2^{pot}$, income $Y_1^{D,actual}$ must be corrected downwards. Substitute Y_2^{pot} by $\mathfrak{f}_2(Y_1^{pot}) = Y_2^{D,actual}$:

$$Y_1^{eq} = Y_1^{pot} < \mathfrak{f}_1\big(\mathfrak{f}_2(Y_1^{pot})\big) = \tilde{Y}_1^{D,actual} \quad \Longrightarrow \Gamma_1 = I_1^{pr,D} - I_1^{pr} > 0$$
$$Y_2^{eq} = \mathfrak{f}_2(Y_1^{pot}) = Y_2^{D,actual} < Y_2^{pot} \quad \Longrightarrow \Gamma_2 = 0$$

Case 3: $Y_2^{D,actual} \geq Y_2^{pot}$ and $Y_1^{D,actual} < Y_1^{pot}$. Here

$$Y_1^{eq} = \mathfrak{f}_1(Y_2^{pot}) < Y_1^{pot} \quad \Longrightarrow \Gamma_1 = 0$$
$$Y_2^{eq} = Y_2^{pot} < \mathfrak{f}_2\big(\mathfrak{f}_1(Y_2^{pot})\big) = \tilde{Y}_2^{D,actual} \quad \Longrightarrow \Gamma_2 = I_2^{pr,D} - I_2^{pr} > 0$$

Calculate for both regions on the basis of Y_i^{eq}

$$Y_i^{pr,r} = (1 - t_i)(Y_i^{eq} - r_i^* B_i^S)$$
$$Y_i^{pu,r} = (1 - \tau_i)[t_i Y_i^{eq} + (1 - t_i) r_i^* B_i^S] + F_{Si}^{pu}$$

where F_{Si}^{pu} is a portion of

$$F^{pu} = \tau_1[t_1 Y_1^{eq} + (1 - t_1) r_1^* B_1^S] + \tau_2[t_2 Y_2^{eq} + (1 - t_2) r_2^* B_2^S]$$

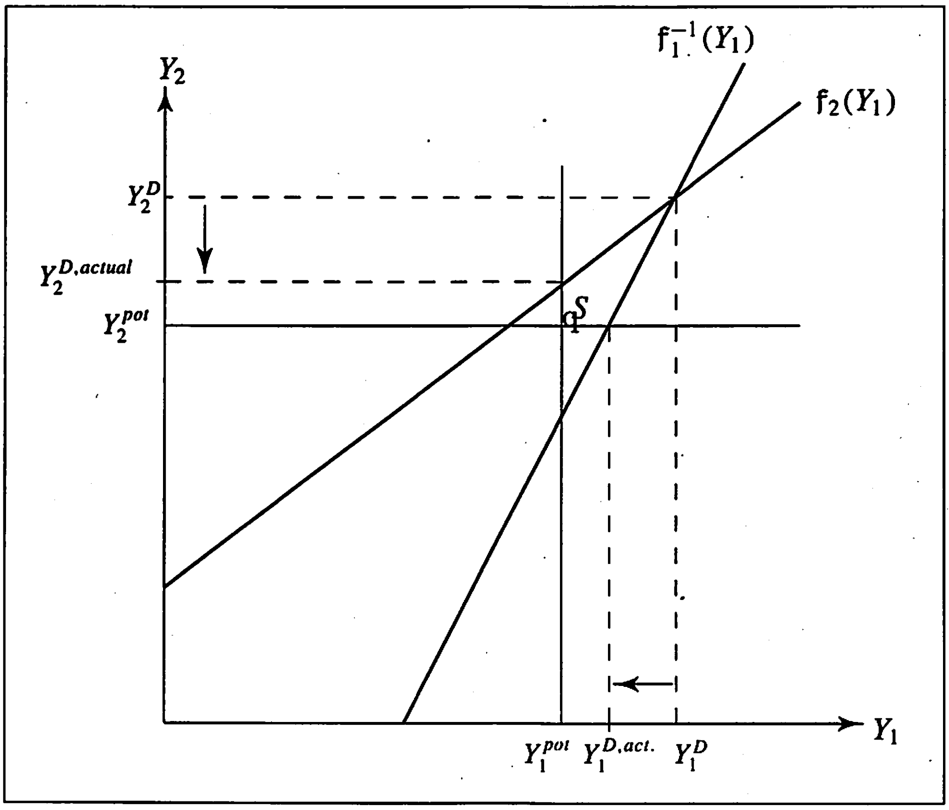

Figure 4: Excess demand in R1 and R2

V. Dynamics of the Model

A system of differential equations describes the dynamics of the model. These equations refer to

