The Economic Reunification of Korea:
A Dynamic General Equilibrium Model

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Abstract

This paper considers the impact of Korean reunification on the economies of North and South Korea. We focus on changes in real wages and output as a result of serveral kinds of reunification and/or reform. We are interested in the differential impacts on wages of skilled and unskilled workers. To do this we construct a dynamic general equilibrium model of North and South Korea, treating both countries as small economies.

As a baseline we assume autarky with internal market reforms in the North, and free trade in most goods for the South. Using both the long-run steady state and the short-run transition to it, we compare this baseline to several scenarios involving increasing levels of reform and unification.

We find that skilled wages in the South depend critically on the nature of the reform or unification policy pursued. Wages in the North rise dramatically in almost every case.

1 Introduction

When World War II ended on August 15, 1945, Japanese forces occupying Korea south of the 38th parallel were directed to surrender to US forces. Those in the north surrendered to Soviet forces and Korea became effectively divided into two parts. Ideological differences led to a cancellation of country-wide elections and the establishment of two separate governments in 1947 and 1948. In June of 1950 war broke out and the ensuing stalemate has left Korea divided ever since.

Recent revelations of a clandestine atomic weapons program in North Korea and the resultant international tension between the two Koreas, China, Japan, Russia and the US have made the prospects for Korean reunification rather dim. Despite this, Koreans on both sides of the border have a strong collective desire to reunite. There seems little doubt that given the right political climate reunification will occur, though it is anyone's guess at this point when the climate will be right.

In the six decades since Korea was divided there has been much economic change. The economic miracle in South Korea is well known. Following the Japanese model of export oriented growth, output grew rapidly in the 1970's and 1980's and the South still maintains an annual average real growth rate of over five percent per annum. Despite a severe recession following the 1997 Asian financial crisis, South Korea today enjoys a robust, healthy economy.

The Japanese occupation of Korea from 1910 to 1945 left the North with greater industrial capacity, but much of this legacy was rendered moot by the destruction associated with the Korean War. During the Cold War, the North nimbly played on animosities between its two main benefactors, China and the Soviet Union, and made remarkable progress in standards of living. However, things have changed since the demise of the Soviet Union. Markets for North Korean manufactures have all but disappeared and while China does supply some aid, it is nowhere near the levels the Soviet Union used to provide. Famines have repeatedly swept through the country in recent years as poor agricultural management policies and unfortunate weather conditions have combined to yield sub-par harvests.

While the South has continued to grow and now enjoys per capita GDP on par with those of many developed nations, the North has slowly slid into poverty. South Korea trades heavily with the rest of the world, North Korea is isolated and, at least economically, bears a remarkable resemblance to old Korea, which was often called the Hermit Kingdom for its closed borders and unwillingness to deal with outsiders.

If reunification occurs anytime in the near future the huge differences in standards of living are likely to cause much economic adjustment. With 22 million people in the North and another 47 million in the South the problems will be at least as daunting as those that confronted East and West Germany over a decade ago. Indeed, given the larger difference in standards of living in the Korean case, they are likely to much bigger.

This paper focuses on the likely consequences of the reunification of the two Koreas. We are interested in several questions. There is little doubt that North Korea will benefit from almost any change in policy. We examine the effects of various kinds of reform on the North Korean economy. These range from internal reforms that encourage the establishment of markets to complete economic integration with the South. While happenings in the North are of vital importance to the lives of millions, the questions are not as economically interesting as those facing the South. There is so much wrong in North Korea it would be surprising if adoption of more economically rational policy did not make the vast number of people there substantially better off.

Questions facing the South are more subtle, and hence have less obvious answers. Will the South benefit in net from reunification? South Korea is already an open economy. What benefits can accrue to allowing free trade with an economy so backward as that found in the North? Will South Korean wages or standards of living be lowered due to competition from workers in the North? Will the South still be able to attract international capital when there is so much investment that could be done in the North? We attempt to address these questions using a calibrated dynamic general equilibrium model of the North and South Korean economies.

Of course, we are not the first researchers to examine the economic consequences of reform and reunification on the Korean peninsula. For obvious reasons, researchers in Korea have examined this issue for many years. Shim (1993) is a good example which focuses on the optimal timing of various reform and unification policies. Most work in this literature has concentrated on the politics of reunification, however, and the economics have not kept pace with developments in macroeconomic and international trade modeling.

A notable exception to this generalization is Noland, Robinson & Liu (1999) which calibrates an eight sector, four factor constant returns-to-scale computable general equilibrium model (CGE) for North and South Korea for 1990. This basic model is updated in Noland, Robinson & Wang (1999). Our model is similar in that we also choose eight (differently defined) intermediate sectors and make constant returns to scale assumptions for production. We use only three factors, however, and assume different functional forms. The biggest area of difference is in the dynamics of the models. Our model is based on dynamic programming tools used widely in the real business cycle literature. The evolution of the economy over time depends upon the intertemporal decisions of households that own and hold capital, as well as on the decisions made by governments in accumulating infrastructure and military capital. Also our characterization of technology and its evolution over time differs. Noland, et al focus on the transfer of technology from the South to the North. Our model focuses on the ability of both economies to implement the current best worldwide technology. We model this ability as a function of the infrastructure in place. Undoubtedly both sources of technological progress are important and we view our work as complimentary to Noland et al and not as a substitute.

Our choice of a modeling framework is not entirely new, though its application to Korean unification certainly is. Both Eaton (1987) and Roldos (1991) presented early work on dynamic specific factors models. Eaton viewed land and capital as specific factors that could also be used as optimally acquired financial assets. Using labor as the mobile factor, he focuses on the conditions under which the dynamic model displays behavioral properties similar to the static model. Roldos used a model conceptually very similar to ours to examine the effects of various types of tariffs on the current account. More recent uses include: Kose (2002) which uses a similar model to find the proportion of business cycle movements in developing economies attributable to international price fluctuations; and Albert & Meckl (1998) which examines the role of qualitatively rational expectations in capital accumulation.

Our choice of a model is motivated by the simplicity and well understood properties of the specific factors model along with a desire to build a model that can be calibrated to reasonably mimic the actual North and South economies.

We model skilled labor as a specific factor and capital and unskilled labor as mobile factors. We also model defense considerations by having a government that invests in military capital and conscripts workers to provide some chosen level of defense.

With this model properly calibrated we can examine a variety of reforms and types of reunification. We first derive and calibrate a baseline model in sections 2 and 3. This baseline model is built assuming profit maximizing firms and utility maximizing consumers. For this reason it does not correspond to the current situation in North Korea. We interpret this baseline as the situation that would prevail if the North were to adopt internal economic market reforms, but still remain closed to trade and maintained defense parity with the South. Section 4 examines the impact of trade liberalization, defense reduction, a free trade arrangement, common policy and full integration. It also considers a scenario where these reforms are phased in over time. Section 5 concludes with a summary of the results and suggestions for further research.

2 A Dynamic Model

We build a dynamic general equilibrium model with agents that optimize over time. The key agents are infinitely-lived consumers who maximize discounted lifetime utility. They derive utility from consumption of a single non-traded final good, which can also be used to form capital. This final good is produced using a set of *J* intermediate goods, which are, in turn, produced using capital, unskilled labor, and skilled labor. Skilled labor is specific to the industry in which it is used; that is, it cannot be used to produce any other intermediate good. Both capital and labor are mobile across all *J* sectors. Skilled and unskilled labor are assumed to be fixed by endowment and are non-traded, while capital is accumulated optimally over time and is traded internationally. Intermediate goods can be traded or non-traded and we calibrate the model accordingly once we identify each of these sectors. The final good is non-traded.

The government engages in two activities, accumulation of infrastructure capital and provision of national defense. We assume it imposes lump-sum taxes each period sufficient to provide chosen levels of infrastructure and military capital. It also imposes conscription on unskilled labor which is used along with military capital to provide a desired level of national defense.

In the long-run the economy grows because of exogenous technical progress. The progress comes primarily from overseas and we impose a constant growth rate for this external process. Domestic productivity levels are assumed to be influenced by the level of infrastructure, however, and changes in the stock of infrastructure can therefore have short-run effects on the growth of domestic productivity.

We now proceed to formally setup and solve the model

2.1 Households

Households are infinitely-lived and assumed to maximize the discounted sum of all lifetime utility. We choose to write this optimization as a standard dynamic programming problem using the following Bellman equation:

$$V(K,\Theta) = \underset{K'}{\text{Max}}\; U(C) + \beta E\{V(K',\Theta')\} \tag{2.1}$$

where C is consumption, K is the household's capital stock, Θ is its information set used to take expectations, and the primes indicate values of variables next period.

