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# The Costs and Benefits
# of Korean Unification

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March 1998

## Abstract

Existing estimates of the costs of unification are inadequate for a number of reasons. In this paper we use a dynamic computable general equilibrium model to calculate South Korean and total peninsular income streams under a variety of unification (and non-unification) scenarios. We find that there are scenarios in which the present discounted value of South Korean income is higher with unification than without it. Although lower income groups in South Korea experience reduced incomes under this scenario, with redistribution of the gains, everyone can be made better off. Indeed, this scenario, which involves relatively low levels of South Korean private investment in the North together with relatively high levels of North-South migration, is also the one which generates the highest level of total peninsular income as well. The latter point is critical in that it suggests that there is no necessary conflict between the economic interests of North and South Koreans after unification.

# The Costs and Benefits of Korean Unification

## Introduction

A cottage industry now exists devoted to the estimation of the prospective costs of Korean unification (some of the more notable studies are summarized in Table 1). These studies have adopted one of two approaches. The first is to take data from the German experience and apply it to the Korean case (S.M. Lee, 1993; Bae, 1996). The concept of cost here is government expenditure, and benefits are viewed through a similarly narrow prism of offsetting possibilities for budgetary expenditure reduction (primarily through military demobilization). A second approach attempts to measure the resources necessary to raise North Korea to some share of South Korean income (Hwang, 1993; Yeon, 1993; Y.S. Lee, 1994; Noland, Robinson, and Scatasta, 1997). Cost in these studies is measured in terms of resource transfer, typically taking the form of investment capital or government expenditure. Benefits are typically ignored. With one exception, all of these studies are based on simple spreadsheet calculations; only Noland, Robinson, and Scatasta use a behavioral model as the basis of calculation.

This paper extends this literature by adopting a conceptually superior measure of the costs and benefits of potential unification, namely the present discounted value (PDV) of income under alternative scenarios of unification.[1] We calculate this measure for both South

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[1] To be precise, political unification is not a necessary precondition for the calculations that we will report, and the term "unification" should be regarded as a convenient shorthand for a customs and monetary union in which a certain degree of cross-border factor mobility is permitted. This does not require either the dissolution of either state currently existing on the peninsula or presuppose a German-style collapse of the North and its absorption by the South. The scenarios assume a significant deepening of economic integration. Political unification would be one way that this could occur, but is by no means necessary, and the results reported herein do not presuppose unification. In this sense, the shorthand of the paper's title is misleading: unification would be a sufficient, though not necessary, condition for the simulations that we report.

Korea alone and for the peninsula as a whole, which allows us to identify both the set of conditions that would maximize South Korean income (were it to behave selfishly under unification) as well as the conditions that would maximize peninsular income (were South Korea to behave altruistically). Furthermore, our model permits us to examine the distributional implications within South Korea for these alternative paths. In making these calculations we identify the key economic forces and key policy issues that may shape economic outcomes on the peninsula. To preview the bottom line, we identify one scenario in which the South Korean PDV income stream is higher than the one associated with the baseline scenario of no unification. This scenario, in which unification yields positive net benefits to South Korea, is characterized by relatively low levels of South Korean private investment in the North combined with relatively high levels of North-South labor migration.

## Conceptualizing the Costs and Benefits of Unification

There are two basic approaches to conceptualizing the costs and benefits of unification. The first takes the government budget as the fundamental variable of interest; the second focuses on transfers as the relevant measure. With respect to the former, costs are measured in terms of budgetary expenditures, which are relatively straightforward to calculate. For example, in the case of German unification one can measure net transfers from the West to the East (i.e., expenditures less taxes paid). Likewise, budgetary benefits associated with things like military demobilization, reduction in expenditures on duplicative diplomatic activities, etc. can be measured in terms of spending. These are the initial direct budgetary impacts. Most analysts, Bae (1996), for instance, stop there.[2] This is not the end of the story, however. For the sake of concreteness, take the example of military demobilization. Both East and West Germany maintained conscript armies (as do both North and South Korea). Conscripts are presumably paid less than what they could earn in other activities in the civilian economy. Their wages are not the true measure of the cost to the economy of maintaining the army—the wages they would have otherwise earned are. So, when the army demobilizes resources are released from relatively low productivity activities (the army) into relatively higher productivity activities in the civilian economy, national income increases, and with it so does the tax base. In other words, those lowly paid conscripts leave the army, join the civilian economy, and begin paying taxes on their higher wages.

But this logic applies to the whole economy—not just the government budget. The process of unification will be accompanied by a reallocation of resources throughout the economy as factors are deployed in more productive ways. The result is an increase in national income, and an increase in tax receipts. Calculations such as Bae's, which ignore these general equilibrium effects, systematically underestimate the benefit side of the cost-benefit calculus.

Even if one were to implement the budgetary analysis properly, it is not at all clear that budgetary savings is the best measure of net benefits. The government's budget balance in

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[2] Bae (1996) concludes that in the mid-1990s, the annual "peace dividend" for the two economies, broadly defined, would have been on the order of $7 billion. However, this estimate (like earlier ones) is based on military budget expenditure rather than the more appropriate opportunity or shadow cost measure of resources used by the military. Our modeling work implicitly embodies the latter approach in its treatment of the reallocation of resources in the context of economic integration.

and of itself is not very interesting—what is relevant is not the size or sign of any imbalance, but rather its implications for income and consumption growth, which are the ultimate measures of economic welfare. (For example, most people would choose a future of slight budget deficits and steady robust growth over one characterized by fiscal balance and negative growth.) The second set of studies, which measure the costs of unification in terms of overall resource transfers, could be interpreted as heading in this direction—they measure the transfer costs, but do not measure the benefits. For example, if the transfers take the form of investment in the North by Southern owners of capital, those investments will yield a stream of profits remitted to Southern investors that directly adds to Southern income. Moreover, to the extent that the rate of return on capital investment is higher in the North than the South, those investors will earn higher returns than if they had invested in the South. Again, more generally, opening up of exchange between the North and South could be expected to be accompanied by reallocation of resources that would raise the level of income in both economies. Unfortunately, none of the studies surveyed attempts to measure the impact of economic integration in either the narrow or broader sense noted above.

In summary, there is a substantial literature on the costs of unification, but the measures of costs are inadequate and potential benefits are ignored. The remainder of this paper is devoted to addressing this problem.