(a) changes of private and public capital stocks:

$$\dot{K}_1^S = I_1^{pr} + F_{21}^{pr},$$
$$\dot{K}_2^S = I_2^{pr} + F_{12}^{pr},$$
$$\dot{B}_i^S = I_i^{pu} + F_{Si}^{pu} - F_{iS}^{pu}, \quad (i = 1, 2);$$

(b) changes in the pool of knowledge for research and development and in the level of education:

$$\dot{K}_i^{dev} = I_i^{pr,dev}, \quad (i = 1, 2),$$
$$\dot{B}_i^{edu} = I_i^{pu,edu}, \quad (i = 1, 2),$$

the initial values being

$$K_i^{dev} = \eta_i^{pr,dev} K_i^S, \quad (i = 1, 2),$$
$$B_i^{edu} = \eta_i^{pu,edu} B_i^S, \quad (i = 1, 2);$$

(c) changes in the labor force:

$$\dot{L}_1^j = n_1^j L_1^{j,S} - L_{12}^j, \quad j \in \{raw, edu\},$$
$$\dot{L}_2^j = n_2^j L_2^{j,S} + L_{12}^j, \quad j \in \{raw, edu\},$$

where total migration is $L_{12} = L_{12}^{edu} + L_{12}^{raw}$,

$$L_{12}^{edu} = L_{12}^{edu,A} + L_{12}^{edu,B} + L_{12}^{edu,C},$$
$$L_{12}^{raw} = L_{12}^{raw,A} + L_{12}^{raw,B};$$

the first incentive for migration ($j \in \{edu, raw\}$) is captured by

$$L_{12}^{j,A} = \begin{cases} e_{A1}^j (w_2^j - w_1^j) L_1^{j,S}, & \text{if } w_1^j < w_2^j, \\ e_{A2}^j (w_2^j - w_1^j) L_2^{j,S}, & \text{if } w_1^j \geq w_2^j, \end{cases}$$

the second incentive ($j \in \{edu, raw\}$) by

$$L_{12}^{j,B} = \begin{cases} e_{B1}^j \big(\ell(L_1^j) - \ell(L_2^j)\big), & \text{if } \ell(L_1^j) > \ell(L_2^j), \\ e_{B2}^j \big(\ell(L_1^j) - \ell(L_2^j)\big), & \text{if } \ell(L_1^j) \leq \ell(L_2^j), \end{cases}$$

where

$$\ell(L_i^j) := \frac{L_i^{j,S} - L_i^{j,D}}{L_i^{j,S}} \qquad i = 1, 2; \;\; j \in \{edu, raw\},$$

and the third incentive specified only for educated labor (cf. Palivos, Wang (1996)) by

$$L_{12}^{edu,C} = \begin{cases} e_{C1}^{edu} \left(\frac{H_2^S}{L_2^{edu,S}} - \frac{H_1^S}{L_1^{edu,S}} \right) L_1^{edu,S}, & \text{if } \frac{H_1^S}{L_1^{edu,S}} < \frac{H_2^S}{L_2^{edu,S}} \\ e_{C2}^{edu}, \left(\frac{H_2^S}{L_2^{edu,S}} - \frac{H_1^S}{L_1^{edu,S}} \right) L_2^{edu,S}, & \text{if } \frac{H_1^S}{L_1^{edu,S}} \geq \frac{H_2^S}{L_2^{edu,S}}; \end{cases}$$

all migration parameters e are assumed to be positive;

