Economics and Business Letters
2(4), 161-168, 2013

Does the neoclassical growth model predict interregional convergence? On the impact of free factor movement and the implications for the European Union

Sascha Sardadvar*

Department of Socioeconomics, Institute for Economic Geography and GIScience, Vienna University of Economics and Business, Austria

Received: 27 August 2013
Revised: 25 October 2013
Accepted: 28 October 2013

Abstract

This paper sets up a theoretical model of regional growth with free factor movement. The analysis shows that factor endowments are crucial for a region's attractiveness regarding factor relocations. In particular, lower endowments of human capital within other regions are advantageous for a region's growth prospects, and vice versa. The paper concludes that under the framework of free factor movement, the European Union's objective of interregional convergence can only be achieved by subsidising disadvantaged economies.

Keywords: neoclassical growth theory, human capital, migration, regional development
JEL Classification Codes: F43, R11

1. Introduction

Since the outbreak of the current crisis in 2008, the euro-zone's wealthy member states have displayed relatively high GDP growth. Germany's industrial sector is currently suffering from a labour shortage and has started to actively recruit workers from Southern Europe. At the same time, the former cohesion countries of Greece, Ireland, Portugal and Spain, which were once the primary examples of quick convergence processes, display negative growth rates. During the years of successful cohesion before the crisis, all of these countries turned from typical emigration countries to countries with positive net-migration rates. During the crisis,

* E-mail: sascha.sardadvar@wu.ac.at.

Citation: Sardadvar, S. (2013) Does the neoclassical growth model predict interregional convergence? On the impact of free factor movement and the implications for the European Union, *Economics and Business Letters*, 2(4), 161-168.

however, these countries returned to negative net-migration rates.[1] This indicates that they may return to their role of supplying the industrialised core with labour, in particular with highly qualified personnel. In other words, the euro-zone's peripheral countries and regions currently lose human capital to the core, a process which will possibly further support the core.

Over the past decades, the European Union's horizontal as well as vertical integration have both increased considerably. As a (preliminary) result, the EU represents an economic system in which 28 member states and the respective regional economies are open to free factor movement and trade. In the same year in which the Treaties of Rome were signed, Gunnar Myrdal released his model of regional development, in which he criticises neoclassical theory for its fondness for balancing forces and stable equilibria (see Myrdal 1957, p. 135). Indeed, Solow's (1956) famous model of economic growth predicts convergence to a particular steady state output. It is important to note, however, that his model considers only one economy. Therefore, the Solow model predicts convergence within the same economy. The expectation that various economies will converge in terms of output is reasonable only if all economies under consideration have identical steady state levels. Given that two economies have access to the same technology but their steady states vary, they can only converge in terms of growth rates while approaching different output levels.[2]

Nevertheless, Barro and Sala-i-Martin (2004, p. 461) argue that regional economies are similar to each other and therefore should converge in terms of production. Islam (2003, p. 322) points out that "When it comes to regions within the same country, the assumption of identical steady states, and hence of unconditional convergence, becomes more plausible." In contrast, Myrdal (1957, p. 38) argues that it is more likely that centripetal forces work in favour of those economies which are already advanced. According to his model, investments are more likely to take place in already advanced economies, and skilled workers are more likely to move from peripheral to core regions than the other way round. Krugman's (1991) influential model formally shows how factor movements and deepening integration between two regional economies may work in favour of the already advanced region.

In recent years, empirical studies (Olejnik 2008, Ramos et al. 2010, Fischer et al. 2010, Sardadvar 2012, Resende et al. 2013) have repeatedly found a negative effect of human capital endowments in neighbouring regions on economic growth. This result might seem counterintuitive to the idea that regions may benefit from existing knowledge in their neighbouring regions as discussed in some studies (e.g. Le Gallo et al. 2003, Ertur and Koch 2007). These phenomena, however, are neither contradictory to each other nor to neoclassical growth theory. Although abstract knowledge (technology) and human capital (skills) are related, there is a clear distinction between these concepts: While abstract knowledge spreads at low cost and allows lagging behind economies to catch up by adopting, human capital is embodied in persons and hence rival and excludable.