## Measuring the Costs and Benefits of Unification

To properly measure the net benefits of any particular economic integration or unification scheme, one must specify a counterfactual. To do this one needs a measure of the dynamic growth path of the economy in the absence of unification, and some alternatives with which to compare it. We generate both baseline projections of the North and South Korean economies and projections of eight alternative unification scenarios using the Korean Integration Model (KIM), a simple dynamic two-country computable general equilibrium (CGE) model linking North and South Korea. KIM is a member of a growing family of trade-focused, multi-country, CGE models designed to analyze the impact of trade liberalization and the formation of free trade areas, customs unions, and monetary unions. It consists of two linked country CGE models, one for North Korea and one for South Korea. The rest of the world is included by means of a simple representation of fixed world prices for North and South Korean exports and imports. The countries are linked by trade flows, and the model solves for all internal prices, including commodity and factor prices, and external prices of all traded goods. Domestically produced and traded goods are specified as imperfect substitutes, which provides for a realistic continuum of "tradability" and allows for two-way intersectoral trade. The model also includes includes quantity rationing of both exports and imports. North Korea is assumed to have levels of "desired" exports and imports that would be typical for a country of its size and per capita income, but in practice exports and imports are rationed physically, yielding the low levels observed in the base data.[3] South Korean trade with North Korea is similarly assumed to be rationed in physical

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[3] The volume of "desired" trade is obtained through the use of a gravity model of international trade. The sectoral composition of that trade was estimated using detailed sectoral data on North Korean trade, together with the equivalent data from South Korea and Japan—North Korea's principal "natural" trading partners according to the gravity model. See Noland, Robinson, and Scatasta (1997) for details.

terms, and "desired" trade between the two countries is assumed to equal levels that would be predicted from a gravity model.

The model has eight sectors: agriculture/forest/fisheries, mining, light manufacturing, industrial intermediates, capital goods, construction, public administration, and services. There are three "demanders": a single aggregate household which buys consumer goods, a government which spends on goods and public administration, and an aggregate capital account which purchases investment goods.[4] Primary factors of production are capital, agricultural labor, high-skill urban labor, and low-skill urban labor. Land is not explicitly modeled as a separate factor and can be considered as subsumed in agricultural capital.[5] (Additional description of the model is contained in the appendix.)

The model was calibrated for 1990, the most recent year for which reliable (we use this term advisedly) data on North Korea were available. The labor-force growth of the two economies is set exogenously on the basis of economically active labor force projections released by the Ministry of National Unification. Total factor productivity growth rates were set exogenously on the basis of econometric estimates. Capital accumulation was calibrated to reproduce the pattern of economic growth observed over the period 1991–1996. KIM is essentially a long-run equilibrium model and is not designed to capture short-run cyclical effects.

To obtain the baseline scenario, the model was run out to 2007 under the assumption of no change in policy in either North or South Korea.[6] In the case of South Korea, the growth rate of the economy steadily slows, averaging between four and five percent real growth for the period 1998–2007. In the case of North Korea, the rate at which the economy shrinks moderates, and North Korea averages between negative two and negative three percent growth for the period.

The alternatives take the form of economic integration scenarios. These are modeled by removing all quantity rationing and imposing a common external tariff equal to South Korean tariffs, together with the specification of a fixed internal exchange rate between North and South Korea and a unified, fixed, balance of trade for the two countries together (implying a monetary union). In the case of North Korea, the economy experiences significant gains due to the static reallocation of factors, as well as an "obsolescence shock" reduction in the value of its pre-integration capital stock.[7] It also experiences an increase in total factor productivity (TFP) associated with the importation of capital equipment and new technology from South Korea and the rest of the world. We make two assumptions

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[4] With respect to the North Korean military, we assume that half are already engaged in non-military activities that normally would be undertaken by the civilian sector of an economy (see Noland (1996) for evidence on this point). In the subsequent simulations, we allow government expenditure to grow in real terms, but increases in productivity mean that employment falls in the public administration sector. This could be thought of as military modernization and/or partial demobilization.

[5] See Noland, Robinson, and Liu (1997a) for a complete elaboration of the model and its parameterization.

[6] Another possibility is that North Korea could reform but does not integrate with South Korea. As it turns out, this does not make a whole lot of difference in terms of the South Korean baseline scenario: the North Korean economy is very small relative to South Korea, so from the perspective of South Korea, the size of the one-time positive trade shock associated with opening is relatively small (only about one percent of national income). The real effects on the South occur when cross-border factor mobility is permitted. See Noland, Robinson, and Liu (1997a) for a more detailed quantitative analysis of this issue.

[7] See Noland, Robinson, and Scatasta (1997) for a more detailed discussion of these issues.

about the nature of this technological transfer. In the scenarios in which capital transfers are "low," the level of North Korean TFP in each sector rises to the level of its South Korean counterpart at the end of the decade-long integration process. This is consistent with the German experience.[8] In the scenarios in which capital transfers are "high," North Korea literally adopts South Korean technology. At the end of the integration process, North Korea has not only attained South Korea's level of TFP, but it is using the same intermediate input mix as well. The implication is that North Korea stops wasting produced intermediate inputs.[9] Sectoral results reported by Noland, Robinson, and Scatasta (1997) and Noland, Robinson, and Liu (1997a) indicate that reform in North Korea would be accompanied by an enormous shift in the composition of output and employment toward the light industry sector (and to a lesser extent mining), while agriculture and the capital goods sector would tend to contract as factors were reallocated in a more economically rational way. Similar results were obtained in the exercises described below, but for the sake of brevity are not reported here.

## Scenarios

Economic integration between North and South Korea could occur in many ways. For the purposes of modeling costs and benefits of unification, we assume that in 1998 North Korea undergoes fundamental economic reform and forms a monetary union with South Korea. One can interpret this as the economic manifestation of political union, but this is not necessary.[10]

In such a situation, a key determinant of economic outcomes would be the extent of cross-border factor mobility.[11] In the case of labor migration, following Park (1997), we posit a "high" migration condition in which 2 million workers migrate from North to South over the course of the decade.[12] Under the "low" migration assumption, we cut Park's estimate in half. Similarly, in the "high" capital transfer scenario, South Korea transfers between five and six percent of its base national income annually, following the German example as analyzed by Kwon (1997).[13] (Unlike the German case, we assume that these

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[8] See Kwon (1997).

[9] See Noland, Robinson, and Liu (1997a) for a more detailed discussion of the technology transfer issue.

[10] In the analysis that follows we interpret income as a measure of welfare, and ignore the role of security and the implications of economic change for military expenditure on the peninsula. It is possible, for example, that part of the welfare gains generated by economic integration could be lost if the two states used the gains to increase their military threat capabilities. If economic integration were accompanied by political integration, this issue would be moot.

[11] While we present results on possible cross-border labor migration, we do not attempt to analyze negative congestion externalities or other spillover costs associated with significant population movements. Rather, our focus is on the implications of economic integration for the macroeconomic performance of the two economies.

[12] As a matter of convenience we have specified these scenarios based on estimates of potential cross-border factor flows found in the literature (e.g. Park (1997) and Kwon (1997)). These studies in turn run off of the German case. History does not operate by analogy and we want to make clear that we do not believe that Korean unification, should it occur, necessarily would be "like" the German experience. Rather, we use the German example as a convenient way to generate some numbers for our simulations. For a detailed discussion of the German case and its possible relevance (or irrelevance) for the Korean situation, see Noland (1997).

