Comparisons and Implications of Alternative Views of the Soviet Economy

Mark M. Hopkins, Michael Kennedy
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Comparisons and Implications of Alternative Views of the Soviet Economy

Mark M. Hopkins, Michael Kennedy

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PREFACE

This report uses the Hopkins-Kennedy optimal control model of the Soviet Union to explore the implications of and make comparisons between three “worlds” (views) that hold differing assumptions concerning the nature of the Soviet economy. These are the “Birman world,” the “CIA world,” and the “Rosefielde-Lee world.” A secondary objective is to investigate a large number of scenarios concerning foreign trade so as to improve understanding of this important aspect of the Soviet economy. This is the second in a series of reports that use the relatively new optimal control methodology. In both this report and its predecessor, estimates are made of the tradeoff curve between Soviet consumption and defense spending for the 1980s and of how this curve is affected by various parameters and uncertainties. The model is explained in detail in the first report by Mark Hopkins, Michael Kennedy, with the assistance of Marilee Lawrence, *The Tradeoff Between Consumption and Military Expenditures for the Soviet Union During the 1980s*, The Rand Corporation, R-2927-NA, November 1982.

The project has been sponsored by the Director of Net Assessment, Office of the Secretary of Defense. This report should be of general use to analysts and decisionmakers concerned with the Soviet economy, and of particular use to those interested in predicting Soviet GNP, consumption, and defense expenditures, or in studying Soviet foreign trade issues of the 1980s. It will also be of interest to those concerned with the development and use of optimal control theory for the modeling of centrally planned economies.
SUMMARY

Igor Birman, the CIA, and, taken as a team, Steven Rosefield and William Lee hold dramatically different views of the current and future state of the Soviet economy. If Birman is correct, the Soviet economy is in a severe crisis and faces a bleak future. If Rosefield and Lee are correct, the Soviet economy is in excellent condition and has a bright future. The CIA takes an intermediate view. We define the Birman, CIA, and Rosefield-Lee views and their implications for the future to be the Birman, CIA, and Rosefield-Lee "worlds," respectively. The Soviet economy in the "Birman world" is smaller than it is in the "CIA world," and has a larger defense share and slower technological growth. The Soviet economy in the "Rosefield-Lee world" is larger than it is in the "CIA world" and has a larger defense share and faster technological growth.

The primary objective of this report is to determine and compare the implications of the three worlds. A secondary objective (which is an add on to this phase of the project as originally conceived) is to develop and analyze a large number of foreign trade scenarios to improve our understanding of the role of foreign trade in the Soviet economy.

Our main approach is to employ the Hopkins-Kennedy optimal control model of the Soviet Union to calculate tradeoff curves between the average annual rate of growth of consumption and the average annual rate of growth of defense spending for the Soviet economy for the 1980s. Tradeoff curves for 71 scenarios are calculated and presented in various graphs.

When we explore a particular issue (e.g., the price of gold), our usual procedure is to define a high and low price scenario for the "CIA world" and then calculate and compare the corresponding pair of tradeoff curves. Next, we calculate the pairs of tradeoff curves for the same scenarios for both the Birman and the Rosefield-Lee "worlds," and then compare all three pairs of tradeoff curves.

The West could increase the pressure on the Soviet economy by means of foreign-trade-related policies intended to produce some combination of the following effects: reducing the amount of credit extended to the Soviets by the West, increasing the amount of foreign aid that the Soviets give to their client states, "opening of the umbrella" by the Soviets (their taking some responsibility for the debts of client Eastern European nations), and reducing the efficiency superiority of Western capital exported to the Soviet Union as compared with Soviet-produced capital. Departures from the base case
assumptions concerning these issues can also occur in the remainder of
the decade for reasons unrelated to Western policies. We find the
impact of these considerations, except for capital efficiency, to be small
when dealt with in isolation, but to be substantial considered together.

Soviet foreign trade issues can be defined more broadly so as to
include gold prices, agricultural prices, weather, and Soviet oil prices
and production. The results indicate that gold prices and weather
issues are of small importance, while oil issues and agricultural prices
are of substantial importance.

Comparisons of the pairs of curves for the three worlds provide
several interesting results. Since the tradeoff curves are measured in
terms of rates of growth of consumption and defense, a change of given
dollar size will tend to have a larger impact on a "world" the smaller
the size of the GNP and the lower its growth rate. Examples include:
a change in the amount of credit extended to the Soviets, a change in
the amount of oil produced by the Soviets, and a change in the price of
gold. We label this effect the "size effect." It has a larger impact on
the "Birman world" than on the "Rosefielde-Lee" world with the "CIA
world" in between.

