A RAND NOTE

Long–Term Economic and Military Trends, 1950–2010

Charles Wolf, Jr., Gregory Hildebrandt, Michael Kennedy, Donald Putnam Henry, Katsuaki Terasawa, K. C. Yeh, Benjamin Zycher, Anil Bamezai, Toshiya Hayashi

April 1989

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PREFACE

This Note presents estimates of certain key economic and military trends for 15 countries for the period 1950–2010 and explains the method, assumptions, and data used in making the estimates. The analysis was developed as an input to the report of the Future Security Environment Working Group for the Commission on Integrated Long-Term Strategy.

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SUMMARY

In this study, prepared for the Future Security Environment Working Group of the Commission on Integrated Long-Term Strategy, certain global economic and military trends are estimated for the period from 1950 through 2010. These trends are summarized for 15 countries in terms of three major indicators: gross national product (GNP), annual military spending, and accumulation of military capital stocks. The 15 countries are the United States, the Soviet Union, Japan, China, West Germany, the United Kingdom, France, India, South Korea, Taiwan, Turkey, Egypt, Brazil, Argentina, and Mexico. These countries currently produce more than two-thirds of the global product. The time series estimates for each of the three indicators are intended to be internally consistent over time and among the 15 countries. Clearly, this aim can, at best, be only roughly approximated because of fundamental limitations associated with both the data and the estimation methods.

METHOD

The method applied in making the estimates uses an aggregate national production function for each of the 15 countries, in which the inputs are capital, labor, and factor productivity and the output is the estimated GNP. Estimates of military spending and the military capital stock for each country are derived by several additional steps and calculations superimposed on the GNP time series. This Note contains estimates of the three sets of trends for each sample country for 1950–2010. In general, dollar conversions have been made from estimates originally calculated in local currencies by using a purchasing-power parity rate rather than an official foreign exchange rate.

GNP TRENDS

Although the calculations are subject to many uncertainties and should only be treated as rough approximations—even for the past (1950–1987) let alone for the future (1988–2010)—the analysis suggests several salient points:

1. By 2010, the Soviet Union will probably have the fourth largest GNP, following that of the United States, Japan, and China. Our base-case estimates for the Soviet Union imply an annual growth rate in the 1990–2010 period of 1.6 percent.
2. By 2010, the Chinese GNP may well exceed that of the Soviet Union by over 20 percent, whereas in 1980, China's GNP was about 40 percent that of the Soviet Union.
3. Because the Soviet Union's economic prospects are especially uncertain, several alternative estimates have been made, based on differing assumptions about the effects of *perestroika*, as well as about the initial (1985) level of the Soviet GNP. The resulting estimates for the Soviet Union cover an extremely wide range, from more than 62 percent above the base-case GNP estimate for 2010 (4.7 trillion 1986 U.S. dollars at the upper end, compared with 2.9 trillion in our base-case estimate) to 28 percent below the base-case estimate (2.1 trillion 1986 U.S. dollars).
4. By 2010, the combined national products of the East Asian countries in the sample (Japan, China, South Korea, and Taiwan) will exceed the GNP of the United States (8.5 trillion 1986 U.S. dollars versus 7.9 trillion for the United States). These estimates imply annual growth rates over the 1990–2010 period of 2.8 percent for Japan, 4.7 percent for China, 4.9 percent for Korea, 5.8 percent for Taiwan, and 2.6 percent for the United States.
5. The combined national products of these same East Asian countries will, by 2010, exceed the combined national products of West Germany, the United Kingdom, and France by more than 120 percent, compared with an excess of less than 20 percent in 1980. The implied annual growth rates for West Germany, France, and the United Kingdom during the 1990–2010 period are 2.1 percent, 2.6 percent, and 1.8 percent, respectively.
6. Several middle-level regional powers are likely to grow significantly relative to the rest of the world. For example, in 1980 the combined national products of India, Korea, Taiwan, Turkey, Brazil, Argentina, and Mexico were about 70 percent as large as the GNPs of West Germany, France, and the United Kingdom. By 2010 the same seven regional powers will probably have combined GNPs nearly 20 percent larger than those of the same three West European countries.

7. For the period from the late 1960s through 2010 the U.S. share of the global product remains remarkably stable—between 22 percent and 23 percent—representing between 29 percent and 34 percent of the combined GNPs of the 15 countries included in our sample.
8. Although the estimates for Mexico and Egypt show positive rates of growth, they are so low in relation to expected population growth that these countries would probably experience extremely high rates of unemployment (over 40 percent), perhaps resulting in serious risks to political and social stability.

TRENDS IN MILITARY SPENDING

Military spending estimates confront additional uncertainties besides those already noted in connection with the GNP estimates. As a reflection of these uncertainties, the U.S. military spending estimates have been based on three different assumptions: military spending as a constant (6.2 percent) share of GNP; military spending as a constant (1988) U.S. dollar level from 1988–2010; and military spending growing at a slow rate of 1 percent per annum between 1988 and 2010. Four different sets of estimates are made for military spending in the Soviet Union, reflecting major uncertainties that apply in that case also. Depending upon which pairing of these U.S. and Soviet alternatives one compares, U.S. military spending by the first decade of the 21st century may vary from one-third above that of the Soviet Union to less than half of it.

With respect to the military spending of other countries, two points are worth noting:

1. Our estimates of future military spending by China in constant 1986 U.S. dollars, if and as China realizes its planned military modernization, are about half those for the U.S. and Soviet base cases, compared with the present estimate of less than a fifth of those.
2. Japan's defense spending, even if it remains a very small part of Japan's expanding GNP, will approach the spending levels of each of our principal West European allies. If Japan were to boost its share of GNP devoted to defense to, say, 3 percent by the first part of the 21st century, Japanese military spending would be nearly 70 percent of the combined military spending of the United Kingdom, West Germany, and France.

MILITARY CAPITAL STOCKS

With respect to our estimates of military capital stocks (equipment plus construction less depreciation), the alternative assumptions we used for the U.S. and Soviet military spending estimates generate a considerable range of comparisons between the United States and the Soviet Union, though narrower than the military spending comparisons cited earlier. Thus, by 2010 the U.S. military capital stock may be as much as 20 percent greater than that of the Soviet Union, or as little as 30 percent below that of the Soviet Union.

With respect to other countries included in the sample:

1. China's military capital stock, hitherto small relative to that of the United States and the Soviet Union, may rise to roughly 40 percent of the stocks of each of the superpowers by 2010.
2. The accumulated military capital of the UK, Germany, and France remains in the future about as significant in the balance between the United States and the Soviet Union as it has in the past.
3. If Japan were to increase its military spending to, say, 3 percent of GNP in 1990, by 2010 the Japanese military capital stock would be about 24 percent above that of West Germany.
4. Although the military capital stocks of middle regional powers (such as Korea, Taiwan, Turkey, India, Brazil, and Egypt) are small relative to those of the larger powers, they will represent a formidable supply of weapons, very likely including advanced systems, during the rest of the century and in the beginning of the 21st century. Furthermore, these middle regional powers will acquire a growing capacity to produce and to export a wide range of weapons, including all but the most sophisticated types.

CONCLUSION

In light of these forecasts of long-term economic and military trends, and recognizing the uncertainties surrounding them, a general conclusion emerges: the latter part of the present century and the early part of the 21st century will be characterized by a continuing shift of economic and military power toward the Pacific Rim countries. Consequently, it may well be that the orientation of Japan and China toward the United

States and each other—whether they are allied, friendly, neutral, or belligerent—will be no less important for U.S. interests than is the continued adversarial posture of the Soviet Union.

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I. INTRODUCTION

The Commission on Integrated Long-Term Strategy (CILS) was established in October 1986 by the Secretary of Defense and the Special Assistant to the President for National Security Affairs. The Commission's purpose was to propose a defense strategy for the United States that would integrate the changing security environment, newly emerging technology, and resource constraints over the next two decades.

To assist the commission in its work and in its final report,[1] four Working Groups were formed dealing with the Future Security Environment, Offensive and Defensive Forces, Third-World Conflicts, and Technology.

The RAND study summarized in this Note was prepared for the Future Security Environment Working Group to provide a broad survey and estimation of certain global economic and military trends for the period from 1950 to 2010. These trends—covering economic growth, military spending, and military investment—are important influences on the international environment of the past, present, and future.

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[1] *Discriminate Deterrence*, The Report of the Commission on Integrated Long-Term Strategy, U.S. Government Printing Office, Washington, D.C., January 1988.

II. TRENDS IN GROSS NATIONAL PRODUCTS

Trying to envisage the future of the U.S. economy alone is difficult and inevitably shrouded in uncertainty. When the angle of vision is widened to cover a large number of other countries as well, the difficulties and uncertainties are compounded. Recognizing these limitations, our aim in this section is to provide a broad-brush treatment of major changes that have occurred in the past several decades in the relative economic growth of 15 key countries, as well as the relative growth that seems to impend in the next two decades.

No single indicator suffices to convey the trend in an economy's behavior over time, still less to compare and size the performances of a large number of national economies with one another. Growth in real national product is clearly one salient indicator, but other ones are important and relevant, depending on the purposes for which the comparisons are made. Other relevant indicators include exports and imports, capital flows, per capita income, domestic capital formation, resource allocations for research and development and science and technology, international holdings of assets and liabilities, demographic changes, and so on.

Some of these other dimensions (e.g., per capita income, demographic changes, and technology comparisons) will be touched on later. Our initial evaluation focuses on gross national product for several reasons: first, we are interested in charting economic trends for 15 countries over a 60-year period, and hence, because the breadth is so wide, some narrowing of focus is necessary; second, GNP is probably the most useful single indicator of economic size for purposes of international comparisons over long periods; and third, our ability to forecast most of the other indicators mentioned above—which are themselves usually linked in some way to GNP—is even more limited than our ability to forecast GNPs.

The reason for making estimates for the entire 60-year period—for "backcasting" as well as "forecasting"—is to exhibit as clearly as possible the changes that impend in the global economic environment against the backdrop of current and past environments. This perspective was adopted because of its congruence with the purpose of the commission.

The methodology used in making the GNP estimates is summarized in the appendix to this Note. However, two points about the estimates are important to note: first, the growth rates reflected in the following estimates are *derived*[1] rather than assumed; second, the estimated GNP figures for the period 1987 to 2010 are intended to be consistent with the actual GNP figures for 1950–1986.

Nevertheless, despite these attributes, it would be misleading to attribute a high degree of accuracy to the estimates. Indeed, elements in the world economy that the method ignores are likely to be no less influential than the ones it includes. For example, how the international debt of more than $1 trillion owed by the developing countries is managed—whether by a gradual marking down and easing of servicing terms, or by outright default, or by repatriation of capital in response to changes in internal economic policies, or by new lending that contributes to increased exports by the debtor countries and their enhanced servicing capacities—will have a serious impact on economic growth in some of the major developing countries, as well as in the creditor countries. Of still greater significance in affecting GNP growth would be a sharp or cumulative increase in protectionist trade policies by the world's major trading countries or blocs: the United States, Japan, and the European Economic Community (EEC).

To delineate the international economic landscape of the future, and to compare it with that of the past, GNP estimates, employing the same methodology, have been made for 15 countries: the United States, the Soviet Union, Japan, China (PRC), West Germany (FRG), the United Kingdom, France, India, South Korea (ROK), Taiwan, Brazil, Argentina, Turkey, Mexico, and Egypt. The list, although it omits numerous important countries, was chosen by the Future Security Environment Working Group as illustrative and indicative of some of the principal trends in the main regions most relevant to the commission's task. These countries currently produce over two-thirds of the global product, a proportion that probably will rise to more than three-quarters by the next century. They also include the major current and prospective world economic powers (United States, Japan, Soviet Union, West Germany, China), most of the major current or prospective regional economic powers (Korea, India, France, United Kingdom, Brazil, Argentina, Taiwan, and Turkey), and two potentially quite vulnerable economies (Mexico and Egypt). To the extent that the EEC acts as a unit, the bulk of its

[1]That is, derived from data, assumptions, and judgments about rates of change in labor, capital, and technology inputs in each of the 15 countries.

formidable economic capabilities is already represented by the FRG, France, and the United Kingdom.

The results are summarized in Table 1 and in Figs. 1–3. Several points that are significant as indicators and sources of change in the future security environment can be inferred from the table and graphs:

1. By 2010 the Soviet Union will probably have the fourth largest gross national product, following those of the United States, Japan, and China; currently Soviet GNP is about the same as that of Japan. (See Fig. 1.) Also, by 2010, the Soviet national product will be about 26 percent less than the combined national product of West Germany, France, and the United Kingdom; currently, the Soviet economy is only slightly smaller than that of the three West European ones. These base-case Soviet estimates imply an average annual growth rate in the 1990–2010 period of 1.6 percent. Because the Soviet Union's economic prospects are particularly uncertain, as well as especially significant, several alternative estimates based on differing assumptions about the effects of *perestroika* are described below.

Table 1

GROSS NATIONAL PRODUCTS OF SELECTED COUNTRIES, 1950–2010
(In billions of 1986 U.S. dollars)[a]

Nation	1950	1960	1970	1980	1990	2000	2010
United States	1378	1907	2767	3649	4682	6072	7859
Soviet Union	492	855	1411	1935	2088	2455	2873
Japan	189[b]	336	936	1476	2127	2856	3714
China[c]	114	232	417	793	1520	2395	3791
West Germany	172	402	622	815	1009	1244	1525
United Kingdom	251	349	463	560	670	807	949
France	172	282	486	695	843	1109	1410
India	152	202	294	408	598	897	1330
South Korea[c]	18	27	67	147	274	455	709
Taiwan	5	11	25	57	103	180	317
Brazil	34	65	117	272	353	571	939
Argentina	38	51	78	106	107	119	133
Turkey[c]	32	59	104	171	256	367	501
Mexico	58	104	203	378	444	548	679
Egypt	16	31	49	98	132	158	190

[a]Converted from local currencies using purchasing-power parities of 1980.
[b]Japanese GNP estimate for 1953.
[c]Gross domestic product.

