A RAND NOTE

Korean and U.S. Economic and Technological Capabilities to Support Defense Burdens

Charles Wolf, Jr., Yong-Sup Han

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Charles Wolf, Jr., Yong-Sup Han

Prepared for the
Director of Net Assessment,
Office of the Secretary of Defense
Under Secretary of Defense for Policy

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PREFACE

This Note examines certain aspects of the changing U.S. and Korean economic and technological capabilities bearing on military burdens and responsibilities. It is part of a study, undertaken in collaboration with the Korea Institute for Defense Analyses (KIDA), that addresses possible changes in the roles, structures, and responsibilities of Korean and U.S. military forces, and the sharing of corresponding costs between the two countries. The project's aim is to formulate several broad alternatives for Korean and U.S. forces and to evaluate them in light of the changing Asian security environment and the changing capabilities of the two allies to assume responsibilities for their mutual security interests.[1]

The plan for the collaborative project was developed jointly in a meeting between members of the two research teams in Santa Monica in the spring of 1989 and in an interim review of the status and schedule for the concluding phase of the work in Seoul in June 1990. A final meeting of the joint KIDA and RAND teams was held in Santa Monica in December 1990.

The RAND research is part of its International Economic Policy program. It was sponsored by the Under Secretary of Defense for Policy, and the Director of Net Assessment, Office of the Secretary of Defense, under the auspices of RAND's National Defense Research Institute, a federally funded research and development center supported by the Office of the Secretary of Defense and the Joint Staff. The KIDA work was sponsored by the Korean Ministry of National Defense. Initial portions of the work have been briefed in the Defense Department in Washington, D.C., and at KIDA in Seoul, Korea.

The Note should be of interest to those in the Department of Defense, the Department of State, and other government agencies concerned with U.S.-Korean alliance issues and with issues of force structure and responsibility-sharing between the United States and Korea in furtherance of their joint alliance objectives.

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[1]The other principal component of the RAND work is Norman D. Levin, *Security Trends and U.S.-ROK Military Planning in the 1990s*, N-3312-NA/USDP, 1991. An executive summary of the entire study is presented in Charles Wolf, Jr., et al., *Korean and U.S. Forces and Responsibilities in the Changing Asian Security Environment*, R-4095-NA/USDP, 1991.

SUMMARY

This Note reviews the relative changes that have occurred during the past decade in the Korean and U.S. positions with respect to a wide range of economic and technological indicators. The extent to which the Korean position has improved relative to that of the United States suggests, though is not necessarily determinative of, a presumptive increase in the capacity of Korea to bear these joint costs and burdens. The assessment also includes estimates of the expected economic and technological performance of Korea and the United States during the 1990s.

At a macroeconomic level, the comparison of the two economies leads to two observations:

1. The Korean gross national product (GNP) is substantially increasing in size relative to the U.S. GNP. In 1980, the South Korean economy was between one-fiftieth and one-twenty-fifth the size of the U.S. GNP; by 2000, it will be between one-twentieth and one-fifteenth the size of the U.S. economy.
2. Per capita Korean GNP is also increasing rapidly relative to that of the United States. In 1980, Korea's per capita GNP was between 10 and 25 percent of the U.S. per capita GNP; by 2000, Korea's per capita GNP will be between 28 and 40 percent of the corresponding U.S. figure.

In assessing the changing technological capabilities of the two countries, we review several proxy indicators, resulting in the following conclusions:

1. During the 1980s, Korean research and development spending has risen substantially relative to that of the United States.
2. The number of scientists and engineers employed in R&D has risen considerably more rapidly in Korea than in the United States.
3. Total factor productivity in Korea has grown at an annual rate at least 50 percent above that in the United States.
4. The predominance of U.S. patent awards over those granted in Korea remains relatively unchanged.
5. Korea's technology "balance of payments" reflects increasing technology imports and utilization, while that of the United States shows a decline in the value of technology exports measured in constant dollars.

6. Korea's "indigenization" of standard defense procurement has progressed, although reliance on high technology imports of defense items (e.g., helicopters, jet fighters) continues, but probably at a diminishing rate.

