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THE HYPOTHETICAL CASE OF KOREAN UNIFICATION**

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Growth and Convergence in a Two-region Model: The Hypothetical Case of Korean Unification

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Abstract

The paper discusses the impact and implications of Korean unification by setting up a two-region endogenous growth model. The numerical solutions are based on the formal analytical model, and have been calibrated so that they reflect the observed features of the North and South Korean economies. The numerical solutions provide evidence about the speed of convergence and the large amount of interregional transfers that would be required to make the North Korean economy economically viable. We also model the impact of foreign aid, migration and borrowing abroad for the transition process.

Keywords: Korean Unification, Regional Convergence, Economic Growth

JEL Classification: O41, O52, H31, H40

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1. Introduction

Looking into the political future of a nation tends to be a highly speculative endeavour. With little empirical data available to guide their predictions, Koreans have come to cherish Germany's experiences, as many see this country's unification saga as an important, if not the most important, point of reference. Probably, Korea's unification will be more difficult and complex than Germany's unification in October 1990. On the other side, the Koreans have one major advantage: they may study the German developments, and avoid mistakes, which for one reason or another have been committed in the heart of Europe.

For more than four decades, the two Korean states have developed entirely different economies, with the South prospering under a market system and the North stagnating under an inefficient centrally planned economy with serious macroeconomic imbalances. But for how much longer? Internally North Korea's political outlook remains stable. Its leader, Kim Jong-il, appears firmly in control of the government. On the other hand, history teaches - and Germany's more recent past is just one case in point - that it is impossible to make safe predictions. In Germany, we used to say, unification lies far away in the future, assuming that the communist regimes to our East are stable. But then we found out, they were in fact far less sustainable than generally assumed.¹

These developments simultaneously present to Korea a challenge and an opportunity. What remains unclear is how fast this process will go on. Therefore, it is important to get some idea as to how large the macroeconomic impacts of unification can actually be. This paper examines the impact and implications of Korean reunification based on a two-region endogenous growth model and aims to provide economic policy guidance for such an event.² For that purpose, we transpose to Korea the framework in Funke and Strulik (2000) which has been used to analyze the German unification process. This approach is, to the best of our knowledge, new in the literature.³ Naturally, the integration of the Korean peninsula provides tough challenges. North Korea has a substantial population, which is about half the population of South Korea, while its per capita income is only one tenth of South Korea's. Therefore, South Korea's fiscal burden would be substantially larger than West Germany's if Korea were to follow the German-style reunification. Given these initial conditions, the paper turns to an assessment of likely post-unification dynamics in Korea and produces a number of capsule lessons about the appropriateness of various policy scenarios.

¹ We would also like to highlight one very important common feature: the strategies adopted by the West German governments in the years ahead of unification and the South Korean government today. South Korea's "Sunshine Policy" may be called a carbon copy of Bonn's so-called "Ostpolitik". Both policies focused at increasing cooperation, and engaging the other side - with the ultimate goal of keeping alive the notion of one nation.

² This implies that both governments have either agreed on unification or formed a commonwealth or confederation under the principles of a market economy ("de facto unification"). Another possibility is an unexpected sudden collapse of the communist dictatorship as it occurred in eastern Germany in 1989. Such an implosion still remains a likely scenario for the next few years. Therefore unification scenarios for the North Korean economy are not totally unrealistic. In other words, waiting for North Korea to reform resembles Godot, except that it really will come in the end. Therefore, one is well advised to be prepared for this contingency. The official Korean unification policy is available via the Internet at <http://www.unikorea.go.kr>.

³ It should also be emphasized that the approach presented here is intended as a complement to other approaches to the issue of Korean unification. A substantial body of literature using different modelling approaches has developed over recent years to analyze the impact of Korean unification. An excellent summary is provided in Noland (2000).

The remainder of the paper is organized as follows. Section 2 describes the underlying theoretical growth model. In Section 3, we report results from a series of calibration experiments. Some final remarks and policy conclusions are contained in Section 4.

2. The Theoretical Setup

This paper transposes to Korea a framework used by Funke and Strulik (2000) to analyze the German unification process. The framework is an extension of Ono and Shibata's (1992) two-country model with capital accumulation and interregional transfers. The model can also be understood as a two-region generalization of Barro's (1990) model on government spending and economic growth.

2.1 Firms

We consider two regions, the South and the North. Regional variables are indexed by $i = S, N$, variables without index apply to the economy as a whole. In each region there exists a large number of competitive firms which use capital K_i and labor L_i to produce output Y_i . Prices are normalised to one. Homogenous output is used for consumption and private and public investment. Firms have identical Cobb-Douglas technologies

$$Y_i = A_i K_i^\alpha L_i^{1-\alpha} \quad (1)$$

and private capital evolves according to

$$\dot{K}_i = I_i - \delta K_i. \quad (2)$$

Here, I_i denotes net investment and δ is the depreciation rate which is a positive constant. Given wages w_i and interest rates r_i , firms are assumed to maximize the present value of intertemporal profits which leads to factor demand according to

$$(1-\alpha)A_i(K_i/L_i)^\alpha = w_i \quad (3)$$

and

$$\alpha A_i(K_i/L_i)^{\alpha-1} - \delta = r_i. \quad (4)$$

For identical interest rates all firms would select the same capital-labor ratio if regional productivities A_i are the same. Since this would imply identical regional wages, regional differences are eventually explained by different regional productivity. Regional productivity, however, is itself an endogenous variable. From a large set of possible determinants of regional differences, e.g. skill level and health of the labor force,

secure property rights, or climate, we concentrate on the one we regard as most important for Korea after unification: the regional level of infrastructure.⁴

2.2 Government

We assume a government that uses the same tax policy but possibly different expenditure policies in both regions. It applies a single tax rate on all sources of income. Tax earnings are spent on the accumulation of regional infrastructure, income redistribution within a region, and income redistribution between regions.⁵ The government runs a balanced budget. Although the government may eventually decide on regional expenditures independently from regional revenues, it facilitates interpretation of results to imagine a two-step procedure in government budgeting. In the first step the government decides separately for each region how much of regional tax revenues are spent on infrastructure and intra-regional transfers. In the second step it performs interregional redistribution. Let q_i denote the share spent on infrastructure, G_i the regional stocks of infrastructure, δ its rate of depreciation, Z_i interregional redistribution, and x the share of South Korean tax revenues transferred to the North.⁶ Government behavior is then described by:

$$\dot{G}_i = q_i \tau Y_i - \delta G_i \quad (5)$$

$$Z_S = (1 - q_S - x) \tau Y_S \quad 0 < q_S < 1 \quad (6)$$

$$Z_N = [1 - (1 - \mu) q_N] \tau Y_N + x \tau Y_S \quad (7)$$

We account for the possibility that parts of North Korean infrastructure expenditures may be financed through foreign capital, particularly development aid, to help meet North Korea's large infrastructure needs. These sources will help ease the burden on South Korea's public finances. In equation (7), the parameter μ denotes the share of infrastructure investment which is financed by development aid. Note

⁴ We have not emphasized human capital as a key factor driving long-term growth because North Korea is equipped with relatively well-educated human resources. Official North Korean data on school enrollment and educational attainment shows that North Korea has a substantial educational stock almost comparable to that of South Korea (see Noland, 2000, p. 74-75). A comprehensive estimate of the South Korean human capital stock over the period 1963 to 1993 is available in Lee and Kim (1997). Yet recent research shows that not all is well in this front. Boeri (2000) highlights the fact that skills acquired under communism are overly specialized and therefore not easily transferable.

⁵ There are many possible definitions of infrastructure capital publicly provided or owned. The one that makes the most sense from an economic standpoint consists of the large capital-intensive "core infrastructure" categorized by the World Bank (1994). The "core" includes public works (canal works, roads, etc.), public utilities (electricity, piped gas, telecommunications, etc.), and transport sectors (railways, seaports, airports, etc.). A more broadly defined version that focuses ownership includes the tangible capital stock owned by the public sector, which includes human capital investment, protection facilities and equipment, and research and development capital. See World Bank (1994) and Jimenez (1995) for details. Aghion and Schankerman (1999) and (2000) have recently shown that public infrastructure projects in transition economies generate dynamic gains in productivity by improving the ability of the market to weed out inefficient existing firms ("market selection"), by changing the incentives for firms to lower their costs by restructuring, and by providing greater (less) incentives to enter for low (high) cost potential entrants.