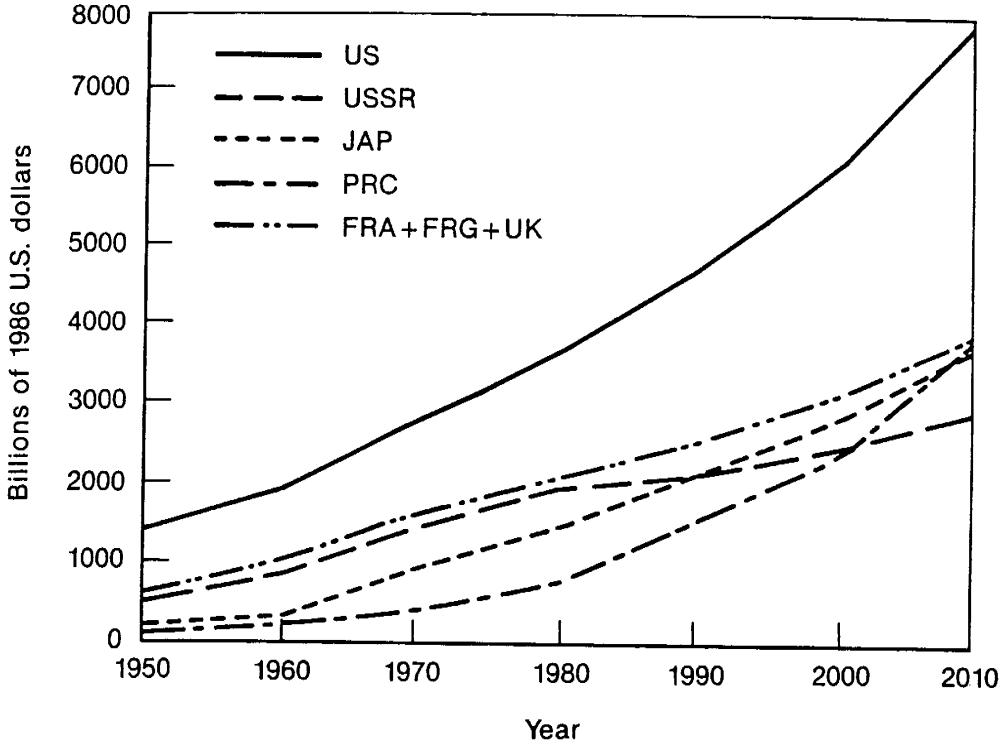

Fig. 1—Gross national products: United States, USSR, Japan, China, and three NATO countries

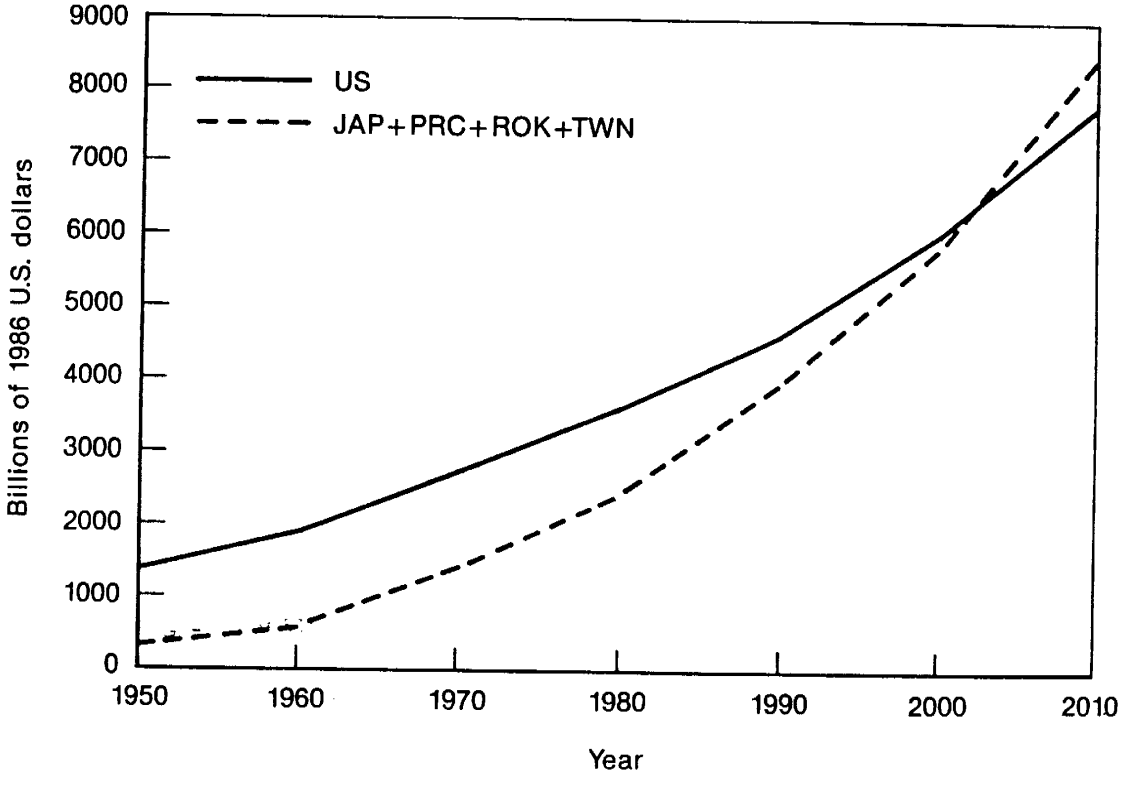

Fig. 2—Gross national products: United States and four Asian countries

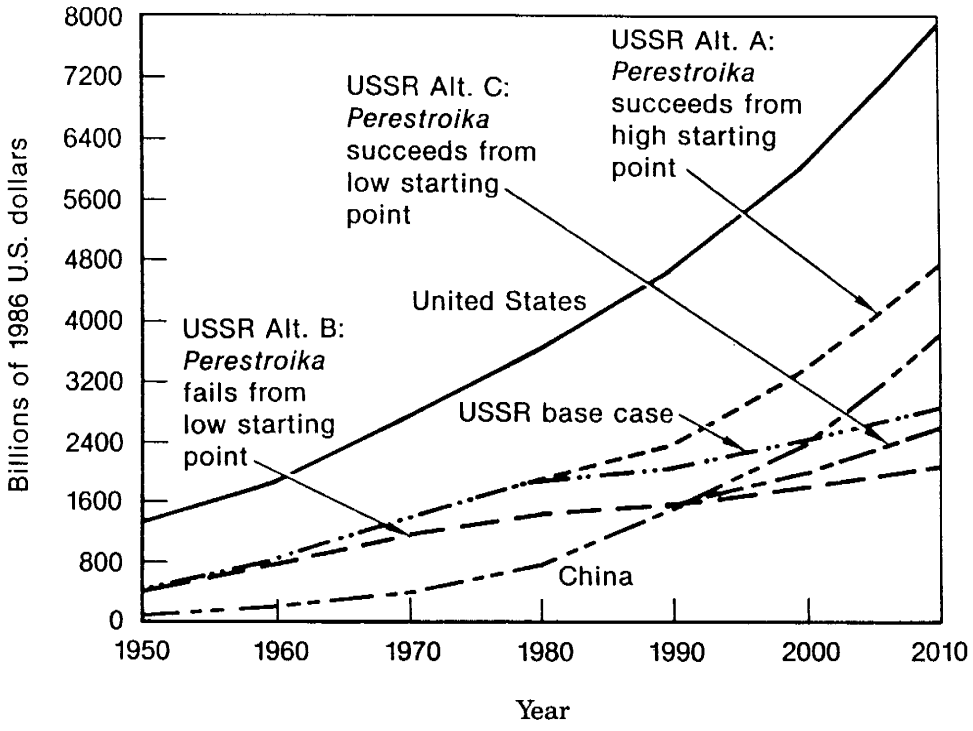

Fig. 3—Gross national products: United States, USSR, China

2. In 1980, China's national product was about 40 percent that of the Soviet Union; by 1990 the Chinese national product will probably be more than 70 percent that of the Soviet Union and by 2000 nearly equal to it; by 2010 the Chinese GNP will perhaps exceed that of the Soviet Union by over 20 percent.[2] (See Table 1 and Fig. 1.)
3. By 2010, the combined national products of the East Asian countries in the sample (Japan, China, South Korea, and Taiwan) will exceed the GNP of the United States (8.5 trillion 1986 U.S. dollars versus 7.9 trillion for the United States). (See Fig. 2.) These estimates imply that Japan's average annual growth rate over the 1990–2010 period will be about 2.8 percent, China's 4.7 percent, Korea's 4.9 percent, Taiwan's 5.8 percent, and that of the United States 2.6 percent.

[2]See "Uncertainties Concerning GNP Estimates for China" below for further explanation of these striking results.

4. The combined national products of these same East Asian economies will, by 2010, exceed the combined national products of West Germany, the UK, and France by more than 120 percent (8.5 trillion 1986 U.S. dollars versus 3.9 trillion); in 1980 their combined national products exceeded those of West Germany, France, and the UK by less than 20 percent (2.5 trillion 1986 U.S. dollars for the East Asian countries versus 2.1 trillion for the West European ones). (See Table 1.) The implied annual growth rates for West Germany, France, and the United Kingdom during the 1990–2010 period are 2.1 percent, 2.6 percent, and 1.8 percent, respectively.
5. The share represented by the U.S. GNP in the collective national products of the 15 countries in the sample remains remarkably stable from about the late 1960s through 2010. Recalling that the 15 countries' national products comprise between two-thirds and three-quarters of the global product, the U.S. share in the 15-country sample remains between 29 percent and 34 percent throughout 1970 to 2010, or between 22 percent and 23 percent of the global product.[3]
6. The middle regional powers are likely to grow significantly relative to the economies of Western Europe. For example, in 1980 the national products of India, Korea, Taiwan, Turkey, Brazil, Argentina, and Mexico were about 70 percent as large as the national products of West Germany, France, and the UK (1.4 trillion 1986 U.S. dollars compared with 2.1 trillion for the FRG, France, and the UK). (See Table 1.) By 2010, the same seven regional economic powers will probably have combined national products about 18 percent larger than those of the three West European economies (4.6 trillion 1986 U.S. dollars for the seven non-European countries versus 3.9 trillion for the European ones).
7. Although the estimates for Mexico and Egypt show positive rates of growth, the rates are low in relation to expected population and labor force growth (see subsequent discussion of demographic trends and per capita GNP). High rates of unemployment (over 40 percent) and stagnating per capita GNP may result, perhaps posing serious risks to political and social stability

[3]Assuming that the 15 countries' share of the global product rises from two-thirds to three-quarters between 1970 and 2010.

in these countries and the adjacent regions. This unemployment expectation is incorporated in the analysis by assuming that the employed labor force probably will increase at annual rates of 1.4 percent and 1.8 percent for Egypt and Mexico, respectively, during 1987 to 2010, rates which are well below the probable increases in the working-age population.

Table 2 summarizes the GNP growth rates derived from the methodology described in the appendix and implicit in the GNP estimates of Table 1.

ALTERNATIVE SOVIET GNP ESTIMATES

As noted above, perhaps the most significant uncertainties in the foregoing calculations concern the economic performance of the Soviet Union in response to the new rhetoric and policies associated with Gorbachev's reform efforts. To bound these uncertainties, three alternative Soviet GNP calculations have been constructed for the 1985–2010 period, based on the following assumptions:

Alternative A: High initial (1985) level of Soviet GNP, sharply increased (tripled) productivity growth, moderate military burden ("*perestroika* succeeds I").

Table 2

GROSS NATIONAL PRODUCT GROWTH RATES OF SELECTED COUNTRIES, 1950–2010
(In percent)

Nation	1950–60	1960–70	1970–80	1980–90	1990–2000	2000–10
United States	3.3	3.8	2.8	2.5	2.6	2.6
Soviet Union	5.7	5.1	3.2	0.8	1.6	1.6
Japan	5.9	10.8	4.7	3.7	3.0	2.7
China	7.4	6.0	6.6	6.7	4.7	4.7
West Germany	8.9	4.5	2.7	2.2	2.1	2.1
United Kingdom	3.4	2.9	1.9	1.8	1.9	1.6
France	5.1	5.6	3.6	1.9	2.8	2.4
India	2.9	3.8	3.3	3.9	4.1	4.0
South Korea	4.1	9.5	8.2	6.4	5.2	4.5
Taiwan	8.2	8.6	8.6	6.1	5.7	5.8
Brazil	6.7	6.1	8.8	2.6	4.9	5.1
Argentina	3.0	4.3	3.1	0.1	1.1	1.1
Turkey	6.3	5.8	5.1	4.1	3.7	3.2
Mexico	6.0	6.9	6.4	1.6	2.1	2.2
Egypt	6.8	4.7	7.2	3.0	1.8	1.9

Alternative B: Low initial (1985) level of Soviet GNP, productivity growth slow, high military burden ("*perestroika* fails").
Alternative C: Low initial level of Soviet GNP, sharply increased productivity growth, high military burden ("*perestroika* succeeds II").

The differing assumptions about the 1985 level of Soviet GNP derive from an unresolved controversy, both in the United States and in the Soviet Union, over the size of the Soviet GNP in 1980 and its real growth between then and 1985. Results of the alternative calculations are shown in Table 3 and Fig. 3, together with the prior base-case Soviet and U.S. estimates.

As Table 3 suggests, if Gorbachev's economic reforms succeed dramatically—a tripling of total factor productivity growth *throughout* the 1990–2010 period would be an extraordinary success—*and* if the level from which the Soviet economy "takes off" is high, the combined effects on Soviet GNP are substantial. The Soviet economy would remain the world's second largest, its ratio to that of the United States in 2010 would be 60 percent instead of less than 40 percent in the base case, and its military production base would probably be correspondingly larger.