[13] In this paper we do not specifically model foreign capital inflows. See Noland, Robinson, and Liu (1997a, 1997b) for discussion of this issue.

transfers go to investment, not to support consumption.)[14] Again, in the "low" capital transfer case we cut in half Kwon's figure for Germany. Since we identify technological convergence with the magnitude of capital transfer, in the "low" capital transfer case, we impose "low" productivity gains (i.e., attainment of South Korea's level of TFP), while in the "high" capital transfer case we impose "high" productivity increases (i.e., attainment of South Korea's level of TFP plus adoption of South Korea's intermediate input requirements).[15]

A final issue involves the nature of capital transfers from the South to the North.[16] These could take the form of grants, or they could take the form of private investment. In the former case, capital would be transferred to the North, and there it would remain, providing economic benefits to the Northern economy. In the latter case, Southern investors would retain ownership, and the investments would yield a stream of remitted profits that would add to Southern income. In the event of unification, actual transfers would probably reflect a mix of grants (perhaps funding public infrastructure) and private profit-making investments (factories, etc.). We have simulated the model treating the capital transfers both ways.[17]

All together, there is a base scenario of no integration and four integration scenarios:

• Scenario 1A: labor migration is "high," capital and technology transfers are "low," and capital transfers take the form of grants.

• Scenario 1B: same as Scenario 1A, except capital transfers take the form of private investment.

• Scenario 2A: labor migration is "low," capital and technology transfers are "low," and capital transfers take the form of grants.

• Scenario 2B: same as Scenario 2A, except capital transfers take the form of private investment.

• Scenario 3A: labor migration is "low," capital and technology transfers are "high," and capital transfers take the form of grants.

• Scenario 3B: same as Scenario 3A, except capital transfers take the form of private investment.

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[14] In reality some consumption transfers would probably be required to support a Northern population weakened by years of deprivation.

[15] In earlier work we have also explored more extreme scenarios in which the attainment of the 60 percent per capita income target is achieved purely through labor migration or purely through capital transfers. Noland, Robinson, and Liu (1997a) found that if income convergence was achieved solely through migration, approximately three-quarters of the North Korean population would move South. If capital transfer was the only equilibrating mechanism, it could take upwards of one trillion dollars to achieve the income target.

[16] We assume that the transfers to the North come completely at the expense of investment in the South (i.e., there is complete crowding out of investment, and no crowding out of consumption or foreign direct investment). This assumption has the effect of tending to bias the model against ourselves in that it reduces the likelihood of unification having a net positive impact on the South's dynamic income stream.

[17] In all cases we assume that these changes occur smoothly over the course of a decade. In reality, factor movements could occur with considerable abruptness. Endogenization of the cross-border factor flow is an obvious direction for future research.

- Scenario 4A: labor migration is "high," capital and technology transfers are "high," and capital transfers take the form of grants.

- Scenario 4B: same as Scenario 4A, except capital transfers take the form of private investment.

## Results

Simulation results are shown graphically in Figures 1–6 and summarized in Table 2. In response to unification in 1998, in seven of eight cases North Korean income drops as the obsolescence shock dominates the static reallocation gains, and then begins rising as the effects of capital transfers and technological change kick in. The exception is Scenario 3A, in which the combination of high grant transfers, rapid technological change, and low migration means that aggregate income rises from the outset in 1998. The 1990 base level of income is reattained in one to four years, with the high grant transfer Scenarios 3A and 4A exhibiting the most rapid income gains and Scenarios 1B and 4B displaying the slowest.[18]

In the case of South Korea, the economy experiences a one-time static income gain, equal to approximately one percent of national income with the opening of trade with North Korea. In the four private investment scenarios (Scenarios 1B–4B) and the scenario with low grant transfer and high migration (Scenario 1A), this effect is sufficiently large that the economy actually experiences a temporary acceleration of growth. In the other three cases (Scenarios 2A–4A) the negative impact of the grant transfers overwhelms the positive trade shock and the economy experiences an initial slowdown in growth.

The present discounted values (PDV) of these income streams are summarized in Table 2.[19] From a South Korean perspective the worst case is Scenario 3A (high grant transfers and low migration) in which the PDV of the South Korean income stream is more than one half trillion dollars lower than the base.[20] With the combination of high grants and low migration, one might think of this as the German scenario. However, South Korea is actually better off in Scenario 1B (low private investment, high migration) with the PDV of its income stream in this scenario $35 billion higher than the base. In other words, in Scenario 1B South Korea is actually better off with unification than without it.

From the standpoint of the peninsula as a whole, the PDV of peninsular income is maximized under Scenario 1. This result is critical, since it implies that a social welfare function that ignored the interests of North Koreans, and one that treated all Koreans equally, would select the same set of policies—relatively low levels of private investment

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[18] The very high growth rates in the North are a purely mechanical outcome of the model. It is quite possible that institutional constraints might prevent the identification of investment projects and their implementation in reality (i.e., North Korea might not have the necessary absorptive capacity in actuality).

[19] These figures were calculated using an annual discount rate of five percent. For sensitivity analysis, the results were also calculated using a rate of ten percent. As can be seen in Figures 1–6 there was not a lot of crossing of income paths across the different cases and as a consequence the qualitative results discussed in the text are not sensitive to choice of discount rate.

[20] All figures are reported in 1990 purchasing power adjusted international dollars, derived from the Penn World Tables. Purchasing power adjusted figures take into account that the prices of internationally non-tradable goods (such as housing, personal services, etc.) are systematically lower in poor countries. See Summers and Heston (1991) for a description of the methodology and Noland (1996) for a discussion of purchasing power figures in the North Korean context.

flows combined with substantial migration. Peninsular income is minimized under Scenario 2. There is effectively no difference between the grant and private investment cases, since the returns to capital remain on the peninsula in both cases. However, although Scenario 1 generates the highest income stream, it is also associated with the slowest reduction in inequality between North and South. Some previous studies have looked at per capita income differences among South Korean provinces, American states, and members of the European Union, and have concluded that cross-jurisdictional per capita income differences on the order of 40 percent are consistent with social stability (Chun, 1993; Noland, Robinson, Scatasta, 1997). Depending on the political context in which economic integration arose, this assumption would appear to raise questions about the sustainability of the South Korean–preferred Scenario 1B, absent additional capital flows or some mechanism for limiting migration.

**Distribution**

Thus far the results have been discussed in terms of the aggregate effects on the two economies. Economic integration will also have effects on the distribution of income, as well as on its level. An example of this is shown in Table 3, which reports the distribution of income in the base case, as well as Scenarios 1A and 1B, calculated with respect to current residents of South Korea (i.e., migrants' wages are excluded from the calculation). Economic integration with the North leads to a shift in the distribution of income away from labor income and toward capital income. This is particularly pronounced in Scenario 1B, in which the capital transfers to the North take the form of private investments yielding a stream of remitted profits. Indeed, as the agricultural and urban low-skilled wages fall and urban high-skilled wages rise in absolute terms, there is also a shift within labor income toward higher-skilled groups. If the ultimate owners of capital are predominately the higher-skilled, this this suggests that, absent some redistributive mechanism, economic integration with the North is likely to be accompanied by increased income and wealth inequality in the South. However, aggregate income in Scenario 1B is higher than the base, so that with redistribution everyone in South Korea could be made better off with unification relative to the no unification case.