Consumption is income from skilled labor (L), unskilled labor (N), and capital less taxes (T), depreciation and investment in new capital as below.

$$C = \sum_i w_i \overline{L}_i + v(1-f)\overline{N} + (1+r-\delta)K - K' - T \tag{2.2}$$

where w_i is the wage rate for skilled labor in sector i, v is the wage for unskilled labor, r is the rental rate for capital, δ is the depreciation rate, and f is the government conscription rate.

We assume a constant elasticity of substitution utility function of the following form:

$$U(C) = \tfrac{1}{1-\sigma}[C^{1-\sigma} - 1] \tag{2.3}$$

Hence, the Euler equation associated with this optimization problem is:

$$C^{-\sigma} = \beta E\{C'^{-\sigma}(1 + r' - \delta)\} \tag{2.5}$$

2.2 Final Goods Producers

The final goods sector is perfectly competitive with free entry and zero profits. Firms therefore solve the following profit maximization each period:

$$\underset{\{F_i\}}{\text{Max}}\; \Pi_F = \prod_j F_j^{a_i} - \sum_j P_j F_j ; \sum_i a_j = 1 \tag{2.6}$$

where F_j is the amount of good j used in production of the final goods and P_j is its price.

The first-order conditions reduce to the following J conditions:

$$P_j F_j = a_j Y \,;\; Y \equiv \prod_j F_j^{a_j} \;\; \forall j \tag{2.7}$$

2.3 Intermediate Goods Producers

Intermediate goods are also competitively produced and the firms solve the following problem:

$$\underset{K_j, L_j, N_j}{\text{Max}} \; \Pi_j = P_j A_j K_j^{\,b} (ZN_j)^c (ZL_j)^{1-b-c} - rK_j - w_j L_j - vN_j \tag{2.8}$$

where A_j is a sector-specific level of productivity that we will allow to vary from country to country and Z is an economy-wide level of domestic productivity which is driven by external productivity and domestic infrastructure.

The first-order conditions reduce to the following $3J$ conditions:

$$rK_j = bP_j Y_j \,;\; Y_j \equiv A_j K_j^{\,b} (ZN_j)^c (ZL_j)^{1-b-c} \;\; \forall j \tag{2.9}$$

$$vN_j = cP_j Y_j \;\; \forall j \tag{2.10}$$

$$w_j L_j = (1-b-c) P_j Y_j \;\; \forall j \tag{2.11}$$

2.4 Government

The government imposes taxes sufficient to provide enough final goods to build up the domestic stock of military capital (M) and infrastructure (I) to desired levels. We take these levels as exogenous and do not model them. Investment in these two capital stocks is indicated by a preceding Δ. The government's budget constraint is:

$$T = \Delta M + \Delta I \tag{2.12}$$

Military capital and infrastructure evolve over time according the following two laws of motion:

$$M' = (1-\delta) M + \Delta M \tag{2.13}$$

$$I' = (1-\delta) I + \Delta I \tag{2.14}$$

The government also conscripts soldiers from the ranks of unskilled labor. It combines these soldiers with the military capital to produce a level of national defense as shown below:

$$D = M^d (ZfN)^{1-d} \tag{2.15}$$

2.5 Technology

Sector specific technologies, the A_j's, are assumed constant. The economy-wide level, Z, evolves over time as a function of the external level of technology and the domestic level of infrastructure per unskilled worker:

$$Z = z^h (I / N)^{1-h} \tag{2.16}$$

where z is the external technology level.

This formulation is intended to capture movements in total factor productivity (TFP) that are unrelated to technology, *per se*. It reflects the notion that even though the North has access to the same level of technology, it has generally lower total factor productivity than the South. Using infrastructure per worker assumes that infrastructure is primarily rival in nature and that greater amounts are needed for a larger population.

External technology grows at a predetermined constant rate of g_z each period.

$$z' = (1 + g_z)z \tag{2.17}$$

Combining (2.16) and (2.17) gives a law of motion for Z that depends on last period's level and the growth rate of the infrastructure stock.

$$Z' = (1 + g_z)^h (1 + g_I)^{1-h} Z \ ; \ 1 + g_I \equiv \tfrac{I'}{I} \tag{2.18}$$

2.6 Market-Clearing

The final goods market and the markets for both kinds of labor are closed to imports and must equate domestic supply to domestic demand. In contrast, the capital market is open to imports and exports. Intermediate goods may be either closed or open to trade. We adopt notation that allows for all intermediate goods to be traded, but will impose zero export restrictions in the appropriate industries.

The market-clearing conditions are:

$$K = \sum_j K_j \tag{2.19}$$

$$(1 - f)\overline{N} = \sum_j N_j \tag{2.20}$$

$$\overline{L}_j = L_j \tag{2.21}$$

$$Y_j = F_j + X_j \tag{2.22}$$

$$Y + (1 - \delta)K = C + K' + \Delta M + \Delta I \tag{2.23}$$

2.7 Solving the Model

The above sections define a model with growth. Some variables, such as, consumption and production, grow at the rate g_z in the steady state. Others, such as goods prices, remain constant. In order to solve the household's dynamic programming problem we rewrite the system in a stationary form by dividing all growing variables by Z. This yields a steady state where all values are constant and where the off steady state dynamics are characterized by convergence to these constant values. We solve this altered set of equations, but then readjust once we are done so that all growing variables have the appropriate growth component added back in our simulations.

The model as a whole has three endogenous state variables, *K*, *M* & *I*. It also has three exogenous policy variables which should also be viewed as state variables. These are the conscription rate, *f*, and decisions about the accumulation of infrastructure and military capital. We choose to characterize government policy as the percent of *Y* that will be allocated as investment in these two stocks. We define the following $i \equiv \Delta I / Y$ and $m \equiv \Delta M / Y$ and model the government as setting these exogenously. Hence, the exogenous state variables are *f*, *i* & *m*.

The numerical techniques for solving these types of problems are well-known.[1] We use the method of undetermined coefficients to solve for a linear approximation to the decision rule for capital and the accumulation rule for infrastructure about their steady state values. Hence we are able to examine not only the steady states associated with various policies and types of openness, but we are also able to examine the path of the economy from some initial state to the steady state implied by a new set of policies.

3 Baseline Model Calibration & Simulation

We calibrate our model by choosing the baseline scenario of South Korea with openness to trade and an isolated North Korea. For calibration purposes our time-period is one year and we choose our parameter values accordingly. We need to set the following parameter values for both countries: $\{a_i\}, b, c, h, \beta, \delta, \sigma, \{A_i\}, g_z$. In addition we need to pick values for labor endowments, $\{\overline{L}_i\}$ & N , and world prices, $\{P_i\}$, for traded intermediate goods.

β, the time discount factor is set to .975, implying a subjective discount rate of 2.56%; δ, the depreciation rate is set to .10, and g_z, the trend growth rate of technology is set to .035, which is the post-war average real growth rate for the US. The steady state version of (2.5) below is used to choose the value of σ.

$$1 = \beta(1 + g_z)^{-\sigma}(1 + \bar{r} - \delta)\} \quad (3.1)$$

[1] See, for example, Uhlig (1999) or Christiano (1998)

We set the user cost of capital, $\bar{r}-\delta$, equal to 3% and solve to get σ=.087. All these values apply to both the North and South.

We use data from the Global Trade Analysis Project (GTAP) to find the share of capital and unskilled labor in GDP. These values are b=.4414 and c=.3943 for South Korea.

The values for the a_i's come from aggregating the 57 industries in the GTAP dataset into eight. Our industries and their shares in GDP are listed in table 1.

The GTAP data show that total compensation for skilled workers is about 40% of the total compensation of unskilled workers. Since wages should be higher for skilled workers this is an upper bound on their number. We assume an unskilled labor force of 300 and a skilled labor force of 100. To calibrate the distribution of skilled labor over our eight industries we assume a common real wage and make labor proportional to total compensation.[2] When we compare North Korea to this baseline, we will choose different values for the L_i's.

We set all the A_i's equal to 1 as a way of defining units and solve for the prices that set exports as a percentage of output equal to their observed values. Korea runs a current account surplus and our model implies that the balance of payments sums to zero. We reconcile this by assuming that our last industry, traded services, includes imports and exports of capital services. We allow it to include not just capital services from the current account, but also purchases and sales of capital goods included on the capital account. The value of exports in this sector is determined by default once exports for the other seven sectors are known.

For the policy variables we note that roughly 10% of GDP is government purchases in South Korea. Of this roughly one-fourth is spent on defense. We therefore set m=.025 and assume all other government expenses are spent on various forms of infrastructure, giving i=.075. The labor force is roughly 22 million, while the military has three-quarters of a million men under arms. Since we have already assumed that three-fourths of the labor force is unskilled, our conscription rate is set to f=.045.

