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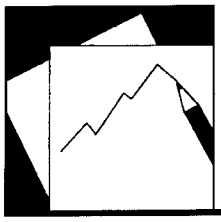

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Growth and Convergence in a Two-Region Model: The Hypothetical Case of Korean Unification

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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 are required to make the North Korean economy economically viable.

Keywords: Korean Unification, Regional Convergence, Economic Growth

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I. INTRODUCTION

For more than four decades, soldiers from North and South Korea have watched each other at the cease-fire line, with an uneasy peace prevailing. Over the last decades, the two 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, as ever little is known about intra-elite policy debates in North Korea. But the end of the Cold War and the June 2000 North-South summit have changed the probability of Korean economic and/or political union. These changes simultaneously present to Korea a challenge and an opportunity. What remains unclear is how fast this process will go on. Nevertheless, this process of inter-Korean rapprochement and increased likelihood of unification has raised concerns about the nature of such a transition, particularly in the light of German unification.[2] Therefore, it is important to get some idea as to how large the macroeconomic impacts of unification can actually be.

This paper takes as its hypothetical starting point a rapid process of Korean unification (big-bang) and aims to provide economic policy guidance for such an event.[3] If the Korean peninsula becomes economically and/or politically united, what are the medium and long run economic implications for the southern and the northern economy? The unification of the North with the South will bring about a turbulent short run transition period to the North. The process is likely to be similar to what we have observed in the states of the former Soviet Union since they began their transformation in the early 1990s. Large supply and demand shocks are likely to occur in the North as prices are realigned sharply, demand for goods shifts suddenly and supply links break down. The following paper is not concerned with these short run impacts. The paper does also not cover several other important economic policy areas such as privatization and financial sector reform. 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 modeling approaches

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[2] Although the Asian crisis in 1997/98 has pushed the North issue into the background, it has also made the prospect of having to absorb the North even more alarming.

[3] 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 a political and economic 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 unification policy of the South Korean Ministry of Unification is available via the Internet at http://www.unikorea.go.kr.

has developed over recent years to analyze the impact of Korean unification. An excellent summary is provided in Noland (2000). Our paper is not intended as competition for such rich and detailed analyses. The point here is instead to show how much insight can be gained from models of economic growth. The value added of our paper is to use a two-region endogenous growth model to analyze the medium-to-long-run implications of Korean unification. This approach is, to the best of our knowledge, new in the literature.
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.

II. The Theoretical Setup

In thinking about unification, it is instructive to start with a model of economic growth. In this section, we therefore present an endogenous two-region growth model comprising of private and public capital.[4]

A. 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 normalized to one. Homogenous output is used for consumption and private and public investment. Firms have identical Cobb-Douglas technologies

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

and private capital evolves according to

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

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[4] Our ambition is not to survey the vast growth literature here. But we do want to paint a rough background of the approach we will take in the paper. The theoretical model below can be understood as 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. The model either assumes monetary integration at the outset of unification [see Kwon (2000)] or that monetary policy would firmly anchor the northern currency via, e.g. a currency board system, to the Won.

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

$$(3) \qquad (1-\alpha)A_i(K_i/L_i)^{-\alpha} = w_i$$

and

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

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, like 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 Korean after unification: the regional level of infrastructure.[5]

B. 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.[6] 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

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[5] 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).

[6] 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.

infrastructure, G_i the regional stocks of infrastructure, δ its rate of depreciation, Z_i inter-regional redistribution, and x the share of South Korean tax revenues transferred to the North.[7] Government behavior is then described by:

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

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

(7) $Z_N = (1 - q_N)\tau Y_N + x\tau Y_S$

Note 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, are necessarily required for Z_N to be non-negative.

The effect of infrastructure on regional productivity is modeled 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:

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

The parameter A represents the constant intrinsic productivity of both regions.[8] 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.

C. 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

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

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[7] 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.

[8] The precise way how (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.