# Conclusion

Existing estimates of the costs of unification are inadequate for a number of reasons. In this paper we have used a dynamic computable general equilibrium model to calculate South Korean and total peninsular income streams under a variety of unification (and non-unification) scenarios. We find that there are scenarios in which the present discounted value of South Korean income is higher with unification than without it. Although lower income groups in South Korea experience reduced incomes under this scenario, with redistribution of the gains everyone can be made better off. Indeed, this scenario, which involves relatively low levels of South Korean private investment in the North together with relatively high levels of North-South migration, is also the one which generates the highest level of total peninsular income as well. The latter point is critical in that it suggests that there is no necessary conflict between the economic interests of North and South Koreans. However, under this scenario after a decade of adjustment the level of North Korean per capita income

would still be less than 40 percent of the South's. Whether this degree of disparity would be politically sustainable in a unified Korea is an open question.

**Table 1. Estimated Costs of Unification**

| Source | Methodology | Definition of Cost | Unification Date | Results |
|--------|-------------|--------------------|------------------|---------|
| Hwang (1993) | Income Target | Total investment (including private) | 1990 | $300 billion, over an undefined period[a] |
| | | | 1995 | $700 billion, over an undefined period[a] |
| | | | 2000 | $1,200 billion, over an undefined period[a] |
| S.M. Lee (1993) | German Comparison | Government Expenditure | 2000 | $200 billion over 10 years |
| Yeon (1993) | Income Target | Government Expenditure | 2000 | $230–250 billion over 10 years |
| Y.S. Lee (1994) | Income Target | Government Expenditure | 1990 | PDV $330 billion over 40–50 years |
| | | South Korean Income Foregone | | PDV $841 billion over 40–50 years |
| Bae (1996) | German Comparison | Government Expenditure | 1993 | $488 billion over 5 years |
| Noland, Robinson, Scatasta (1997) | Income Target | Total investment | 1990 | $600 billion |
| | | (CGE model, North Korean capital-output ratio) | 1995 | $1,378 billion |
| | | | 2000 | $3,172 billion |
| | | (CGE model, market economy capital-output ratio) | 1990 | $319 billion |
| | | | 1995 | $754 billion |
| | | | 2000 | $1,721 billion |

Note: [a] This figure can be doubled to include the cost of "socio-economic adjustment."

**Table 2. Summary of Alternative Income Streams**

| | PDV of South Korean Income (1990 PPP$ billions) | PDV of Total Peninsular Income (1990 PPP$ billions) | Ratio of North to South Korean Per Capita Income, 2007 |
|---|---|---|---|
| Base Scenario | 5,660 | — | — |
| Scenario 1A | 5,519 | 6,201 | 55 |
| Scenario 1B | 5,695 | 6,201 | 38 |
| Scenario 2A | 5,338 | 6,113 | 64 |
| Scenario 2B | 5,524 | 6,113 | 46 |
| Scenario 3A | 5,119 | 6,116 | 91 |
| Scenario 3B | 5,503 | 6,116 | 52 |
| Scenario 4A | 5,293 | 6,173 | 79 |
| Scenario 4B | 5,659 | 6,173 | 41 |

Note: PDVs calculated assuming annual discount rate of five percent.

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**Table 3. South Korean Income Distribution**

|  | Base, 1990 | Scenario 1A, 2007 | Scenario 1B, 2007 |
|---|---|---|---|
| Agricultural labor | 2.8 | 1.5 | 1.5 |
| Urban low-skilled labor | 19.3 | 17.1 | 16.6 |
| Urban high-skilled labor | 28.4 | 24.6 | 23.9 |
| Capital | 49.5 | 56.7 | 58.0 |

Note: Migrants' income excluded from calculations for Scenarios 1A and 1B

# Appendix

KIM has a standard neoclassical specification, except that the model incorporates severe quantity controls in exports and imports, with concomitant distortions in domestic product and factor markets. The markets for goods, factors, and foreign exchange are assumed to respond to changing demand and supply conditions, which, in turn, are affected by government policies, the external environment, and other exogenous influences. The model can be considered medium-to-long run in that all factors are assumed to be intersectorally mobile. It is Walrasian in that only relative prices matter. Sectoral product prices, factor prices, and the exchange rate are determined relative to an aggregate consumer price index, which defines the numeraire.[21]

Sectoral production technology is represented by a set of Cobb-Douglas functions of the primary factors, while intermediate inputs are demanded according to Leontief, fixed input-output coefficients.[22] On the demand side, import demand functions are specified as AIDS (Almost Ideal Demand System)-translog—which allows substitution elasticities to differ between domestic-, Korean partner-, and rest-of-the-world-produced goods.

KIM focuses on real trade flows, relative prices, and the real exchange rate. The aggregate price level in each country is taken as exogenous, and the model does not include money or other assets. The model includes the basic macro aggregates for each country, including the government deficit, the balance of trade, and the savings-investment balance. The combined North-South trade balance of trade with the rest of the world is fixed exogenously (except when modeling full integration), so the model does not consider any possible macro feedbacks from trade liberalization to changes in international capital flows. The macro "closure" for each country is simple. Government revenue is determined endogenously, given a variety of fixed tax rates, while government expenditure is fixed exogenously. The government deficit is endogenous. Aggregate investment in each country is assumed to be a fixed share of GDP, and aggregate savings is assumed to adjust to equate total savings and investment.

In the case of North Korea, the major distortion in the economy is assumed to be quantitative controls on both imports and exports. Because of data problems we assume no other sources of price distortions such as sectorally differentiated taxes and subsidies, which we treat explicitly in the case of South Korea. Such sectoral distortions undoubtedly exist in North Korea, but due to the organization of the North Korean economy are effectively impossible to conceptualize, much less measure, so we focus only on trade liberalization.[23] (However, the "high" technological transfer scenarios in which North Korea adopts South

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[21] The exchange rate variable in the model can be seen as a price-level deflated (PLD) real exchange rate, deflating by the numeraire cost of living index.

[22] In the case of North Korea, aggregate production functions were estimated for aggregate capital and labor using data reported in Hwang (1993) and Y.S. Lee (1994). The results are remarkably robust and plausible given the quality of the underlying data. Constant elasticity of substitution specifications yielded estimates of the substitutability between capital and labor of around unity. The hypothesis that the aggregate production function was Cobb-Douglas could not be rejected. In most specifications, North Korea exhibited slightly negative total factor productivity growth, which is typical of many pre-reform socialist economies.

[23] Sectoral tax rates, for example, are impossible to conceptualize: government revenues are raised through a transaction tax whose rate varies depending on the legal status (state-owned, co-op, etc.) of the transacting parties.

Korean technology imply the elimination of any non-trade related distortions in factor markets as a product of economic liberalization.) We implicitly assume that North Korea is on, rather than inside, its production possibility frontier, though our method of modeling technological transfer would put it on the frontier whether it started off on it or not.