⁶ Contrary to Barro (1990) we treat productive government expenditures as a flow variable that extends the stock of public capital. Therefore the model exhibits transitional dynamics.

that q_N is allowed to be larger than one. In this case the government spends more on northern infrastructure than northern tax revenues allow, and therefore transfers from the South ($x > 0$) or foreign aid ($\mu > 0$) are necessarily required for Z_N to be non-negative.

The effect of infrastructure on regional productivity is modelled according to Barro (1990) so that the macroeconomic production function shows constant returns to scale in private and public capital and long-run growth is possible. To eliminate unwanted scale effects, we additionally take into account that regions differ in size so that total regional infrastructure has to be scaled by regional population:

$$A_i = A (G_i/L_i)^{1-\alpha} \quad A > 0 \quad (8)$$

The parameter A represents the constant intrinsic productivity of both regions.⁷ The key assumption in (8) is that an increase in a region's level of public capital per capita improves that region's level of technology, A_i . The reduced-form expression for output is therefore given by $AG_i^{1-\alpha} K_i^\alpha$.

2.3 Households

Each region is populated by a large number of households each supplying, without loss of generality, one unit of labor. It is assumed that a representative household maximizes the intertemporal utility function

$$U_i = \int_0^{\infty} \frac{c_i^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} dt \quad (9)$$

where c_i is consumption, ρ denotes the time preference rate, and $1/\sigma < 1$ is the intertemporal elasticity of substitution. Households may differ in financial wealth a_i and in transfers received, z_i . Heterogeneity in wealth of households within one region may explain existence of intra-regional transfers. Given a tax rate τ on interest income and wage income, households face the budget constraint

$$c_i + \dot{a}_i = (1-\tau)(r_i a_i + w_i) + z_i \quad (10)$$

The left side of the budget constraint represents expenditures, while the right side represents wage income net of taxes and transfers. First order conditions provide a unique Ramsey rule for all households independently from wealth and provenance.

$$\frac{\dot{c}_i}{c_i} = \frac{(1-\tau)r_i - \rho}{\sigma} \quad (11)$$

The intertemporal approach suggested above can be used to think rigorously about national intertemporal budget constraints and government intertemporal budget constraints.

⁷ The precise way that (8) is specified has crucial policy implications. The empirical papers by Duggal et al. (1999) and Shioji (2001) provide a rationale for the chosen specification.

2.4 Convergence of Regional Per Capita Income Levels

We assume that regional infrastructure is immobile and private capital flows freely between regions. Hence, unification leads to a spontaneous equalization of regional interest rates. The region with the higher marginal product of capital attracts private investment. Since capital productivity depends on regional infrastructure which is immobile and comparatively slowly evolving over time, private capital movements cannot produce spontaneous equalization of regional disparities. This constitutes the crucial feature of the model, regional productivity disparities are determined by regional endowment with immobile infrastructure, which is instantaneously predetermined but in the long-run controllable by the government. To see this insert (8) into (4) and apply interest parity to obtain:

$$\theta \equiv \frac{y_N}{y_S} = \frac{K_N/L_N}{K_S/L_S} = \frac{G_N}{\lambda G_S} \quad (12)$$

where

$$\lambda \equiv \frac{L_N}{L_S}. \quad (13)$$

The variable θ measures the relative backwardness of the northern region in terms of northern income per capita relative to southern income per capita. The (fixed) scale variable λ controls for the smaller size of the northern region. To see how government policy affects regional convergence, insert (8) and (12) into (5) to obtain

$$\gamma_\theta \equiv \frac{\dot{\theta}}{\theta} = (q_N - q_S) \tau A \left(\frac{G_S}{K_S} \right)^{-\alpha}. \quad (14)$$

If the successful southern policy is simply imposed upon the North, $q_N = q_S$, then there will never be convergence. In order to attract enough private capital to manage convergence, infrastructure spending in the North has to be temporarily higher. The simple policy rule for convergence reads: As long as the North lags behind the South, spend a larger share of regional tax revenues on infrastructure in the North. If we additionally require smooth convergence, the policy rule is fulfilled by a set of monotonous functions f such that

$$q_N = [f(\theta) + 1]q_S \quad f' < 0, f(1) = 0. \quad (15)$$

In the following we assume that the government aspires regional convergence and chooses a fiscal policy according to (15). Consequently, the economy may have a long-run equilibrium at $\theta = 1$.

2.5 Regional and National Dynamics After Unification

In this economy, a dynamic equilibrium is determined as follows. We begin with developing a differential equation for the nation-wide capital stock, K . Consumption and regional infrastructure are then expressed as fractions of the nation-wide capital stock. Using the measures for relative backwardness and relative size, the national capital stock can be expressed in terms of the southern capital stock:

$$K = K_S + K_N = (1 + \theta\lambda)K_S \quad (16)$$

Any income which is not spent on consumption or infrastructure is spent on private investment, so that nation-wide capital evolves according to $\dot{K} = (1 - \tau q_S)Y_S + (1 - (1 - \mu)\tau q_N)Y_N - C - \delta K$, i.e.

$$\dot{K} = (1 - \tau q_S)A \left(\frac{G_S}{K_S} \right)^{1-\alpha} K_S + (1 - (1 - \mu)\tau q_N)A \left(\frac{G_N}{K_N} \right)^{1-\alpha} K_N - C - \delta K \quad (17)$$

After insertion of (12), (15) and (16) into equation (17), the growth rate of the nation-wide capital stock can be expressed as

$$\gamma_K = \frac{\dot{K}}{K} = \left\{ 1 + \theta\lambda - (1 - \mu)\tau q_S \left[1 + \lambda\theta(f(\theta) + 1) \right] \right\} A g_S^{1-\alpha} (1 + \lambda\theta)^{-\alpha} - \chi - \delta \quad (18)$$

where $\chi \equiv C/K$ denotes the economy-wide consumption-capital ratio and $g_S \equiv G_S/K$ denotes infrastructure of the South per unit of nation-wide private capital. Inserting (4) into (11), the growth rate of the consumption capital ratio is obtained as

$$\gamma_\chi \equiv \frac{\dot{C}}{C} - \gamma_K = \frac{1}{\sigma} \left[(1 - \tau)\alpha A g_S^{1-\alpha} (1 + \lambda\theta)^{-\alpha} - (\delta + \rho) \right] - \gamma_K \quad (19)$$

Using the newly introduced notation, equations (5) and (14) can be rewritten as

$$\gamma_{g_S} \equiv \frac{\dot{G}_S}{G_S} - \gamma_K = q_S \tau A g_S^{-\alpha} (1 + \lambda\theta)^{-\alpha} - \delta - \gamma_K \quad (20)$$

and

$$\gamma_\theta = f(\theta) q_S \tau A g_S^{-\alpha} (1 + \lambda\theta)^{-\alpha} \quad (21)$$

Regional and nation-wide dynamics are therefore summarized by three differential equations for θ , g_S and χ . An equilibrium of complete convergence uniquely determines $\theta^* = 1$ from (21). Insertion of (20) into (19) provides the the implicit function

$$0 = F(g_s^*) = \frac{1}{\sigma} \left[(1-\tau)\alpha A g_s^{*1-\alpha} (1+\lambda)^{1-\alpha} - (\delta+\rho) \right] - q_s \tau A g_s^{*-\alpha} (1+\lambda)^{-\alpha} + \delta \quad (22)$$

which determines the equilibrium ratio of southern infrastructure. Since $F' > 0$ for all positive g_s and $\lim_{g_s \rightarrow 0} F(g_s) = -\infty$ and $\lim_{g_s \rightarrow \infty} F(g_s) = \infty$ a unique equilibrium g_s^* exists.⁸ Finally, χ^* is obtained from (18) and (19) as:

$$\chi^* = (1+\lambda)^{1-\alpha} A g_s^{*1-\alpha} \left(1 - (1-\mu)\tau q_s - \frac{(1-\tau)\alpha}{\sigma} \right) + \frac{(\delta+\rho)}{\sigma} - \delta. \quad (23)$$