(d) changes in assets:

$$\dot{W}_{12} = G_2^{pu} + F_{12}^{pr} + Z_1^{pr} - Z_2^{pr} + r_2 W_{12} - r_1 W_{21},$$
$$\dot{W}_{21} = G_1^{pu} + F_{21}^{pr}.$$

VI. Competition among Regions

Regional competition is expressed by changes of the regional and state parameters. They are ($i = 1, 2$)
technical parameters:
A_i, A_i^H, a_i (a_{i0}, a_{i1}, a_{i2}, a_{i3}), a_i^{edu}(a_{i0}^{edu}, a_{i1}^{edu}, a_{i2}^{edu}), a_i^{raw} (a_{i0}^{raw}, a_{i1}^{raw}), b_i (b_{i0}, b_{i1}), k_i (k_{i0}, k_{i1}, k_{i2}, k_{i3}), α_i^B, α_i^H, α_i^K, $\eta_i^{pr,dev}$, $\eta_i^{pu,edu}$, ρ_i, φ_i, ω_i
private (behavioral) parameters:
c_i^{pr}, e_{Ai}^{edu}, e_{Bi}^{edu}, e_{Ci}^{edu}, e_{Ai}^{raw}, e_{Bi}^{raw}, n_i^{edu}, n_i^{raw}, $i_{12}(i_{21})$, u_i, u_i^{aut}, $v_{12}(v_{21})$, $\varepsilon_i^{dev}(\varepsilon_{i0}^{dev}$, $\varepsilon_{i1}^{dev})$
market parameters:
r_i, r_i^*, δ_i^{raw}
regional public parameters:
c_i^{pu}, h_i, t_i, $\varepsilon_i^{edu}(\varepsilon_{i0}^{edu}$, ε_{i1}^{edu}, ε_{i2}^{edu}, $\varepsilon_{i3}^{edu})$
state parameters:
ν, τ_i
The influences of these parameters on regional and national growth are of central interest in the present context. The numerical and empirical implications of this topic will be dealt with in Bobzin (2000).

VII. Concluding Remarks

The basic advantage of the presented approach to modelling regional economic growth is that the static part of the model may be alternatively formulated with respect to different aspects, such as the emphasis on economic phenomena considered for investigation or the chosen degree of disaggregation and thus the size and details of the approach. The dynamic part of this growth model is maintained by changing factor stocks. Thus, regional economic growth is the result of motivated and adjusted economic activities, with an important adjustment mechanism being regional competition.

VIII. List of Symbols

(Index D refers to demand, index S to supply; $i = 1, 2$)

A_i	absolute level of production of region i (parameter)
A_i^H	absolute level of human capital in region i (parameter)
B_i	stock of infrastructure capital in region i
B_i^{edu}	level of education in region i
C_i^{pr}	private consumption in region i
C_i^{pu}	public consumption in region i
Ex_i^{pr}	total private exports of region i (including capital exports to the other region)
ΔF_1^n	net investment of R1 in R2
$F_{12}^{pr}(F_{21}^{pr})$	transfer of private investment from R1 to R2 (from R2 to R1)
F^{pu}	total state revenue
F_{iS}^{pu}	public resources transferred from the public sector of region i to the State
F_{Si}^{pu}	public resources transferred from the State to region i
G_i^{pu}	public investment subsidies of region i
H_i	stock of human capital in region i
$\tilde{I}_i^{pr}$	private expenditures on investment and on research and development (R&D) in region i
I_i^{pr}	private investment of region i
$I_i^{pr,dev}$	private expenditures on research and development (R&D) of region i
I_i^{pu}	public investment in region i
$I_i^{pu,edu}$	public expenditure on education in region i
Im_i^{pr}	total private imports of region i (including capital imports from the other region)
K_i	private capital stock of region i
K_i^{dev}	pool of knowledge for research and development (R&D) in region i
L_i	labor force of region i
L_i^{edu}	educated labor of region i
L_i^{raw}	raw labor of region i
L_{12}	migration from R1 to R2
L_{12}^{edu}	educated workers migrating from R1 to R2