The model utilizes four main databases, macroeconomic and microeconomic Social Accounting Matrices (SAMs) of North and South Korea for 1990, the most recent year for which data were relatively unaffected by the severe macroeconomic shocks that North Korea began to suffer in 1989. In the case of South Korea, construction of the SAMs was straightforward. In the case of North Korea, however, the approach we adopted was to draw on a variety of data sources and use a matrix balancing technique to ensure consistency that is essentially Bayesian in that it stays "close" to known controls (or Bayesian prior) while imposing all the consistency requirements of the balanced accounts.[24]

Data for the North Korean macroeconomic SAM were primarily derived from North Korean government budget data as reported in Hwang (1993). One assumption made to build the macro SAM is that the North Korean government makes all investments. Government revenues are treated as being derived solely from direct household and enterprise taxes. Indirect taxes, import tariffs, and export tax rates are set to zero. In reality, revenues are raised from a transaction tax which varies depending on the legal status (state-owned, co-op, etc.) of the transacting parties, thus obviating the whole notion of a sectoral tax rate. In the absence of precise information about tax incidence, this was computed on the basis of a number of assumptions: (i) households' marginal propensity to save is between 30 percent and 40 percent; (ii) private savings are seized by the government via a number of instruments which are here summarized as a direct income tax; (iii) data about government current expenditure and investment are assumed to be reliable; (iv) part of capital/land returns are distributed to households, but capital/land income from public enterprises is appropriated by the government in the form of a enterprise tax.

The input-output coefficients are contained in a microeconomic SAM which was derived from a pre-reform (1979) Chinese input-output table compiled by the World Bank. This table was constructed to SNA standards, expanding on the material product accounts (World Bank, 1985). The assumption is that a good starting point (or prior) for inter-industry input-output relations in North Korea is pre-reform China, reflecting their common links to 1970s vintage Soviet manufacturing technology. This does not imply that the structure of the North Korean economy is the same as China's, only that the inter-industry input-output relations are the same in the baseline scenario.

Urban workers are divided into high skilled (professional, technical, and managerial) and low skilled (the remainder). The initial starting point for industry employment structure was taken from the Chinese data. The wage premium was calculated on the basis of South Korean data. While one might expect a priori that wage dispersion in the North would be less than in the South, at this level of sectoral aggregation the skilled wage premium obtained from the South Korean data was within the dispersion observed in fragmentary data on North Korean wages. Sectoral outputs are derived from estimates of North Korean GDP (Noland, 1996) and output shares reported by the Korea Development Bank (1994). When these output shares were applied to the labor data they yielded a rural wage that was too high relative to urban wages. The agricultural sector's share was reduced to about 21 percent of value-added which reduced agricultural wages to a level more consistent with the

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[24] The particular technique we used is a "minimum entropy difference" method that is described in Golan, Judge, and Robinson (1994).

fragmentary North Korean wage data.[25] A real exchange rate was constructed from the GDP estimates reported in Noland (1996). The real (PPP adjusted) North Korean won–U.S. dollar exchange rate was used to convert export and import data from dollars into won to obtain the domestic resource equivalent of external trade. A complete algebraic description of the model and a listing of its parameters is contained in Noland, Robinson, and Liu (1997a).

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[25] This highlights the importance of working within a SAM framework which enables the researcher to detect potential discrepancies between the available data sources and to adjust the data sets in a way which is internally consistent.
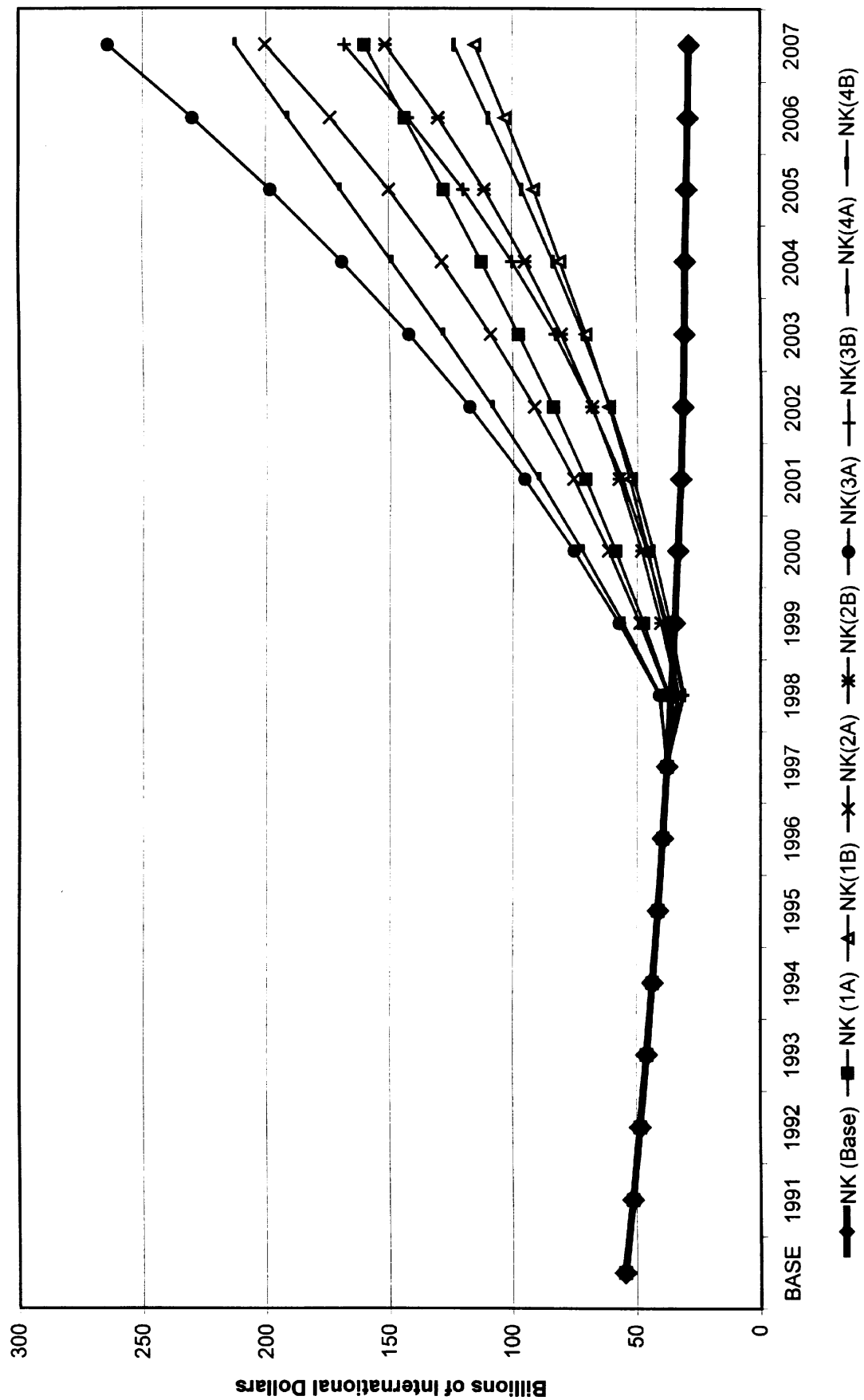
Figure 1: North Korean GDP under 8 Scenarios