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

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

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

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

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

D. 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:

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

where

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

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 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 (7) to obtain

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

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 lacks 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

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

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 $\theta = 1$.

E. 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:

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

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

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

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

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

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 (10), the growth rate of the consumption capital ratio is obtained as

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

Using the newly introduced notation, equations (7) and (14) can be rewritten as

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

and

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

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 implicit function

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

which determines the equilibrium ratio of southern infrastructure. Since $F' > 0$ for all positive g_S and $\lim_{gS \to 0} F(g_S) = -\infty$ and $\lim_{gS \to \infty} F(g_S) = \infty$ a unique equilibrium g_S^* exists.[9] Finally, χ^* is obtained from (18) and (19) as:

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

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

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[9] 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.

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

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

and

$$(25) \qquad \frac{\partial\gamma_{g_S}}{\partial g_S} - \frac{\partial\gamma_\chi}{\partial g_S} = -\alpha(1+\lambda)^{-\alpha} q_S \tau A g_S^{-\alpha-1} - (1-\alpha)(1-\tau)(1+\lambda)^{1-\alpha} \frac{\alpha A g_S^{-\alpha}}{\sigma} < 0$$

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

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

and

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

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.[10]

F. Interregional Income Redistribution

The problem of regional productivity convergence has been solved independently from redistributional 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. $a_N(0) = K_N(0)/L_N < a_S(0) =$

[10] 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).

$K_S(0)/L_S$ 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 $z_N = (1 - q_N)(1- q_S - x)\tau Y_N/L_N + x\tau Y_S/L_N$. The variable ϕ denotes the post-tax income of an average North Korean aspired by the government in percent of average South Korean income. It may serve as a proxy for the pressure to migrate. For $\phi = 1$ the government fully compensates lower wages in northern 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.

Post-tax income consists of wages and transfers, i.e. $(1-\tau)(1-\alpha)y_i + z_i$. After substituting transfers from above and using the definition of θ one obtains the relative North-South income ratio

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

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

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

where we have taken into account that transfers are non-negative.[11]

III. 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

[11] 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 his worse initial position of financial wealth.

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.[12] 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 is 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 poll. 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. Given these numbers, we define a benchmark value of $\theta(0) = 0.10$.[13] Given the enormous uncertainty, however, we also discuss an alternative, more optimistic scenario with $\theta(0) = 0.20$.[14]

Between 1990 and 2000 South Korea grew with an average rate of 6.1% [OECD (2001)]. The EIU (2000) estimates that growth continues with an average rate of 6.1% from 2001 to 2005. Given an average annual population growth rate of 1 percent 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 eventually converges towards the growth rates of countries at the frontier, a value of five percent may, however, be too high. We therefore also provide a sensitivity analysis assuming an annual steady state growth rate of 3%.[15]

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[12] Our results should therefore be considered as a „rigorous speculation" using up-to-date modeling techniques.

[13] Claims by the South's Central Bank, the Bank of Korea, that the North's GDP grew by just over 6% in 1999 are dubious.

[14] 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.

[15] 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 $\alpha = 0.19$.[16] Since South Korea has about double the population size 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 has been about 0.20 from 1970 to 1993 [Park (1998), Table 10.1]. According to OECD (2001), 83 percent 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.[17]

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

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[16] 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.

[17] 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.

rule is to a large extent arbitrary. For the benchmark scenario we assume that Korean unification is accompanied by the same policy rule as in Germany, i.e. we address the question how 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

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

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

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

and the derivative with respect to θ

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

which is zero for benchmark values $\lambda = ½$ and $a = 2/3$. Hence, the share of northern infrastructure spending in total revenues is independent from 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 $\sigma = 2.80$ and $A = 0.53$ and an equilibrium ratio of public to private capital of $(G/K)^* = 0.11$. Table 1 summarizes the benchmark specification.