$L_{12}^{edu,A}$	migrating educated workers oriented to wage rate differences between the regions
$L_{12}^{edu,B}$	migrating educated workers oriented to differences between the unemployment rates of the regions
$L_{12}^{edu,C}$	migrating educated workers oriented to differences in the relative regional supply of human capital
L_{12}^{raw}	raw laborers migrating from R1 to R2
$L_{12}^{raw,A}$	migrating raw laborers oriented to wage rate differences between the regions
$L_{12}^{raw,B}$	migrating raw laborers oriented to differences between the unemployment rates of the regions
P_i	price level of region i
S_i^{pr}	private savings of region i
S_i^{pu}	public savings of region i
T_i	direct tax revenue of region i
$W_{12}(W_{21})$	assets of R1 held in R2 (assets of R2 held in R1)
X_i	output of region i
X_i^{eq}	equilibrium output of region i
X_i^{pot}	potential output of region i
Y_i	income (net social product) of region i
Y_i^{eq}	equilibrium income of region i
Y_i^{pot}	potential income of region i
$Y_i^{pr,r}$	retained private income of region i
$Y_i^{pu,r}$	retained public income of region i
Z_i^{pr}	private goods exports of region i
a_i	production coefficient referring to human capital of region i
a_{i0}	autonomous production coefficient referring to human capital of region i
a_{i1}	technical progress dependent production coefficient referring to human capital of region i
a_{i2}	public capital dependent production coefficient referring to human capital of region i
a_{i3}	private capital dependent production coefficient referring to human capital of region i

a_i^{edu}	educated labor parameter of aggregating human capital of region i
a_{i0}^{edu}	autonomous educated labor parameter of aggregating human capital of region i
a_{i1}^{edu}	educated labor parameter of aggregating human capital of region i dependent on the level of education in region i
a_{i2}^{edu}	educated labor parameter of aggregating human capital of region i dependent on the pool of knowledge for research and development in region i
a_i^{raw}	raw labor parameter of aggregating human capital of region i
a_{i0}^{raw}	autonomous raw labor parameter of aggregating human capital of region i
a_{i1}^{raw}	raw labor parameter of aggregating human capital of region i dependent on the level of education in region i
b_i	production coefficient referring to infrastructure capital of region i
b_{i0}	autonomous production coefficient referring to infrastructure capital of region i
b_{i1}	technical progress dependent production coefficient referring to infrastructure capital of region i
c_i	cost function of region i
c_i^{pr}	marginal (average) private propensity to consume of region i
c_i^{pu}	marginal (average) public propensity to consume of region i
e_{Ai}^{edu}	coefficient of migrating educated workers of region i oriented to wage rate differences between the regions
e_{Bi}^{edu}	coefficient of migrating educated workers of region i oriented to differences between the unemployment rates of the regions
e_{Ci}^{edu}	coefficient of migrating educated workers of region i oriented to differences in the relative regional supply of human capital
e_{Ai}^{raw}	coefficient of migrating raw laborers of region i oriented to wage rate differences between the regions
e_{Bi}^{raw}	coefficient of migrating raw laborers of region i oriented to differences between the unemployment rates of the regions
h_i	quotient of public subsidies and public investment in region i
$i_{12}(i_{21})$	parameters of exports from R1 to R2 (from R2 to R1)

k_i	production coefficient referring to private capital of region i
k_{i0}	autonomous production coefficient referring to private capital of region i
k_{i1}	technical progress dependent production coefficient referring to private capital of region i
k_{i2}	public capital dependent production coefficient referring to private capital of region i
k_{i3}	private capital dependent production coefficient referring to private capital of region i
$\ell(L_i^j)$	rate of unemployment in region i for category of labor j ($j \in \{edu, raw\}$)
n_i^{edu}	growth rate of educated natural labor force in region i
n_i^{raw}	growth rate of raw natural labor force in region i
r_i	rental rate of private capital in region i
r_i^*	rental rate of infrastructure capital in region i
t	time
t_i	direct tax rate of region i
u_i	investment parameter referring to disposable private income in region i
u_i^{aut}	investment parameter referring to capital supply of region i
$v_{12}(v_{21})$	parameter of private capital attracted from R1 to R2 (from R2 to R1)
w_i	rental rate of human capital in region i
w_i^{edu}	wage rate of educated labor in region i
w_i^{raw}	wage rate of raw labor in region i
α_i^B	production coefficient referring to infrastructure capital in region i
α_i^H	production coefficient referring to human capital in region i
α_i^K	production coefficient referring to private capital in region i
δ_i^{raw}	variation rate in time of wage rate for raw labor in region i
ε_i^{dev}	quotient of private expenditures for research and development (R&D) and private expenditures on investment and on research and development (R&D) in region i (in short: research and development quotient)