Billions of International Dollars

BASE  1991  1992  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004  2005  2006  2007

NK (Base)  ■ NK (1A)  ▲ NK(1B)  ✳ NK(2A)  ✳ NK(2B)  ● NK(3A)  + NK(3B)  ✕ NK(2A)  NK(4A)  NK(4B)

Figure 2: South Korean GDP Under 8 Scenarios

SK (Base) — SK (1A) — SK(1B) — SK(2A) — SK(2B) — SK(3A) — SK(3B) — SK(4A) — SK(4B)
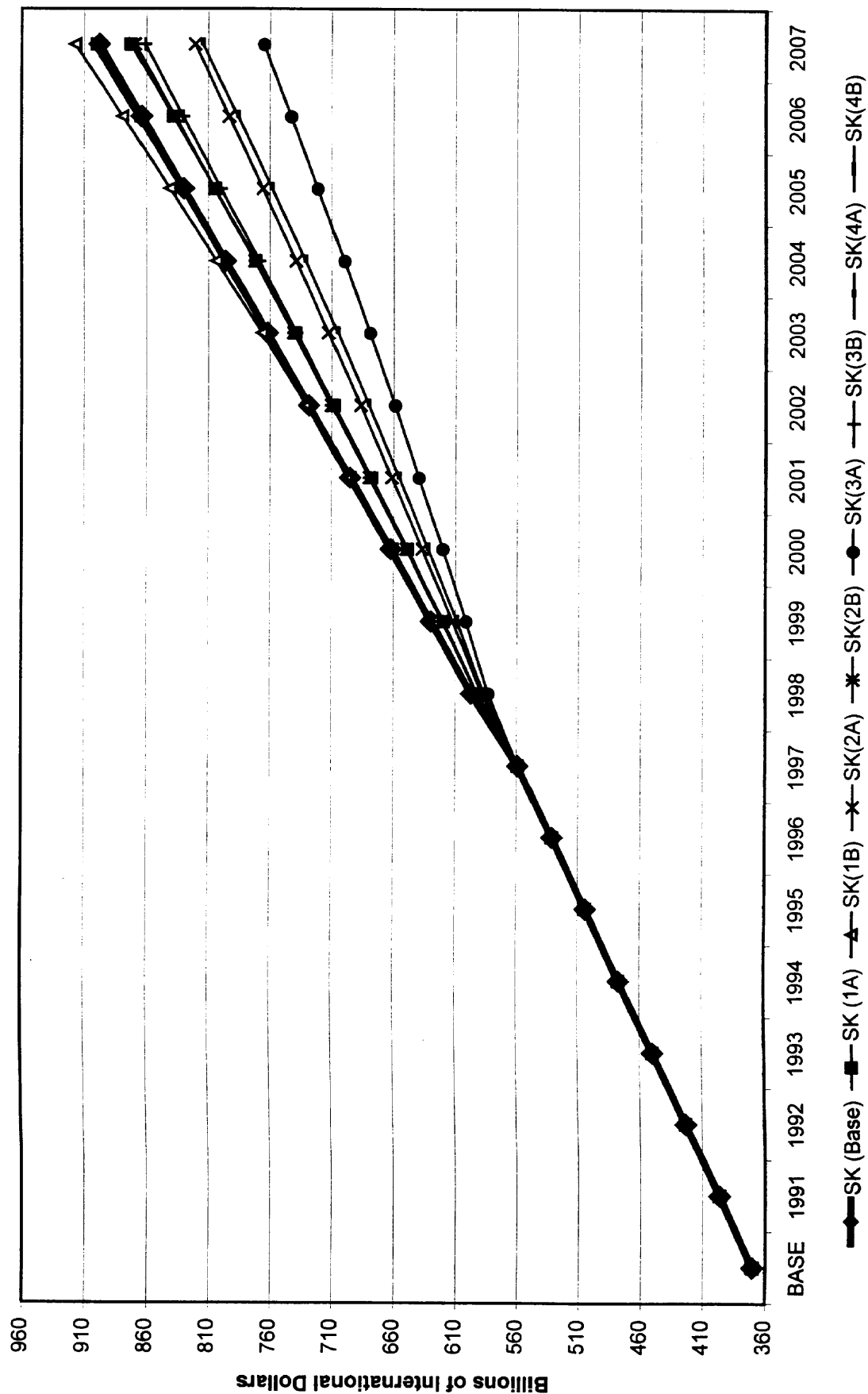
Figure 3: Korean Peninsula GDP under 8 Scenarios

Legend:
- Peninsula (Base)
- Peninsula (1A)
- Peninsula (3A)
- Peninsula (1B)
- Peninsula (3B)
- Peninsula (2A)
- Peninsula (4A)
- Peninsula (2B)
- Peninsula (4B)

Y-axis: Billions of International Dollars (400 to 1100)