Table 1. Benchmark Parameters and Equilibrium Values

θ	α	λ	τ	q_S	δ	ρ	σ	A	a	ϕ	g_y^*	$(K/Y)^*$	$(I/Y)^*$
0.10	0.79	0.50	0.20	0.17	0.05	0.02	2.80	0.53	0.67	1.00	0.05	3.00	0.30

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 both 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 the West'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 neighbor. 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 converges 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 grows with a much higher equilibrium rate than West Germany (5.0% compared to 1.75%). While one cannot a priori decide if this implies also 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 (2001). 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.

IV. 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 ten percent, 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.[18] 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 three percent.[19]

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 have to be transferred to the North for complete post-tax wage compensation.[20] This suggests that benchmark absorption scenario is out of reach for the Korean government.[21] We therefore consider alternative compensation rules below. Like in the German case, Korean unification has only little impact on interest rates and therewith 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 has only little effect on the intertemporal allocation of capital, it has relatively strong effect on the spatial allocation of capital. This can be seen in the γ_{KS}-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 decreases significantly from 5% to about 1.5% initially. Ten

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[18] 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. A great deal of poverty, in other words, may be easily avoidable.

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

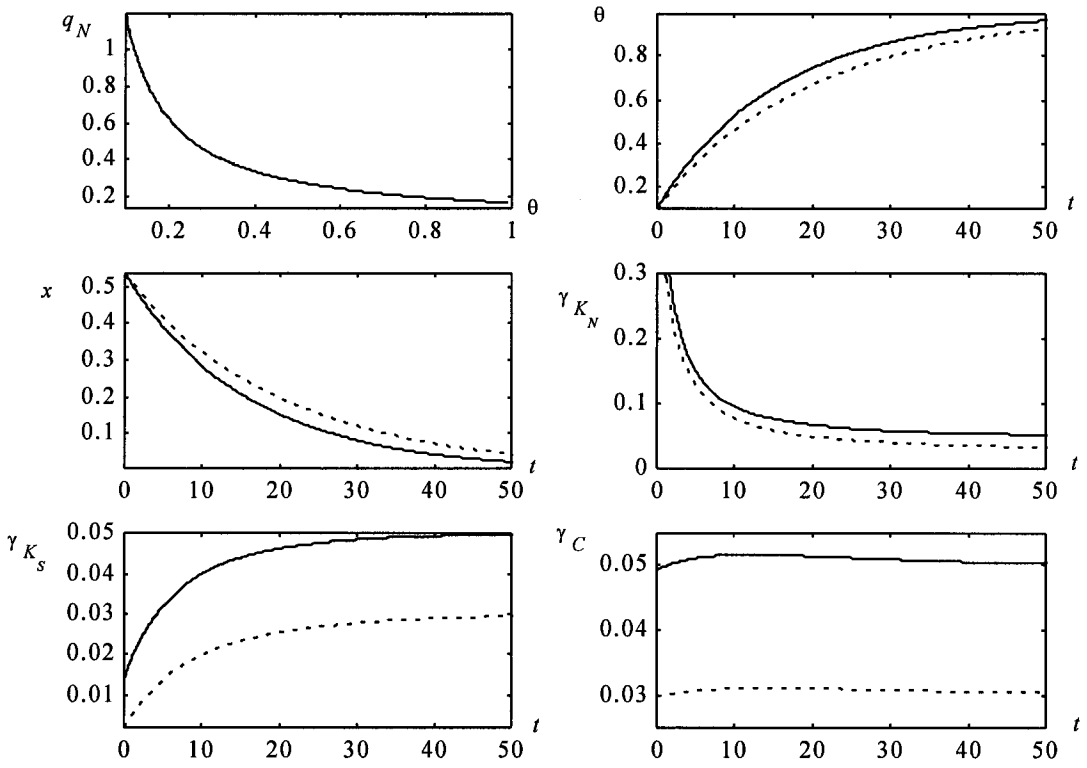
[20] For comparison, the initial share of transfers to East Germany was 14% of West Germany's tax revenues [see Funke and Strulik (2000), p. 375].