ε_{i0}^{dev}	autonomous research and development quotient of region i
ε_{i1}^{dev}	human capital dependent quotient of research and development in region i
ε_{i}^{edu}	quotient of public expenditures on education and public investment in region i (in short: quotient of education)
ε_{i0}^{edu}	autonomous quotient of education in region i
ε_{i1}^{edu}	income dependent quotient of education in region i
ε_{i2}^{edu}	quotient of education in region i dependent on the pool of knowledge for research and development in region i
ε_{i3}^{edu}	quotient of education in region i dependent on human capital of region i
$\eta_{i}^{pr,dev}$	quotient of the pool of knowledge for research and development (R&D) and private capital stock in region i
$\eta_{i}^{pu,edu}$	quotient of the level of education and the public capital stock in region i
ν	parameter of the State for the distribution of revenues to R1 and R2
ρ_i	production parameter of region i
σ_i	elasticity of factor substitution for region i ($\sigma_i = 1/(1-\rho_i)$)
τ_i	state share in the revenue of the public sector of region i
φ_i, ω_i	parameters of deriving human capital for region i

IX. References

R. J. Barro, X. Sala-i-Martin, *Economic Growth*, New York, McGraw-Hill, Inc., 1995.

H. Bobzin, »Computer Simulation of Reallocating Resources among Growing Regions«, J. R. Roy, W. Schulz (eds.), *Theories of Regional Competition*, Baden-Baden, Nomos, 2000, 31–56.

W. Buhr, »Regional Economic Growth by Policy-Induced Capital Flows: I. Theoretical Approach«, *The Annals of Regional Science*, 1995, 29, 17–40.

F. H. Hahn, T. Negishi, »A Theorem on Non-Tâtonnement Stability«, *Econometrica*, 1962, 30, 463–469.

T. Palivos, P. Wang, »Spatial Agglomeration and Endogenous Growth«, *Regional Science and Urban Economics*, 1996, 26, 645–669.

H. J. Ramser, M. Stadler, »Keynesianische Aspekte der modernen Wachstumstheorie«, G. Bombach et al. (Hrsg.), *Der Keynesianismus VI: Der Einfluß keynesianischen Denkens auf die Wachstumstheorie*, Berlin et al., Springer Verlag, 1997, 35–186.

H. R. Sneesens, »Rationing Macroeconomics. A Graphical Exposition«, *European Economic Review*, 1984, 26, 187–201.

G. I. Treyz, D. S. Rickman, G. Shao, »The REMI Economic-Demographic Forecasting and Simulation Model«, *International Regional Science Review*, 1992, 14, 451–483.

Liste der seit 1992 erschienenen Volkswirtschaftlichen Diskussionsbeiträge

Diese Liste sowie Zusammenfassungen aller Beiträge sind auch online unter http://www.uni-siegen.de/dept/fb05/vwliv/sonstig.htm verfügbar. Anfragen nach Diskussionsbeiträgen sind direkt an die Autoren zu richten, in Ausnahmefällen an Prof. Dr. R. Pethig, Universität - Siegen, 57068 Siegen. Ab dem Beitrag 60-97 kann die Liste ferner auch unter der Adresse http://ideas.uqam.ca/ideas/data//siesiegen.html online eingesehen werden, mit entsprechenden Verweisen auf herunterladbare Beiträge.