X-axis: BASE, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007
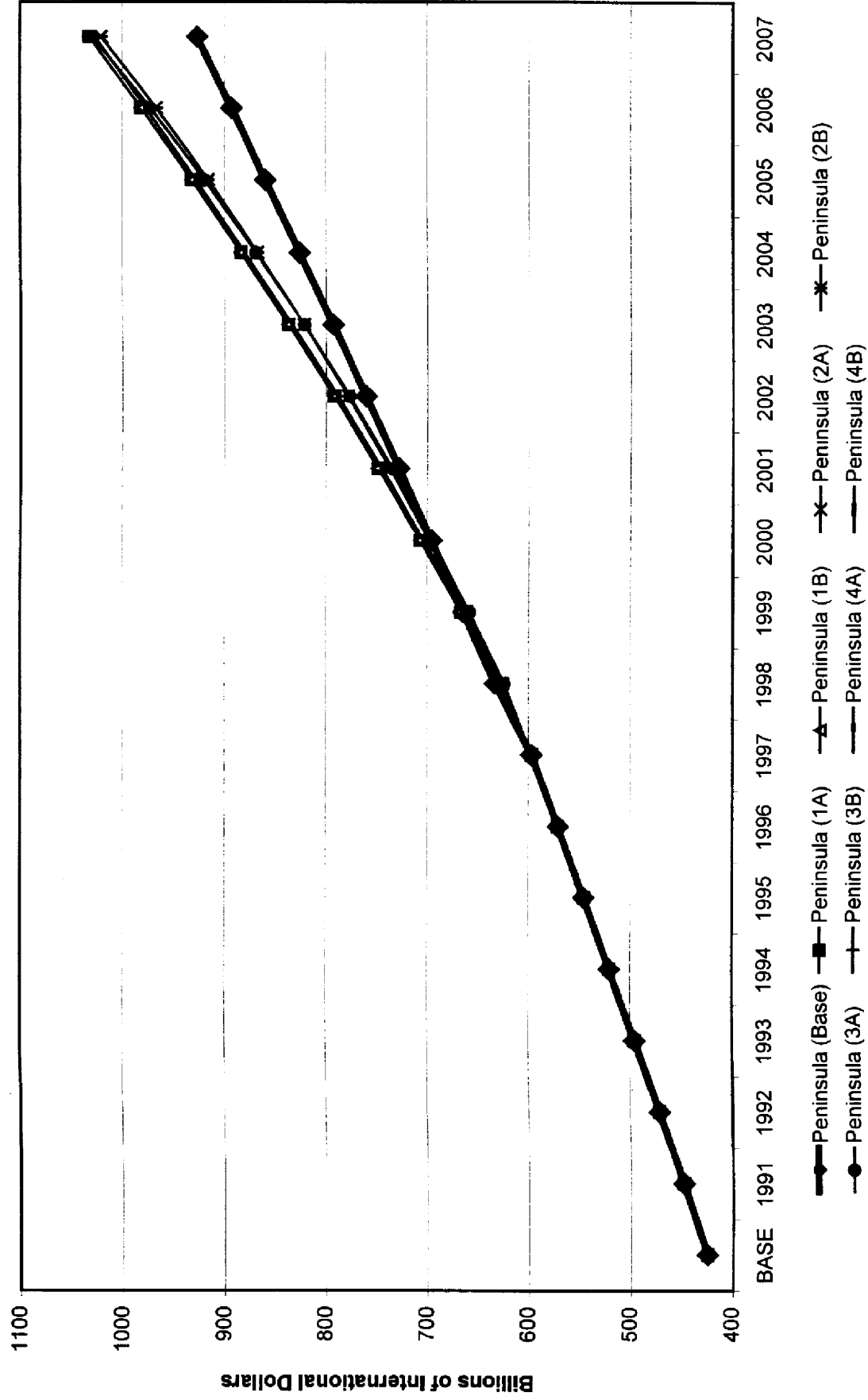
Figure 4: North Korean GDP Growth Rate under 8 Scenarios
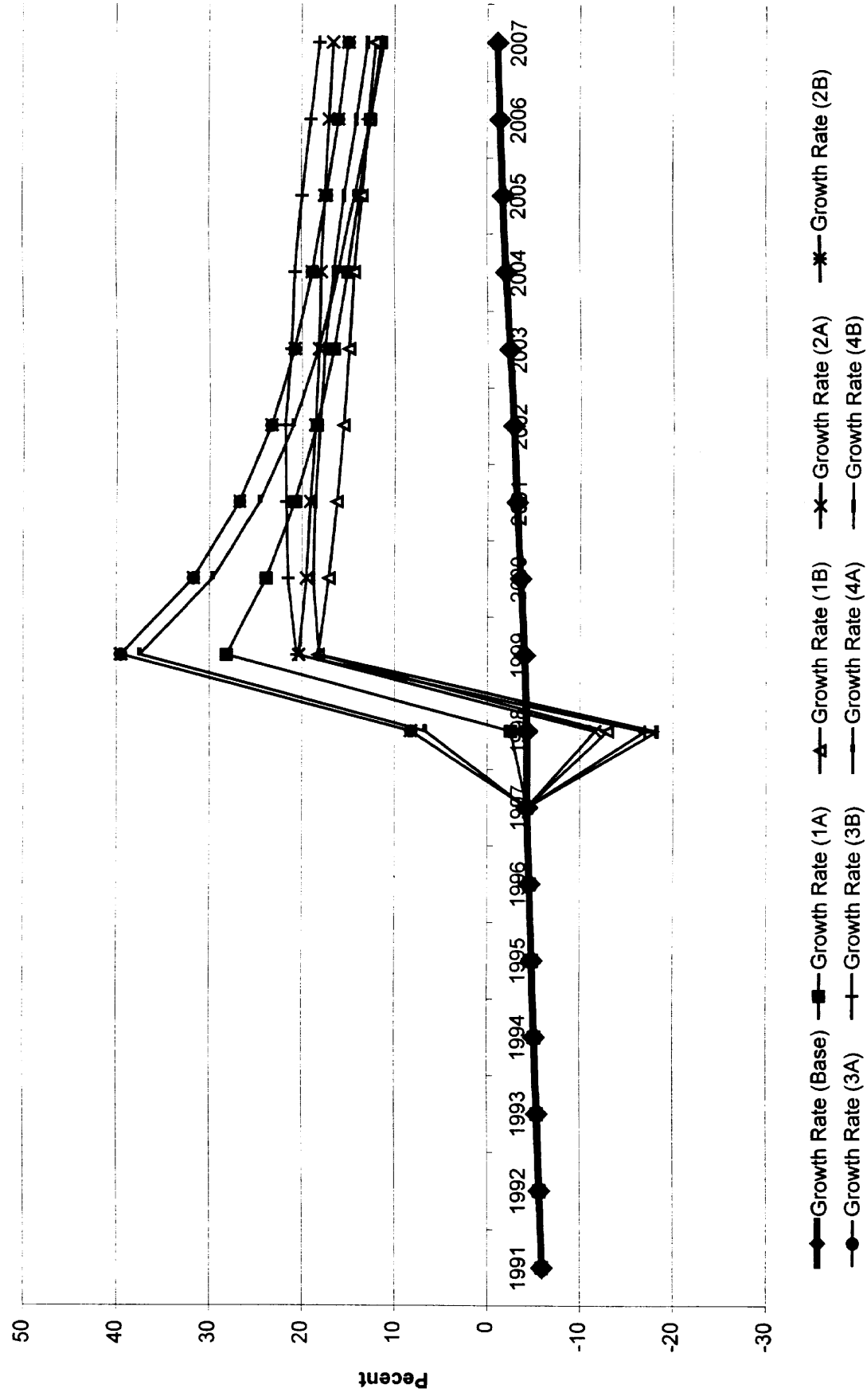
Figure 5: South Korean GDP Growth Rate under 8 Scenarios