From (19) and (20) one sees that consumption, public capital, and private capital grow at the same rate along the equilibrium growth path. Inspection of (11) and (12) shows that the regional components y_i , c_i , K_i , and G_i , also grow at equal rates in the long run. The Jacobian determinant at the steady state is computed as $\det J = \partial\gamma_\theta / \partial\theta \left(\partial\gamma_{g_s} / \partial g_s - \partial\gamma_\chi / \partial g_s \right)$ with

$$\partial\gamma_\theta / \partial\theta = f'(\theta)(1+\lambda)^{-\alpha} q_s \tau A g_s^{-\alpha} < 0 \quad (24)$$

and

$$\frac{\partial\gamma_{g_s}}{\partial g_s} - \frac{\partial\gamma_\chi}{\partial g_s} = -\alpha(1+\lambda)^{-\alpha} q_s \tau A g_s^{-\alpha-1} - (1-\alpha)(1-\tau)(1+\lambda)^{1-\alpha} \frac{\alpha A g_s^{-\alpha}}{\sigma} < 0 \quad (25)$$

so that the equilibrium is a saddlepoint. It is easily seen that the corresponding eigenvalues are

$$\lambda_1 = \frac{\partial\gamma_\theta}{\partial\theta} < 0 \quad (26)$$

and

$$\lambda_{2,3} = \frac{1 + \partial\gamma_{g_s} / \partial g_s \pm \sqrt{\left(1 + \partial\gamma_{g_s} / \partial g_s \right)^2 - 4 \left(\partial\gamma_{g_s} / \partial g_s - \partial\gamma_\chi / \partial g_s \right)}}{2} \quad (27)$$

Since $\partial\gamma_{g_s} / \partial g_s - \partial\gamma_\chi / \partial g_s < 0$ all eigenvalues are real so that the adjustment path towards the equilibrium is monotonous. For all relevant parameter specifications two eigenvalues are negative. On this line of reasoning, one could infer that the stable manifold is two-dimensional and a unique adjustment path after unification is determined by two initial conditions.⁹

⁸ Generally, g_s^* can only be obtained numerically. Funke and Strulik (2000) discuss a special case for which an analytical solution exists and show that the corresponding equilibrium growth rate reaches a maximum when $\tau = 1-\alpha$. Hence, the two-region growth model also reflects Barro's (1990) finding that the optimal tax rate equals the production elasticity of infrastructure.

⁹ In this model without convexities, the steady state is unique and saddle-path stable. This is in contrast with models of endogenous growth with externalities or increasing returns to scale, which can generate multiple steady states or equilibria. See, e.g., Azariadis and Drazen (1990).

2.6 Interregional Income Redistribution

The problem of regional productivity convergence has been solved independently from redistributive issues. We now consider income transfers from the South towards the North. Along the adjustment path an average North Korean is worse off for two reasons. First, he is equipped with less initial wealth than his southern counterpart, i.e. $a_N(0) = K_N(0)/L_N < a_S(0) = K_S(0)/L_S$ at unification time. Second, he suffers from lower wages due to the lower northern productivity. Disparities in wealth reflect the poor economic performance of the North *before* unification and are perhaps more easily regarded as irreversible. Disparities in wages, however, reflect the poor economic performance of the North after unification. Obviously, these wage differentials may induce unwanted migration from the North towards the South.

To discuss interregional income distribution we consider two policy variables, x and ϕ . The variable x denotes the share of southern tax revenue transferred to the North. Hence, the average South Korean receives income transfers $z_S = (1 - q_S - x)\tau Y_S/L_S$ and the average North Korean receives $z_N = [1 - (1 - \mu)q_N]\tau Y_N/L_N + x\tau Y_S/L_N$. The variable ϕ denotes the wage income (net of taxes and transfers) of an average North Korean that the government aspires to, as a percentage of average South Korean income. It may serve as a proxy for the pressure to migrate. For $\phi = 1$ the government fully compensates for lower wages in North Korea through lump-sum transfers and therefore there is no economic incentive for the abundant North Korean labor force to migrate. Both policy variables are obviously interrelated. We assume that the government tries to set ϕ such that x develops endogenously.

Wage income net of taxes and transfers is $(1 - \tau)(1 - \alpha)y_i + z_i$. After substituting transfers from above and using the definition of θ one obtains the relative North-South income ratio

$$\phi = \frac{[1 - \alpha(1 - \tau)]\theta - q_N(1 - \mu)\tau\theta + x\tau(L_S/L_N)}{1 - \alpha(1 - \tau) - q_S\tau - x\tau} \quad (28)$$

Inserting the policy rule and the definition of λ and solving for x yields

$$x = \max \left\{ 0, \frac{\{[1 - \alpha(1 - \tau)](\phi - \theta) - q_S\tau[\phi - (1 - \mu)\theta] + f(\theta)q_S(1 - \mu)\tau\theta\}\lambda}{\tau(1 + \lambda\phi)} \right\} \quad (29)$$

where we have taken into account that transfers are non-negative.¹⁰

¹⁰ Because the equilibrium at $\theta = 1$ is not reached in finite time one can only determine a point of time when transfers are arbitrarily small. Note also that regional convergence of consumption levels would temporarily require $\phi > 1$ because the North additionally has to be compensated for its worse initial position of financial wealth.

3. Model Calibration and Solution Technique

The above model allows us to address rigorously a number of issues related to Korean unification. The analysis is carried out through calibrations and numerical solutions which are meant to account for the effects of government policy, without estimating real-economy parameters out of the growth model they build upon. Instead, we “borrow” sensible parameters estimated by other researchers.

A precise quantitative assessment of the North Korean economy at the outset of the transition is virtually impossible since the data are fragmentary.¹¹ It is therefore not surprising that existing studies on the relative performance of the Korean economies show considerably varying results. Noland (2000) cites six studies providing estimates between 2.49 and 5.40 for the ratio between South and North Korean income per capita GDP in 1990. These values suggest a degree of initial backwardness, θ , between 0.18 and 0.40. On the other hand, the North Korean economy has been in a wretched state since the mid 1990s because of energy shortages and a deteriorating Soviet-style industrial base. Famine is claiming North Korean lives, although disagreement remains as to its associated death toll. Taking the steady deterioration of economic conditions into account, Noland (2000) calculates that the estimates above would imply a ratio between 8:1 and 11:1 in the year 1997. In any case, these numbers imply that North Korea is in a poverty trap. Given these numbers, we define a benchmark value of $\theta(0) = 0.10$. Given the enormous uncertainty, however, we also discuss an alternative, more optimistic scenario with $\theta(0) = 0.20$.¹²

Between 1990 and 2000 South Korea grew at an average rate of 6.1% (OECD, 2001). The EIU (2000) estimates that growth will continue at an average rate of 6.1% from 2001 to 2005. Given an average annual population growth rate of 1% from 1990 to 1999, we set South Korea’s annual steady state per capita growth rate to 5.0%. If one expects that South Korea’s growth rate will eventually converge towards the growth rates of countries at the frontier, a value of 5% may, however, be too high. We therefore also provide a sensitivity analysis assuming an annual steady state growth rate of 3%.¹³

¹¹ Our results should therefore be considered as a “rigorous speculation” using up-to-date modeling techniques.

¹² A North/South productivity ratio of 20% has also been assumed in Horn (1996), pp. 144-145. Given the inherent difficulties in measuring North Korean GDP, the measures of initial backwardness discussed in the text should be considered only as rough guesstimates. Before German unification, for example, East Germany was considered the most modern economy in the communist block. But its industry was found to be in far worse shape than the statistics had suggested. In North Korea, the truth may be even more dreadful. Noland (2000), pp. 59-142 contains a discussion of the hazards of estimating North Korean GDP and a summary of alternative estimates. The historical irony is that the North, until 1950, has been the industrial powerhouse of the united Korea. Heavy industry and science were all concentrated in the North. The South was home to agriculture and light industry.