The Note concludes that, subject to appropriate alliance agreements and coordination between U.S. and Korean security policies, Korea's enhanced economic and technological capabilities, and their growth prospects, enable it to bear a larger share of the joint costs and responsibilities of the U.S.-Korean alliance.

This conclusion leaves open the question of the desirable forms of sharing costs, burdens, and responsibilities. For example, Korea can shoulder an increased burden by a greater sharing of the costs of U.S. forces or, alternatively, compensate for larger U.S. force reductions by augmenting the size or capabilities of Korea's own forces.[2] To the extent that Korea's capacity to enhance the quality of its own forces by producing more advanced systems internally is limited by its indigenous technological capabilities, U.S. policy toward technology transfer may be an important instrument to encourage Korean burden sharing along these lines.

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[2]Drawn from other RAND work by James H. Hayes and John Schank dealing with the capabilities and costs of alternative combinations of Korean and U.S. forces.

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I. INTRODUCTION

The purpose of this Note is to compare certain aspects of the changing economic and technological capabilities of Korea and the United States to share the costs and burdens of their joint security concerns. The assessment is made on the basis of certain premises, which should be made clear at the outset:

1. The enhanced security that results from the U.S.-Korean alliance, and from U.S. and Korean forces, represents a joint benefit available to both alliance members (and incidentally to other friendly but nonalliance members in the Asian-Pacific region) but is largely independent of how the costs of those benefits are shared. Thus, the security benefits from the alliance are a classic example of a "public" or "collective" good.
2. Viewed in an aggregate sense, the U.S. and Korean economies have adequate total resources to meet the costs of their alliance. The crucial issue in this case, as with the costs of alliance public goods more generally, is the sharing of burdens, costs, and responsibilities between alliance members in an appropriate and equitable manner.

To be sure, this latter premise begs the question of how to define "appropriate and equitable," and what criteria to use in evaluating the respective contributions of alliance members in providing for their joint security benefits. This issue has bedeviled discussions and negotiations over "burden sharing" in the NATO alliance for much of the past three decades. The issue involves considerations of whether "appropriate and equitable" should be construed in terms of equal proportionate GNP shares contributed by each alliance member, whether differing standards of living and relative deprivation should be allowed for, how the real estate of host countries and the relative exposure of forward-located countries should be allowed for, and whether account should be taken of other forms besides military ones of contributing to the collective interests of the alliance (e.g., foreign aid, debt rescheduling).[1]

The assessment of U.S. and Korean economic and technological capabilities in this Note will not address these issues directly. Instead, the assessment will simply review the

[1]For further discussion of these issues, see the Defense Department's Annual Report to the Congress on NATO Burden Sharing, "Report on Allies Assuming a Greater Share of the Common Defense Burden," Department of Defense, Office of the Secretary, February 15, 1989. For a theoretical treatment of these issues, see Benjamin Zycher, *A Generalized Approach for Analysis of Alliance Burden-Sharing*, RAND, N-3047-PCT, September 1990; Gregory G. Hildebrandt, *Measuring the Burden of Alliance Activities*, RAND, N-3048-PCT, September 1990; and Charles A. Cooper and Benjamin Zycher, *Perceptions of NATO Burden-Sharing*, RAND, R-3750-FF/RC, June 1989.

relative changes, over the past decade, in the Korean and U.S. positions with respect to a wide range of indicators of their economic and technological capabilities. The extent to which the Korean position, with respect to all or most of these indicators, has improved relative to that of the United States suggests a presumptive increase in Korea's capacity to bear these joint costs and burdens. The assessment also includes estimates of the expected economic and technological performance of Korea and the United States during the 1990s.

II. AGGREGATE ECONOMIC AND MILITARY COMPARISONS BETWEEN THE UNITED STATES AND KOREA

GLOBAL ECONOMIC COMPARISONS

To set these issues in a broader context, it is useful at the outset to scale the U.S. and South Korean economies in relation to the global economy and other major economies. Table 1 presents some rough order-of-magnitude estimates of these relationships.