By accounting for the fact that regions are necessarily open and therefore subject to factor movements, the aim of this paper is to show that (i) advanced regions may further benefit from these movements and that (ii) human capital plays a decisive role regarding the movements's directions. This paper is organised as follows. First, a basic model with human capital migration is presented. After that, the model is extended to allow for two types of labour migration as well as variable returns. The final section draws conclusions regarding the EU's cohesion policy.

[1] Official data as available from Eurostat, as of 16 April 2013.

[2] The concept that economies converge in terms of output by any means is usually referred to as unconditional (absolute) convergence. If variables which distinguish economies from each other are considered, the concept is referred to as conditional convergence. For a comprehensive discussion of various concepts of convergence see Islam (2003).

2. The basic model and underlying assumptions

When Solow (1956) designed his ground-breaking model, his aim was to explain the US economy's growth in the first half of the 20th century. Therefore some of the underlying assumptions are appropriate for a very large and relatively closed economy, but for several reasons not necessarily for regional economies. Firstly, the assumption of a closed economy seems inappropriate for regional economies at the sub-national level, in particular with respect to trade, labour migration and investment flows. Secondly, the assumption of constant returns depends on the size of the region, as agglomeration effects may play a role at smaller scales (e.g. cities). Thirdly, due to open trade and investment flows as well as investment activities by the superordinate administrative unit (usually but not necessarily the state), regional saving most likely does not equal regional investments.

Barro et al. (1995) extend the Solow-model for human capital immigration. In their model, immigration has a negative effect on the per capita growth of an economy because it decreases the physical capital stock per worker. Therefore, labour migration is expected to accelerate convergence between nation states as well as regions (Barro and Sala-i-Martin, 2004, p. 389 and p. 462).

As will be shown below, an increase in the human capital stock has also the ability to attract further relocations of human as well as physical capital and may in turn lead to divergence in the medium and long run. Although Mankiw et al.'s (1992) augmentation of Solow's model assumes closed economies, it successfully explains why some economies are more attractive for capital relocations. By abstracting from technology and allowing for variable returns to scale, the production function has the following Cobb-Douglas form:

$$Q_i = K_i^{\alpha} H_i^{\beta} L_i^{\gamma} \tag{1}$$

where K is the stock of physical capital, H is the stock of human capital and L is crude labour. If $\gamma = 1 - \alpha - \beta$, the production function fulfils the assumption of constant returns which corresponds to a scenario in which no further gains from specialization are possible, i.e. with relatively large economies (Romer 2005). The production function's first derivative to any of its factors is always positive, for instance the first derivative with respect to K:

$$\frac{\partial Q_i}{\partial K_i} = \alpha K_i^{\alpha-1} H_i^{\beta} L_i^{\gamma} > 0 \tag{2}$$

For any factor whose migration decision depends on marginal productivity, already well endowed regions become more attractive. For instance, human capital will ceteris paribus be attracted by a region which is rich in physical capital:

$$\frac{\partial Q_i / \partial K_i}{\partial H_i} = \alpha\beta K_i^{\alpha-1} H_i^{\beta-1} L_i^{\gamma} > 0 \tag{3}$$

The higher the importance of a particular factor, e.g. human capital, the higher its effect:

$$\frac{\left(\partial Q_i / \partial K_i\right) / \partial H_i}{\partial \beta} = \alpha K_i^{\alpha-1} H_i^{\beta-1} L_i^{\gamma} \left(1 + \beta \ln\left(H_i\right)\right) > 0, H_i \geq 1 \tag{4}$$

If, however, the endowment and importance of human capital are small enough so that $\beta \ln\left(H_i\right) < -1$, the economy loses attractiveness.