The steady state for this baseline parameterization is reported in table 2

To examine North Korea we parameterize a baseline where the country is in autarky. We keep the same values for b, c, h, g_z, β, δ & σ. The total population in North Korea is 22.3 million

[2] The used of land and natural resources in some industries complicates things. When we calculate equilibrium for North Korea we will adjust the values of the A_i's in those industries that use significant amounts of land or natural resources.

versus South Korea's 47.3 million, and the labor forces are 9.2 and 22.0 million respectively. Hence overall labor is forty to fifty percent that of South Korea. The distribution of skilled versus unskilled labor is more difficult to pin down. For lack of defensibly better numbers, we assume that the mix is the same as in South Korea. Hence we choose N=135 and the L_i's sum to 45.

For our eight aggregated industries, the last five do not use any land or natural resources. We therefore assume all output differences are due to different employment of factors, or to overall productivity differences as modeled by Z. The A_i's for these industries are kept at the South Korean value of 1. The first three industries, however, use significant amounts of land and/or resources. The endowment of arable land in North Korea is 1.33 million hectares vs 1.55 hectares in the south. We adjust A_1 down to .86 to reflect this difference. North Korea mines significant amounts of iron ore and coal, suggesting that the appropriate value for A_2 is higher than one, but we have little guidance on how much higher; we choose a value of 1.5. Finally, for industry 3 – traded foods, where the only industry using resources is fishing, we set the value to 1 under the assumption that both countries have access to the same international fishing grounds.

The allocation of skilled labor across industries is guided by figures from the South Korean Ministry of Reunification which report industrial distributions for the two countries over a set of 5 aggregate sectors that are fairly similar. The one exception is agriculture, which accounts for 30.4% or GDP in the north, but only 4.4% in the south. We adjust skilled labor to hit the share values reported by the Ministry when output is evaluated at South Korean prices.[3]

For policy variables we take a military force of 1 million and divide by 75% of the 9.2 million labor force to get f=.145. Determining the values of military and infrastructure parameters is the most problematic of all. The value of m is chosen to give the north and the south equal levels of defense in the steady state. i is set to .05, a number one-third lower than in the South.

Finally, we need to know the difference between overall technology in North and South Korea. We use steady state versions of equation (2.16) and define the relative technology measure, $\xi \equiv Z_N / Z_S$ to get

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[3] Where the Ministry's industries are broader and include more than one of our 8 industries, we assume the relative distribution is the same as South Korea.

$$\xi = \left(\frac{\bar{I}_N \bar{K}_S}{\bar{I}_S \bar{K}_N} \right)^h \tag{3.1}$$

The values of the parameters and the steady state values for this baseline model are reported in table 1.

We assume that presently neither the South nor the North are in the steady state. This means we need to pick starting values for five values: capital stocks in both countries, infrastructure in both countries, and the relative level of technology in the North.[4]

South Korean growth rates are higher than 3.5% per year with a gradual downward trend. We constrain the initial ratio of capital to infrastructure to be equal to the steady state values and then choose initial values for the capital stock and infrastructure so that the initial growth rate in the South is 5% per annum, which is approximately the average real growth rate over the last five years.

The South Korean Ministry of Reunification reports relative sizes of various "Social Overhead Capital."[5] The average of these values puts the initial value of *I* in the North at 17.5% of the initial value of *I* in the South. In the absence of better data we assume the initial capital stock is also 17.5% of the southern value. Equation (2.16) yields the initial level of technology.

These assumptions yield initial per capita income levels in the North that are 44% the levels in the South. These seem implausibly high. We note that when Germany reunified as much as two-thirds of the East German capital stock was scrapped as useless. The situation is likely to be similar in North Korea. Since much of the capital which was originally built to meet central planning targets it may well be worth only a fraction of its value after reform. We therefore set the initial capital stock and infrastructure to 5.83% of the value in the South. This gives an initial per capita income level that is 20% of the South. These levels seem more reasonable and we use them throughout the rest of the paper.

The baseline model assumes that North Korea is characterized by agents responding optimally to market signals. Since this is obviously not the case now, we must interpret this model as a scenario where the north has already engaged in some kind of market reform. In the steady state, the overall GDP of the South will be almost nine times that in the North. However,

[4] We can normalize the initial level in the South to one.

[5] This included railroads, highways & harbors.

the Ministry of Reunification estimates that South Korea's GDP was actually 26.8 times that of North Korea in 2001. Our initial values give a South-North ratio of 10.7 which implies that internal reform in the North would result in a 150% increase in output even if the capital stock and level of technology remained unchanged.

Given these starting values we proceed to simulate the model economies. The transition paths for key growth rates in both the North and South along with log-levels of GDP and ratios of key variables are shown in Figure 1. Note that both output and the capital stock growth rates are initially very high in the North and that the growth rates of infrastructure and technology are much more modest, though still higher than in the South. In the North, output grows at a rate of 19.7% the first year, but falls below 10% by year five.

4 Unification Scenarios

With the model solved, calibrated and simulated for a baseline case, we now proceed to consider various steps on the road to unification. We consider six additional scenarios in addition to the baseline. These are as follows:

- Baseline Scenario – South unchanged, North adopts market reforms.
- Scenario 2 – Same as above, but North also opens to world trade.
- Scenario 3 – Same as above, but both North and South reduce defense
- Scenario 4 – Same as above, but North and South are a free trade area
- Scenario 5 – Same as above, but North and South adopt identical government policies
- Scenario 6 –Fully integrated economy; all goods are tradable and all factors are mobile between the North and the South

We examine each of these in turn.

Secenario 2

Suppose that in addition to internal reforms the North also moves to open its markets to the world. Obviously the exact nature and timing of this opening matters for the time path of the economy. We adopt the simple assumption that the North's trade policies result in the same domestic prices for traded intermediate goods as are observed in the South. This would be the result, for example, if the North mimicked the tariff and non-tariff barriers imposed in South Korea. The non-traded intermediate goods sectors are shown in table 1 with an asterisk. Prices for these goods will be determined by the simulation each period to ensure that exports are always zero.

The steady state values for this scenario are given in table 3 and figure 2 shows the transition paths. The transition paths in the baseline scenario are drawn in lightly for comparison purposes. In the long-run opening up to world prices results in increases in output, capital, infrastructure of 11.2% in the North. Unskilled wages along with skilled wages in non-traded sectors also rise by 11.2%. In traded foods and traded services skilled wages actually drop; by 6.1% and 3.3% respectively. Along the transition path output, capital, infrastructure and level of defense all grow at higher rates than in the baseline case. For example in year one output grows by 22.9% as opposed to 19.7% in the baseline. It falls below 10% in year six, rather than year five.

Scenario 3

Now suppose that in addition to opening to world markets, the North and South were able to lower military tension significantly. It is possible to imagine all sorts of scenarios with varying degrees of tension. For simplicity sake, suppose tensions were lowered sufficiently that both countries were able to halve the military burden. We model this as a reduction in the conscription rate and the tax used to buy military capital by 50%. Since the North has higher rates for both of these the difference will have a stronger effect there.

Table 4 and figure 3 illustrate this case. In the long-run output, capital, infrastructure, and the wages for the North mentioned in scenario 2 all rise an additional 6.5% relative to the baseline from 11.2% higher to 17.7% higher. The wage rate in trade foods falls by only half a percent and actually rises by 2.4% in traded services. The transition path also has higher growth rates than scenario 2, with initial output growth of 23.1% and output falls below 10% in year six, though just barely.[6] In the South the gains are much more modest. Output, infrastructure, capital and wages are 1.7% higher in the long-run. Along the transition path initial output growth is 5.3% vs the calibrated value of 5.0% in the baseline.

Scenario 4

[6] 9.87%

Both the above scenarios involved changes that either the North or the South could take unilaterally if they wished. Suppose now the two governments negotiated a free trade area, allowing intermediate goods (but not final goods) to move freely across the border, but still restraining flows of skilled and unskilled labor. We continue to maintain the assumption the military tensions are low. In this scenario, we no longer force the value of net exports equal to zero for non-traded industries. Instead, we force the sum over both the North and South to zero. The results of this simulation are reported in table 5 and figure 4.

Here we observe huge gains for the North relative to the first three scenarios. In the long-run, output, capital, infrastructure and unskilled wages are 165% higher than the baseline. Gains in skilled wages now differ even in formerly non-traded sectors, but all the long-run gains are very large. The lowest being an increase of 123.2% in non-traded services and the highest being a gain of over 500% in natural resources. For the South the long-run gain in output, capital, infrastructure and unskilled wages is only 1.4% and skilled wages fall dramatically in the non-traded foods, natural resources & utilities industries.

The relative size of these gains is explained the fact that the South is a large country relative to the North even in the steady state. It has more than twice the population and a level of productivity that is 50% higher.