UNCERTAINTIES CONCERNING GNP ESTIMATES FOR CHINA

The estimates for China also entail considerable uncertainty. The uncertainty arises both from the difficulty of establishing a dollar figure for China's current or recent

Table 3

ALTERNATIVE SOVIET GROSS NATIONAL PRODUCT SCENARIOS AND ESTIMATES, 1985–2010
(In billions of 1986 U.S. dollars)

Category	1985	1990	2000	2010
Soviet base case	1993	2088	2455	2873
Alt. A: *Perestroika* succeeds, I	2176	2398	3368	4697
Alt. B: *Perestroika* fails	1504	1564	1821	2119
Alt. C: *Perestroika* succeeds, II	1504	1601	2017	2613
U.S. base case	4105	4682	6072	7859

GNP and from deriving a reasonable estimate of its expected growth over the next two decades.

Expressing China's recent GNP in dollars depends on using an appropriate exchange rate; this is especially difficult because of the very different weights and structure of China's goods and services from those of the United States. The GNP estimate that results can vary as much as threefold. As previously noted, our estimate of China's recent GNP in dollars employs a purchasing-power parity rate, derived as described in the appendix to convert yuan to dollars. In principle, this rate reflects the relative value of yuan and dollars in purchasing the particular combination of goods and services produced in both countries. Our resulting estimate for China's recent GNP—about $1.2 trillion in 1986 U.S. dollars—is much higher (and we believe it to be more reliable) than most other published estimates.

A crude impressionistic check is useful to confirm this conclusion. Thus, if (1) one acknowledges that the Chinese are generally living at least at subsistence levels of consumption (a judgment readily inferred from observations of living standards in China), (2) one acknowledges that something over 80 percent of the Chinese national product is devoted to consumption, and (3) one adopts U.S. dollar prices in converting this proportion to dollars, then a 1986 estimate for China's gross domestic product (GDP) per capita in the neighborhood of $1,000 is entirely reasonable. Combining this figure with China's population estimates (by the Bureau of the Census and other sources), which vary between 1 billion and 1.15 billion, results in an estimate of China's gross domestic product remarkably close to our estimates. It is reassuring that the two estimates, developed by such different methods, produce such closely consistent results.

The second source of uncertainty relates to the method we have used to estimate China's aggregate growth through 2010. This method, described in the appendix, results in an estimated average annual growth rate of about 4.6 percent over the next two decades, considerably slower than China's recent record and well below the 6 to 7 percent envisaged by the Chinese themselves for the rest of this century. Of course, whether our estimate, let alone the still higher one of the Chinese, is actually realized will depend on many factors not directly included in our estimation model—especially the persistence and effectiveness of China's market-oriented reform efforts.

In any event, while our resulting estimates place China's GNP in 2010 roughly equal to Japan's (and second only to that of the United States), China's product *per capita* would remain far below that of the other major powers.

PER CAPITA NATIONAL PRODUCTS

When the previous GNP estimates are combined with Bureau of Census estimates of demographic trends (Table 4), some striking differences emerge in per capita GNP.

- Although China's GNP in 2010 may well be the second or third largest in the world, its per capita GNP will be only 10–11 percent that of the United States and Japan, and about one-third that of the Soviet Union. (See Fig. 4.)
- The per capita GNP of Japan in 2010 will be as high or higher than that of the United States due in part to slow population growth in Japan. (See Fig. 4.)
- Per capita GNP in Korea and Taiwan will be about half that in the United States and Japan by 2010. (See Figs. 4 and 5.)
- Population growth in Mexico and Egypt at annual rates of about 2.0 percent and 1.9 percent, respectively, in the next two decades will probably approximate their corresponding GNP growth rates (2.1 percent and 1.8 percent, respectively). The result will probably be stagnation in per capita

Table 4

1985 POPULATIONS AND 1950–2010 POPULATION GROWTH RATES OF SELECTED COUNTRIES

Nation	1985 Population (Millions)	Growth Rate, 1950–1985 (Percent)	Growth Rate, 1985–2010 (Percent)
United States	238.0	1.28	0.74
Soviet Union	278.6	1.25	0.77
Japan	120.7	1.05	0.39
China	1059.5	1.87	0.99
West Germany	60.9	0.57	–0.25
United Kingdom	56.1	0.30	0.00
France	54.6	0.77	0.24
India	758.9	2.17	1.43
South Korea	41.3	2.04	1.22
Taiwan	19.1[a]	n.a.	0.87[a]
Brazil	135.6	2.70	1.72
Argentina	30.5	1.65	1.24
Turkey	49.3	2.50	1.75
Mexico	79.0	3.07	1.96
Egypt	46.9	2.41	1.91

SOURCE: United Nations, *World Population Prospects*, New York, 1986.

NOTE: n.a. means data were not available.

[a]1985 population derived from 1980 and 1990 populations of 17.8 and 20.5 million, respectively, and derived growth rate of 1.42 percent.

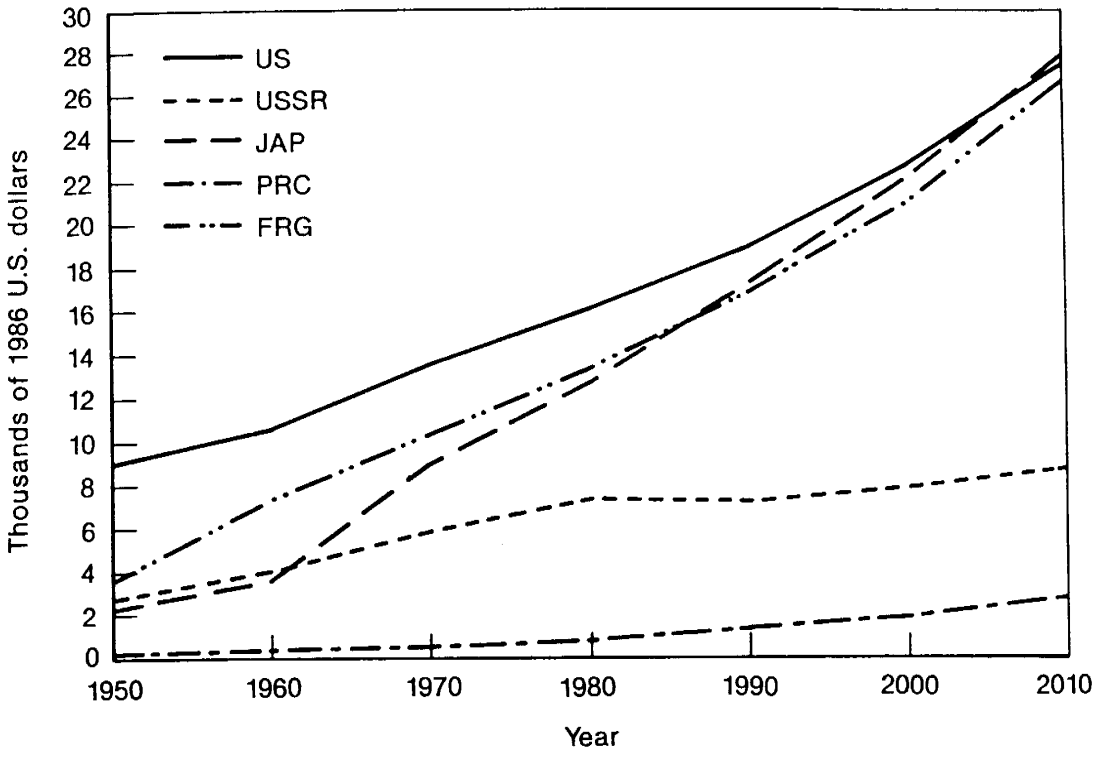

Fig. 4—Per capita gross national products: United States, USSR, Japan, China, and West Germany

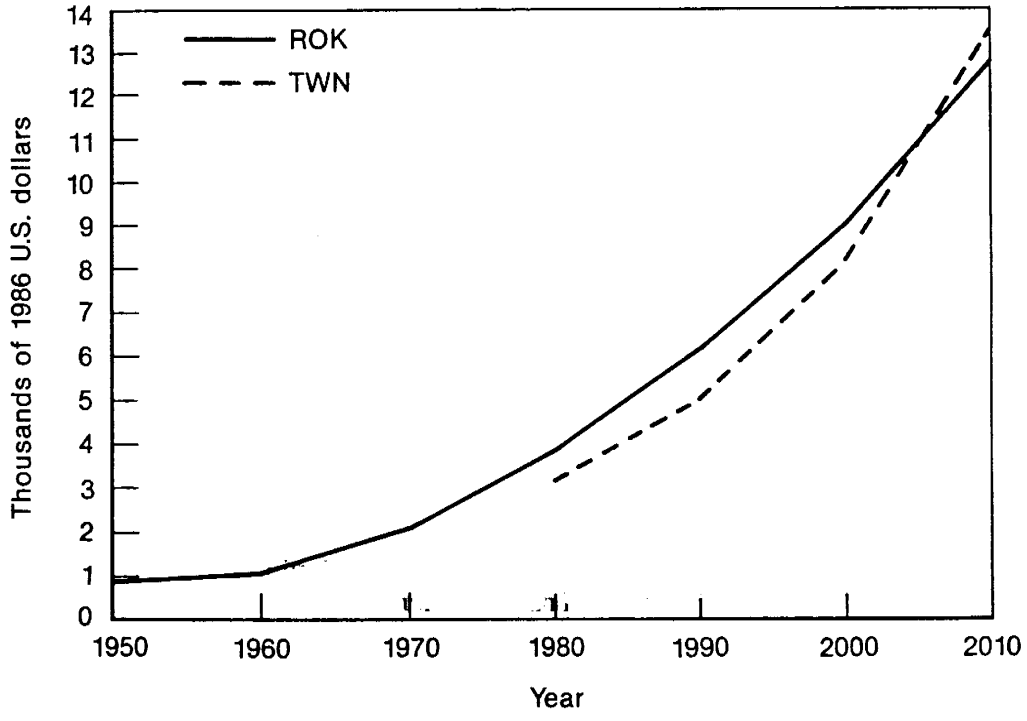

Fig. 5—Per capita gross national products: South Korea and Taiwan

GNP as well as high rates of unemployment (over 40 percent), because labor force growth exceeds employment growth. The consequent situation may pose serious risks to political and social stability in these countries. (See Fig. 6.)

IMPLICATIONS OF GNP TRENDS

These calculations and the inferences drawn from them provide only a broad and general perspective. They do not measure all important economic trends of the next two decades. They do not address a number of salient economic indicators referred to earlier and a number of important countries. Nor do they treat such other important economic developments, bearing on the future security environment, as the control of military-related technology exports and U.S. dependence on imports for a perhaps growing proportion of military-related components.

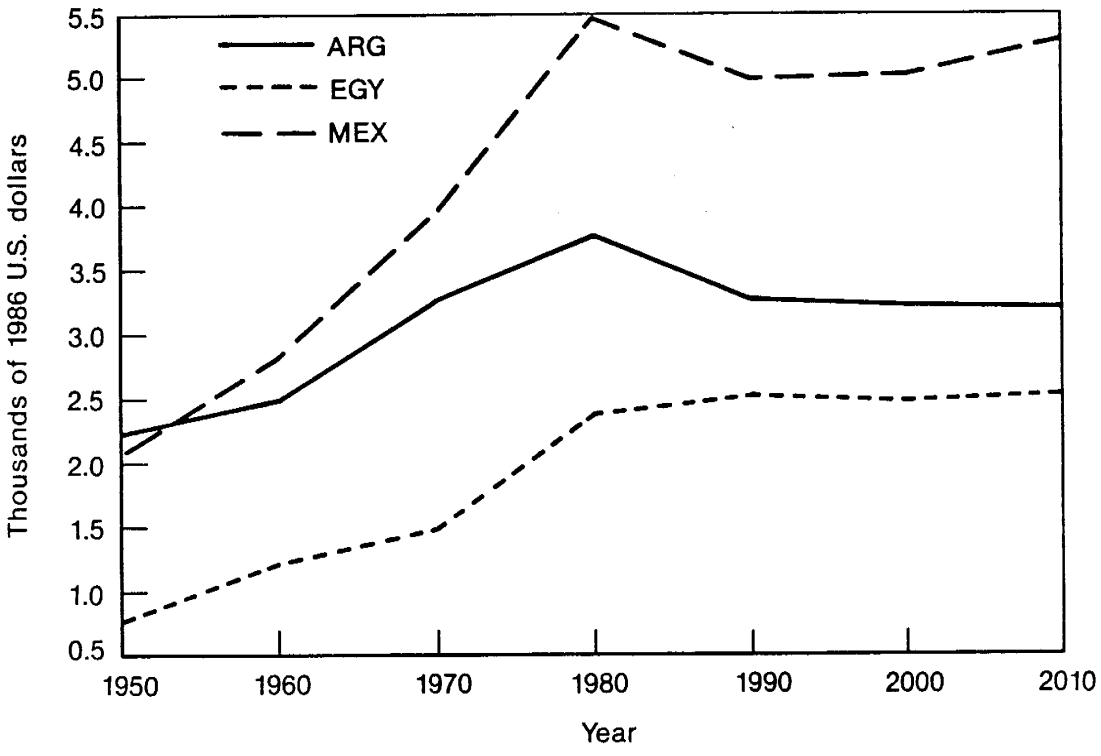

Fig. 6—Per capita gross national products: Argentina, Egypt, and Mexico

Despite these limitations, the trends shown in Table 1 suggest several striking and significant changes that impend in the economic environment:

- the center of activity in the global economy shifts to Asia and the Pacific Rim;
- non-European economic powers display economic growth and prominence relative to those of Western Europe;
- the share represented by the Soviet Union in the international economy will probably further diminish (although Gorbachev's policies create particular uncertainties for the base-case Soviet GNP estimates, as noted above);
- the share represented by the United States in the international economy remains remarkably stable over the same 20-year period in which the Soviet share will probably be diminishing.