The Double Role of Human Capital

On the one hand, human capital is another type of capital in which investments in the past (educational costs) yield higher revenues in the future (output). On the other hand, human

capital is embodied in workers as it represents their talents and acquired skills. Therefore, a worker who supplies human capital receives compensation for the raw labour he or she supplies plus a premium for his or her human capital's additional product. It follows that in equilibrium, the wage for a worker who supplies one unit of raw labour plus one unit of human capital equals the sum of their marginal products

$$v_i = \frac{\partial Q_{i,t}}{\partial L_{i,t}} + \frac{\partial Q_{i,t}}{\partial H_{i,t}} = q_i\left(\gamma + \frac{\beta}{h_i}\right) \tag{5}$$

where $q = Q/L$ and $h = H/L$ are output and human capital per labour unit, respectively. The expression reacts sensitively to changes in h, as it is also included in q: An increase in h decreases its own marginal productivity, but at the same time increases marginal productivity of the other factors.

Factor Growth

In each region, a constant share of output, $s_{K,i}$, is re-invested in the physical capital stock, and a constant share δ of the existing stock depreciates. Moreover, additional investment, R, may take place which is financed by the superordinate system. Physical capital relocations take place if marginal productivities across regions vary so that the speed of these relocations is given by $\lambda > 0$. For simplicity assume that each region has constant returns, there is neither technological progress nor natural population growth, and output elasticities are identical in each region so that output per labour unit $q = k^{\alpha}h^{\beta} \forall i, j, t$. The differential equation which describes the evolution of the physical capital stock in i at t then has the form

$$\frac{dk_{i,t}}{dt} = s_{K,i}q_{i,t} + r_{i,t} + \lambda\alpha\left(\frac{q_{i,t}}{k_{i,t}} - \frac{q_{j,t}}{k_{j,t}}\right) - \delta k_{i,t} \tag{6}$$

where small letters indicate levels per labour unit, and where the form has made use of the fact that $\partial q/\partial k = \alpha q k^{-1} \forall i, j, t$. Note that it follows from eq. (6) that this expression strictly decreases with increases in $h_{j,t}$ as $\partial\left(dk_{i,t}/dt\right)/\partial h_{j,t} < 0$.

Each region spends a constant share of output , $s_{H,i}$, for its own educational system. In addition, human capital suppliers migrate if their wages differ, as laid out above. For simplicity, the speed of migration and the rate of depreciation for human capital movements are also given by λ and δ, respectively. The differential equation which describes the evolution of the human capital stock in i at t then has the form

$$\frac{dh_{i,t}}{dt} = s_{H,i}q_{i,t} + \lambda\left(v_{i,t} - v_{j,t}\right) - \delta h_{i,t} \tag{7}$$

Whether a region is able to gain from the migration of human capital suppliers depends on whether it is able to attract the corresponding migrants. If this is not the case for i because wages for human capital suppliers are higher in j, it will lose human capital to j. Because i permanently produces human capital via its autonomous spending $s_{H,i}q_{i,t}$, it will certainly never run out of human capital but the expression may be negative even if net migration is positive. Nevertheless, any increase in $v_{j,t}$ leads ceteris paribus to a decrease in i's future human capital stock.

Economic Growth

Growth in i at t is estimated by the total differential of the production function with respect to time

$$\frac{dq_{i,t}}{dt} = \frac{\partial q_{i,t}}{\partial k_{i,t}} \frac{dk_{i,t}}{dt} + \frac{\partial q_{i,t}}{\partial h_{i,t}} \frac{dh_{i,t}}{dt} \tag{8}$$

In order to estimate the influence of human capital in j on economic growth in i, eq. (8) is differentiated with respect to h_j

$$\frac{\partial \left(dq_{i,t} / dt \right)}{\partial h_{j,t}} = -\lambda\beta \frac{q_{i,t} q_{j,t}}{k_{i,t} k_{j,t} h_{i,t} h_{j,t}^2} \left(\alpha^2 h_{i,t} h_{j,t} + \beta k_{i,t} k_{j,t} \left(\beta + \gamma h_{j,t} - 1 \right) \right) \tag{9}$$

The expression is negative if $\alpha^2 h_{i,t} h_{j,t} + \beta^2 k_{i,t} k_{j,t} + \beta\gamma k_{i,t} k_{j,t} h_{j,t} - \beta k_{i,t} k_{j,t} > 0$. If $h_{j,t} > (1-\beta)/\gamma$, the expression is unambiguously negative regardless of other values.