Along the transition path, the North now grows 30.7% in year one, though output growth still drops below 10% in year six. The South grows at 5.3% in year one.

Obviously a free trade area has important effects on both North and South Korea. In the North the result is an improvement for everyone, though the size of the improvements vary depending on the factors owned. In the South the effects are redistributional, with skilled labor in a few small sectors losing dramatically and owners of other factors gaining slightly, though still enough to pass a compensation test.

<u>Scenario 5</u>

In scenario 4 above we kept the policy variables in both parts of Korea different. This would be consistent with a free trade agreement between sovereign states. In this scenario we equalize the policy variables and interpret this as political reunification. We hasten to note that under reunification it may not be optimal to keep the policy variable the same in both parts of Korea. In the German case, for example, the government invested more in the infrastructure of the East than the West. It also put incentives in place to encourage firms to relocate capital to the East. Again, for the sake of simplicity, we make the infrastructure tax rates equal rather than making them higher in the North. Since the baseline case had a lower rate of infrastructure investment in the North, the results amount to a lower bound.

We set the rates of conscription, military investment and infrastructure investment equal to the South's value in the baseline scenario. The results are reported in table 6 and figure 5. Again other than the redistributional effects on certain skilled wages, the effects on the South are minor. In the North, however, the results are huge gains over and above those from scenario 4. In the long-run output, capital and unskilled wages rise by over 330%. Infrastructure rises by almost 550%. Skilled wages go up by at least 267% (in traded services) and by as much as 1113% (in natural resources). In the long-run productivity in the North is virtually the same as the South (actually higher by 3.5%).

Along the transition path, output grows by 41.3% in year one in the North and by 5.3% in the South. It drops below 10% in the North in year 9.

We emphasize that the gains here are all realized without any labor mobility. We now proceed to allow for movements of workers across the border.

Scenario 6

Suppose that capital can be moved from South to North, but workers cannot. In the long-run steady state the economy will look exactly like scenario 5 where (as table 6 shows) the interest rates in the two countries are the same. However, the transition path will look different, since in scenario 5 interest rates differ when not in the steady state.

The other two possible cases where capital is not allowed to move, but one of the two kinds of labor are, are only of theoretical interest since it seems unlikely that the two countries would adopt a policies that allow for labor movements without also allowing movement of capital.

We therefore focus in this scenario on a situation where all factors move freely between the North and South. In this case, if the total factor productivities in the two countries are different, then all the factors flow into the one with the highest value. Note however, that equation (2.16) specifies that the TFP levels depend on infrastructure per unskilled worker. As these workers move from one country to another they put an additional burden on the destination country's infrastructure and reduce the burden in the origin country. This causes the TFP levels to equilibrate and the equilibrium is one where the total stocks of all three factors are allocated across the North and South in the same proportion as the stocks of infrastructure. Table 7 shows the long-run values for this scenario. The exact division of economic activity depends upon the allocation of infrastructure across the North and South. This is a policy decision which we do not model endogenously. We assume that an integrated government allocates total infrastructure to the two regions in proportion to the initial population levels. The integration of the two Koreas immediately would lead to huge movements in unskilled workers. Given our assumptions about the initial levels of infrastructure almost 90% of the North's unskilled workers would choose to move South[7], a migration that is well beyond what policy makers would allow. The numbers vary for skilled workers, but are of similar magnitude. Only as the stocks of infrastructure per worker become more equal does the number of workers migrating become more manageable. When the North's infrastructure is 30% of the South (67% in per capita terms) migration is 25% of Northern unskilled workers. It drops below 10% when the North has 39% of the South's infrastructure level.

Scenario 7

Given that integration leads to unacceptable rates of migration, we finally consider a scenario where policies are phased in over time. Shim (1993) advocates the following phases of integration: 1) economic reform and openness in the North, 2) economic cooperation between the North and South, 3) joint ventures & 4) full integration.

We adopt a similar phasing in of various policies and simulate the results using specific assumptions about the timing. Our phases are as follows: 1) Economic reform and openness in the North corresponding to scenario 2 above. We assume this phase lasts for five years. 2) Reduction of defense spending by 50% in both the North and South corresponding to scenario 3. We also assume this phase lasts five years. 3) Adoption of both a free trade area on the Korean peninsula and the adoption of identical conscription and tax policies, corresponding to scenario 5. We assume this lasts until the relative levels of infrastructure reach the point that opening to labor migration would lead to less than 20% of the North's unskilled labor moving to the South.

[7] Noland, Robinson & Wang (1999) get similar results and model the policy response as annual restrictions on migration.

This takes nineteen years, but could be shortened by having a higher investment rate for infrastructure in the North than in the South. 4) Full economic integration, corresponding to scenario 6. The time path for this scenario is illustrated in figures 6 and 7.

In terms of per capita income, the North converges to the same value as the South. Changes in the North are dramatic, particularly at the beginning. The only major movements in the South come with full integration and are the result of the migration of labor.

Generally the South gains from various kinds of openness with the North, be it free trade in goods or mobility of the factors of production. However, the wide swings in prices of non-traded goods result in wide swing in wages of the associated skilled labor. The formation of a free trade area, for example results in dramatic drops in skilled wages in the food, natural resource and utilities industries in the South, while wages in non-traded services rise, albeit not as dramatically.

Unskilled wages rise in both countries, though much more rapidly in the North. The movement is relatively smooth over time with the largest jump coming when labor mobility is allowed. Interest rates are initially very high in the North, but rapidly decline as the capital stock there rises rapidly. Rates jump up whenever policy changes, but then continue on their downward trend.

5 Conclusions

This paper has examined the effects of various reforms and unifications strategies for both North and South Korea. While the gains are clearly huge for the North in both the long and the short-run, the results are more ambiguous for the South and for the wages of workers with specific skills.

The model presented in this paper is a compromise between the highly stylized neoclassical models of trade found in the theoretical trade literature, and the highly disaggregated data found in the empirical literature. The model attempts to implement the insights gleaned from trade theory, but without being so stylized that the real world analogs are difficult to identify.

Our model does not do everything, of course, and misses several key elements of trade. For example, we have made no allowance for intra-industry trade. Nor do we consider the role of tariff policy or industrial policy in trade and growth. While our model could be adjusted to incorporate these features, doing so would introduce even greater complexity and we have chosen to focus on a simpler model for the time being.

There are other modifications that might usefully be made without adding too much complexity. First we could make the migration decision more realistic. Currently, workers simply compare real wages in the North and South and then move costlessly to the region with the higher wage. If we were to add a significant migration cost, or to keep some kinds of goods non-traded (such as housing) we should be able to generate more realistic migration patterns over time. Also, the assumption that the populations of skilled and unskilled workers are exogenously set might be usefully relaxed. This would involve an additional decision on the part of the household to withhold unskilled labor from the labor market and instead acquire a specific skill. Given that most skills can be acquired in a few years and our transition lasts for several decades, this type of mobility from unskilled to skilled could significantly alter aggregate behavior in our simulations. Finally, it might be useful to allow for other policy scenarios that explicitly involve transfers from the South to the North. Given the huge amount of migration predicted, such policies may well be attractive they reduce migration pressure. A policy of deliberately putting more infrastructure investment in the North would speed up the long-run convergence of the North and South, albeit at the cost of lower growth in the South. It would be informative to experiment with a wider array of more sophisticated policies than are presented in this paper.

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Table 1

Aggregation of GTAP Industry Classifications

Non-traded foods* (1-6, 8-11, 19, 22):	crops, livestock
Natural Resources* (12, 13, 15-18):	wool, silk, forestry, oil, gas, minerals
Traded foods (7, 14, 20, 21, 23-26):	plant fibers, fishing, processed foods
Processing (27-37):	textiles, apparel, paper, wood, petroleum, chemicals
Manufacturing (38-42):	motor vehicles, electronics, machinery
Utilities* (43-45):	gas, electricity, water
Non-traded Services* (46, 52, 56, 57):	construction, housing, financial services, public administration
Traded Services (47-51, 53-55):	trade, transport, communications, insurance, recreation