[21] 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 eastern 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 than sought sucessfully 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 more prosperous areas in the South. The government of a unified Korea should therefore think of banning or limiting migration and/or forking out welfare programs in the North.

years after unification, however, the South Korean growth rate has already 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.

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

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



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's, the adjustment paths are very similar to Figure 1. After ten years North Korea has now reached 60% of southern productivity. The most noticeable change applies to northern infrastructure spending which is reduced to 60% of tax revenues initially.

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

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

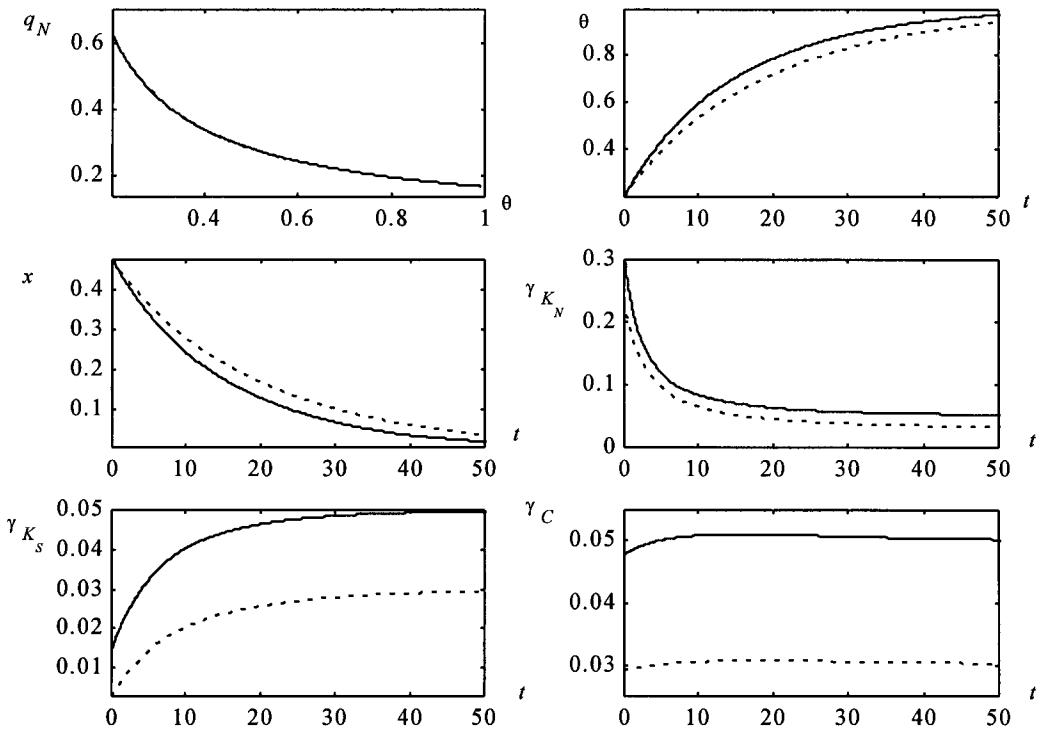
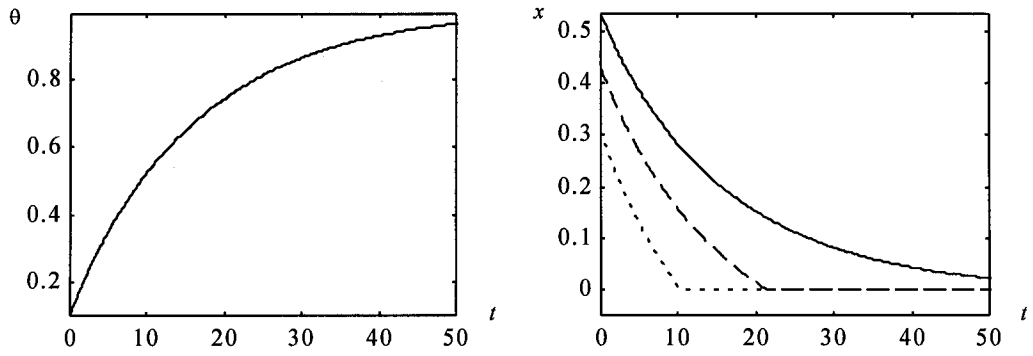