These trends suggest that the international economic environment's broad contours will be undergoing gradual changes over the next two decades, with cumulative effects that will be dramatic. To be sure, the uncertainties attending these calculations are substantial. For example, the moderate growth rates implied over the 1987–2010 period for Japan (varying between 2.5 and 3.5 percent) and for the United States (varying between 2.3 and 2.7 percent) might turn out to be too high (or too low) or might be interrupted by cyclical recessions (or expansions). And, as noted earlier, some of the developing countries might experience acute political and social instability that would critically affect, as well as be critically affected by, their economic growth. While the future is inevitably uncertain, and there are bound to be surprises, the broad economic trends described above suggest that the economic environment emerging in the 1987–2010 period will be very different from that of the past two decades.

III. TRENDS IN MILITARY SPENDING

In measuring military trends, as in measuring economic trends, no single indicator suffices to evaluate major developments in individual countries over time or to compare numerous countries at any point in time. Besides annual and cumulative military spending and accumulated stocks of military equipment, relevant indicators of military strength include order-of-battle data on forces and weapons (both conventional and nuclear); military training, morale, and leadership; command, control, communications, and intelligence; operational readiness; air and sea lift; research and development; and defense mobilization capabilities.

For a very rough indicator of military trends over the 1950–2010 period, we have focused on two aggregate measures of military efforts and military power: first, annual military spending expressed in 1986 U.S. dollars for each of the 15 countries; second, annual estimates of the military capital stock of each country, representing the net value of military equipment and structures held by each country, also expressed in 1986 U.S. dollars for each year of the 60-year period.

Estimates of *military spending* for the period from 1950 to the present are derived from several international as well as national sources in the 15 countries.[1] For the period from the present to 2010, the spending estimates are linked to prior GNP estimates through parameters relating to each country's military burden (the ratio of military spending to national product). These burden parameters were derived from historical and recent experience in each of the 15 countries, combined with explicit judgments about how the parameters may in the future diverge from historical experience. We have not attempted to estimate confidence intervals for these parameters.

U.S. AND SOVIET ALTERNATIVES AND COMPARISONS

For the United States, the burden parameter is assumed in the base case to average 6.2 percent of GNP over the next two decades. Two alternatives are also presented, reflecting sharply different burden assumptions and sharply tighter resource constraints:

[1]See the appendix for a description of sources used for each of the 15 countries.

1. *Alternative 1* assumes constant levels of real annual U.S. military spending; with this assumption, the burden parameter declines from 6.2 percent in 1988 to 4.5 percent in 2000 and 3.5 percent in 2010.
2. *Alternative 2* allows for a 1 percent annual growth in real U.S. military spending from 1988 onwards. Because U.S. GNP is estimated to grow at an average rate of about 2.6 percent, the military spending share of GNP in this alternative falls to 5.1 percent in 2000 and 4.3 percent in 2010.

In terms of the current budgetary outlook, either Alternative 1 or 2 seems more probable than the base case.

For the Soviet Union, four alternatives to the base-case estimates are calculated. The Soviet base case assumed that Soviet GNP in 1985 represented about one-half the U.S. GNP, and Soviet military spending was 14.3 percent of its GNP. The first of these two assumptions is very likely too high, while the Soviet military spending share of GNP is probably considerably above 14.3 percent. Therefore four alternatives were constructed as follows:

1. *Alternative A* assumed the same initial 1985 level of Soviet GNP as in the base case, a tripling of productivity growth ("*perestroika* succeeds"), and a reduced military spending share in GNP (13.1 percent).
2. *Alternative B* assumed an initial 1985 level of Soviet GNP that was 25 percent below the base-case level, slow productivity growth ("*perestroika* fails"), and a higher military spending share in GNP (18.9 percent).
3. *Alternative C* assumed the same 1985 GNP level adopted in Alternative B, the productivity growth of Alternative A, and a military spending share varying between 18.5 percent and 18.9 percent.
4. *Alternative D* is the same as Alternative A except that Soviet military spending remains constant from 1990 to 2010; therefore, the military burden ratio falls to 9.3 percent in 2000 and 6.7 percent in 2010.

Table 5 summarizes the base-case military spending estimates for the 15 countries. Annual Soviet military spending remains above that of the United States through the early 1990s, if the base-case assumptions are sustained (14.3 percent military

Table 5

ANNUAL MILITARY SPENDING
BY SELECTED COUNTRIES,
1950–2010
(In billions of 1986 U.S. dollars)

Nation	1950	1960	1970	1980	1990	2000	2010
United States	69	168	209	196	288	365	462
Soviet Union	91	95	170	247	299	351	411
Japan	4	4	7	14	22	29	37
China	8	16	37	45	53	120	218
West Germany	0	20	21	27	32	40	49
United Kingdom	23	29	26	29	35	42	50
France	11	22	21	28	34	45	57
India	2	4	9	12	24	36	53
South Korea	1	1	1	5	9	15	23
Taiwan	1	1	2	3	6	11	19
Brazil	1	1	3	1	3	4	7
Argentina	1	1	2	3	3	3	3
Turkey	2	3	5	8	12	17	23
Mexico	0	1	1	2	2	3	3
Egypt	1	2	9	7	9	11	13

spending share for the Soviet Union and 6.2 percent for the United States) and if our calculated U.S. and Soviet growth rates are realized.

However, these conclusions are substantially altered if, instead, our alternative assumptions are used. Table 6 summarizes the U.S.-Soviet spending comparisons for Alternatives 1 and 2 and A through D. Among the Soviet alternatives, Alternative A generates the largest military spending because of the combined effect of the higher initial (1985) level of Soviet GNP and the rise of productivity, notwithstanding a relatively low military burden.

As Table 6 indicates, in both U.S. Alternatives 1 and 2—which assume constant and slow growth military spending, respectively—the U.S. figures are substantially lower by 2000 than Soviet military spending. If Soviet economic reforms result in sharply raised productivity and if Soviet military spending remains about as large a share of Soviet GNP as it has been, U.S. military spending would, under Alternatives 1 and 2, be well below that of the Soviet Union unless Soviet military spending were to be held constant, as illustrated by Alternative D.[2]

[2]Obviously, U.S. and Soviet defense efforts are likely to influence each other. Moreover, *perestroika* in the Soviet Union could affect the size of the Soviet defense effort.

Table 6

ANNUAL U.S. AND SOVIET MILITARY SPENDING, ALTERNATIVES AND BASE CASES, 1985–2010
(In billions of 1986 U.S. dollars)

Category	1985	1990	2000	2010
Soviet Union				
Base case (military burden 14.3%)	285	299	351	411
Alt. A (*perestroika* succeeds I, low military burden ~13%)	285	314	441	615
Alt. B (*perestroika* fails, high military burden ~19%)	285	296	345	402
Alt. C (*perestroika* succeeds II, high military burden ~19%)	285	296	382	495
Alt. D (*perestroika* succeeds III, constant military spending and decreasing military burden)	284	314	314	314
United States				
Base case	270	288	365	462
Alt. 1 (constant military spending)	270	276	276	276
Alt. 2 (slow growth military spending)	270	281	310	338

MILITARY SPENDING IN OTHER COUNTRIES

The comparisons shown in Fig. 7 and Table 5 for other countries suggest several noteworthy points.

- Military spending by China rises substantially and significantly due to both the relatively rapid growth of China's GNP (between 4 percent and 5 percent per annum) and the relatively large and rising share of GNP devoted to the military after 1990. (As and if China's three "economic modernizations"—in agriculture, industry, and technology—are realized, the Chinese defense burden will probably rise from about 3.5 percent to about 6 percent of GNP between 1990 and 2010, as military modernization proceeds.)
- Whereas Chinese military spending in 1980 and 1990 is less than a fifth that of the Soviet Union and a quarter that of the United States, by 2000 Chinese military spending will be about a third of the U.S. and Soviet figures and by 2010 about half their sizes. In terms of aggregate military spending, China

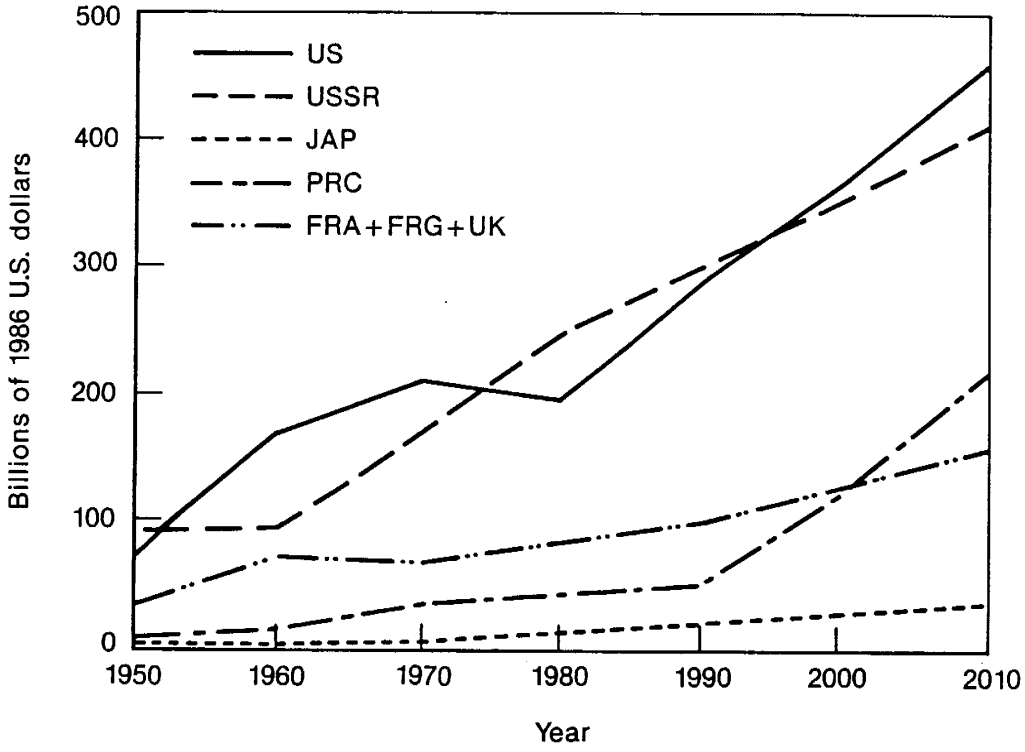

Fig. 7—Annual military spending: United States, USSR, Japan, China and three NATO countries

becomes more significant in the spending balance between the United States and the Soviet Union during the rest of this century and into the 21st century. Repercussions from increased Chinese military spending might ensue elsewhere in Asia, especially in Japan and perhaps India, but these possibilities are not reflected in Table 5.

- Defense spending by Japan remains small relative to those of the United States and the Soviet Union. Nevertheless, because of the expansion and size of Japan's economy, even a relatively small defense burden results in rising real levels of Japanese defense spending which, toward the end of the century, approaches the spending levels of each of our principal West European allies. If, in response to increased military efforts by China or for other reasons, Japan were to boost its defense share of GNP to, say, 3 percent, the effects would be significant: by 1990, Japan's military spending would be over 60 percent as large as the combined military spending of the

UK, West Germany, and France, and by 2000, the Japanese figures would be nearly 70 percent of their combined military spending.

- Defense spending by our principal West European allies (the United Kingdom, West Germany, and France) is estimated as falling relative to that of the United States between 1980 (when their spending was about 43 percent of ours) and 2010 (when their spending declines to about 32 percent of ours). However, military spending by these three West European allies would represent, in 2010, about the same proportion of the corresponding Soviet figure, and therefore would remain a highly significant element in the U.S.-Soviet balance. (The possibility that European military spending might rise, perhaps to compensate for possible reductions in U.S. NATO spending, is not reflected in these estimates.)

IV. MILITARY CAPITAL STOCKS

The following estimates of *military capital stocks* for the 15 countries cover their respective holdings of weapons and structures over the 1950–2010 period. The estimates are based on two very rough, order-of-magnitude approximation methods, each applied to particular countries depending on whether the available data made one or the other more appropriate. Both methods require a benchmark capital stock measure for at least a single year to generate the entire 1950–2010 series.

To provide this benchmark where one did not already exist from another source, one method began with an estimate of defense spending devoted to military investment in 1950; then it built up the subsequent years' estimates by adding new investment and depreciating the accumulated military capital stock at a "forward" rate, ∂_1.

For the other method, the capital stock in 1985 was estimated from a country's inventory of military equipment that had been scaled to other countries in the sample. In this case, estimates for the earlier years were constructed by *subtracting* each prior year's military investment and *adding* depreciation from that year's capital stock at a "backward" depreciation rate, ∂_2.

Based on the U.S. capital stock data, which are available for all of the 1950–1985 period, a "forward" depreciation rate of 3.5 percent and a "backward" rate of 4.5 percent yield a close approximation of the actual data series. These rates were therefore used for other countries, depending on which of the two approximation methods was applied.[1]

In both methods, military capital estimates for the 1980s through 2010 were derived by adding new military investment, as a share of total military spending, and subtracting depreciation from the annual capital stock figures. Table 6 summarizes the results of these calculations, Fig. 8 displays the results for the major countries, and Fig. 9 shows the several comparisons between U.S. and Soviet military capital stocks that result from alternative assumptions about their respective levels of military investment.

As Table 7 and Fig. 8 indicate, Soviet military capital stock is expected to be above that of the United States until 2000, falling below the U.S. level by about 11 percent in 2010. This compares with a 28 percent Soviet advantage in 1980. As noted

[1]For a more complete explanation of the methods and data, see the appendix.