The figures presented in Table 1 for the first decade of the 21st century are obviously fraught with uncertainties. For example, the estimates for China were made before the Tian An Men repression of June 1989 and the severe deflationary economic policies that preceded it. The estimates for West Germany, the United Kingdom, and France do not allow for either the unification of Germany or for the downstream effects of the European Community after 1992. Table 1 also ignores the short-term effects of changes in world oil prices and cyclical changes in the performance of the U.S. and other industrialized economies. Its intent is simply to provide a rough aggregate measure of the global economy as context for comparisons between the United States and Korea.

Several general points about the emerging global economic context can be inferred from Table 1.

1. The U.S. share of the global product seems likely to remain stable throughout the later years of the 20th century and the first part of the 21st century.
2. The shares represented by the principal economies of the Asia-Pacific region (Japan, China, and Korea) show an appreciable rise over the same period.
3. The Soviet share in the global economy has already diminished and is likely to decline still further in the next decade or two.
4. Finally, the West European component of the total may also decline, although this inference should be qualified by the previous comment about the uncertainties connected with both the unification of Germany and the influence of the European Community.

KOREAN AND U.S. GNPs

Table 2 summarizes U.S. and Korean GNPs from 1980 through 2000, and Fig. 1 presents estimated compound annual growth rates for the two countries over this period, using two alternative estimates for Korea. The first is based on the use of purchasing power parity (ppp) exchange rates between the dollar and the won to convert from constant price

Table 1

Global economic context: Approximate shares of global product (In percent)

Country	1950	1970	1990	2010
United States	35	24	22	21
Japan	6	8	11	12
China	3	4	8	10
Soviet Union	12	10	10	8
FRG, UK, France	13	16	12	11
South Korea	1	1	1.5	2

SOURCES: Charles Wolf, Jr., et al., *Long-Term Economic and Military* Trends, 1950–2010, RAND, N-2757-USDP, April 1989, pp. 2–8; and Report of the Future Security Environment Working Group, "The Future Security Environment," submitted to the Commission on Integrated Long-Term Strategy, Washington, D.C., October 1988, pp. 3–8.

Table 2

Comparative U.S. and Korean GNPs (In thousands of 1986 dollars)

Country	1980	1990	2000
(a) United States	3649	4682	6072
(b) Korea (RAND, ppp)	147	274	455
(c) Korea (KDI, exchange rate)	61	162	312
Ratios:			
(b)/(a)	0.04	0.06	0.07
(c)/(a)	0.02	0.03	0.05

SOURCES: Wolf et al., 1989, pp. 4 and 8; and Korean Development Institute (KDI), "Nation's Long-Term Development Projection for the Year 2000," Seoul, 1985, p. 58 ff.

won GNP to 1986 dollars. The second estimate is a calculation by the Korean Development Institute, using relative foreign exchange rates between the won and the dollar to make this conversion. Regardless of which conversion procedure is used, Table 2 and Fig. 1 indicate that Korea's economy has been expanding substantially relative to that of the United States and will almost certainly continue to do so.

A similar picture emerges if the Korean and U.S. GNPs are placed on a per capita basis. This calculation, again using both RAND and KDI sources, is shown in Fig. 2.

Table 2 and Fig. 1 lead to the following general conclusions:

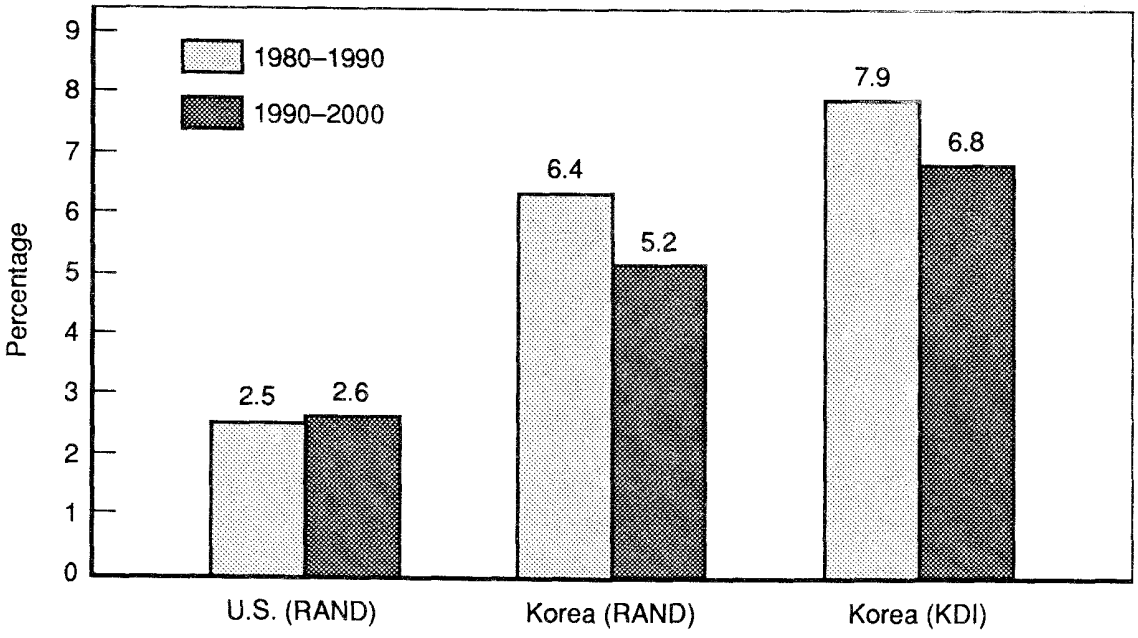
1. The Korean GNP is substantially increasing in size relative to the U.S. GNP. In 1980, the South Korean economy was between one-fiftieth and one-twenty-fifth the

size of the U.S. GNP; by 2000, it will be between one-twentieth and one-fifteenth the size of the U.S. economy.

2. Per capita Korean GNP is also increasing rapidly relative to that of the U.S. In 1980, Korea's per capita GNP was between 10 and 25 percent of the U.S. per capita GNP; by 2000, Korea's per capita GNP will be between 28 and 40 percent of the corresponding U.S. figure.

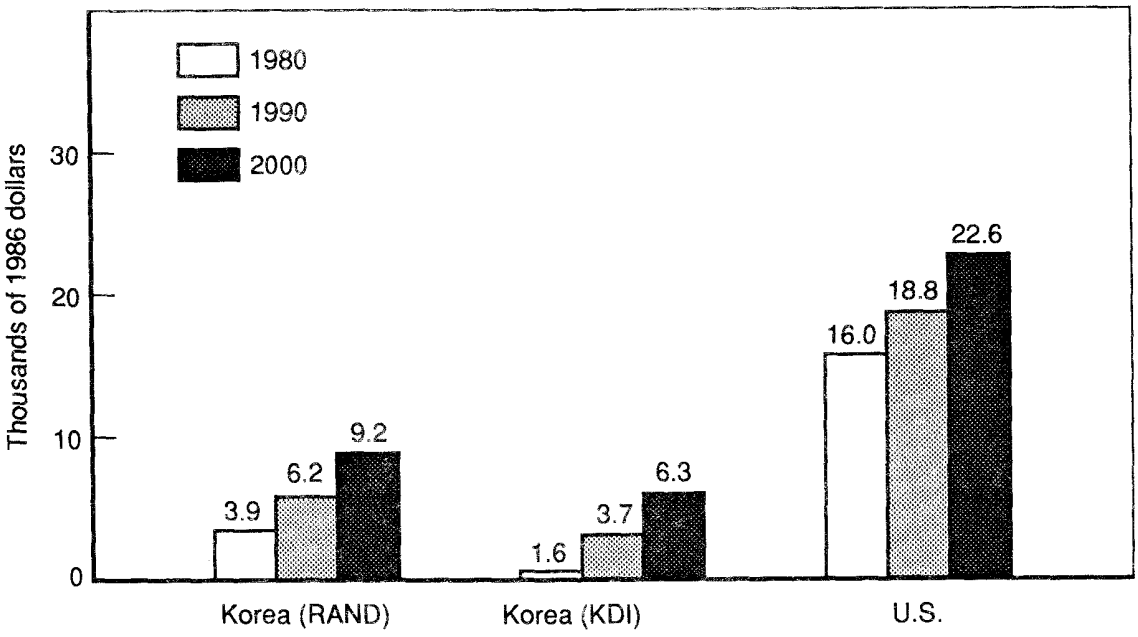
KOREAN AND U.S. ANNUAL MILITARY SPENDING