¹³ Lee (2001, p. 111) has estimated that South Korea is likely to grow at around 2.6% per year for the period 1995 - 2020.

Calibration of the parameter α entails a trade-off: α can either closely reflect the production elasticity of private capital or the production elasticity of public capital. Since private capital flows freely across regions, infrastructure is the limiting factor for convergence and it is more important to match its production elasticity accurately. Following Uchimura and Gao (1993), we assume that the production elasticity of public capital $(1-\alpha)$ is equal to 0.19.¹⁴ Since South Korea has about double the population of North Korea (Noland 2000, p. 295), we set λ to 0.50.

With respect to the capital-output ratio we use the average estimate for the Korean manufacturing sector from 1960 to 1990 ($k^* = 3.0$) in Timmer and van Ark (2000). The value is lower than Noland's (2000) estimate for 1990 ($k^* = 6.44$). On the other hand, however, it is much higher than Timmer and van Ark's (2000) average estimate for Korea's total economy ($k^* \approx 1.5$).

In addition, on the fiscal policy side, it is further assumed that τ is identical to the South Korean government share of GDP which was about 0.20 from 1970 to 1993 (Park, 1998, Table 10.1). According to OECD (2001), 83% of government expenditure was either government consumption or social security transfers. Assuming that the remaining fraction was productive spending we set q_s to 0.17. This value corresponds with the share of expenditure for economic development in central government expenditure which was around 0.20 according to Park (1998), Table 10.5.

According to conventional wisdom in calibration exercises, we set the benchmark value for time preference ρ to 0.02 and the depreciation rate δ to 0.05. This implies an equilibrium investment rate of 0.30, which corresponds with the South Korean performance since the eighties (OECD, 2001) as well as with the EUI forecast (EUI, 2000) for the years up to 2005.¹⁵

Finally, we have to specify the fiscal policy rule. In Funke and Strulik (2000) the policy rule is specified so that it is reasonably consistent with infrastructure spending in East Germany and with transfer payments from the West to the East for the first ten years after unification. Since the Korean unification experiment is purely hypothetical, specification of the policy rule is to a large extent arbitrary. For the benchmark scenario we assume absence of foreign aid ($\mu = 0$) and that Korean unification is accompanied by the same policy rule as in Germany, i.e. we address the question of what the unification process would look like if Korea follows the same expenditure rule as Germany. This procedure has the advantage that both unification scenarios are more easily comparable with regard to their impact, their costs, and speed of adjustment dynamics. We specify

$$f(\theta) = a \left(\frac{1-\theta}{\theta} \right) \quad (30)$$

¹⁴ This assumption is consistent with the recent estimates for the elasticity of output with respect to infrastructure in Shioji (2001). There have been numerous other estimates, which we do not have the space to discuss in a systematic way. Luckily, Sturm et al. (1998) have provided a comprehensive survey. The literature review shows that although the stunning conclusion from the original work by Aschauer (1989) seems to have overestimated the role of public capital, it is also a mistake to dismiss public capital as inconsequential for growth.

¹⁵ A value of 0.30, however, seems to be rather high if one expects convergence towards the investment rates of countries at the world-wide frontier. Since $(I/K)^* = (g_K^* + \delta)(K/Y)$, a sensitivity analysis with respect to lower equilibrium growth rates will simultaneously lead to lower equilibrium investment rates.

and set $a = 2/3$ in the benchmark case. The policy rule is consistent with (12) and assumes that government spending is convex in θ , i.e. $f'' > 0$. The parameter a controls for the magnitude of infrastructure spending. For the Korean case, this benchmark value has an interesting side-effect: The share of North Korean infrastructure spending in total (i.e. North and South) tax revenues is constant over time. To see this calculate

$$\tilde{q} = \left(\frac{a(1-\theta)}{\theta} + 1 \right) q_s \frac{\tau Y_N}{\tau (Y_N + Y_S)} = \left(\frac{a(1-\theta) + \theta}{\theta\lambda + 1} \right) \lambda q_s \quad (31)$$

and the derivative with respect to θ

$$\frac{\partial \tilde{q}}{\partial \theta} = \left(\frac{1-a(1+\lambda)}{(\lambda\theta+1)^2} \right) \lambda q_s \quad (32)$$

which is zero for benchmark values $\lambda = 1/2$ and $a = 2/3$. Hence, the share of northern infrastructure spending in total revenues is independent of the degree of backwardness and constant over time. It is $q_s \lambda / (1+\lambda) = 5.67$, which is half the equilibrium share of infrastructure spending in the South, $q_s' / (1+\lambda) = 11.33\%$. In the baseline scenario, we set $\phi = 1.0$ to compare the results with the German unification scenario in Funke and Strulik (2000). Additionally we provide a sensitivity analysis for this parameter.

The two remaining parameters, σ and A , are jointly determined with g_s^* so that equations (18) - (21) are fulfilled for predetermined values of g_y^* and k^* . This leads to $\sigma = 2.92$ and $A = 0.50$ and an equilibrium ratio of public to private capital of $(G/K)^* = 0.11$. Table 1 summarizes the benchmark specification.

Comparison with the benchmark case in Funke and Strulik (2000) shows besides almost identical preferences (ρ , σ), technologies (α) and production techniques (k^*), five crucial differences between the two unification scenarios. First, North Korea's initial backwardness is much more severe than that of East Germany ($\theta = 0.1$ vs. $\theta = 0.4$). Second, North Korea's population is about half of South Korea's; East Germany's was only a quarter of West Germany's ($\lambda = 0.5$ vs. $\lambda = 0.25$). Compared with West Germany, South Korea would therefore have to swallow a relatively more populous, much poorer neighbour. Third, the share of infrastructure spending in South Korea is larger than in West Germany (0.17 vs. 0.10). Given the same policy rule, this implies more effort in infrastructure spending in North Korea than in East Germany for any given level of relative backwardness. This does, however, not necessarily imply that North Korea would converge faster than East Germany since the higher share of infrastructure spending applies to both regions. Fourth, the tax share of GDP is much smaller in Korea than in Germany. Finally, the South Korean economy has grown at a much higher equilibrium rate than West Germany (5.0% compared to 1.75%). While one cannot a priori decide if this also implies faster convergence of both economies, high growth will certainly ease the burden of unification.

In order to identify a unique adjustment path from the set of feasible trajectories on the two-dimensional stable manifold we have to specify a second initial condition besides $\theta(0)$. We use the assumption that South Korea was approximately developing on its equilibrium growth path prior to unification. Therefore the ratio of public to private capital before unification is implicitly determined by the steady state after unification through $G_S(0)/K_S(0) = g_s^*(1+\lambda)$. Hence, $g_s(0) = g_s^*(1+\lambda)/(1+\theta(0)\lambda)$.

We obtain the solution employing the method of backward integration as described in Brunner and Strulik (2002). We use a fourth-order Runge-Kutta-Fehlberg procedure and integrate backwards from a point arbitrarily close to the steady state after unification and integrate backwards until $\theta(0)$ is matched. Since any trajectory on the manifold cuts a circle around the steady state (with arbitrarily small radius) exactly once, we use alternative starting values on such a circle on the manifold to generate a large set of trajectories fulfilling $\theta(0)$. From the set of trajectories we iteratively determine the one that matches $g_s(0)$ best.