An effect running in the opposite direction is associated with
changes in prices of agricultural imports. It is larger for the
"Rosefielde-Lee world," smaller for the "Birman," and intermediate for
the "CIA world." This occurs because the larger the decade average
GNP of a world, the more agricultural imports are needed to satisfy
consumption, and hence, the greater the importance of agricultural
prices to the economy. This effect and the size effect interact to make
the total impact of agricultural prices largest for the "Rosefielde-Lee
world," smallest for the "CIA world," and intermediate for the "Birman
world."

Changes in oil prices have an effect which reinforces the size effect.
The larger the decade average GNP of a world, the greater its domestic
oil consumption and the smaller its oil exports; thus, the smaller the
impact of changes in oil prices.

The impact for the three worlds of changes in the efficiency ratio of
imported capital as compared with Soviet domestically produced capital
is too complicated to be discussed more than cursorily in this summary.
At high levels of defense growth such changes tend to be important
because: the Soviets then need heavy imports of capital because they
are channeling into weapons production a large fraction of their Soviet
economic capacity to build capital goods. As the rate of defense growth
is lowered (and, hence, the rate of consumption growth is raised), the
level of agricultural imports rises at the expense of capital imports,
reducing the impact of changes in the efficiency ratio. This occurs
faster for the “Rosefield-Lee world” than for the “Birman world,” with the “CIA world” being intermediate, because of the generally greater demand for agricultural goods in the worlds with the larger, more dynamic economies.

To test which of the three worlds is the most accurate representation of reality, we calculated shadow prices for oil for each of the worlds for the 1970-1980 period. These prices measure the actual value of oil to the Soviet economy; they need have no particular relation to the prices that were assigned by the Soviet government. During this period the real world price for oil, as a consequence of the 1973 oil embargo, increased 500 percent. Given the Soviets' strong connection with the world oil market because of their substantial oil exports, their oil shadow price should have increased during this period. Our preliminary results indicate that this is what happened in the Rosefield-Lee and CIA “worlds.” For the “Birman world,” the shadow price actually dropped. We interpret these results as new evidence against the dynamic aspects (rate of total factor productivity and GNP growth) of the “Birman world.”

For the “CIA world” uncertainty concerning the rate of growth of total factor productivity for the remainder of this decade was found to have the largest impact of all the issues studied.

The main conclusions of this report are that credit, the price of gold, and weather have only a small economic impact; that agricultural prices, oil issues, and credit, when augmented by related scenarios such as increased Soviet foreign aid, “opening the umbrella,” and, particularly, relative capital efficiency have substantial impact; that technology, and, to an even greater extent, the issue of which of the three worlds is correct, have a dramatic impact; and that there are reasons to doubt the dynamic aspects of the “Birman world.”
ACKNOWLEDGMENTS

This project has benefited substantially from the insightful comments of a panel of senior Rand experts, which was formed to follow the progress of the project through a series of internal Rand briefings. The members of this panel are Arthur Alexander, Abraham Becker, Mike Landi, and Charles Wolf, Jr. Research assistance and assistance with computer graphics were provided by Marilee Lawrence and Mitchell Tuller, respectively. We would also like to thank C. Lance Barnett, Don Henry, and David Epstein for comments on earlier drafts that led to numerous improvements.

While the research reported here was being done, Michael Kennedy was senior research fellow at the Institute for Constructive Capitalism at the University of Texas at Austin. He is grateful to the institute and particularly to its director, Professor George Kozmetsky, for generous provision of research support.
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I. INTRODUCTION

The primary goal of this report is to determine and compare, for a large number of interesting scenarios, the ramifications of three dramatically different views concerning the past and present state of the Soviet economy and their implications for the future. These are the views, or in our terminology, which will be defined more precisely later, the "worlds," of Igor Birman, the CIA, and Steven Rosefielde and William Lee. If it were discovered that either the Birman or the Rosefielde-Lee "world" was correct, instead of the more generally accepted "CIA world," the implications for U.S. policy, and for many other issues of general interest, would be enormous.

Birman argues that GNP in the Soviet Union is roughly 60 percent of what the CIA maintains it is. If this is true, despite the substantially greater defense share in GNP for which Birman also argues, the Soviet Union is a far weaker adversary than it is generally thought to be.