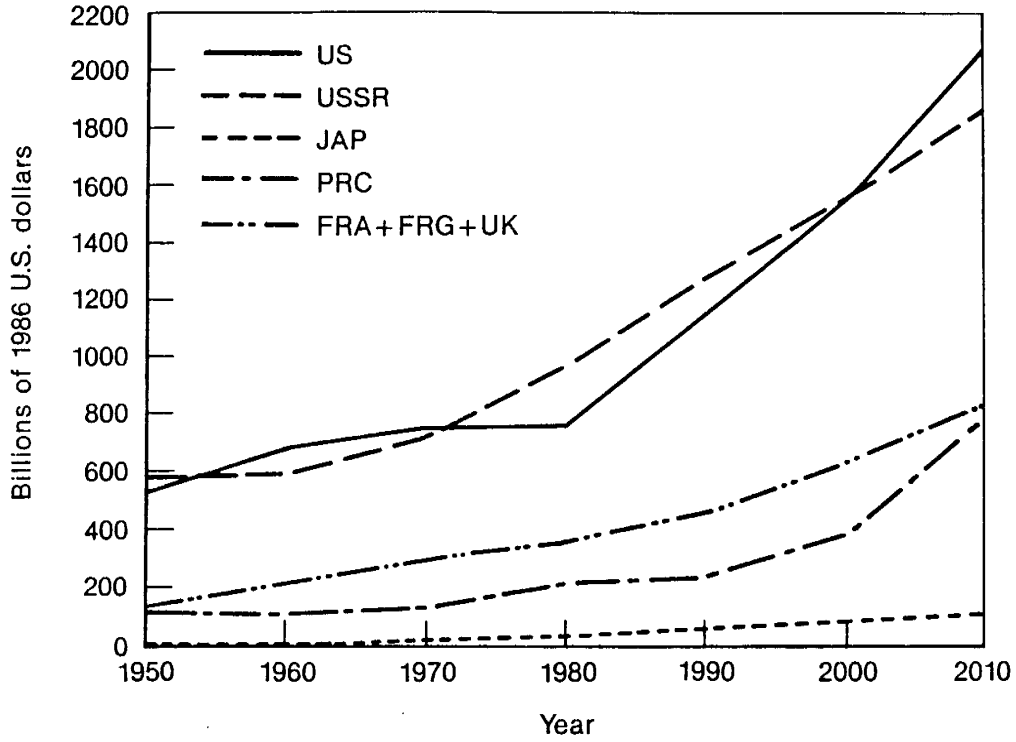

Fig. 8—Military capital stocks: United States, USSR, Japan, China and three NATO countries

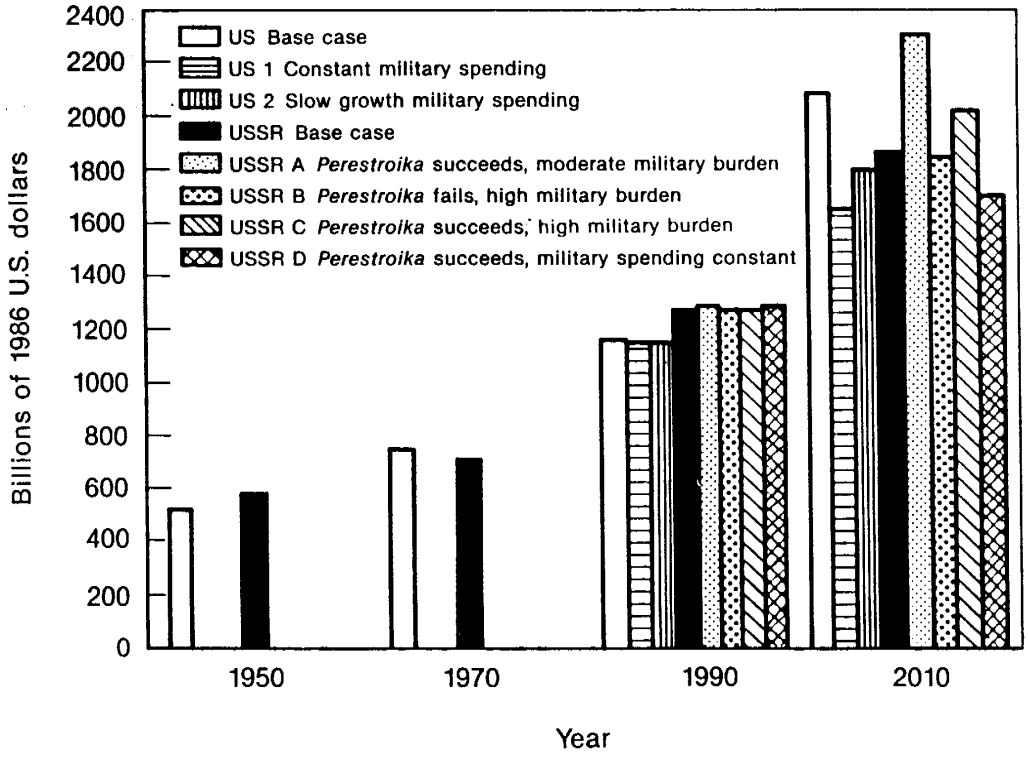

Fig. 9—Military capital stocks: United States (base and Alternatives 1 and 2) and USSR (base and Alternatives A through D)

Table 7

MILITARY CAPITAL STOCKS (WEAPONS AND STRUCTURES) OF SELECTED COUNTRIES, 1950–2010
(In billions of 1986 U.S. dollars)[a]

Nation	1950	1960	1970	1980	1990	2000	2010
United States	525	677	747	755	1157	1562	2089
Soviet Union	584	592	719	965	1278	1559	1867
Japan	0	6	15	31	55	82	115
China	107	103	129	211	236	392	785
West Germany	0	24	68	101	138	197	260
United Kingdom	78	113	130	139	171	227	284
France	52	74	91	107	148	215	292
India	8	9	15	21	42	81	131
South Korea	1	1	2	15	37	75	131
Taiwan	3	4	6	10	15	24	40
Brazil	7	6	8	9	10	12	18
Argentina	7	7	7	8	11	12	14
Turkey	5	8	12	23	33	48	68
Mexico	5	4	5	6	8	10	12
Egypt	18	14	17	37	39	44	51

[a]Converted from local currencies using 1980 purchasing-power parities.

earlier, the U.S. base case, on which this comparison is predicated, makes the dubious assumption that U.S. military spending will remain at about the same share (6.2 percent) of GNP in the next two decades that it represented in the mid 1980s. The picture changes sharply if U.S. military spending is held constant (Alt. 1) or grows slowly (Alt. 2), and still more sharply if Soviet productivity rises (*perestroika* succeeds) and the defense burden remains moderate or high (Alt. A or Alt. B). On the other hand, if both the Soviets and the United States were to maintain military spending at their current levels (Alt. D for the Soviets and Alt. 1 for the United States), their respective military capital stocks in 2010 would be about equal.

Table 8 shows the effects of the alternatives on U.S. and Soviet military capital stocks.

Regarding Table 7 and Figs. 8 and 9, several points are worth noting:

- China's military capital stock, hitherto small relative to those of the United States and the Soviet Union, rises to roughly 40 percent of each superpower's military capital stock by 2010. In terms of aggregate military stock comparisons, China becomes the balancing item in the parity between the Soviet Union and the United States from 1990 into the 21st century. In

Table 8

ALTERNATIVE U.S. AND SOVIET MILITARY CAPITAL STOCKS, 1985–2010
(In billions of 1986 U.S. dollars)

Category	1985	1990	2000	2010
United States				
Base case	950	1157	1562	2089
Alt. 1 (constant military spending)	[a]	1154	1432	1648
Alt. 2 (slow growth military spending)	[a]	1155	1479	1796
Soviet Union				
Base case	1131	1278	1559	1867
Alt. A (*perestroika* succeeds I, moderate military burden)	1131	1288	1686	2293
Alt. B (*perestroika* fails, high military burden)	1131	1277	1548	1842
Alt. C (*perestroika* succeeds II, high military burden)	1131	1277	1589	2021
Alt. D (*perestroika* succeeds III, military spending constant)	1131	1288	1543	1696

[a]Not computed.

relation to regional military balances, the Chinese military capital stock in 2010 will be about six times that of India; currently, their ratio is about 7 to 1.

- The accumulating military capital of the principal West European allies will remain about as significant in the balance between the United States and the Soviet Union as it has in the past. Thus, in 1980 the military capital of France, West Germany, and the United Kingdom amounted to about 46 percent of the U.S. figure; by 2010, the corresponding ratio is about 40 percent (836 billion 1986 U.S. dollars for the three European countries versus 2,089 billion for the United States).
- Japan's military capital stock remains small relative to the other countries but, by the early part of the 21st century, its military capital reaches about 40 percent of that of each of our principal West European allies. Of course, if Japan's military spending were to increase appreciably—in response to China's military modernization or for other reasons—the resulting effects on Japan's military capital would be consequential. For example, if Japan were

to increase its military spending to, say, 3 percent of GNP in 1990, by 2000 the Japanese military capital stock would be 70 percent that of West Germany; by 2010 Japanese military capital would reach $321 billion, about 24 percent above that of West Germany.

- Although the military capital of the middle regional powers (Korea, Taiwan, Turkey, India, Brazil, Egypt) is small relative to that of the larger powers, it represents a formidable stock of weapons, very likely including advanced systems, in the next two decades.

Along with increases in their military capital stocks, as well as growth of their economies and their technological sophistication, these middle regional developing countries will acquire a growing capacity to produce and to export a wide range of weapons, including all but the most sophisticated types. This trend is already evident as indicated by these countries' increased share of the $30–40 billion annual level of world arms exports: from 2 percent in 1973 to 11 percent in 1984,[2] although this percentage apparently decreased in 1985 and 1986. By the 1990s, arms exports by Brazil, both Koreas, and India, as well as China, are likely to reach a still larger and more significant scale.

Two important general conclusions emerge from combining the estimates of major economic trends and trends in the military aggregates: first, looking forward to the rest of this century and the beginning of the 21st century, whether Japan and China are allied, friendly, neutral, or belligerent vis a vis the United States will be no less important for U.S. interests than is the continued adversarial posture of the Soviet Union; second, inasmuch as some of the middle-level regional powers are likely to gain in economic and military capabilities and are likely to be more prominent actors in the international arena, U.S. policy formulation will probably grow increasingly concerned with closer cooperation and coalitions with them.

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[2]See Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers 1987*, Washington, D.C., 1988, pp. 10–11.

Appendix

SOURCES AND METHODS FOR THE ECONOMIC AND MILITARY PROJECTIONS

This appendix describes the method used in estimating economic and military trends for the period 1950 through 2010 for 15 key countries: United States, Soviet Union, Japan, China, United Kingdom, France, Federal Republic of Germany, Turkey, India, South Korea, Taiwan, Egypt, Brazil, Mexico, and Argentina. The initial discussion is confined to the general theoretical framework applied to all of the countries. In some cases, further adjustments were made because of data limitations or for other reasons. More detailed explanations of these adjustments and of the specific data sources used for each country are presented in the sections below on individual countries.

METHODOLOGY

Economic Trends

To depict the gross magnitude of impending economic changes, we derived GNP estimates for the 15 countries from data and judgments concerning recent and pending changes in rates of capital formation, employment, and productivity. No single indicator suffices to convey the trend of an economy over time, still less to compare and size the performance of a large number of economies at any given point in time. Growth in real national product is clearly one salient indicator, but other ones are important and relevant, depending on the purposes for which the comparisons are intended. Other relevant indicators include capital flows, exports and imports, per capita income, domestic capital formation, resource allocations for research and development and science and technology, international holdings of assets and liabilities, and demographic changes.

Our initial evaluation of major economic trends focuses on gross national product because we are interested in examining economic trends for a large number of countries over a 60-year period—from 1950 to 2010—and GNP is probably the most useful single indicator of economic size for making international comparisons over long periods.

The estimates from the present to 2010 employ the same methodology that we used in reestimating the actual GNP figures for 1950 to the present; thus, the past and future series are intended to be consistent with one another.

The 15 countries we covered account for more than two-thirds of the global economic product (see Table 1), as well as the overwhelming preponderance of global military power (see Table 7). While none of these estimates is intended as a precise forecast, particular uncertainties surround estimates for the Soviet Union and China. To reflect these uncertainties, several alternative estimates have been made.

The basic model used in the estimates makes the simplifying assumption that output (gross national product or gross domestic product) can be represented as a Cobb-Douglas production function. The function specifically assumes constant returns to scale, two factors of production—capital and labor, and Hicks-neutral technological change. Equation (1) shows the functional form of the model:

$$GNP = C * (EXP(a * t)) * (K)^{b} * (L)^{1-b} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where,

C is a constant,

a is the rate of technological change,

t is years elapsed since the base year (1950),

b is the share of capital in GNP,

K is the index of capital input in a given year, and

L is the index of labor input in a given year.

The indices of capital input (K) and labor input (L) were estimated for each country. Measurement of both indices involves certain conceptual issues which are not addressed in the study.[1]

We have used these simple measures because our aim is to compare differences among nations, rather than to make precise forecasts of their individual GNPs; the simplified measures are less likely to affect relative GNP differences than they are to affect the GNP estimate of any individual country.

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[1]Capital services are difficult to estimate. Gross capital stock is the present value of future services that the capital stock will provide. If the lifetime of the capital stock is long, and the depreciation rate is constant among its various components, then the market value or the "net capital" measure serves as an appropriate proxy for capital service input. Or, if the lifetime and depreciation rate are constant among the various components of the capital stock, the "gross" measure is an appropriate proxy. However, uncertain equipment lifetimes and technological obsolescence make the assessment of input of capital services difficult. To keep the analysis simple, we use the gross capital stock as a proxy for the capital service input. Similar problems are encountered in calculating a labor input index. Labor can differ by hours worked, individual worker efficiency, educational level, and so on. These differences exist at each point in time, over periods of time, and across countries. In any event, for most countries such detailed data are not available, so we have used gross numbers of persons employed.