4. Quantitative Results

We are now ready to analyze the quantitative macroeconomic effects of immediate unification in Korea. The adjustment dynamics for the benchmark values are shown by the solid lines in Figure 1. The upper left panel shows the benchmark policy rule $q_N(\theta)$. The other figures show implied adjustment paths over time. The most important finding is that the speed of convergence is very fast. Starting at a level of 10%, relative productivity in North Korea (θ) has reached 50% after ten years. This fast adjustment speed is mainly a consequence of high marginal returns of capital at very low levels of the capital-output ratio.¹⁶ This is also reflected in the γ_{KN} -panel showing growth rates of the North Korean capital stock above 30% initially. Additionally, we have conducted the numerical solutions using a steady state growth rate of 3%. The key finding is that convergence would be slightly slower for an equilibrium growth rate of 3%.¹⁷

The initial q_N above unity shows that the North is unable to finance its infrastructure spending by its own tax revenues. Since the share of northern infrastructure spending in total Korean tax revenues is only 5.67%, the result demonstrates the extremely weak initial position of the North. The x -Panel shows that a complete compensation of wage-income disparities would require very high interregional transfers from the South which are too large compared with the size of the South Korean economy. Initially, over 50% of southern tax revenues would have to be transferred to the North for complete net wage income compensation.¹⁸ This suggests that the benchmark absorption scenario is out of reach for the Korean government.¹⁹ We therefore consider alternative compensation rules below. As in the German case, Korean unification would have little impact on interest rates and therefore on consumption growth. The slight fall of interest rates reflects reduced productivity of the Korean economy as a whole caused by the lack of infrastructure in the North. While unification would have little effect on the intertemporal allocation

¹⁶ Another factor which might help to explain this fast adjustment speed is the creation of efficient institutions in North Korea. The World Bank (2001) has gathered information from 100 countries showing that economies that provide good protection to property rights, broad access to judicial systems and allow open flows of information are most likely to grow fast.

¹⁷ The rationale for the rather small impact is that the steady state growth rate applies to both regions.

¹⁸ For comparison, the initial share of transfers to East Germany was 14% of West Germany's tax revenues (see Funke and Strulik, 2000, p. 375).

¹⁹ A similar conclusion is available in Noland et al. (2000), pp. 410-411. The Koreans' task may be a bit easier if they avoid Germany's mistakes after unification. One mistake was to pay East German workers far more than their productivity initially justified. Their wages in east marks were converted into west marks (*DM*) at a generous exchange rate of 1:1. Unions then sought successfully to bring eastern wages closer to western levels. This left the East German industry uncompetitive, discouraged investment and pushed unemployment up. Korea faces the same dilemma. An enduring gap in wages will prompt Northerners to move to the more prosperous areas in the South. The government of a unified Korea should therefore think of banning or limiting migration and/or implementing welfare programmes in the North.

of capital, it has relatively strong effect on the spatial allocation of capital. This can be seen in the γ_{KN} -panel of Figure 1. Fixed capital growth in the North is mainly financed by less than equilibrium investment in the South. Although growth is still positive in South Korea, its rate would decrease significantly from 5% to about 1.5% initially. Ten years after unification, however, the South Korean growth rate will already have reached about 4%. Since temporary losses of growth in investment translate to temporary losses in growth of wages, a definite loser of unification can be identified: the average South Korean worker.

The robustness of the numerical solution results is obviously an issue in such an exercise and therefore we will investigate various alternative scenarios in Figure 2 – 4 below. Figure 2 shows the development paths for the more optimistic scenario of $\theta(0) = 0.20$. Since the economy adjusts very fast for low θ , the adjustment paths are very similar to Figure 1. After ten years North Korea will have reached 60% of southern productivity. The most noticeable change applies to northern infrastructure spending which is reduced to 60% of tax revenues initially.

Figure 3 shows the numerical solution results for the less ambitious alternative lump-sum consumption transfer rules ($\phi = 0.75$ and $\phi = 0.50$). Both scenarios reduce the unification costs. But even in the scenario where the government aims for average North Korean net wage income to be 75% of average South Korean income, it has to transfer 40% of southern tax revenues to the North initially and about 20% after ten years. After about 20 years transfers could be terminated. If the average income level that the government aspires to in the North is only 50%, transfers could be terminated after ten years. Initially, however, transfers are still about 30% of southern tax revenues.²⁰ In other words, less ambitious targets would be cheaper, but mainly in the long run.

For our final set of experiments, we specified an alternative policy rule (30). Figure 4 shows the results for $a = 4/3$, i.e. for the case where the government has doubled northern infrastructure spending. Adjustment dynamics are further accelerated. After ten years the North will have reached the 80% productivity level as shown by the solid line in the left figure. The dashed line on the left shows the implied share of northern infrastructure in total tax revenues. This share is now no longer constant but adjusts from about 10% towards its equilibrium value of 5.67%.

The right panel of Figure 4 shows that the increasing infrastructure effort initially requires higher transfers but pays off after some time due to faster speed of convergence. For example, if the government aims for the 75% level, transfers are initially about 10% higher but can be terminated about ten years earlier.

Next, we consider the impact of foreign aid. The fact that parts of North Korea's infrastructure needs are financed by foreign aid does not influence the policy rule $f(\theta)$ and therefore it has no impact upon the speed of convergence in (21). Foreign aid, however, eases the burden on South Korea's public finances, i.e. a given ratio of North Korean net wage income, ϕ , can be financed by less transfers x . Figure 5 shows the impact of foreign aid for full compensation ($\phi = 1$) on the left and for the less ambitious income ratio goal of 75 percent ($\phi = 0.75$) on the right. Solid lines reflect the basic scenario without foreign aid and dashed (dotted) lines show adjustment dynamics when 30% (50%) of northern infrastructure are financed by foreign aid.

²⁰ Kwon (2000) has produced similar numbers.

The main insight drawn from Figure 5 is that even a large contribution of foreign aid to infrastructure will only have a minor impact on South Korea's public finances to achieve a given ϕ . This result reflects the fact that the main burden on South Korea's public finances is caused by the wage differential, i.e. the term $[1-\alpha(1-\tau)](\phi-\theta)$ in equation (29).

The baseline model assumes that there is no migration of labor between the two regions although we consider $\phi < 1$ in Figure 3 and 4.²¹ Apparently, to many people in South Korea mass migration, from the North is likewise more of a threat than a blessing. Against this background and widespread anxiety about a migration deluge, how do the simulation results change if we allow for the presence of labor mobility across space? Following Noland (2000, p. 297, footnote 26) we assume that 1.4 to 4 million North Koreans would head south if the border were opened.²² In the baseline scenario we have assumed $\lambda = 23.6/45.5 \approx 0.5$. Adding migration to the model implies $0.40 < \lambda < 0.47$. The second variable which is changing due to migration is θ . The congestion effect in equation (8) implies that θ is determined as $\theta = [G_N(0)/G_S(0)]/\lambda$. Compared to the benchmark case ($\theta = 0.10$) the relative backwardness of the northern region is declining to $\theta = 0.106$ (for $\lambda = 0.47$) and $\theta(0) = 0.125$ (for $\lambda = 0.40$), respectively. The solution for the modified setup is given in Figure 6 below.

The solid lines give the benchmark case without labor migration. The dashed (dotted) line gives the transition path for 1.4 (4.0) million migrants. The calibration indicates that the impact upon the speed of adjustment measured by θ is negligible, but x is about 10% lower at the beginning of the transition path. Given the uncertainty surrounding the exact number of migrants we additionally test for the sensitivity of the calibration results assuming 2 to 8 million migrants. The corresponding results are given in Figure 7 below.

The solid lines again give the benchmark case without labor migration. Even for 8 million migrants (dotted lines), the impact upon the speed of adjustment θ is rather small. On the contrary, but the fiscal burden (x) is further reduced for 8 million migrants.

An important assumption of the estimates in Figure (1) – (6) is that two regions live in financial autarky relative to the rest of the world. In other words, infrastructure cannot be financed by external borrowing, it has to be financed by the sacrifice of domestic consumption over time. How would the simulation results change if Korea borrows externally to smooth the burden of unification?²³

²¹ Full employment is assumed throughout the paper. While the model can be modified to account for labor supply, allowing for nonclearing labor markets would require significant modifications to this model.

²² These estimates are consistent with persistently low wages in Eastern Europe, and finite rates of factor movements. According to survey data, Eastern Europeans do not exhibit a great willingness to migrate despite a large wage differential. Papapanagos and Sanfey (2001) report results of an extensive survey in the *Journal of Population Economics*, in which they found a remarkable hesitancy to migrate. Even in Germany, migration rates remained finite and actually slowed in the aftermath, despite the best of all imaginable circumstances for spatial mobility. For an analysis of the microeconomic calculus in migration and models in the tradition of the Harris-Todaro type, see Stark (1991).

²³ In order to keep things simple, the design implies that we are overlooking all aspects of maximization in the Rest-of-the-World model. Since these questions are outside the model, we do not want to dwell too much on them.