List of Economics Discussion Papers released as of 1992

This list as well as abstracts of all Discussion Papers are also available online under http://www.uni-siegen.de/dept/fb05/vwliv/sonstig.htm. Discussion Papers can be only ordered from the authors directly, in exceptional cases from Prof. Dr. R. Pethig, University of Siegen, D- 57068 Siegen, Germany. From the paper 60-97 onwards the list can further be accessed through http://ideas.uqam.ca/ideas/data//siesiegen.html

28-92 **Jürgen Ehlgen**, Lösen des stochastischen Wachstumsmodells durch Parameterisieren der Entscheidungsfunktion

29-92 **Alfred W. Marusev** und **Andreas Pfingsten**, Zur arbitragefreien Fortrechnung von Zinsstruktur-Kurven

30-92 **Jürgen Ehlgen, Matthias Schlemper, Klaus Schöler**, Die Anwendung branchenspezifischer Konjunkturindikatoren

31-92 **Klaus Schöler**, Zum strategischen Einsatz räumlicher Preistechniken

32-92 **Günter Knieps** and **Rüdiger Pethig**, Uncertainty, Capacity Costs and Competition in the Electric Power Industry

33-92 **Walter Buhr**, Regional Economic Growth by Policy-Induced Capital Flows: I. Theoretical Approach

34-92 **Walter Buhr**, Regional Economic Growth by Policy-Induced Capital Flows: II. Policy Simulation Results

35-92 **Andreas Pfingsten** and **Reiner Wolff**, Endowment Changes in Economic Equilibrium: The Dutch Disease Revisited

36-92 **Klaus Schöler**, Preiselastische Nachfrage und strategische Preisreaktionen in einem räumlichen Wettbewerbsmarkt

37-92 **Rüdiger Pethig**, Ecological Dynamics and the Valuation of Environmental Change

38-93 **Reiner Wolff**, Saddle-Point Dynamics in Non-Autonomous Models of Multi-Sector Growth with Variable Returns to Scale

39-93 **Reiner Wolff**, Strategien der Investitionspolitik in einer Region: Der Fall des Wachstums mit konstanter Sektorstruktur

40-93 **Axel A. Weber**, Monetary Policy in Europe: Towards a European Central Bank and One European Currency

41-93 **Axel A. Weber**, Exchange Rates, Target Zones and International Trade: The Importance of the Policy Making Framework

42-93 **Klaus Schöler** und **Matthias Schlemper**, Oligopolistisches Marktverhalten der Banken

43-93 **Andreas Pfingsten** and **Reiner Wolff**, Specific Input in Competitive Equilibria with Decreasing Returns to Scale

44-93 **Andreas Pfingsten** and **Reiner Wolff**, Adverse Rybczynski Effects Generated from Scale Diseconomies

45-93 **Rüdiger Pethig**, TV-Monopoly, Advertising and Program Quality

46-93 **Axel A. Weber**, Testing Long-Run Neutrality: Empirical Evidence for G7-Countries with Special Emphasis on Germany

47-94 **Rüdiger Pethig**, Efficient Management of Water Quality

48-94 **Klaus Fiedler**, Naturwissenschaftliche Grundlagen natürlicher Selbstreinigungsprozesse in Wasserressourcen

49-94 **Rüdiger Pethig**, Noncooperative National Environmental Policies and International Capital Mobility

50-94 **Klaus Fiedler**, The Conditions for Ecological Sustainable Development in the Context of a Double-Limited Selfpurification Model of an Aggregate Water Recourse

51-95 **Gerhard Brinkmann**, Die Verwendung des Euler-Theorems zum Beweis des Adding-up-Theorems impliziert einen Widerspruch

52-95 **Gerhard Brinkmann**, Über öffentliche Güter und über Güter, um deren Gebrauch man nicht rivalisieren kann

53-95 **Marlies Klemisch-Ahlert**, International Environmental Negotiations with Compensation or Redistribution

54-95 **Walter Buhr** and **Josef Wagner**, Line Integrals In Applied Welfare Economics: A Summary Of Basic Theorems

55-95 **Rüdiger Pethig**, Information als Wirtschaftsgut

56-95 **Marlies Klemisch-Ahlert**, An Experimental Study on Bargaining Behavior in Economic and Ethical Environments