Some interesting conclusions can be drawn from eq. (9). Firstly, if the human capital endowment in j has reached a certain threshold level, i will suffer from further human capital increases in j. Secondly, this threshold level decreases with increases in β. Thirdly, neither education costs nor subsidies for physical capital investments enter eq. (9), but they are part of eq. (6). The consequence of the latter is twofold. On the one hand, if region i has a lower initial stock of human capital than region j which lies above the threshold level, then under free market forces it can never converge to j because it permanently loses human capital to j. On the other hand, increases in $s_{K,i}$, $s_{H,i}$ and r_i lead to higher growth in i and in turn i becomes more attractive. However, if $s_{K,j}$ and $s_{H,j}$ are also increased or are equal to i's values at any t, then an increase in r_i remains the only means to alleviate or reverse the divergence process caused by the migration of human capital suppliers.

3. Extending the model and interpretation

If returns to scale are allowed to vary across regions, the model becomes more complex because the available amount of raw labour has to be considered, too. To this end, eqs. (6) and (7) are re-specified for total stocks, so that $\dot{K}_{i,t} = s_{K,i} Q_{i,t} + R_{i,t} + \lambda \left(\partial Q_{i,t} / \partial K_{i,t} - \partial Q_{j,t} / \partial K_{j,t} \right) \left(K_{i,t} + K_{j,t} \right) - \delta K_{i,t}$ and $\dot{H}_{i,t} = s_{K,i} Q_{i,t} + \lambda \left(v_{i,t} - v_{j,t} \right) \left(H_{i,t} + H_{j,t} \right) - \delta H_{i,t}$. In addition, the migration of raw labour between regions takes place as

$$\frac{dL_{i,t}}{dt} = \lambda \left(\frac{\partial Q_{i,t}}{\partial L_{i,t}} - \frac{\partial Q_{j,t}}{\partial L_{j,t}} \right) \left(L_{i,t} + L_{j,t} \right) + \frac{dH_{i,t}}{dt} \tag{10}$$

where the first term on the right hand side considers that L strictly follows marginal productivity, and the second term takes into account that each unit of H is embodied in one unit of L. Note that H might increase while L decreases, or vice versa.

The influence of j's human capital stock on i's growth can be derived as

$$\frac{\partial\left(dQ_{i,t}/dt\right)}{\partial H_{j,t}} =$$

$$\underbrace{-\beta_j\lambda\frac{q_{i,t}q_{j,t}}{h_{j,t}L_{j,t}}}_{<0}\left(\underbrace{\gamma_i\gamma_j\left(1+\lambda L_{i,t}L_{j,t}\right)}_{>0}+\underbrace{\beta_i\gamma_j\frac{1}{h_{i,t}}}_{>0}+\underbrace{\alpha_i\alpha_j\left(\frac{L_{j,t}}{k_{i,t}}+\frac{L_{i,t}}{k_{j,t}}\right)}_{>0}+\underbrace{\left(\beta_j-1\right)\frac{1}{h_{j,t}}\left(\gamma_i+\beta_i\frac{1}{h_{i,t}}\right)}_{<0}\right) \quad (11)$$

The equation has the same implications as (9), but in addition shows the interplay between elasticities and the regions' sizes. Three of four terms within parentheses support the negative effect of $h_{j,t}$ on i's growth. Furthermore, the influence of $h_{j,t}$ becomes more severe if j's population becomes larger, while variations with respect to output elasticities tend to increase or decrease the influence of $h_{j,t}$, depending in which region and direction they appear.