In order to model the issue of external borrowing and loan servicing, let's assume that Korea can borrow an amount $B_0 = b_0 Y_S(0)$ at a constant world interest rate i . Korea has accumulated a huge pile of reserves over recent years. We therefore assume that Korea can borrow a fraction b of the South Korean GDP to reduce the fiscal burden if Korea were to follow the German-style reunification. We now show how to reformulate the model taking into account borrowing abroad. The growth rate of b is determined by

$$\gamma_b \equiv \frac{\dot{b}}{b} = \frac{\dot{B}}{B} - \gamma_{y_s} \quad (33)$$

Assuming a constant repayment rate s , growth of B in (33) is given by $\dot{B}/B = -s$. One possibility for the Korean government would be to pay out the total credit received immediately after unification. However, the model's solution so far has indicated that the burden of unification (measured by relative backwardness θ) exists for a substantial period. For the basic scenario the half time is approximately ten years. Therefore a more plausible policy would be for the payout of credit-financed transfers to be stretched over time and assume that the credit B_0 received at unification time $t_0 = 0$ is paid out as an infinite stream of payments where current payments decline at a constant rate ν over time. The credit actually paid out at time t is defined by $\tilde{B}(t)$ such that

$$B_0 = \int_0^{\infty} \tilde{B}(t) dt = \int_0^{\infty} \bar{B} e^{-\nu t} dt. \quad (34)$$

Hence, one can imagine the credit actually paid out at time t as a compound of a constant (\bar{B}) and a discount factor ($e^{-\nu t}$). We consider ν as a policy variable with which the government can control how the burden of unification is allocated over time. Increasing ν , the government pays out a higher fraction of the credit initially. The allocation of credit for alternative parameters ν ($\nu = 0.1$ and $\nu = 0.2$, respectively) is given in Figure 8 below.

The various graphs for \tilde{b} [see equation (35)] indicate that $\nu = 0.1$ (0.2) implies more (less) smoothing over time.

Given ν , equation (34) can be solved for \bar{B} : $\bar{B} = \nu B_0$ and hence $\tilde{B}(t) = \nu B_0 e^{-\nu t}$. Additionally, we assume that the part of the credit not yet paid is put out at interest rate i . Hence the payment at time t is $\tilde{B}(t) = \nu B_0 e^{-\nu t} e^{it}$. We measure the credit in units of South Korean GDP, i.e. $\tilde{b}(t) = \tilde{B}(t) / Y_S(t)$. Since $Y_S(t) = Y_S(0) e^{g(t)}$ we have

$$\tilde{b} = \nu \frac{B_0}{Y_0} e^{-(\nu-i)t - g(t)} \quad (35)$$

where $B_0/Y_0 \equiv b_0$ measures the amount borrowed in terms of South Korean GDP and $g(t) = \int_0^t \gamma_{y_s}(u) du$.

Let us now consider the government's budget. When considering foreign debt we ignore foreign aid for simplicity, i.e. we set $\mu = 0$. The credit is paid out to the North Koreans who receive total per capita transfers

$$\frac{Z_N}{L_N} = (1 - q_N)\tau y_N + x\tau \frac{Y_S}{L_S} \frac{L_S}{L_N} + \tilde{b} \frac{Y_S}{L_S} \frac{L_S}{L_N} = (1 - q_N)\tau y_N + (x\tau + \tilde{b}) \frac{Y_S}{\lambda} \quad (36)$$

Equation (36) replaces equation (7) above. The credit charges are paid by the South Koreans who therefore receive less transfers. Per capita transfers to South Koreans are given by

$$\frac{Z_S}{L_S} = (1 - q_S - x)\tau y_S - d y_S \quad (37)$$

where d are the credit charges in units of South Korean GDP. d is determined as follows: Outstanding debt declines at rate s , i.e. credit charges (interest and repayment) at time t are $D = (i+s)B_0 e^{-st}$. Since $Y_S(t) = Y_S(0)e^{gt}$, credit charges in units of South Korean GDP, $d \equiv D/Y_S$ are calculated according to

$$d(t) = (i + s) e^{-(st+g(t))} b_0. \quad (38)$$

Relative non-financial North Korean income aspired to by the government becomes

$$\phi = \frac{(1 - \alpha)(1 - \tau)y_N + Z_N/L_N}{(1 - \alpha)(1 - \tau)y_S + Z_S/L_S} = \frac{[1 - \alpha(1 - \tau)]\theta - [f(\theta) + 1]q_S\tau\theta + x\tau/\lambda + \tilde{b}/\lambda}{1 - \alpha(1 - \tau) - q_S\tau - x\tau - d} \quad (39)$$

Solving for the policy variable x finally yields

$$x = \max \left\{ 0, \frac{\{[1 - \alpha(1 - \tau)](\phi - \theta) + [(f(\theta) + 1)\theta - \phi]q_S\tau - d\phi\}\lambda - \tilde{b}}{\tau(1 + \lambda\phi)} \right\}. \quad (40)$$

In the calibrations below we generally assume $i = 0.05$ and $s = 0.1$ as well as the accelerated infrastructure spending rule $a = 4/3$ already analyzed in Figure 4.²⁴ Figure 9 shows the resulting fiscal burden for two alternative debt levels ($\tilde{b}_0 = 1/3$ versus $\tilde{b}_0 = 1/2$) and two “smoothing parameters” ($v = 0.1$ versus $v = 0.2$).

In sum, the results show that massive borrowing abroad is indeed a mechanism which allows for the reduction of the very high initial fiscal transfer level and therefore the neglect of borrowing is probably an important limitation of the analysis. In the most optimistic scenario, x is reduced to about 10% which is similar to the current German West-East transfer level. As a result, a rapid reform strategy turns out to be a more viable option. In other words, borrowing abroad is a workable alternative that could cushion the required fiscal burden. This extension thus nicely complements the baseline scenario. Again, we would like to present some sensitivity analysis. Figure 10 below presents the fiscal burden for the benchmark case $\tilde{b}_0 = 0$ (solid line), $\tilde{b}_0 = 0.1$ (dashed line) and $\tilde{b}_0 = 0.75$ (dotted line), respectively.

The results for $\tilde{b}_0 = 0.75$ confirm the previous findings that massive borrowing abroad can cushion the fiscal burden substantially.

²⁴ This implies that the speed of convergence (θ) is given by the left panel of Figure 4.

5. Conclusions

Looking into the political future of a nation necessarily tends to be a highly speculative endeavour. In this paper we explore the implications of an endogenous growth model for post-union regional inequality, and the transfers required to mitigate them. We think that our work points to certain impacts that are highly relevant for future discussions of policy regime designs. In other words, subject to limitations imposed by the quality of the data, the paper has led to some critical guidelines for the transformation of the North Korean economy. One question we are addressing is how much would the South have to pay for the cost of rebuilding the backward North? The results indicate that proper consideration of borrowing is essential for assessing the fiscal impact of Korean unification. All in all, the calibration results indicate that a German-style unification, known as the Monetary, Economic and Social Union of July 1, 1990 would only be feasible if South Korea finances large parts of reunification costs by borrowing abroad.

With little empirical evidence available to guide policy, economists have come to cherish Germany's unification experiences as an important point of reference. German unification has been (and continues to be) a very costly undertaking. Regarding the Koreas, the longer division continues, the higher the costs of unification will eventually be. Korean unification implies putting under one governmental roof one of the world's most dynamic economies with the most stagnant. Delaying this process will widen South Korea's lead, necessitating even more investment later. Therefore, economic North-South cooperation is in the very best self-interest of south Korea.²⁵

²⁵ Historically, the most important dissimilarity between Korea and Germany is the war on the Korean Peninsula in the early fifties. The Korean War was, for all practical purposes, a civil war. The scars left behind by this conflict are still open, the clash of ideologies has left little room for compromise. Notably, this confrontation has also poisoned domestic politics in the South, with supporters of a reconciliatory approach toward the North poised against followers of a tougher line.