Figure 3 shows the numerical solution results for the less ambitious alternative lump-sum consumption transfer rules ($\phi = 0.75$ and $\phi = 0.50$). Both scenarios reduce the unification costs. But even in the scenario where the government aspires average North Korean post-tax income to be 75% of 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 aspired average income level in the North is only 50%, transfers could be terminated after ten years. Initially, however, transfers are still about 30% of southern tax revenues.[22] In other words, less ambitious targets would be cheaper, but mainly in the long run.

[22] Kwon (2000) has produced similar numbers.

Figure 3. Economic Convergence for Alternative North Korean Post-Tax Income Levels

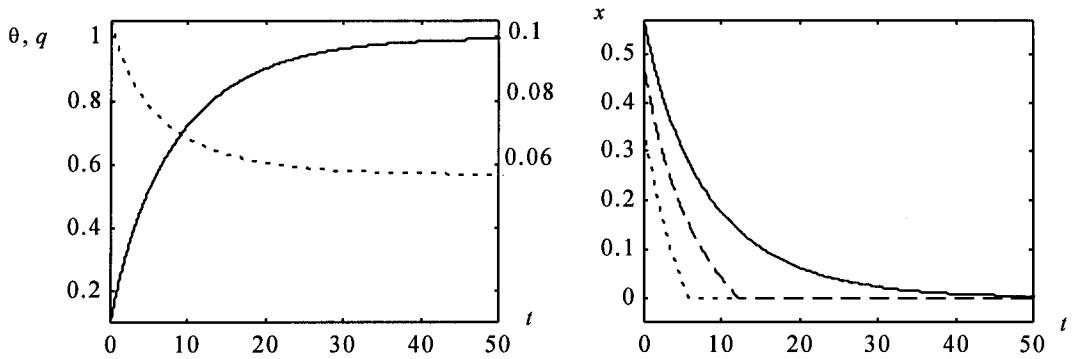
$\theta = 0.10$ and benchmark parameters; Solid Line: $\phi = 1.0$; Dotted Line: $\phi = 0.75$; Dashed Line: $\phi = 0.50$



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 10 years the North has 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%.

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

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



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 aspires the 75% level, transfers are initially about 10% higher but can be terminated about ten years earlier.

V. CONCLUSIONS

In this paper we have captured Korean unification via a framework that sacrifices both realism and rigor in the interest of simplicity. 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? All in all, the calibration results indicate that following the German-style unification example, known as the Monetary, Economic and Social Union of July 1, 1990, is not feasible for Korea because vast financial transfers will be needed to make the North Korean economy economically viable.[23] The reason is that the two Koreas are too far apart in terms of economic development for this to be a realistic option. A workable alternative that could cushion the required fiscal burden is a "piecemeal" approach which initially implies economic integration, perhaps through a confederation of two sovereign states. During this controlled transition period, the two economies will become progressively more closely linked and the relative abundance of labor in North Korea will lead to wage restraint and the ability to compete internationally in labor-intensive manufactures. A commonwealth or a confederation of two sovereign states would also allow to undertake legal efforts restraining North Koreans from migrating to the South.[24]

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[23] This also implies that it will be very difficult to maintain political support for unification in the North and in the South.

[24] This requires that North Korean's don't get the right to receive full citizenship upon arrival in southern Korea. Some Korean economists have even suggested to maintain the existing demilitarized zone to control migration [see, for example, Young et al. (1998)]. When the regime in North Korea collapses, such scenarios may, however, turn out to be impossible for political reasons and, as in the case of Germany, there may be no alternative to big-bang unification.

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