* non-traded goods sectors

Table 2

Parameterizations & Steady State for Baseline Model

Parameters

	South	North	ratio
a_1:	0.0500	0.0500	1.00
a_2:	0.0080	0.0080	1.00
a_3:	0.0225	0.0225	1.00
a_4:	0.1542	0.1542	1.00
a_5:	0.1291	0.1291	1.00
a_6:	0.0240	0.0240	1.00
a_7:	0.3078	0.3078	1.00
a_8:	0.3044	0.3044	1.00
L_1:	0.258	0.940	0.27
L_2:	0.172	0.110	1.56
L_3:	1.368	0.630	2.17
L_4:	10.759	7.010	1.53
L_5:	10.616	6.780	1.57
L_6:	0.465	0.590	0.79
L_7:	50.325	19.010	2.65
L_8:	26.037	9.790	2.66
A_1:	1.00	0.86	1.16
A_2:	1.00	1.50	0.67
A_3:	1.00	1.00	1.00
A_4:	1.00	1.00	1.00
A_5:	1.00	1.00	1.00
A_6:	1.00	1.00	1.00
A_7:	1.00	1.00	1.00
A_8:	1.00	1.00	1.00
b:	0.4414	0.4414	1.00
c:	0.3943	0.3943	1.00
h:	0.5	0.5	1.00
g_z:	0.035	0.035	1.00
β:	0.975	0.975	1.00
δ:	0.1	0.1	1.00
σ:	0.087	0.087	1.00
N:	300	135	2.22
f:	0.0450	0.1450	0.31
m:	0.0250	0.2500	0.10
i:	0.0750	0.0500	1.50

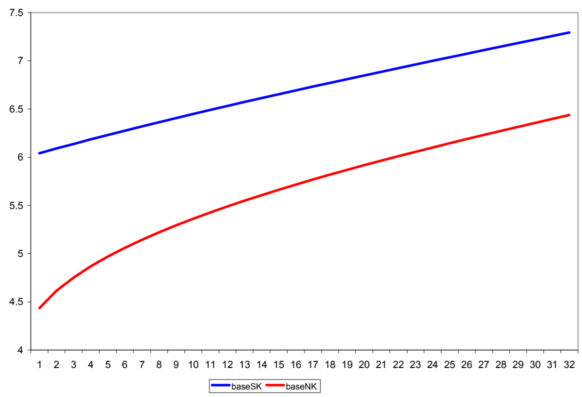
Steady State Values

	South	North	ratio
$\overline{K}$:	1456.28	164.53	8.85
Λ :	39.85	13.56	2.94
$\overline{Y}$:	424.66	47.98	8.85
$\overline{I}$:	235.92	17.77	13.28
$\overline{M}$:	78.64	88.85	0.89
$\overline{D}$:	32.58	22.64	1.44
$\overline{r}$:	0.1030	0.1030	1.00
$\overline{v}$:	0.5581	0.1401	3.98
$\overline{w}_1$:	13.5217	0.4193	32.25
$\overline{w}_2$:	3.2452	0.5733	5.66
$\overline{w}_3$:	1.0267	0.2815	3.65
$\overline{w}_4$:	0.8605	0.1734	4.96
$\overline{w}_5$:	0.7487	0.1501	4.99
$\overline{w}_6$:	3.6011	0.3207	11.23
$\overline{w}_7$:	0.4267	0.1276	3.34
$\overline{w}_8$:	0.9204	0.2451	3.76
P_1:	1.3991	1.1021	1.27
P_2:	1.1067	0.6652	1.66
P_3:	0.9160	0.8877	1.03
P_4:	0.8898	0.8198	1.09
P_5:	0.8697	0.8006	1.09
P_6:	1.1258	0.9069	1.24
P_7:	0.7930	0.7795	1.02
P_8:	0.8997	0.8678	1.04
ξ:		0.2947	3.39

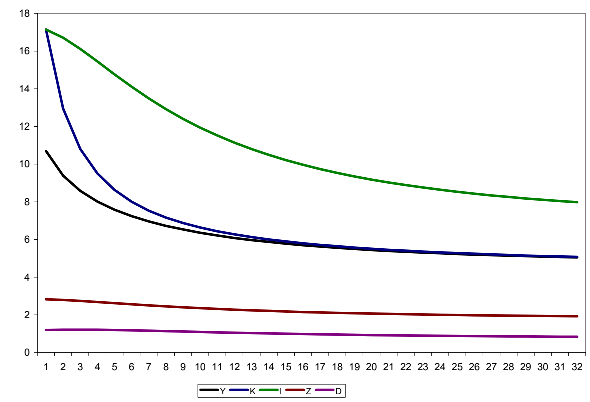
Figure 1

Transition to the Baseline Steady State

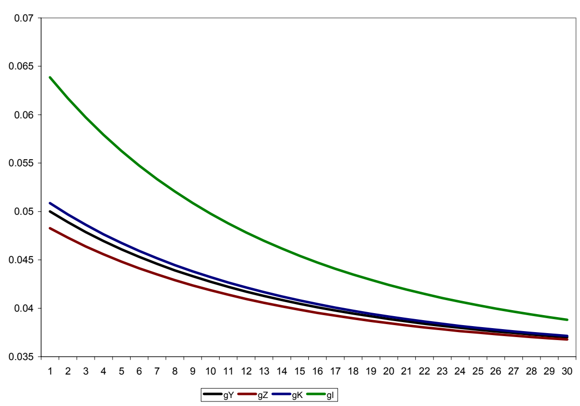
log per capita GDP



South to North Ratios



Growth Rates in the South



Growth Rates in the North

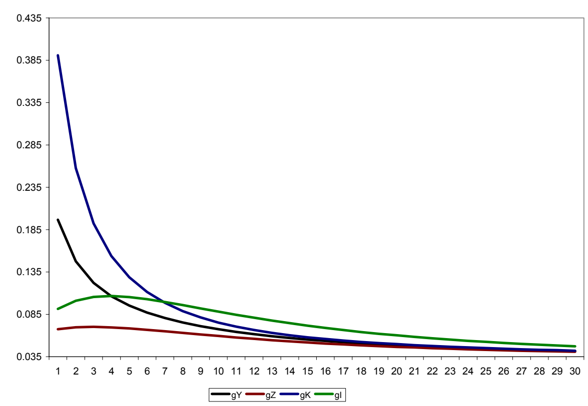


Table 3

Steady State values for Scenario 2

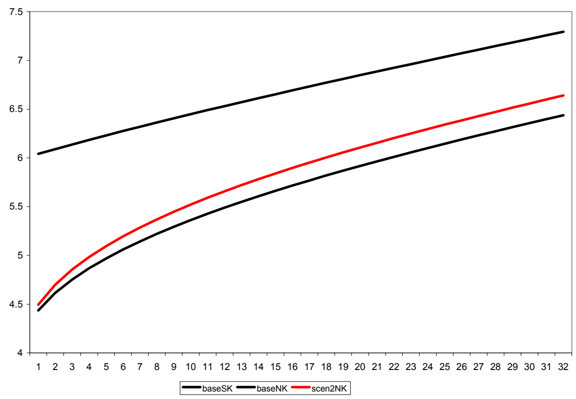
(North Opens to World Trade)

	South	North	% diff from baseline	ratio	baseline ratio
f:	0.045	0.145	0.0%	0.31	0.31
m:	0.025	0.25	0.0%	0.10	0.10
i:	0.075	0.05	0.0%	1.50	1.50
$\overline{K}$:	1456.28	182.89	11.2%	7.96	8.85
Λ :	39.85	19.43	43.3%	2.05	2.94
$\overline{Y}$:	424.66	53.33	11.2%	7.96	8.85
$\bar{I}$:	235.92	19.75	11.2%	11.94	13.28
$\overline{M}$:	78.64	98.76	11.2%	0.80	0.89
$\overline{D}$:	32.58	23.87	5.4%	1.37	1.44
$\bar{r}$:	0.1030	0.1030	0.0%	1.00	1.00
$\bar{v}$:	0.5581	0.1558	11.2%	3.58	3.98
$\overline{w}_1$:	13.5217	0.4661	11.2%	29.01	32.25
$\overline{w}_2$:	3.2452	0.6373	11.2%	5.09	5.66
$\overline{w}_3$:	1.0267	0.2644	-6.1%	3.88	3.65
$\overline{w}_4$:	0.8605	0.2216	27.8%	3.88	4.96
$\overline{w}_5$:	0.7487	0.1928	28.4%	3.88	4.99
$\overline{w}_6$:	3.6011	0.3564	11.2%	10.10	11.23
$\overline{w}_7$:	0.4267	0.1419	11.2%	3.01	3.34
$\overline{w}_8$:	0.9204	0.2370	-3.3%	3.88	3.76
P_1:	1.3991	1.1691	6.1%	1.20	1.27
P_2:	1.1067	0.7057	6.1%	1.57	1.66
P_3:	0.9160	0.9160	3.2%	1.00	1.03
P_4:	0.8898	0.8898	8.5%	1.00	1.09
P_5:	0.8697	0.8697	8.6%	1.00	1.09
P_6:	1.1258	0.9621	6.1%	1.17	1.24
P_7:	0.7930	0.8270	6.1%	0.96	1.02
P_8:	0.8997	0.8997	3.7%	1.00	1.04
ξ:		0.2947	0.0%	3.39	3.39