In 1982, Korea's ratio of military spending to its GNP was 5.8 percent. The U.S. defense spending share rose from just below 5 percent of GNP at the start of the 1980s to 7 percent by 1985, declining by 1990 to approximately the GNP at the beginning of the decade. In both countries, current and future defense spending is under serious pressure and tight constraints. In the U.S. case, the pressure arises from the evident decrease in the Soviet threat and the expectation or hope of realizing an appreciable "peace dividend" from defense savings to be used for federal debt reduction, domestic needs, or a combination. It remains to be seen whether these resource constraints will be somewhat eased because of the Iraqi



SOURCES: Wolf et al., 1989, pp. 4 and 8; KDI, 1985, p. 58 ff.; and Korean Economic Planning Board, "Korea Statistical Yearbook," Seoul, 1989.

Fig. 1—Estimated Korean and U.S. GNP growth rates



SOURCES: Wolf et al., 1989, pp. 4 and 8; KDI, 1985, p. 58 ff.; and Korean Economic Planning Board, 1989.

Fig. 2—Korean and U.S. per capita GNP

invasion of Kuwait in August 1990 and the need to restructure U.S. forces and capabilities along lines different from those resulting from the previous priority accorded to the Soviet threat in Central Europe.

In Korea, equivalent pressures and constraints on defense spending arise from a combination of circumstances: the changing internal political constellation of forces resulting from general democratization; the emergence of some politically influential views of a diminishing threat from North Korea, as well as probably diminishing support for North Korea from China and the Soviet Union; and the evident need for additional resources to meet the costs of improving South Korea's infrastructure, increasing its research and development spending, and relieving pressures in the private sector for higher wages and improved standards of living.

Because of these competing resource claims, in combination with the internal and external political developments previously alluded to, Korea's military spending has decreased to slightly over 4 percent of GNP in 1989 and 1990.

Table 3 compares U.S. and Korean military spending from 1980 to 2000 in billions of 1986 U.S. dollars. As noted earlier, the first set of Korean estimates, based on previous RAND work, has been calculated using ppp conversion rates from constant won to 1986 U.S. dollars.

The second set of Korean estimates is based on KDI's GNP conversion to 1986 dollars using the 1986 won/dollar exchange rate.

The U.S. estimate for 2000 is based on what is probably an upper-bound assumption that the figure for 1990 spending will be maintained, resulting in a decline in the defense share of GNP from 5.3 percent in 1980 to 4.5 percent in 2000. The question mark following the estimate of $276 billion in 1986 dollars is intended to indicate that the actual figure is highly uncertain and probably will be smaller than this upper-bound estimate.

In sum, Table 3 suggests that Korean military spending is probably going to rise relative to that of the United States, or at least fall less rapidly than U.S. military spending.

Table 3

U.S. and Korean annual military spending (In billions of 1986 dollars)

Country	1980	1990	2000
United States	196	276	276 (?)
Korea (RAND)	9	12	20 (18)
(KIDA)	4	7	14 (12)

NOTE: Estimates for Korea are based on the RAND and KDI estimates of GNP shown in Table 2. Korean military spending was 5.8 percent of GNP in 1982 and is assumed to decrease to 4.5 percent in 1990 and 2000. Alternative figures for 2000 shown in parentheses assume that military spending share of GNP is 4 percent.

III. CHANGING KOREAN AND U.S. TECHNOLOGICAL CAPABILITIES

In attempting to compare the "technological capabilities" of different countries, one immediately faces the fact that the concept itself is extremely broad, as well as loose and ambiguous. Indeed, the notion of "technology" conveys rather different meanings to economists, engineers, political analysts, and defense analysts. For example, changes in production functions that allow increased agricultural yields from equivalent inputs would represent technological advancement to economists but would not be relevant to the meaning attached to the term by engineers or defense analysts. The latter typically construe technology as referring to a novel type of equipment (e.g., wide-body jet aircraft, microprocessors) or weapon systems (Patriot missiles, stealth aircraft) usually embodying an advancement in scientific knowledge (laser optics, semiconductors, etc.); whether the technology so defined is worth its cost is often given little attention.