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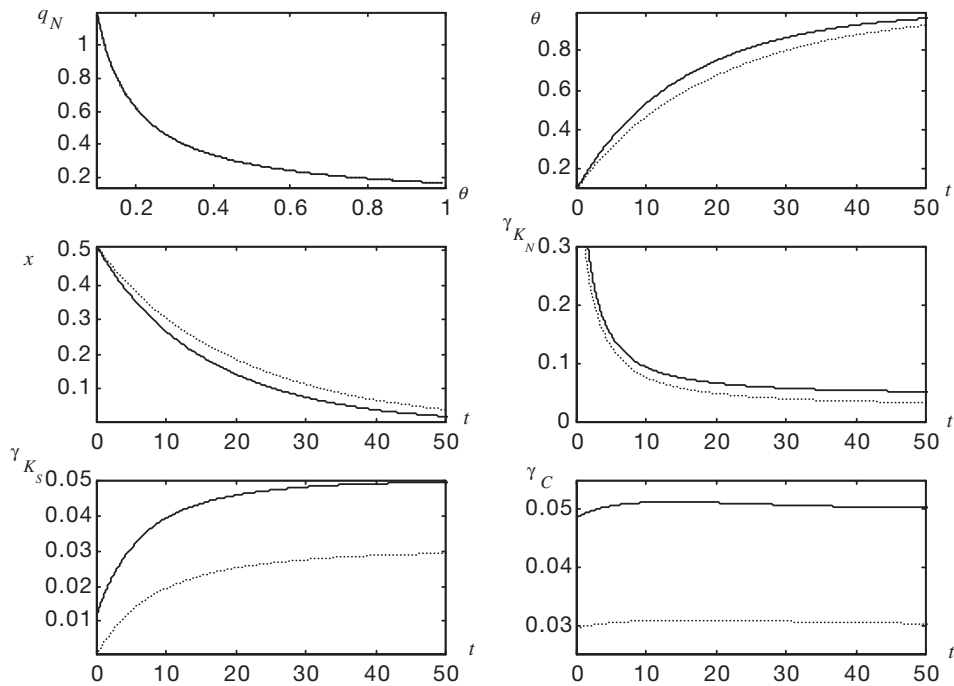
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Table 1. Benchmark Parameters and Equilibrium Values

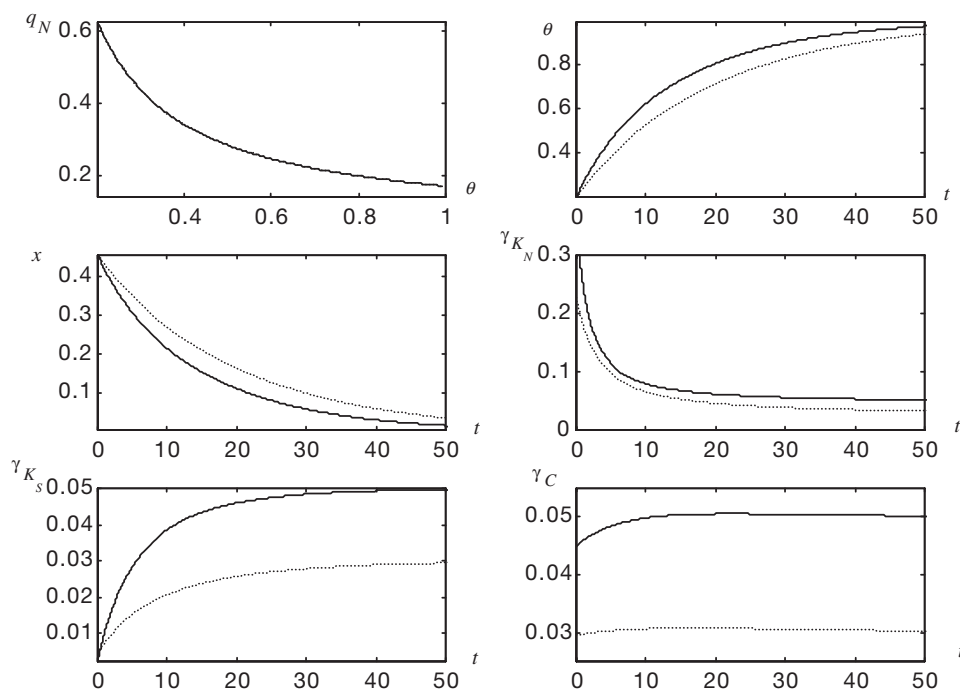
θ	α	λ	τ	q_s	δ	ρ	σ	A	a	ϕ	μ	g_y^*	$(K/Y)^*$	$(I/Y)^*$
0.10	0.81	0.50	0.20	0.17	0.05	0.02	2.92	0.50	0.67	1.00	0.00	0.05	3.00	0.30

Figure 1. Economic Development After Korean Unification for $\theta(0) = 0.10$



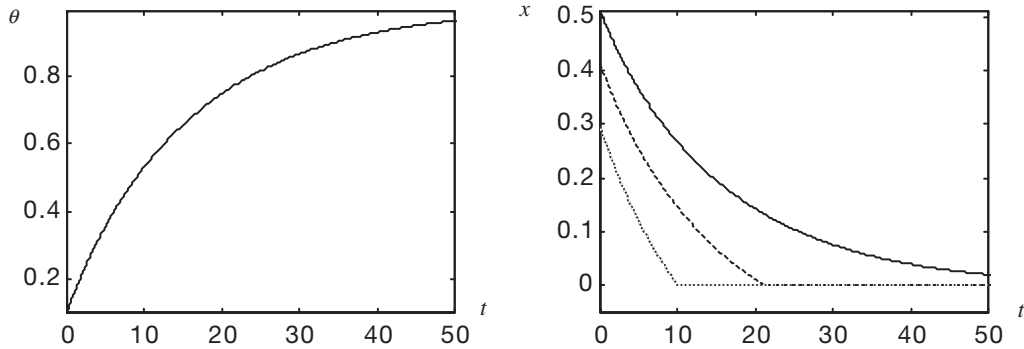
Benchmark Case [$\theta(0) = 0.10, q^{\sim} = 5.67\%$]; Solid Line (Dashed Line): 5% (3%) Steady State Growth Rate

Figure 2. Economic Development After Korean Unification for $\theta(0) = 0.20$



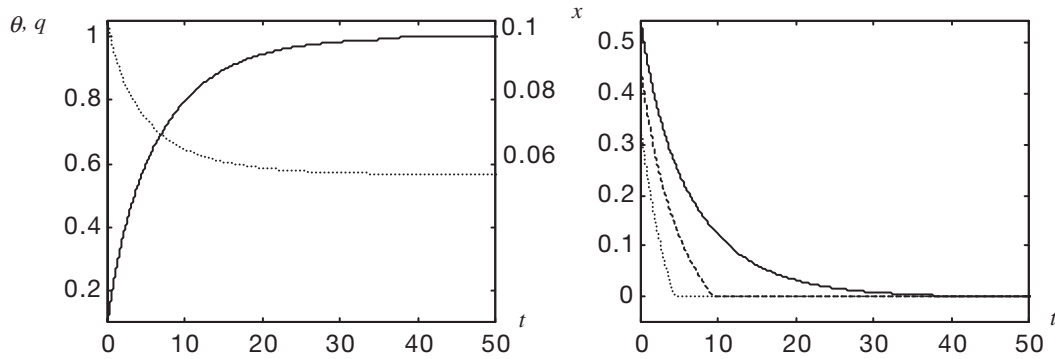
$\theta(0) = 0.20$ and benchmark parameters; Solid Line (Dashed Line): 5% (3%) Steady State Growth Rate