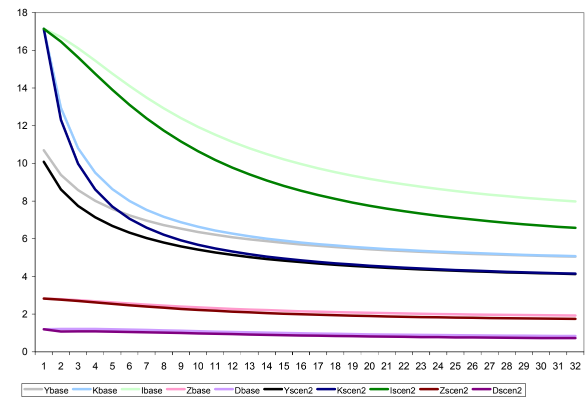
Figure 2

Transition to Scenario 2 Steady State

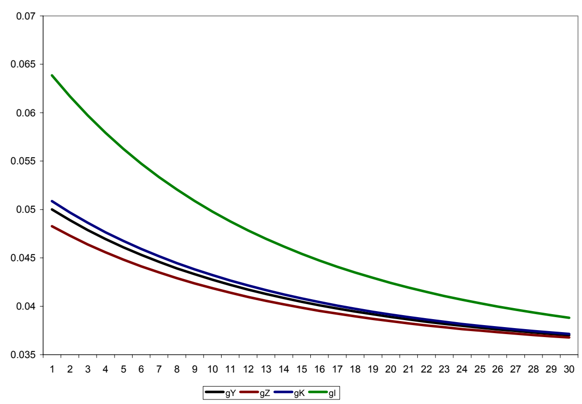
log per capita GDP



South to North Ratios



Growth Rates in the South



Growth Rates in the North

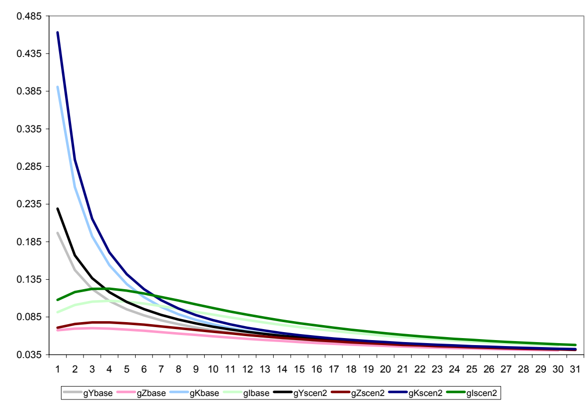


Table 4

Steady State values for Scenario 3

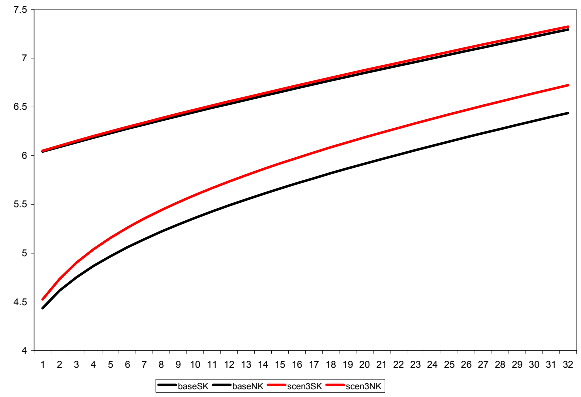
(Defense Reduction)

	South	% diff from baseline	North	% diff from baseline	ratio	baseline ratio
f:	0.0225	0.0%	0.0725	0.0%	0.31	0.31
m:	0.0125	-50.0%	0.125	-50.0%	0.10	0.10
i:	0.075	-50.0%	0.05	-50.0%	1.50	1.50
$\overline{K}$:	1480.42	1.7%	193.70	17.7%	7.64	8.85
Λ :	39.85	0.0%	19.43	43.3%	2.05	2.94
$\overline{Y}$:	431.70	1.7%	56.48	17.7%	7.64	8.85
$\bar{I}$:	239.83	1.7%	20.92	17.7%	11.46	13.28
$\overline{M}$:	39.97	-49.2%	52.30	-41.1%	0.76	0.89
$\overline{D}$:	16.43	-49.6%	12.28	-45.7%	1.34	1.44
$\bar{r}$:	0.1030	0.0%	0.1030	0.0%	1.00	1.00
$\bar{v}$:	0.5674	1.7%	0.1650	17.7%	3.44	3.98
$\overline{w}_1$:	13.7458	1.7%	0.4936	17.7%	27.85	32.25
$\overline{w}_2$:	3.2990	1.7%	0.6749	17.7%	4.89	5.66
$\overline{w}_3$:	1.0437	1.7%	0.2800	-0.5%	3.73	3.65
$\overline{w}_4$:	0.8748	1.7%	0.2347	35.3%	3.73	4.96
$\overline{w}_5$:	0.7611	1.7%	0.2042	36.0%	3.73	4.99
$\overline{w}_6$:	3.6608	1.7%	0.3775	17.7%	9.70	11.23
$\overline{w}_7$:	0.4338	1.7%	0.1503	17.7%	2.89	3.34
$\overline{w}_8$:	0.9356	1.7%	0.2510	2.4%	3.73	3.76
P_1:	1.3991	0.0%	1.1691	6.1%	1.20	1.27
P_2:	1.1067	0.0%	0.7057	6.1%	1.57	1.66
P_3:	0.9160	0.0%	0.9160	3.2%	1.00	1.03
P_4:	0.8898	0.0%	0.8898	8.5%	1.00	1.09
P_5:	0.8697	0.0%	0.8697	8.6%	1.00	1.09
P_6:	1.1258	0.0%	0.9621	6.1%	1.17	1.24
P_7:	0.7930	0.0%	0.8270	6.1%	0.96	1.02
P_8:	0.8997	0.0%	0.8997	3.7%	1.00	1.04
ξ:			0.2947	0.0%	0.00	3.39

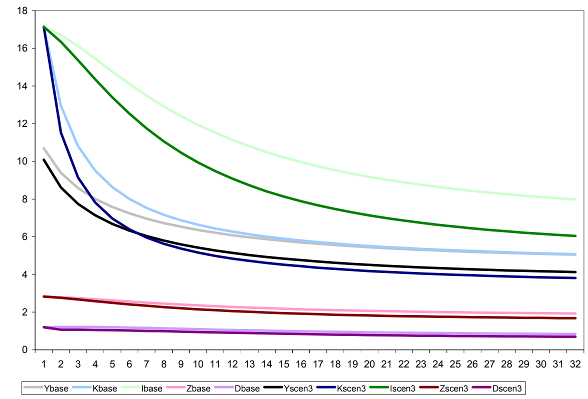
Figure 3

Transition to Scenario 3 Steady State

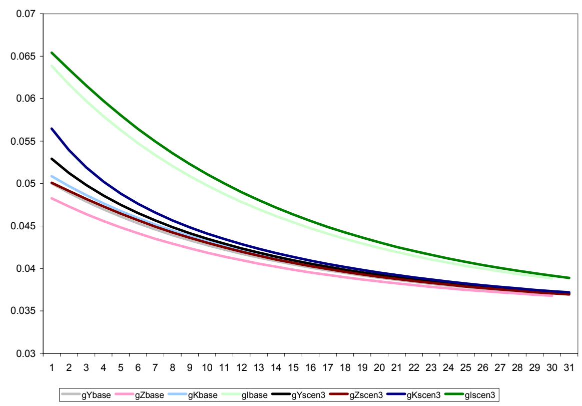
log per capita GDP



South to North Ratios



Growth Rates in the South



Growth Rates in the North

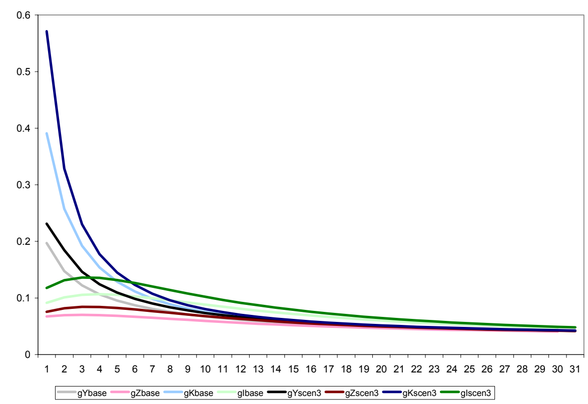


Table 5

Steady State values for Scenario 4

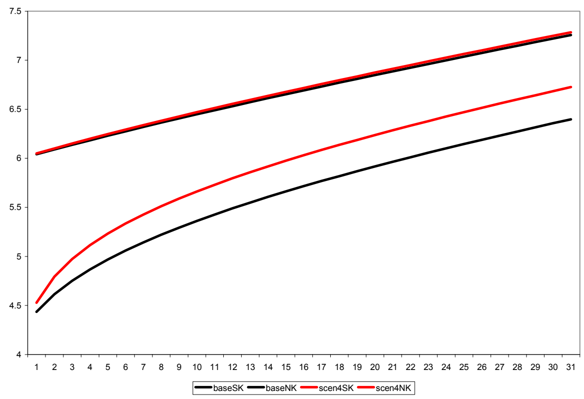
(North-South Free Trade Area)