In the present context of assessing changes in U.S. and Korean capabilities to bear the burdens of their joint security interests, changes in "technological capabilities" relate to their abilities to develop, produce, and operate more advanced and more effective weapon systems. For this sort of assessment, it is useful to focus on changes in U.S. and Korean *inputs* that directly or indirectly relate to advanced technology and to examine changes in measures of *outputs* relating to the same objective.

TECHNOLOGICAL INPUTS

Table 4 shows the research and development expenditures of the United States and Korea in 1980 and 1987.

As a share of its GNP, R&D outlays in Korea more than tripled between 1980 and 1987, while increasing about 20 percent as a share of GNP in the United States. After

Table 4

R&D expenditures and percent of GNP
(In billions of current dollars)

	1980		1987	
	Dollars	Percent	Dollars	Percent
United States	62.6	2.3	124.3	2.8
Korea	0.3	0.6	2.3	1.9

SOURCES: National Science Board, 1987, 1989; and Korean Ministry of Science and Technology, 1988.

allowing for inflation (the figures in Table 4 are in current dollars), U.S. R&D expenditures increased in real terms by about 50 percent, while Korean R&D outlays increased in real terms sixfold.[1] Also, during this period, the relative shares of government and the private sector in R&D spending remained about constant in the United States (47 to 48 percent government, and 52 to 53 percent private), while the private share of R&D in Korea more than doubled from 32 percent in 1980 to 72 percent in 1987.[2]

A related technological input measure involves the numbers of scientists and engineers engaged in R&D in the United States and Korea. Table 5 shows this comparison.

MEASURING TECHNOLOGICAL OUTPUTS

Changes in relative technological capabilities can be indirectly measured by using several proxy indicators: U.S. and Korean rates of growth in total factor productivity (TFP); patent awards, royalties, and licensing fees paid for or received from the import and export of technology; and changes in Korea's domestic production of defense goods.

In the first half of the 1980s, TFP growth in Korea was slightly over 1.5 percent per year.[3] KDI has estimated that Korea's annual growth in TFP will more than double for the period from 1990 to 2000; previous RAND work has made a more conservative estimate that annual TFP growth will be approximately the same as it was during the 1980s, 1.5 percent. For the United States, the comparable annual rate of growth was 1.0 percent for the first half of the 1980s, and previous RAND work has estimated that the 1990–2000 period will see a similar rate of growth in TFP.[4]

Table 5

Scientists and engineers engaged in R&D
(In thousands)

Country	1980	1986
United States	652	825
Korea	18	48
Ratio: Korea/United States	.03	.06

SOURCES: National Science Board, 1987, 1989; and Korean Ministry of Science and Technology, 1986 and 1989.

[1]The U.S. GNP deflator rose by 37 percent between 1980 and 1987.

[2]See National Science Board, *Science and Engineering Indicators*, Washington, D.C., 1987, 1989; and Korean Ministry of Science and Technology, *Science and Technology Annual*, Seoul, 1988.

[3]Total factor productivity is measured as the ratio between output and a weighted combination of factor inputs.

[4]See Wolf et al., 1989, pp. 44, 50–51; and KDI, 1987.

Annual patent awards in the United States and Korea, including those awarded to foreign nationals, are summarized in Table 6 for the 1980s. As Table 6 indicates, patent awards in both the United States and Korea have grown over the 1980 to 1987 period, while the ratio between them—as one indication of changes in their relative technological capabilities—was unchanged.[5]

Royalties and licensing fees received and paid in international commerce provide a very rough indication of the export and import of technology, although with an obvious lag. Table 7 shows net royalties and licensing fees, representing receipts minus payments on current account, for the United States and Korea during the 1980s.

Table 6

Output measures: Patents awarded (In thousands)

Country	1980	1983	1986	1987
(a)United States	61.8	56.9	70.9	83.0
(b) Korea	1.6	2.4	1.9	2.3
Ratio: (b)/(a)	0.03	0.04	0.03	0.03

SOURCES: National Science Board, 1987, 1989; and Korean Ministry of Science and Technology, 1986, 1989.