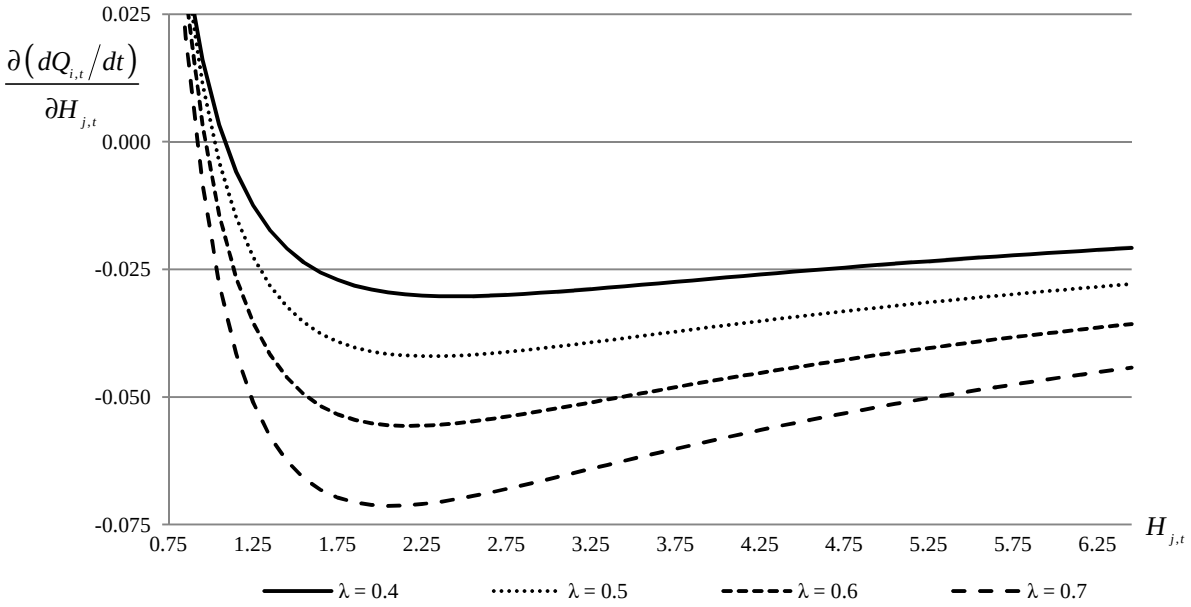
Figure 1 displays eq. (11) as a function in which all variables but $h_{j,t}$ are held constant, with population sizes normalised so that $L_{i,t}=L_{j,t}=1$. $k_{i,t}$, $h_{i,t}$ and $k_{j,t}$ are calculated so that they equal the steady state values implied by the Mankiw Romer Weil model if $a_i=a_j=0.3$, $\beta_i=\beta_j=0.2$, $\gamma_i=\gamma_j=0.5$, $s_{K,i}=s_{K,j}=0.25$, $s_{H,i}=s_{H,j}=0.15$ and $\delta=0.1$. The diagram displays varying values of λ showing how i's growth benefits from extremely low levels of $h_{j,t}$, but above a certain threshold value, this effect is reversed. In Fig. 1, the varying threshold levels lie far below the implied level of $h_{i,t}$. Furthermore, the higher the value of λ, the greater the effect. Changes in other variables than λ shift the curves, but do not change the main implication: if $\lambda>0$, then there is a positive threshold level above which increases in $h_{j,t}$ decrease i's growth.[3]

In sum, the model shows that if human capital endowments have reached relatively high levels, a further increase in other regions' human capital stocks has a negative impact on one particular region's output growth. It follows that ceteris paribus regional economies which start out with relatively high levels of human capital will further benefit because it increases their attractiveness for mobile factors. Since increases in λ increase total relocations at t, a deepening of economic integration accelerates these effects and the resulting divergence.

[3] With $L_{i,t}=L_{j,t}=1$, the threshold can be calculated as

$$h_{j,t}=\left(1-\beta_j\right)\left(\beta_i+\gamma_i h_i\right)k_i k_j\Big/\left(\alpha_i\alpha_j h_i\left(k_i+k_j\right)+\gamma_j k_i k_j\left(\beta_i+\gamma_i h_i\left(1+\lambda\right)\right)\right).$$

Figure 1. The effect of human capital increases in j on i's growth



4. Conclusions and outlook

The model has shown that human capital plays a decisive role regarding the integration process of an economic system such as the EU as it determines a region's attractiveness for mobile factors. Because higher endowments of human capital increase a region's attractiveness, those with initially relatively high endowments will ceteris paribus benefit more from economic integration with the outcome that disparities across regions increase. Although such an outcome would represent nothing but a macroscopic result due to microeconomic decisions, it may nevertheless be undesirable. Therefore, convergence across regions within a well-integrated economic system may not be conceivable in the long run.