	South	% diff from baseline	North	% diff from baseline	ratio	baseline ratio
f:	0.0225	-50.0%	0.0725	-50.0%	0.31	0.31
m:	0.0125	-50.0%	0.125	-50.0%	0.10	0.10
i:	0.075	0.0%	0.05	0.0%	1.50	1.50
$\overline{K}$:	1476.98	1.4%	436.77	165.5%	3.38	8.85
Λ :	39.53	-0.8%	13.02	-4.0%	3.04	2.94
$\overline{Y}$:	430.70	1.4%	127.37	165.5%	3.38	8.85
$\overline{I}$:	239.28	1.4%	47.17	165.5%	5.07	13.28
$\overline{M}$:	39.88	-49.3%	117.93	32.7%	0.34	0.89
$\overline{D}$:	16.41	-49.6%	27.65	22.1%	0.59	1.44
$\overline{r}$:	0.1030	0.0%	0.0682	-33.8%	1.51	1.00
$\overline{v}$:	0.5661	1.4%	0.3720	165.5%	1.52	3.98
$\overline{w}_1$:	7.7249	-42.9%	1.8338	337.4%	4.21	32.25
$\overline{w}_2$:	0.4908	-84.9%	3.4419	500.4%	0.14	5.66
$\overline{w}_3$:	1.0496	2.2%	0.6239	121.6%	1.68	3.65
$\overline{w}_4$:	0.8796	2.2%	0.5229	201.6%	1.68	4.96
$\overline{w}_5$:	0.7653	2.2%	0.4550	203.1%	1.68	4.99
$\overline{w}_6$:	2.2481	-37.6%	1.3364	316.8%	1.68	11.23
$\overline{w}_7$:	0.4793	12.3%	0.2849	123.2%	1.68	3.34
$\overline{w}_8$:	0.9409	2.2%	0.5593	128.2%	1.68	3.76
P_1:	1.2716	-9.1%	1.2716	15.4%	1.00	1.27
P_2:	0.8085	-26.9%	0.8085	21.5%	1.00	1.66
P_3:	0.9160	0.0%	0.9160	3.2%	1.00	1.03
P_4:	0.8898	0.0%	0.8898	8.5%	1.00	1.09
P_5:	0.8697	0.0%	0.8697	8.6%	1.00	1.09
P_6:	1.0381	-7.8%	1.0381	14.5%	1.00	1.24
P_7:	0.8053	1.6%	0.8053	3.3%	1.00	1.02
P_8:	0.8997	0.0%	0.8997	3.7%	1.00	1.04
ξ:			0.6621	124.7%	0.00	3.39

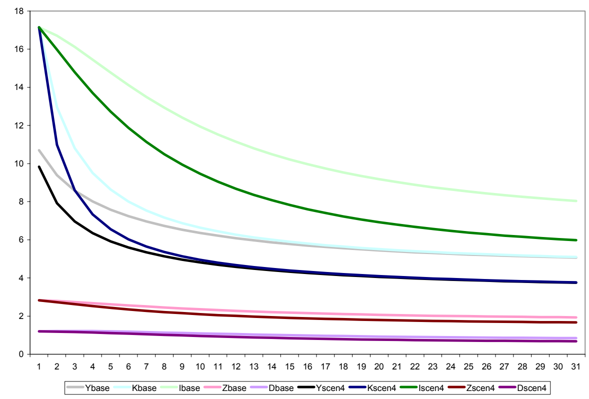
Figure 4

Transition to Scenario 4 Steady State

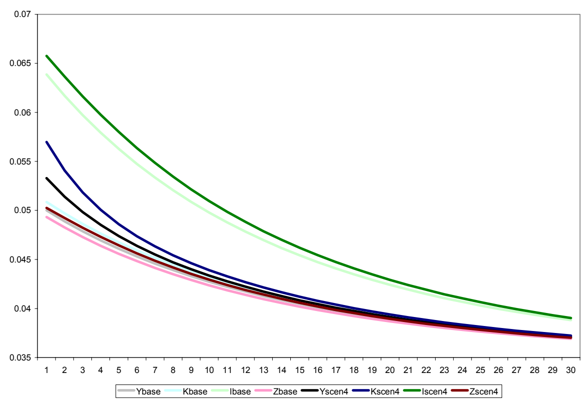
log per capita GDP



South to North Ratios



Growth Rates in the South



Growth Rates in the North

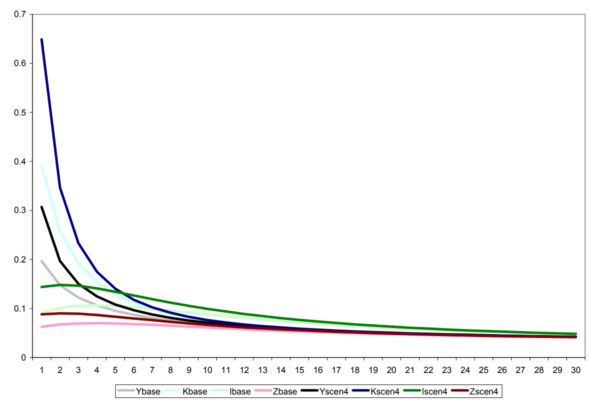


Table 6

Steady State values for Scenario 5

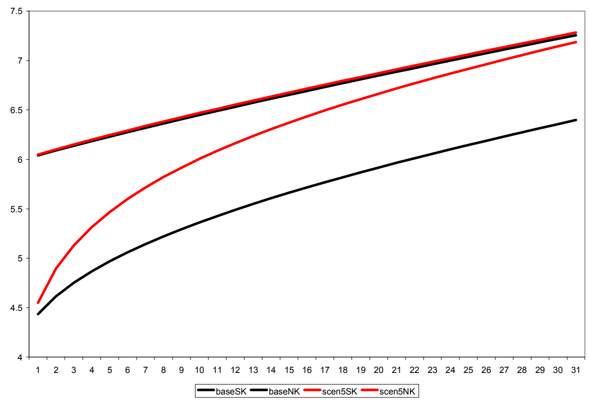
(Free Trade Area with Common Policy)

	South	% diff from baseline	North	% diff from baseline	ratio	baseline ratio
f:	0.0225	-50.0%	0.0225	-84.5%	1.00	0.31
m:	0.0125	-50.0%	0.0125	-95.0%	1.00	0.10
i:	0.075	0.0%	0.075	50.0%	1.00	1.50
$\overline{K}$:	1475.81	1.3%	711.21	332.3%	2.08	8.85
Λ :	39.43	-1.1%	20.61	51.9%	1.91	2.94
$\overline{Y}$:	430.36	1.3%	207.39	332.3%	2.08	8.85
$\overline{I}$:	239.09	1.3%	115.22	548.4%	2.08	13.28
$\overline{M}$:	39.85	-49.3%	19.20	-78.4%	2.08	0.89
$\overline{D}$:	16.40	-49.7%	7.77	-65.7%	2.11	1.44
$\overline{r}$:	0.1030	0.0%	0.1066	3.5%	0.97	1.00
$\overline{v}$:	0.5656	1.3%	0.6057	332.3%	0.93	3.98
$\overline{w}_1$:	8.6530	-36.0%	3.2980	686.5%	2.62	32.25
$\overline{w}_2$:	0.6177	-81.0%	6.9544	1113.1%	0.09	5.66
$\overline{w}_3$:	1.0516	2.4%	1.0037	256.5%	1.05	3.65
$\overline{w}_4$:	0.8813	2.4%	0.8412	385.1%	1.05	4.96
$\overline{w}_5$:	0.7668	2.4%	0.7319	387.6%	1.05	4.99
$\overline{w}_6$:	2.4838	-31.0%	2.3706	639.3%	1.05	11.23
$\overline{w}_7$:	0.4691	9.9%	0.4477	250.8%	1.05	3.34
$\overline{w}_8$:	0.9427	2.4%	0.8997	267.1%	1.05	3.76
P_1:	1.2951	-7.4%	1.2951	17.5%	1.00	1.27
P_2:	0.8393	-24.2%	0.8393	26.2%	1.00	1.66
P_3:	0.9160	0.0%	0.9160	3.2%	1.00	1.03
P_4:	0.8898	0.0%	0.8898	8.5%	1.00	1.09
P_5:	0.8697	0.0%	0.8697	8.6%	1.00	1.09
P_6:	1.0550	-6.3%	1.0550	16.3%	1.00	1.24
P_7:	0.8022	1.2%	0.8022	2.9%	1.00	1.02
P_8:	0.8997	0.0%	0.8997	3.7%	1.00	1.04
ξ:			1.0353	251.3%	0.97	3.39