Table 7

Royalties and licensing fees: Receipts minus payments on current account (In millions of current and 1983 dollars)

	United States		Korea	
Year	Current Dollar	1983 Dollars	Current Dollars	1983 Dollars
1980	1380	1659	NA	NA
1983	1538	1538	(21)	(21)
1985	1560	1462	(184)	(172)
1986	1494	1364	(360)	(329)
1987	1559	1380	(460)	(407)

SOURCES: National Science Board, 1987, 1989; and Korean Ministry of Science and Technology, 1986, 1989. The authors used the U.S. GNP price deflator to convert the current dollar figures to constant dollars.
NOTE: NA means not available.

[5]One indicator of the relative productivity of scientists and engineers in both countries can be derived by combining Table 6 with Table 5, showing the numbers of scientists and engineers engaged in R&D. When the patent awards in the United States are divided by the number of scientists engaged in R&D in 1980, that ratio (61.8/652 = 0.09) is about the same as the corresponding ratio in Korea (1.6/18 = 0.09). By 1986, the corresponding Korean ratio had fallen to 0.04, while the U.S. ratio remained at 0.09 (70.9/825), suggesting that the productivity of Korean scientists and engineers (as measured by patent awards) seems to have declined relative to the productivity of those in the United States.

As Table 7 indicates, although U.S. net earnings from technology exports have been fairly constant in nominal dollars during the 1980s, in constant dollars these earnings have steadily declined: The decline between 1980 and 1987 was 17 percent, and between 1983 and 1987 it was 10 percent. During the same period, Korea substantially increased its importation and use of foreign technology, as reflected by the rapid increase in its net royalties and licensing payments; between 1983 and 1987, these payments increased by a factor of 20.

Finally, one very rough indication of Korea's increasing capacity to produce weapon systems from its domestic industrial base is suggested by a study that focused on Korea's defense industrial production capacity.[6] Table 8 indicates, through the first part of the 1980s, Korea's increased capabilities and limitations in producing major defense items and components.

CONCLUSIONS CONCERNING U.S. AND KOREAN TECHNOLOGY COMPARISONS

Several salient points can be summarized from the foregoing data:

1. During the 1980s, Korean research and development spending as a percentage of GNP has risen substantially relative to that of the United States.
2. The number of scientists and engineers employed in R&D has risen considerably more rapidly in Korea than in the United States.
3. Total factor productivity in Korea has grown at an annual rate at least 50 percent above that in the United States.
4. The predominance of U.S. patent awards over those granted in Korea remains unchanged.

Table 8

Self-sufficiency in Korean defense products (In percent)

Components/parts	1981	1984
Guns/artillery	85	97
Ammunition	96	97
Communications	45	37
Aircraft (helicopters)	20	11
Vehicles	59	75
General supplies	79	87

SOURCE: Kyong-Mann Jeon, 1986.

[6]Kyong-Mann Jeon, "Defense Industrial Capabilities in Korea," RAND Graduate School dissertation, 1986.

5. Korea's technology "balance of payments" reflects substantially increased technology imports and utilization, while that of the United States exhibited a decline in the constant-dollar value of technology exports from 1980 through 1987.
6. Korea's "indigenization" of standard defense procurement has progressed, although reliance on high technology imports of defense items (e.g., helicopters, jet fighters) continues, but probably at a diminishing rate.

IV. CONCLUSIONS

The preceding data and analysis suggest that, subject to appropriate alliance agreements and coordination between U.S. and Korean security policies, Korea's enhanced economic and technological capabilities—and their growth prospects—enable it to bear a larger share of the joint costs and responsibilities of the U.S.-Korean alliance.

This conclusion leaves open the question of the desirable forms of sharing costs, burdens, and responsibilities. For example, Korea can shoulder an increased burden by a greater sharing of the costs of U.S. forces or, alternatively, by compensating for larger U.S. force reductions by augmenting the size or capabilities of Korea's own forces. To the extent that Korea's capacity to enhance the quality of its own forces by producing more advanced systems internally is limited by its indigenous technological capabilities, U.S. policy toward technology transfer may be an important instrument to encourage Korean burden sharing along these lines.