Figure 3. Economic Convergence for Alternative North Korean Income Levels



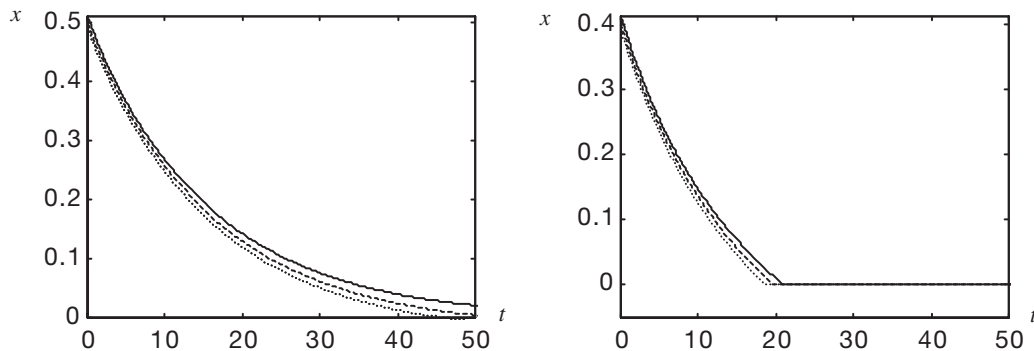
$\theta(0) = 0.10$ and benchmark parameters; Solid Line: $\phi = 1.0$; Dotted Line: $\phi = 0.75$; Dashed Line: $\phi = 0.50$

Figure 4. Economic Convergence for the Fiscal Policy Rule $a = 4/3$



$\theta(0) = 0.10$ and benchmark parameters; Solid Line: $\phi = 1.0$; Dotted Line: $\phi = 0.75$; Dashed Line: $\phi = 0.50$

Figure 5. Redistribution Costs with Foreign Aid



Benchmark parameters; solid lines: basic scenario with $\mu = 0.00$; dashed lines: basic scenario with $\mu = 0.30$; dotted lines: benchmark scenario with $\mu = 0.50$.

Figure 6. Economic Convergence With 1.4 to 4.0 Million Migrants

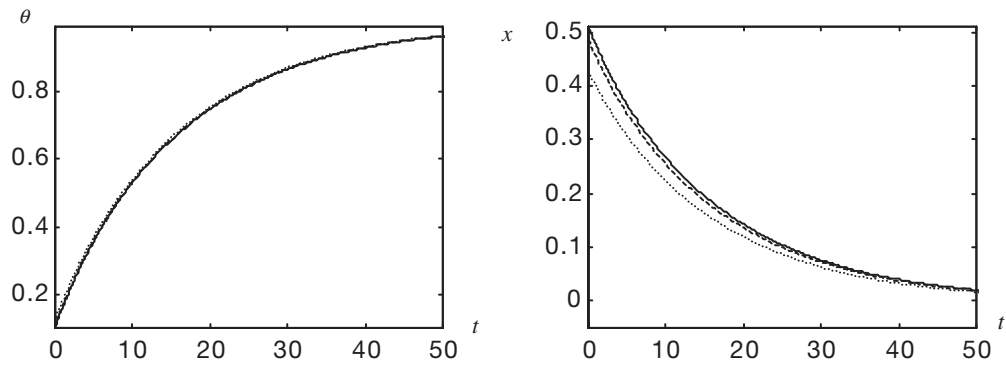


Figure 7. Economic Convergence With 2.0 to 8.0 Million Migrants

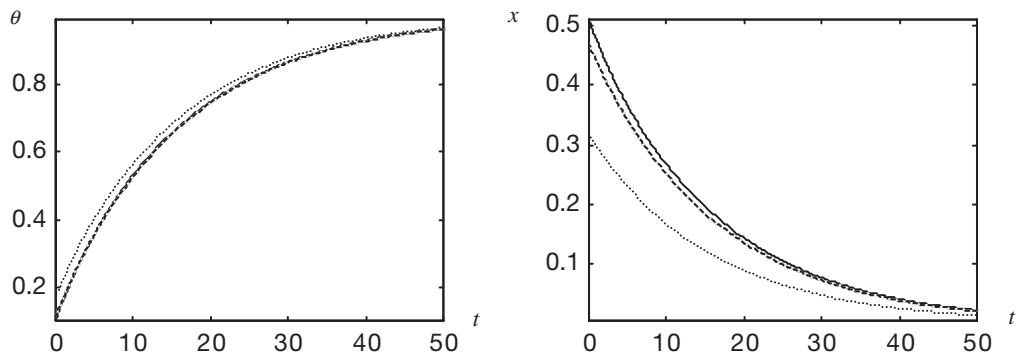
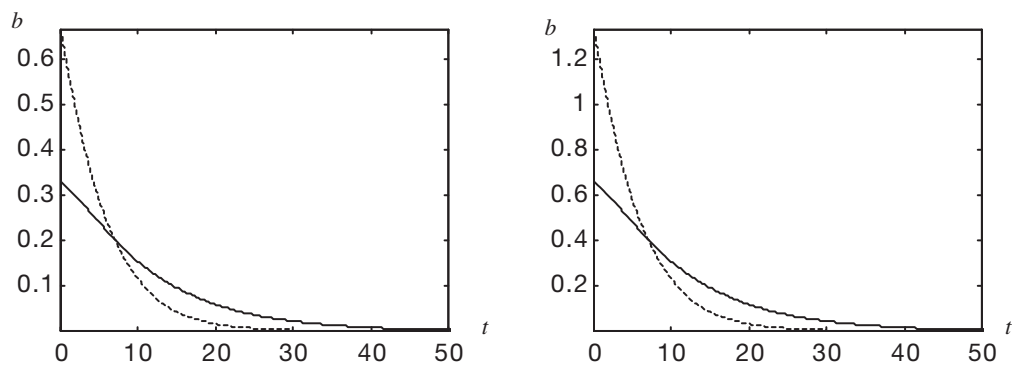
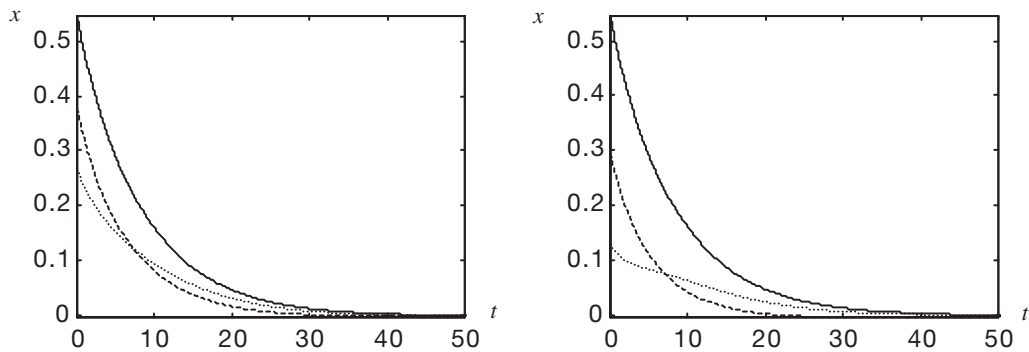


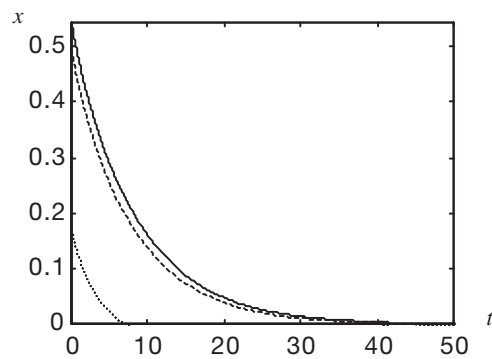
Figure 8. The Allocation of Credit for Alternative “Smoothing Parameters”



Solid line: borrowing scenario with $\nu = 0.1$; dashed line: borrowing scenario with $\nu = 0.2$;
 The left (right) panel gives the results for $b_0 = 1/3$ ($1/2$); \tilde{b} on the vertical axis is measured in percent.

Figure 9. The Fiscal Burden With Foreign Debt

Solid lines: Benchmark parameters without foreign debt; dashed lines: borrowing scenario with $\nu = 0.1$; dotted lines: borrowing scenario with $\nu = 0.2$; the left (right) panel gives the results for $\tilde{b}_0 = 1/3$ ($1/2$).

Figure 10. Sensitivity Analysis for the Fiscal Burden With Foreign Debt

Solid lines: Benchmark parameters without foreign debt; dashed line: borrowing scenario $\tilde{b}_0 = 0.1$; dotted line: borrowing scenario with $\tilde{b}_0 = 0.75$; all results have been computed for $\nu = 0.1$.