The capital stock in a given year is calculated by adding the depreciated sum of all previous investments and the new investment in the given year, as shown by Eq. (2). New investment in a given year is a function of the GNP in that year, as indicated in Eq. (3).

$$K_t = (1 - d) * K_{t-1} + I_t \quad \text{..... (2)}$$

where

K_t is capital stock at time t,

K_{t-1} is capital stock at time t-1,

d is the depreciation rate, and

I_t is new investment in year t.

$$I_t = s * GNP_t \quad \text{..... (3)}$$

where s is the share of GNP devoted to investment in year t.

In this formulation, the capital stock must be known for at least a single year to provide a benchmark value from which the whole stream of capital stock numbers can be generated. Except for the United States and the Soviet Union, total capital stock figures for a specific year were not generally available. To resolve this problem we assumed a ratio of capital stock to GNP in 1950 of about 2.5 for each of the 15 countries, based on the general experience of the United States and other countries, with modifications based on country-specific data.

The index of labor input was calculated as the ratio of total employed persons in a given year to employment in the base year, i.e., 1950. Parameters a and b in Eq. (1), representing technological change and the capital share in GNP, respectively, were estimated from the country-specific data for several of the countries, while in other instances these parameters were drawn from other sources and from prior development research.[2]

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[2]In general, it appears that the share of capital in GNP declines as nations industrialize. For most developing countries the capital share is around 0.45, while for the industrialized nations it is generally 0.35 but may be as low as 0.25. To retain consistency, the present analysis assumes that the share of capital in GNP for the developing nations is 0.45, while for the developed nations it is 0.35. For a good overview see Solow, R. M. (1957): "Technical Change and the Aggregate Productivity Function," *Review of Economics and Statistics*, 39, No. 3, pp. 312–320; Domar, E., et al. (1964): "Economic Growth and Productivity in the United States, Canada, United Kingdom, Germany and Japan in the Post War Period," *Review of Economics and Statistics*, 46, No. 1, pp. 33–40; Kendrick, J. W., and Vaccara, B. N., eds. (1980): *New*

Military Trends

Two gross indices were selected to provide a simple and reasonably comparable basis for assessing the aggregate military status of each country: total annual military spending, and military capital stock for each year of the 1950–2010 period. This, of course, abstracts from numerous other critical influences on military capabilities, such as leadership, training, morale, and logistics.

To estimate military spending, explicit and documented assumptions were made for each country regarding the fraction of GNP devoted to defense spending, in the past, at present, and in the future. Prior and current spending shares accord with actual experience. The future spending share was either assumed to replicate this pattern or was adjusted to accord with intended or anticipated changes in particular countries.

Measurement of the military capital stock presents more complex and difficult theoretical and empirical problems. Among these difficulties are the following: first, the "services" provided by military equipment are difficult to define and quantify; and second, the same piece of equipment can provide varying levels of effective service depending on the type of conflict, terrain, adversaries, allies, and other contingency-specific circumstances. Our methodology measures the value of the military capital based on procurement cost. This implicitly represents the value of services that a particular piece of equipment will provide, relative to other procurements, averaged over the possible scenarios in which it is expected to be used.

A further difficulty in measuring military capital relates to the possibility of accelerated obsolescence depending on the technology embodied in an adversary's military capital.

Additional empirical problems arise in determining what to count toward the military capital stock. Part of military capital budgets is devoted to construction and procurement of civil-type items like office equipment, appliances, and amenities. Whether to include or exclude such items depends on the question being asked.

Generally in our analysis, the military capital stocks of the respective countries were calculated using gross currency outlays for military procurement (principally weapons procurement where it could be separated from total procurements) and construction (covering barracks, airfields, communication facilities, and other structures).

Developments in Productivity Measurement and Analysis, The University of Chicago Press.

The methodology is similar to that applied to civilian capital stock described in Eqs. (2) and (3) above.

As with civilian capital estimates, military capital estimates require that we have a benchmark estimate for at least a single year to enable the entire series to be generated. In the absence of this benchmark figure, we have proceeded in two ways. For some countries, a starting value for the military capital stock in 1950 was estimated based on the amount of defense spending devoted to military investment in that year; we then built the subsequent years' estimates by adding new investment and depreciating the accumulated military capital stock. For other countries, the military capital stock in 1985 was estimated from their inventories of military equipment scaled to those of other countries in the sample; in this case, estimates for the earlier years were built up by subtracting each prior year's new military investment and adding depreciation from that year's existing capital stock.

Looking backward from 1985, the trend in military capital can be estimated by assuming the estimate for 1985 to be accurate and generating backward the capital stock figures for the earlier years from the corresponding military investments in those years and a different depreciation rate.

To determine suitable depreciation rates for the past and the future, this method was applied to the capital stock data for the United States, which is available for all prior years. An annual depreciation rate of 3.5 percent for the future and 4.5 percent for the past, gives a good approximation in the U.S. case. These rates, or close approximations, were applied to other countries as well.[3]

For most countries, data were not available concerning the exact proportion of the defense budget devoted to military investment. In these cases, assumptions were made based on their similarity with other nations whose corresponding figures were known;

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[3]Two exceptions are China and India for the 1985–2010 period. The rate used for China was 7.5 percent; use of this higher rate was considered to be reasonable because military modernization now is the last of China's four "modernizations." By the 1990s and into the next century, it is expected that substantial replacement of the Chinese military capital stock will begin and that the rate of retirement will accelerate. For India, a 3.5 percent rate was used for 1985–2010. This lower rate was believed justified because, while the Indian military is modernizing its equipment, available sources suggest a markedly low rate of retirement is likely to be maintained.

The military capital stock figures generated by the process described in the text were judged subjectively for their reasonableness based on general knowledge regarding the various countries.

e.g., the proportion of defense spending devoted to military investment in South Korea was assumed to apply to Taiwan, as well.

With respect to the estimates for 1987 through 2010, our analysis also assumes that each country's military spending decisions are independent of those of other nations; i.e., reactive effects were not modeled. In making the estimates for the 1987–2010 period, we used (1) military investment shares in total defense spending and (2) depreciation rates based on prior experience or on adjustments of prior experience based on judgments relating to the individual countries.

Currency Conversion

Most of the trend analysis was initially conducted in the separate national currencies of the countries in the sample and subsequently converted to constant price dollars, generally at the 1980 purchasing-power parity rate. There are some exceptions to this procedure (e.g., Argentina, Brazil, and China) for which the available historical data were already in dollars. The procedure used for each country is described in more detail in the following sections.

The currency conversion raises another question concerning the appropriate rate to use, that is, the prevailing exchange rate or a suitable "purchasing-power parity" (PPP) index. The PPP index was generally regarded as preferable.[4]

In general, the PPP index is more appropriate for converting GNP in national currencies to dollars, because it better reflects the real resource parities among currencies unaffected by short-term changes in capital movements and expectations. However, in the case of military capital stocks, the appropriate rate could differ from both the exchange rate and the PPP index because some military capital is procured at costs reflecting domestic prices (construction, indigenously manufactured equipment, etc.), while other military capital is procured at prevailing dollar exchange rates. Moreover, some military capital may be procured at prices that involve commodity "offsets" and associated transactions, which further obscure the actual conversion rate implicit in the acquisition.

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[4]The PPP rates are taken from Summers, R., and Heston, A. (1984): "Improved International Comparisons of Real Product and Its Composition: 1950–1980," *Review of Income and Wealth*, June, pp. 207–262. In general, PPP rates use the geometric mean of the foreign currency and dollar price ratios in the dollar conversions.

Thus, when interpreting the results, further caution is warranted because of the currency conversion process.

ARGENTINA

Data Sources

For the years 1950–1979, the GNP data were taken from the *Statistical Abstract of Latin America* (*SALA*), Vol. 24, Table 3324. Real growth rates for GNP for the period 1980–1985 were also taken from *SALA*, Table 3301. Gross capital formation (civilian investment) as a percent of GDP was taken from the same source, Table 3366, for the years 1962, 1965, 1970, and 1975–1982. For the period 1950–1961, we assumed that 20 percent of GNP was devoted to gross capital formation (probably an optimistic estimate), while for 1971–1974 the estimate was derived by interpolation. For the period 1983–1985, gross capital formation was assumed to be 17 percent of GNP and 17.5 percent thereafter, based on the experience of recent years.

Labor force projections were taken from *Labor Force 1950–2000*, published by the International Labor Office (ILO) in 1977. The growth rate for the period 1995–2000 was assumed to apply thereafter until 2010.

Data for annual defense spending as a proportion of GNP were from the annual *Stockholm International Peace Research Institute (SIPRI)* volumes; for years after 1985, defense spending was assumed to be 2.5 percent based on a weighted average of the recent years' experience. Military capital investment was assumed to average 25 percent of total defense expenditures based on the experience of most non-U.S. NATO countries. The exceptions are 1982 when it was assumed to be 10 percent and 1983 when it was assumed to be 40 percent, because of the Falkland war.

Estimation

The GNP for years beyond 1985 was estimated using the production function method described above. The share of capital in GNP was assumed to be 0.35, and the annual rate of technological change was assumed to be 0.5 percent. To obtain the annual civilian capital stock numbers, we assumed that in 1950 the ratio of the capital stock to the GNP was 2.5, based on the historical experience of the United States. The annual rate of depreciation for civilian capital was assumed to be 5 percent.

The military capital stock was derived by the "past and future" approach described earlier. The depreciation rate for computing in the future direction was assumed to be 3.5 percent and in the past direction, 5 percent. Once having estimated the 1985 figure by means of the "future" method, the imputed figures for the earlier years were derived and used based on "past" calculations employing the 5 percent depreciation rate.

The data reported in *SALA* are already given in dollars, so no conversion is necessary. It is not clear, however, whether these data were originally converted using the exchange rate or a PPP index.

BRAZIL

Data Sources

As with Argentina, GNP data were taken from *SALA*, Table 3324, for the period 1950–1980. The annual GNP growth rates for the years 1981–1985 are available from the same source, Table 3303, and were used to derive the actual GNP figures for those years. Data for the gross fixed capital formation for the years 1962, 1965, 1970 and 1975–1983 are from *SALA*, Table 3366. Gross fixed capital formation was assumed to be 20 percent of GNP for the period 1950–1961, 21.25 percent for the years 1983–1985, and 21 percent subsequently. The latter two figures are based on the weighted average of the most recent years for which gross capital formation data were available. Implicit compound growth rates were computed for the intervals 1966–1969 and 1971–1974, and figures applicable for the various years in those intervals were interpolated.

The labor data are taken from the ILO publication, *Labor Force 1950–2000*, cited earlier. The growth rate for the period 1995–2000 was assumed to hold until 2010.

Defense spending as a proportion of GNP is taken from the *SIPRI* volumes; for the years after 1985, it is assumed to be 0.7 percent, based on the experience of recent years. It is also assumed that 25 percent of the defense budget is devoted to capital expenditures for all years, based on the general experience of the non-U.S. NATO countries.

Estimation

The GNP forecasts are based on the production function model described earlier. Capital's share in GNP was assumed to be 0.35 for all the years, and the annual rate of technological change was assumed to be 1.5 percent for years beyond 1985, reflecting a belief in the continued progress of the Brazilian economy. The civilian capital stock

series was constructed based on the assumption that the ratio of the capital stock to GNP in 1950 was 2.5, based on the historical experience of the United States and other countries. The annual depreciation rate for civilian capital was assumed to be 5 percent.

The military capital stock series was derived using the "future and past" approach described earlier. The depreciation rates used in the future and past directions were 3.5 and 5 percent, respectively.

No currency conversion is necessary as the data reported in *SALA* are already in dollars. Once again, it is not clear whether the data were originally converted using the exchange rate or a PPP index.

CHINA

Data Sources

The GDP (in 1980 dollars) for the years 1950 through 1980 were taken from Herbert Block, *The Planetary Product in 1980*, U.S. Department of State, Washington, D.C., 1981, pp. 42–43. These estimates are believed to be more reliable than the official Chinese figures. Estimates of GDP for the years 1981 through 1985 were obtained by applying a growth rate (derived from the Chinese estimates for that period) to Block's estimate for 1980: this official Chinese growth rate was judged to be more reliable than the GDP estimates themselves. The Chinese GNP estimate for 1980 in yuan was taken from Liu Guoguan, "On the Strategic Objectives of China's Economic Development," *Caimou jingji (Economics of Finance and Trade)*, 1983, No. 1, p. 5. The GNP estimate for 1985 in yuan was taken from *Zhongguo tongji nianjian 1986 (China Statistical Yearbook 1986)*.

Labor force data were from State Statistical Bureau, *Guanghui di san-shi-wu nian* (*The Glorious Thirty-Five Years*), China Statistics Publishing House, Beijing, 1984, p. 152. In the above data series, the labor force figures for 1950 and 1951 were missing; these were interpolated based on the assumption that the growth rate of the labor force was constant between 1949 and 1952. For the 1990s and beyond, labor input was estimated to grow at an annual rate of 1.5 percent. This low figure reflects assumptions of a successful family planning program and the increasing aging of the Chinese population.

Defense spending data were derived indirectly. For 1980 the defense spending figure was an average of high and low estimates from *World Military Expenditures and*

Arms Transfers, 1971–80, U.S. Arms Control and Disarmament Agency. Defense spending figures in yuan for the period 1950–1985 were also taken from the *Statistical Yearbook 1986*. First these yuan figures were converted into 1980 constant prices and then an index was created from the yuan estimates, with the mean defense spending in 1980 being equal to one. From this basis, the full stream of defense spending figures in dollars was derived. This approach was adopted because the yuan estimates published by the Chinese government are likely to have been inflated. The mean proportion of GDP devoted to defense was 3.1 percent in 1985 according to the above method.