The model, however, includes several instruments to support convergence across regions. Firstly, the overall level of integration λ and hence the speed of migration may be altered. Secondly, regions which suffer from factor relocations may be subsidised so they become more attractive. Thirdly, returns to scale may differ across regions, so that for instance some (e.g. metropolitan) regions within disadvantaged areas may nevertheless gain from factor relocations. Fourthly, re-investment and educational spending may be increased and possibly subsidised in disadvantaged regions in order to outbalance negative factor relocation rates.

The EU's internal market's four freedoms of free movement of goods, capital, services and people are usually given within national economies, and large scale migration from poorer to richer regions, e.g. within Germany or Italy, is quite common. In contrast, between nation states barriers against free movements usually exist. However, with each further step of integration the EU's member states give up instruments which are usually associated with nation states. Hence, member states take on characteristics usually associated with regions. Therefore the mechanisms which determine interregional development within a country have become more and more relevant for the EU's member states, too. This paper has shown that by introducing these mechanisms into the framework of neoclassical growth theory, an increase rather than a decrease in existing disparities becomes more likely. It follows that if both interregional convergence and the free movement of production factors are political objectives, the EU as well as its member states should continue subsidising disadvantaged regions and member states.

Acknowledgements. The author wishes to thank Lauren Landsmann for her helpful comments.

References

Barro, R., Mankiw, G. and Sala-i-Martin, X.X. (1995) Capital mobility in neoclassical models of growth, *American Economic Review*, 85, 103-115.

Barro, R.J. and Sala-i-Martin, X.X. (2004) *Economic Growth*, 2nd ed., New York: McGraw-Hill.

Ertur, C. and Koch, W. (2007) Growth, technological interdependence and spatial externalities: Theory and evidence, *Journal of Applied Econometrics*, 22, 1033-1062

Fischer, M.M., Bartkowska, M., Riedl, A., Sardadvar, S. and Kunnert, A. (2009) The impact of human capital on regional labour productivity in Europe, in M.M. Fischer and A. Getis (eds.): *Handbook of Applied Spatial Analysis*, Berlin, Heidelberg and New York: Springer.

Islam, N. (2003) What have we learnt from the convergence debate?, *Journal of Economic Surveys*, 17, 309-362.

Krugman, P. (1991) Increasing returns and economic geography, *Journal of Political Economy*, 99, 483-499.

Le Gallo, J., Ertur, C. and Baumont, C. (2003) A spatial econometric analysis of convergence across European regions, 1980-1995, in B. Fingleton (ed.): *European Regional Growth*, Berlin, Heidelberg and New York: Springer.

Mankiw, N.G., Romer, D. and Weil, D.N. (1992) A contribution to the empirics of economic growth, *Quarterly Journal of Economics*, 107, 407-437.

Myrdal, G. (1957) *Economic theory and under-developed regions*, German edition 1974: Frankfurt am Main: Fischer Taschenbuch Verlag.

Olejnik, A. (2008) Using the spatial autoregressively distributed lag model in assessing the regional convergence of per-capita income in the EU25, *Papers in Regional Science*, 87, 371-385.

Ramos, R., Suriñach, J. and Artís, M. (2010) Human capital spillovers, productivity and regional convergence in Spain, *Papers in Regional Science*, 89, 435-447.

Resende, G.M., de Carvalho, A.X.Y. and Sakowski, P.A.M. (2013) *Evaluating multiple spatial dimensions of economic growth in Brazil using spatial panel data models (1970 - 2000)*, Instituto de Pesquisa Econômica Aplicada Discussion Paper 1830a.

Romer, D. (2005) *Advanced Macroeconomics*, 3rd ed., New York: McGraw-Hill/Irwin.

Sardadvar, S. (2012) Growth and disparities in Europe: insights from a spatial growth model, *Papers in Regional Science*, 91, 257-274.

Solow, R.M. (1956) A contribution to the theory of economic growth, *Quarterly Journal of Economics*, 70, 65-94.