Legend:
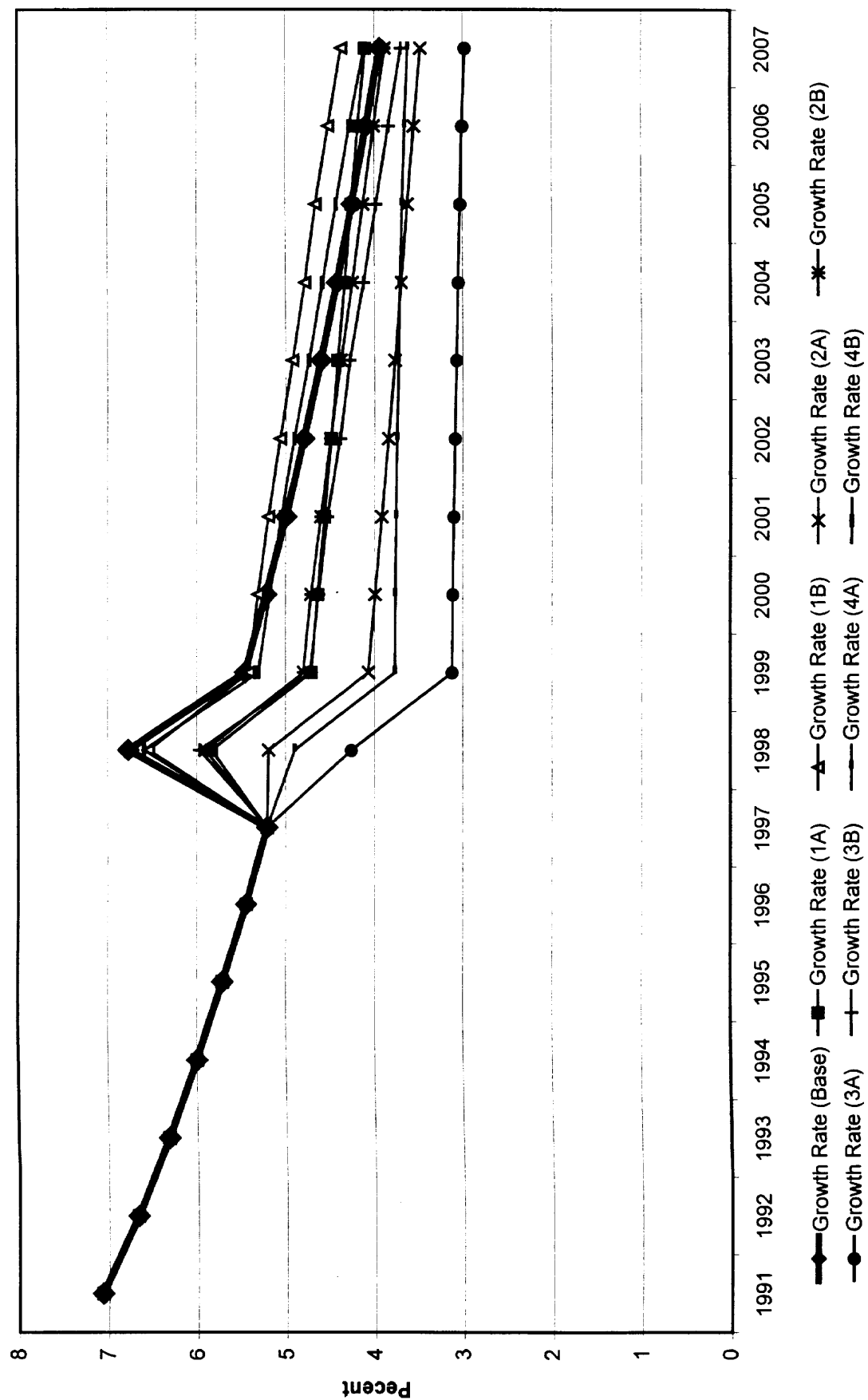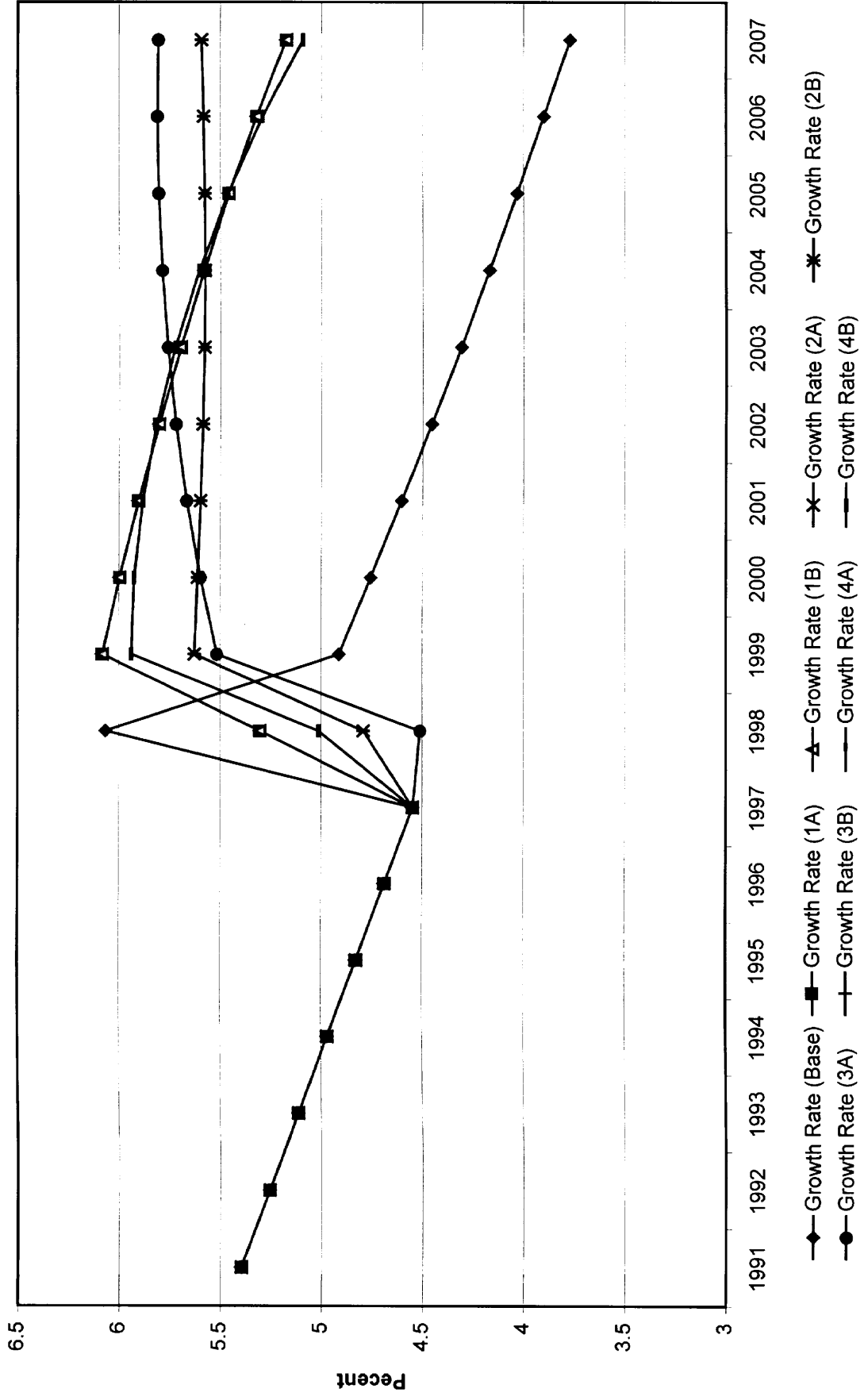Growth Rate (Base)    Growth Rate (1A)    Growth Rate (1B)    Growth Rate (2A)    Growth Rate (2B)
Growth Rate (3A)    Growth Rate (3B)    Growth Rate (4A)    Growth Rate (4B)

# Figure 6: Korean Peninsula GDP Growth Rate under 8 Scenarios



Growth Rate (Base)    Growth Rate (1A)    Growth Rate (1B)    Growth Rate (2A)    Growth Rate (2B)

Growth Rate (3A)    Growth Rate (3B)    Growth Rate (4A)    Growth Rate (4B)

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