The amount of defense spending devoted to military capital was estimated through several steps. Estimates in (1974 constant prices) yuan were available for the years 1967 through 1983 from the Defense Intelligence Agency (DIA), *Chinese Estimated Defense Expenditures, 1967–83*, Washington, D.C., 1984, p. 13. The figure for 1966 was again a DIA estimate taken from *Defense and Economy*, Washington, D.C., 1980, pp. 3–4. Estimates for the years 1950 through 1965 were based on a regression of military investment on the gross value of output of the machine building sector (excluding farm machinery) for the period 1965–1971.

The amount of defense spending devoted to military capital was then converted into 1986 dollars in two different ways. A "high" estimate resulted from converting 1974 yuan into 1974 dollars using a purchasing-power parity index and then inflating 1974 dollars to 1986 dollars. The only PPP index that is available for China is for 1957 and is taken from the Central Intelligence Agency, *Yuan-Dollar Price Ratios for Communist China & the U.S. in 1957*, April 1964. This PPP index was used to convert 1974 yuan into 1974 dollars, which were then inflated into 1986 dollars. The underlying assumption is that the PPP index in 1974 is the same as in 1957. The "low" estimate was derived in the same fashion, except that a lower proportion of defense spending in GNP was assumed.

The actual figures for military capital investments are not shown; what is shown, however, is their depreciated sum to arrive at the military capital stock estimate. As we have two sets of estimates of the amount of defense spending devoted to military capital in each year, we obtain high and low estimates of the military capital stock. These two estimates served as bounds, from which the midpoints were calculated that are shown in Table 5 and Fig. 9. The technique by which the military capital investment estimates were converted into military capital stock figures is described below.

Estimation

The GNP forecasts are based on the production function model described earlier. The only difference is that the capital stock is not calculated explicitly. Instead, it is assumed that the capital stock grows at an average annual rate of 8.0 percent from 1985–1995 and 7.0 percent from 1995–2010. This reflects an averaging of the experiences of countries like Japan and South Korea, which had annual capital stock growth rates of 10 percent or more in past years, and India, whose capital stock annual growth was about 5 or 6 percent on average. The average annual rate of technological change, estimated to be zero in the years prior to 1985, was assumed to be 0.50 percent from 1985–1995 and 1.0 percent from 1995–2010 based on the historical experience of other countries which we considered applicable to China. The share of capital in GNP was assumed to be 0.4.

Defense spending is forecast to rise from 3.1 percent of GNP in 1985 to 3.5 percent of GNP from 1986–1990, 4.3 percent from 1991–1995, 5.0 percent from 1996–2000, and 6.0 percent from 2001–2010. The proportion of defense spending that is devoted to military capital is adopted from the "high estimate" described earlier: 30 percent from 1986–1995, 35 percent from 1996–2000, and 40 percent from 2001–2010. The corresponding figure in all years for the "low estimate" is 66 percent. The relatively high proportions of defense spending assumed to be devoted to military capital reflect the force modernization programs of the Chinese military establishment.

The military capital stock for the historical period is calculated using the "forward and backward" approach. The annual depreciation rates used are 3.5 percent in the forward direction and 5.0 percent in the backward direction. For the forecast years the annual depreciation rate applicable to military capital is expected to be higher in the Chinese case because of the force modernization and equipment retirement programs that the Chinese military establishment is likely to implement in the future. Accordingly, we have assumed the annual depreciation rate for military capital to be 7.5 percent from 1985–2010.

EGYPT

Data Sources

National accounts data for Egypt were taken from *International Financial Statistics, 1986,* published by the International Monetary Fund (IMF). These include the historical estimates of GNP and gross capital formation. For the forecast period, 1985–2010, we assumed that 20 percent of the GNP will be devoted to gross capital formation, based on the experience of recent years.

Labor force data and projections for the future were taken from the ILO publication, *Labor Force 1950–2000.* The labor force projections were modified, however, to take into account a rising level of unemployment and underemployment. We assumed that the employed labor force grows at only 80 percent of the growth rate that is implied by the ILO projections.

Defense spending data were taken from the annual *SIPRI* volumes. For the forecast period 1985–2010, we assumed defense spending to be 7.5 percent of GNP, based on the experience of recent years. Because of lack of data regarding the proportion of defense spending devoted to military capital, we assumed that 25 percent of defense spending was devoted to military capital for all the years based on the general experience of the non-U.S. NATO countries.

Estimation

The GNP was estimated by the method described above. The share of capital in GNP was assumed to be 0.35, and the annual rate of technological change was assumed to be 0.2 percent. The ratio of the civilian capital stock to GNP in 1950 was assumed to be 2.5, and capital stock estimates for the later years were calculated based on that assumption. The annual depreciation rate used for civilian capital was 5 percent.

The military capital stock was derived by the "forward and backward" estimation method described earlier. The annual depreciation rates used were 3.5 percent and 5 percent in the forward and backward directions, respectively.

All calculations were performed in the national currency and then converted into dollars using the appropriate PPP index.

FEDERAL REPUBLIC OF GERMANY

Data Sources

The GNP and civilian gross investment from 1950 through 1985 were obtained from the *International Financial Statistics, 1985*, published by the International Monetary Fund. Analysis of these data indicates that the share of civilian investment in GNP in 1985 was about 20 percent, and this was assumed to hold for the entire forecast period.

Labor data for the period 1960–1980 were from the Organization for Economic Cooperation and Development (OECD), *Historical Statistics: 1960–1980*, Paris, 1982. For years after 1980, the data were from the U.S. Bureau of the Census forecasts.

Historical defense spending for the period 1950–1985 was from data published by Program Analysis and Evaluation (PA&E), Office of the Secretary of Defense. Based on historical experience, we assumed that West Germany will devote roughly 3.2 percent of its GNP to defense. Using the *Report on Allied Contributions to the Common Defense*, Report to the United States Congress by Caspar W. Weinberger, Secretary of Defense, April 1987, we estimate that roughly 25 percent of defense spending was devoted to military capital. This figure is assumed to apply for the subsequent years, as well.

Estimation

The GNP was estimated according to the model described earlier. The share of capital in GNP was assumed to be 0.35, and annual technological change was 1.5 percent. The civilian capital stock was calculated by assuming that the ratio of the capital stock to GNP in 1950 was 2.5. The annual depreciation rate used for civilian capital was 5 percent.

The military capital stock was forecast using the "forward and backward" approach, with depreciation rates of 3.5 and 4.5 percent, respectively.

Estimates in marks were converted to dollars using the PPP index.

FRANCE

Data Sources

The GNP and civilian gross investment from 1950 through 1985 were obtained from *International Financial Statistics, 1985*. Analysis of these data indicates that the share of civilian investment in GNP in 1985 was approximately 19 percent. This figure was assumed for the entire forecast period.

Labor data for the period 1960–1980 were taken from *Historical Statistics: 1960–1980*, OECD, Paris, 1982. For years after 1980, the data were from the U.S. Bureau of the Census forecasts.

Historical defense spending for the period 1950–1985 was taken from the data published by the Office of the Secretary of Defense. Based on historical experience, we assumed that France will devote about 3.3 percent of its GNP to defense. Based on the *Report on Allied Contributions to the Common Defense*, Report to the United States Congress by Caspar W. Weinberger, Secretary of Defense, April 1987, we estimate that roughly 25 percent of French defense spending is devoted to military capital. This was assumed to apply in the future, as well.

Estimation

The GNP was estimated in the usual way, as described above. The share of capital in GNP was assumed to be 0.35, and the annual rate of technological change, 1.5 percent. The civilian capital stock was calculated by assuming that the ratio of the capital stock to GNP in 1950 was equal to 2.5. The annual depreciation rate used for civilian capital is 5 percent.

The military capital stock is forecast using the "forward and backward" approach, with corresponding depreciation rates of 3.5 percent and 4.5 percent, respectively.

Estimates in francs were coverted to dollars using the PPP index.

INDIA

Data Sources

The national accounts data for the period 1950–1984, including estimates of GNP, gross fixed capital formation (annual investment), inflation (GDP deflator), and total population, are from *International Financial Statistics* published by the International Monetary Fund. For the forecast years, we assume that gross capital formation increases linearly from 21 percent in 1984 to 25 percent in 2010, reflecting the general trend observed in other Asian countries.

For the years after 1984, labor supply figures were derived from United Nations' forecasts. We assumed that the labor force grows with the cohort of all those between ages 15 and 64.

The share of GNP devoted to defense for the various years is taken from the *SIPRI Yearbook, 1974*, and *World Military Expenditures and Arms Transfers, 1965–1974 & 1985*, published by the Arms Control and Disarmament Agency (ACDA). For the future, we assumed that 4 percent of GNP is devoted to defense spending. This figure is slightly higher than the 3.5 percent experience of recent years, reflecting India's force modernization programs and the expansion of the Indian Navy.

The above sources do not indicate the percentage of defense expenditures devoted to military capital, but the fraction of the defense budget devoted to military capital expenditures, for certain years, is available in the *Statistical Outline of India*, published by Tata Industries, Bombay. (Figures for the missing years were obtained by interpolation.) These statistics are presumably compiled from various government documents. It is, however, not clear what types of outlays are covered by military capital expenditures. For the 1990–2010 period, we assumed that 20 percent of defense spending is devoted to military capital.

The proportion of defense spending devoted to military capital reflects the general historical trend, but is expected to be maintained at a level somewhat below that of the NATO countries because of the labor-intensive structure of India's forces and the mountainous terrain characterizing its vast border with China.

Estimation

The GNP is forecast according to the same method used for the other countries. The share of capital in GNP was estimated to be 0.45. The parameter a, for the rate of change of technological productivity, was estimated to be not significantly different from zero.

To obtain the stream of the civilian and military capital stock values, assumptions were made regarding their reasonable values in 1950. These served as the starting values. The civilian capital stock was estimated as 1.3 times the GNP based on assumptions concerning investment, GNP levels and growth, and depreciation rates (5 percent) in the period prior to 1950.

For the military capital stock in 1950, we assumed that the share of defense expenditure devoted to "capital" was only for purposes of making up for depreciation, without new investment. Under such an assumption, the capital stock is equal to the capital expenditure divided by the depreciation rate. The above assumption seems reasonable as in 1950, just three years after independence, the national focus was largely

on development and not defense. The annual 1985–2010 depreciation rate used for military capital is 3.5 percent because while the Indian military is engaged in a modernization program, retirement rates are expected to be low, in contrast to the Chinese case.

JAPAN

Data Sources

The principal data source for the Japanese economy is the *Annual Report on National Accounts, 1986*, and its earlier edition, the *Annual Report on National Income Statistics, 1970*, published by the Economic Planning Agency. An additional source is the *Japan Statistical Yearbook (1960–1983)*, compiled by the Statistics Bureau of the Management and Coordination Agency. For the forecast period, gross capital formation (civilian investment) was assumed to be 28 percent of GNP, based on the average of previous years.

The labor input into the Japanese economy was assumed to be the total number of persons employed.

Military expenditure data were from the *Defense Yearbook* (Boei Nenkan, 1953–1974); *Yearbook of the Self-Defense Forces* (Japan Defense Agency, Tokyo, 1963–1974); and *Defense of Japan* (Japan Defense Agency, Tokyo, 1976–1986). There is an unexplained discrepancy of about 7 to 10 percent between the figures for the military budget and the actual expenditures. However, budget figures are preferred because they provide a breakdown of total planned outlays, which is required for computing the military capital stock.

For the forecast period, we assumed, as the base case, that 1 percent of the GNP is devoted to defense spending, based on the experience of the last decade or so. Another case where Japan devotes 3 percent of its GNP to defense spending was also estimated, to bound the forecasts. The proportion of defense spending devoted to military capital was assumed to be 25 percent for the future years based on the historical average.

Estimation

The economic trends are forecast using the familiar production function method. For 1980–1984, the capital share in GNP was estimated to be 0.37 and the annual rate of technological change 1.3 percent; both figures are assumed to hold for the forecast period

also. The results of this direct estimation corroborate the general results of research in economic development and increase the credibility of our assumptions for countries where direct estimates of these parameters were not made. The annual rate of depreciation for civilian capital was assumed to be 6 percent, based on historical data.

For the military capital stock, data are available for the years since 1950. The full stream is built from 1950 onwards using an annual depreciation rate of 5 percent.

Note that all calculations are performed in the national currency and then converted to dollars using the PPP index. For Japan, however, the exchange rate and the PPP index differ only slightly in 1980.

MEXICO

Data Sources

National accounts data for Mexico, including estimates of GNP and gross capital formation, are from the *International Financial Statistics, 1986*, published by the IMF. For the forecast period, it was assumed that 20 percent of GNP would be devoted to gross capital formation.

Labor force data were from the ILO publication, *Labor Force 1950–2000*. These projections were modified to take account of a rising level of unemployment and underemployment. We assumed that employment growth would be 80 percent of the total labor force growth rate implied by the ILO projections.

Defense spending data were taken from the *SIPRI* volumes. For the forecast period, annual defense spending was assumed to be 0.6 percent of GNP, based on recent experience. The proportion of annual defense spending devoted to military capital was assumed to be 25 percent, based on the general experience of other countries.

Estimation

The GNP was forecast using the standard production function model. The share of capital in GNP was assumed to be 0.35 and the annual rate of technological change, 0.2 percent, reflecting Mexico's experience in the last decade, as well as the recent downturn in the Mexican economy. The ratio of civilian capital stock to GNP in 1950 was assumed to be 2.5. The civilian capital stock estimates were made a assuming 5 percent annual depreciation rate.

Military capital stock estimates were based on the "forward and backward" approach, described earlier. Annual depreciation rates for military capital were 3.5 percent and 5 percent for the forward and backward directions, respectively.

Calculations were made in national currency and then converted to dollars using the PPP index.