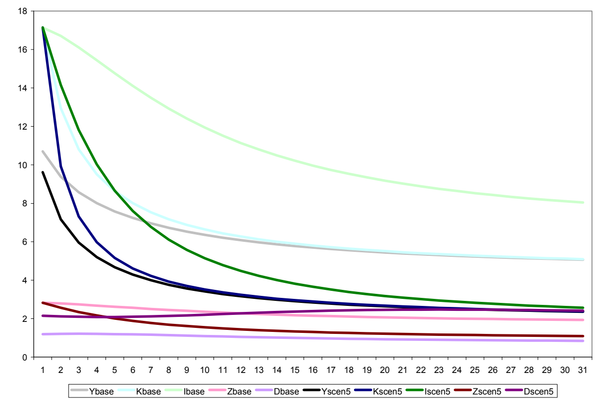
Figure 5

Transition to Scenario 5 Steady State

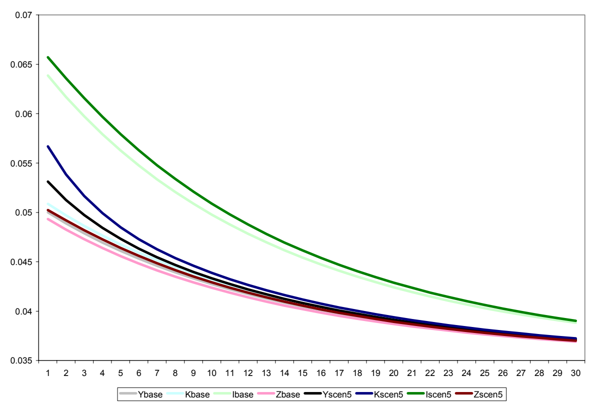
log per capita GDP



South to North Ratios



Growth Rates in the South



Growth Rates in the North

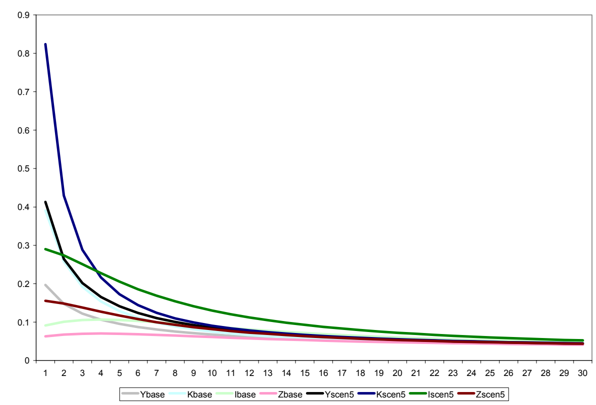


Table 7

Steady State values for Scenario 6

(Full Integration)

Total	South	% diff	North % diff
f:	0.0225	0.0%	-84.5%
m:	0.0125	-50.0%	-95.0%
i:	0.075	-50.0%	50.0%
$\overline{K}$:	2162.89	48.5%	1214.6%
Λ :	59.28	48.8%	337.0%
$\overline{Y}$:	630.71	48.5%	1214.6%
$\bar{I}$:	350.40	48.5%	1871.9%
$\overline{M}$:	58.40	-25.7%	-34.3%
$\overline{D}$:	23.91	-26.6%	5.6%
$\bar{r}$:	0.1030	0.0%	0.0%
$\bar{v}$:	0.5717	2.4%	308.0%
$\overline{w}_1$:	4.3250	-68.0%	931.5%
$\overline{w}_2$:	2.9398	-9.4%	412.8%
$\overline{w}_3$:	1.0250	-0.2%	264.1%
$\overline{w}_4$:	0.8590	-0.2%	395.4%
$\overline{w}_5$:	0.7474	-0.2%	398.0%
$\overline{w}_6$:	2.3574	-34.5%	635.2%
$\overline{w}_7$:	0.4600	7.8%	260.4%
$\overline{w}_8$:	0.9188	-0.2%	274.9%
P_1:	1.2145	-13.2%	10.2%
P_2:	0.9398	-15.1%	41.3%
P_3:	0.9160	0.0%	3.2%
P_4:	0.8898	0.0%	8.5%
P_5:	0.8697	0.0%	8.6%
P_6:	1.0504	-6.7%	15.8%
P_7:	0.8031	1.3%	3.0%
P_8:	0.8997	0.0%	3.7%
ξ:	1.0000		239.4%

Figure 6

Time path for Scenario 7

(Reunification in Phases)

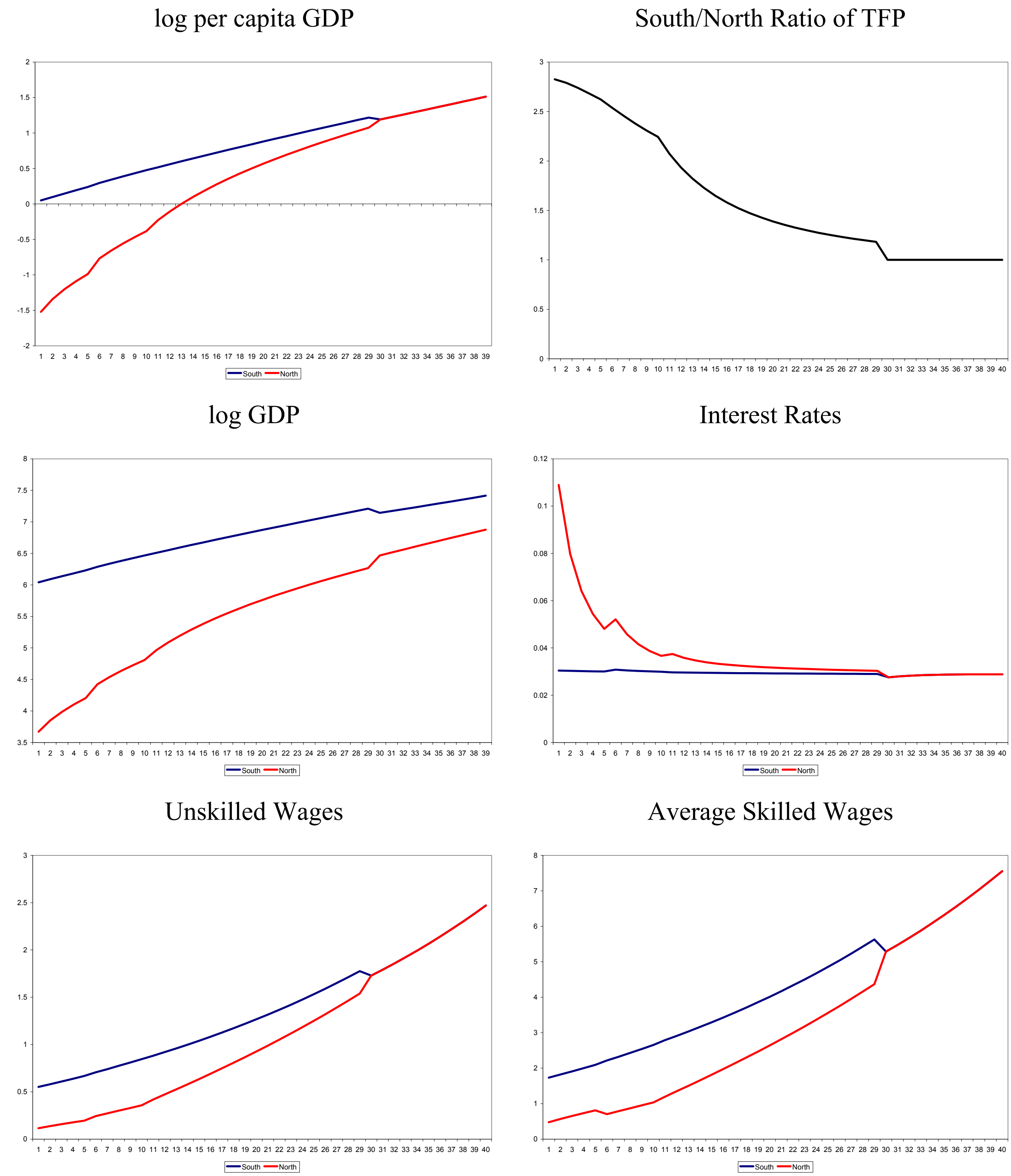


Figure 7

Time path of Skilled Wages for Scenario 7

(Reunification in Phases)