57-96 **Rüdiger Pethig**, Ecological Tax Reform and Efficiency of Taxation: A Public Good Perspective

58-96 **Daniel Weinbrenner**, Zur Realisierung einer doppelten Dividende einer ökologischen Steuerreform

59-96 **Andreas Wagener**, Corporate Finance, Capital Market Equilibrium, and International Tax Competition with Capital Income Taxes

60-97 **Daniel Weinbrenner**, A Comment on the Impact of the Initial Tax Mix on the Dividends of an Environmental Tax Reform

61-97 **Rüdiger Pethig**, Emission Tax Revenues in a Growing Economy

62-97 **Andreas Wagener**, Pay-as-you-go Pension Systems as Incomplete Social Contracts

63-97 **Andreas Wagener**, Strategic Business Taxation when Finance and Portfolio Decisions are Endogenous

64-97 **Thomas Steger**, Productive Consumption and Growth in Developing Countries

65-98 **Marco Runkel**, Alternative Allokationsmechanismen für ein Rundfunkprogramm bei endogener Programmqualität

66-98 **Jürgen Ehlgen**, A Comparison of Solution Methods for Real Business Cycle Models

67-98 **Peter Seethaler**, Zum Einfluß von Devisentermingeschäften auf das Marktgleichgewicht bei asymmetrischer Information

68-98 **Thomas Christiaans**, A Note on Public Goods: Non-Excludability Implies Joint Consumability

69-98 **Michael Gail**, Stylized Facts and International Business Cycles - The German Case

70-98 **Thomas Eichner**, The state as social insurer: labour supply and investments in human capital

71-98 **Thomas Steger**, Aggregate Economic Growth with Subsistence Consumption

72-98 **Andreas Wagener**, Implementing Equal Living Conditions in a Federation

73-99 **Thomas Eichner** and **Rüdiger Pethig**, Product Design and Markets for Recycling, Waste Treatment and Disposal

74-99 **Peter Seethaler**, Zum Einfluß des Hedging auf das Kreditvergabeverhalten der Banken

75-99 **Thomas Christiaans**, Regional Competition for the Location of New Facilities

76-99 **Thomas Eichner** and **Rüdiger Pethig**, Product Design and Efficient Management of Recycling and Waste Treatment

77-99 **Rüdiger Pethig**, On the Future of Environmental Economics

78-99 **Marco Runkel**, Product Durability, Solid Waste Management, and Market Structure

79-99 **Hagen Bobzin**, Dualities in the Functional Representations of a Production Technology

80-99 **Hagen Bobzin**, Behandlung von Totzeitsystemen in der Ökonomik

81-99 **Marco Runkel**, First-Best and Second-Best Regulation of Solid Waste under Imperfect Competition in a Durable Good Industry

82-99 **Marco Runkel**, A Note on 'Emissions Taxation in Durable Goods Oligopoly'

83-99 **Thomas Eichner** and **Rüdiger Pethig**, Recycling, Producer Responsibility and Centralized Waste Management

84-00 **Thomas Eichner** und **Rüdiger Pethig**, Das Gebührenkonzept der Duales System Deutschland AG (DSD) auf dem ökonomischen Prüfstand

85-00 **Thomas Eichner** und **Rüdiger Pethig**, Gebührenstrategien in einem disaggregierten Modell der Abfallwirtschaft

86-00 **Rüdiger Pethig and Sao-Wen Cheng**, Cultural Goods Consumption and Cultural Capital

87-00 **Michael Gail**, Optimal Monetary Policy in an Optimizing Stochastic Dynamic Model with Sticky Prices

88-00 **Thomas Eichner** and **Marco Runkel**, Efficient and Sustainable Management of Product Durability and Recyclability

89-00 **Walter Buhr and Thomas Christiaans**, Economic Decisions by Approved Principles: Rules of Thumb as Behavioral Guidelines

90-00 **Walter Buhr**, A Macroeconomic Growth Model of Competing Regions

91-00 **Hagen Bobzin**, Computer Simulation of Reallocating Resources among Growing Regions