SOUTH KOREA

Data Sources

South Korea's GDP and civilian investment figures for the period 1953–1984 were taken from the IMF's *International Financial Statistics (IFS)*. For the later years, it was assumed that 30 percent of GDP would be devoted to civilian capital investment, based on South Korea's experience over the past decade.

The population cohort between ages 15 and 64 was used as a proxy for the labor input. For the years previous to 1985, this cohort was estimated by multiplying the *IFS* population data by the percent of working age, derived from the World Bank's *World Development Reports* (*WDR*). For the forecast years, labor supply is based on the U.S. Census Department population forecasts by age category, with interpolation for missing years.

The estimates of military spending and military capital are based on data from the Korea Institute for Defense Analysis in Seoul. These data were available only for 1961 through 1982. For the future years, the share of GDP devoted to defense and the share of defense spending devoted to military capital were assumed to be the same as in 1982; namely, 5.8 percent and 31.8 percent, respectively.

Estimation

The GDP is forecast using the production function approach. The capital share of GDP was assumed to be 0.45 and the annual rate of technological change, 1.5 percent, representing the average rate of technological change observed for 1975–1984. The civilian capital stock was calculated iteratively so that the ratio of investment to capital stock in the base year is equal to the average level for the entire period. The annual depreciation rate for the above calculation is assumed to be 5 percent.

The military capital stock was also derived iteratively, using an annual depreciation rate of 5 percent.

National currency values are transformed into dollars using the exchange rates published in the *International Financial Statistics.*

TAIWAN

Data Sources

The GDP (1980 constant dollars) for the years 1950 through 1980 were from Herbert Block, *The Planetary Product in 1980*, U.S. Department of State, Washington, D.C., pp. 36–37. For the years 1981 through 1985, GDP is based on a GDP index in 1981 constant prices based on data in *Industry of Free China*, January 1987, p. 50.

Labor force data are from the *Taiwan Statistical Data Book 1985*, Council for Economic Planning and Development, Taiwan, 1985. For the forecast period, the labor force is expected to grow at roughly 2 percent annually.

Defense spending data for 1961 through 1983 were from *World Military Expenditures and Arms Transfers* (various issues) published by ACDA. Estimates of defense spending for 1954 through 1960 were derived by regressing defense spending on total government expenditures for the period 1961–1970. Data on government expenditures and defense spending for 1961–1970 were taken from the previously cited *Taiwan Statistical Data Book 1985*. For the years prior to 1953, defense spending was derived on the assumption that the defense burden as a fraction of GNP was the same as in 1954. For 1984–1985, defense spending was based on the 1983 figure and an index of defense spending in the *Statistical Yearbook of the Republic of China 1986*, Waiwan, Taipei, p. 179.

Military investment as a proportion of defense expenditure was assumed to be the same as that for South Korea—see Charles Wolf et al., *The Changing Balance: South and North Korean Capabilities for Long-Term Military Competition*, The RAND Corporation, R-3305/1-NA, December 1985, p. 47.

Estimation

The GDP was estimated in the usual way. As in the case of China, the civilian capital stock was not explicitly derived. Instead, it was assumed to grow at an annual rate of 4 percent. The capital stock growth rate is based on data contained in Wu Hui-lin, *The Estimation and Application of Capacity and Capital Utilization Rates in Taiwan*, Chung-Hua Institution for Economic Research, Taipei, 1983, pp. 67–69. The annual rate

of technological change was assumed to be 3 percent based on Taiwan's experience in the 1970s. The share of capital in GDP is assumed to be 0.4.

Annual defense spending as a fraction of GDP was assumed to be 6 percent, based on recent experience, and the proportion of defense spending devoted to military capital was assumed to be 29 percent, the same as that for South Korea. Annual depreciation for military capital was assumed to be 8 percent. Military capital stocks were estimated employing the general methodology described earlier.

TURKEY

Data Sources

The GDP figures from 1950 through 1984 are from PA&E, Office of the Secretary of Defense. For the future years, we assumed that the proportion of GDP devoted to civilian capital investment rises from 25 percent in 1981 to 30 percent in 2010, based on recent historical experience and the trend in gross capital formation in other rapidly developing countries.

Labor input is estimated as the population between ages 15 and 64. For the years prior to 1985, we used the *IFS* population data multiplied by the percent of the working age population, according to the *WDR*. For the forecast years, the labor figures are based on the U.S. Census Department population forecasts by age category. Both series required interpolation for the missing years, based on an exponential function for the population series and linear interpolation for the working age group.

The defense spending estimates were based on PA&E estimates. For the forecast years, the proportion of GDP devoted to defense was assumed to be 4.5 percent, the same as for 1985. The proportion of defense spending devoted to military capital was assumed to be 25 percent.

Estimation

The GDP was forecast using the production function approach. The capital share of GDP was assumed to be 0.45 and the rate of technological change, zero, reflecting past experience. The civilian capital stock is calculated iteratively so that the ratio of investment to capital stock in the base year is equal to the average level for the entire period. The annual depreciation rate for the above calculation is assumed to be 5 percent.

The military capital stock was derived as described above, using an annual depreciation rate of 5 percent.

National currency values were converted to dollars using the exchange rates published in the *International Financial Statistics.*

UNITED KINGDOM

Data Sources

The GNP and civilian gross investment figures from 1950 through 1985 were from the *International Financial Statistics, 1985*, published by the IMF. The data indicate a share of civilian investment in GNP in 1985 of about 17 percent, and this was assumed to hold for the subsequent years, as well.

Labor data for the period 1960–1980 were from *Historical Statistics: 1960–1980*, OECD, Paris, 1982, and for subsequent years from U.S. Bureau of the Census forecasts.

Defense spending for 1950–1985 is from PA&E, Office of the Secretary of Defense. For the forecast period, we assumed that the UK will devote roughly 5.3 percent of its GNP to defense. Based on the *Report on Allied Contributions to the Common Defense*, a Report to the United States Congress by Caspar W. Weinberger, Secretary of Defense, April 1987, we estimate that roughly 25 percent of defense spending has been and will be devoted to military capital.

Estimation

The GNP is forecast using the production function approach, assuming a capital share in GNP of 0.35 and an annual rate of technological change of 1 percent. The civilian capital stock was calculated based on the assumption that the ratio of the capital stock to GNP in 1950 was equal to 2.5 and using an annual depreciation rate of 5 percent.

The military capital stock was forecast using the "forward and backward" approach described earlier, with depreciation rates of 3.5 and 4.5 percent, respectively.

Estimates in sterling were converted to dollars using the PPP index.

SOVIET UNION

Data Sources and Estimation

Historical GNP, civilian investment, and defense spending data in 1970 rubles were from *USSR: Measures of Economic Growth and Development, 1950–1980*, Joint Economic Committee, Congress of the United States, December 8, 1982. GNP and defense spending data have been updated to 1985 as the base forecast year, using *Gorbachev's Modernization Program: A Status Report*, prepared by the Central Intelligence Agency for the Subcommittee on National Security Economics of the Joint Economic Committee, Congress of the United States, March 19, 1987. Information contained in Vasiliy Selyunin and G. Khanin, *Cunning Figures*, NOVY MIR, February 1987, pp. 181–201, indicates that economic growth from 1980–1985 was considerably lower than estimated by the U.S. intelligence community. The Selyunin-Khanin data were used to construct the base-case estimates.

Using our update of *Gorbachev's Modernization Program*, civilian investment is estimated at about 33 percent of GNP in 1985, while Selyunin-Khanin material indicates civilian investment of about 29 percent of GNP in that year.

Civilian capital stock data through 1980 are contained in *Soviet Statistics on Capital Formation*, Central Intelligence Agency, SOV 82-10093, August 1982. The capital stock data can be updated through 1985 using *Gorbachev's Modernization Program*, or using Soviet data combined with Selyunin-Khanin's conclusion that annual inflation in the Soviet investment data was 5 percent. The latter updating approach was used in constructing the base-case estimates. Our analysis of the historical civilian capital stock data indicates that Soviet civilian capital stock depreciates at about 3.5 percent per year, and this rate has also been used for the forecast period.

Labor force data are contained in Stephen Rapawy and W. Ward Kingkade, *Estimates and Projections of the Labor Force and Civilian Employment in the U.S.S.R.: 1950 to 2000*. These data have been updated to 2010 using population data from Ward Kingkade, *Estimates and Projections of the Population of the USSR by Major Nationality: 1979 to 2050*, Bureau of the Census, December 1986.

When the data since the mid 1970s are updated based on *Gorbachev's Modernization Program*, a labor share of 0.65 with no growth in total factor productivity can be inferred. However, using Selyunin-Khanin results in a labor share of 0.85 with no growth in total factor productivity over the 1974/5–1985 period.

The historical share of defense spending allocated to military investment is contained in *Estimated Soviet Defense Spending: Trends and Prospects*, CIA, SR 78-10121, June 1978. A military capital series was constructed for 1950–1985 using the "forward and backward" approach described earlier, with depreciation rates of 3.5 percent and 4.5 percent, respectively.

To convert GNP from 1970 rubles to 1985 dollars, data in *Gorbachev's Modernization Program* were employed. To convert defense spending and military capital to 1985 dollars, we employed *The Annual Report to the Congress, Fiscal Year 1987*, Caspar W. Weinberger, Secretary of Defense, and *The FY 1987 Department of Defense Program for Research and Development*, Statement by the Under Secretary of Defense, Research and Engineering to the 99th Congress, Second Session, 1986.

Base Case

Based on the previously cited report prepared for the U.S. Congress, the ratio of Soviet GNP to U.S. GNP was roughly 0.53 in 1980. Data from Selyunin-Khanin, indicating very slow growth between 1980 and 1985, were used to update the 1980 GNP and civilian capital figures to 1985. Using the CIA estimate of Soviet defense spending in 1970 rubles, one obtains a defense burden of 15 percent in 1985. Also as indicated above, labor's distributive share was assumed to equal 0.85 in the base case, and the capital share 15 percent.

In the base case, we assumed that there was zero growth of total factor productivity through 1990, and 0.5 percent annual growth for the remainder of the forecast period.

Alternative A: *Perestroika* Succeeds

The 1980 GNP estimate obtained from *USSR: Measures of Economic Growth and Development* was updated using *Gorbachev's Modernization Program.* As in the base case, the ratio of Soviet GNP to U.S. GNP was assumed to be 0.53 in 1980. Using CIA data on Soviet defense spending in 1970 rubles implied a burden of 14 percent.

Civilian capital stock data contained in *Soviet Statistics on Capital Formation* were updated using *Gorbachev's Modernization Program.* Based on the previous labor series, forecasts were made assuming that labor's share of GNP is 0.65; total factor productivity was unchanged through 1990 and grew at an annual rate of 1.5 percent thereafter.

Alternative B: *Perestroika* Fails

In this case, Soviet GNP was assumed to be only 40 percent that of the United States in 1980, reflecting a judgment by various analysts that the 53 percent used in the base case is unrealistically high. The 1980 GNP figure was updated to 1985 using the slow-growth estimates of Selyunin-Khanin for the intervening years. The military burden in 1985 was assumed, in this case, to be 20 percent. Using the specified labor series, forecasts were made under the assumption that labor's distributive share was 0.85 and that total factor productivity was unchanged through 1990 and grew at a 0.5 percent annual rate thereafter.

Alternative C: *Perestroika* Succeeds

In this case, the assumptions were the same as in Alt. B except that total factor productivity growth was assumed to be 1.5 percent after 1990. By using a more conservative estimate of Soviet GNP for 1980 compared with Alt. A, this scenario provides a lower bound to Soviet economic and military potential in the eventuality that *perestroika* succeeds.

Alternative D: *Perestroika* Succeeds

This alternative is the same as Alt. A except that Soviet military spending was held constant at the 1990 level (314 billion 1986 U.S. dollars) throughout the 1990–2010 period. Hence, as a proportion of GNP, defense spending would fall from 13.1 percent in 1985 to 6.7 percent by 2010.

UNITED STATES

Data Sources

Historical figures regarding GNP are taken from the *Economic Report to the President (ERP), 1987*. Data for the civilian capital stock are taken from John C. Musgrave, "Fixed Reproducible Tangible Wealth in the United States: Revised Estimates," *Survey of Current Business*, January 1986. For the forecast period (1986–2010), the proportion of GNP invested in civilian capital was assumed to be 16.3 percent, representing the average for 1980–1985.

Data for the labor input and gross civilian investment are also from the *ERP*. For the forecast period, labor is expected to grow at the 1980–1985 annual rate of 1.0 percent.

Data for defense spending are also from the *ERP*. The proportion of defense spending devoted to military capital was drawn from data of the U.S. Department of Commerce (DOC), which will be published soon. The DOC data break military capital into procurement and construction. Although procurement is probably more representative of military potential in a narrow sense, we use both components combined to obtain the U.S. military capital stock estimates, for reasons of comparability with other countries.

We assumed that the ratio of GNP devoted to defense remains at 6.2 percent (1980–1985 average) for the entire 1986–2010 period. The share of the defense budget devoted to procurement was assumed to be 29 percent and that to construction, 2 percent, representing averages for 1962–1986. The annual depreciation rates assumed for the above two components of the military capital stock were 5.8 percent (1950–1985 average) and 1.7 percent (1980–1985 average), respectively. For the depreciation rate applicable to military equipment, the 5.8 percent average over the full historical period was used because the 1980–1985 average (0.039 percent) was considered unrepresentative—it reflects the rapid equipment buildup of the last few years.

Estimation

The GNP is forecast using the standard production function approach employed for all the countries in the samples. We assumed that the capital share in GNP is 0.35 and that the annual rate of technological change is 1.0 percent (1980–1985 average). The civilian capital stock series for the forecast period was constructed using an annual depreciation rate of 2.3 percent (1980–1985 average).

The military capital stock was constructed in a similar manner, based on our data for defense spending and military capital investment and on the appropriate depreciation rates for the two components.