Further, Birman argues that the rate of total factor productivity growth is substantially below the already negative rate that the CIA maintains has persisted for the last few years and is likely to persist for at least the remainder of the decade. If Birman is correct, the Soviet Union is in desperate and rapidly worsening economic straits, with no relief in sight.

Indeed, if total factor productivity remains negative long enough, the Soviet economy will collapse. The picture is one of stagnation and decay, of Communism destroying itself because of its own internally generated poisons. In that case America can defeat the Soviets simply by a policy of containment, whereby the Soviet state will "wither away" for reasons not foreseen by Marx.

The "Rosefielde-Lee world" is dramatically different: GNP is approximately 30 percent larger than the CIA maintains. The share of defense in GNP is also larger than the CIA maintains, thus resulting in a level of defense spending that is 2/3 larger. According to this view the Soviet Union has been underestimated. It is truly a menacing giant that must be met with, among other things, a greatly expanded defense program.

Further, in the "Rosefielde-Lee world" rapid technological progress and growth are occurring. The giant is fast becoming larger. The Soviet economy is a dazzling success; the U.S. economy is the one that is mired in relative stagnation and, in at least a dynamic sense, is
inefficient. The United States must face the possibility that time is not on our side, and that in the long run the Soviets may "bury" us.

The secondary objective of the phase of the overall project covered by this report is to investigate a large number of foreign trade scenarios, to gain insight into the role of foreign trade in the Soviet economy. This objective is an add-on to the research as originally conceived.

Our main approach is to employ the Hopkins-Kennedy optimal control model of the Soviet Union to generate tradeoff curves between consumption and defense for 71 scenarios. The impact on the economy of a particular issue (such as the price of gold) is usually investigated by comparing the tradeoff curves for a high and a low scenario (i.e., high and low price of gold) for the "CIA world" and then extending the analysis to compare this pair of curves with the corresponding pairs for the Birman and Rosefielde-Lee "worlds." If there is little difference between the tradeoff curves in one pair, then the economic impact of the issue in question is small for that world.

The model, most of the data, and the base case for the "CIA world" are summarized in Sections II and III. These have been covered in greater depth in Hopkins et al., 1982, the first report of this project. Sections IV and V cover foreign-trade-related issues for the "CIA world." These include credit, increased Soviet foreign aid, "opening the umbrella" (whereby the Soviets help cover part of the debts of their Eastern European client states), the efficiency ratio of imported as compared with domestically produced capital, the price of gold (an export), agricultural prices (an import), and weather (which affects the level of agricultural imports). The base cases for the Birman and Rosefielde-Lee "worlds" are discussed and compared with each other and with the CIA base case in Section VI. The discussions in Sections IV and V are extended to the Birman and Rosefielde-Lee "worlds" in Section VII. Section VIII deals with oil supply and price issues, including the possibility of OPEC collapsing. Section IX contains calculations of oil shadow prices, a measure of the true value of oil to an economy, for each of the three worlds for the 1970–1980 period. Changes in these prices are compared with the actual 500 percent increase that occurred in world oil prices during that time period. Section X covers the impact of technology and a number of composite scenarios. The conclusions appear in Section XI. Appendix A explores the impact of some alternative specifications of the model. Appendix B discusses data changes that have occurred since the publication of our 1982 report.

Of the issues studied in this report, the impact on the economy of credit, the price of gold, and weather were found to be small. The
impact of agricultural prices, oil supply and price issues, and credit, when combined with the related issues of increased foreign aid, "opening the umbrella," and, particularly, the efficiency ratio of imported as compared with domestically produced capital, were found to be substantial. The impact of technology and, particularly, of the issue of which of the three worlds is the most accurate was found to be dramatic. Finally, our shadow price test for oil indicated that there are reasons to question the GNP and total factor productivity growth rate aspects of the "Birman world."
II. THE MODEL AND THE DATA

The main results presented in this report are generated by the Hopkins-Kennedy (HK) optimal control model of the Soviet Union; output from the model consists mainly of Soviet tradeoff curves from the 1980s between consumption and defense. These curves differ because of varying assumptions concerning such issues as foreign trade, weather, energy, and technical change; they also differ according to whose views of the Soviet economy are assumed to be correct—those of Rosefielsde and Lee, the CIA, or Birman. Since the model has been documented in a previous Rand report, it will be described only briefly here.\(^1\)

The use of an optimal control model to study the policy options open to the Soviet Union is relatively new. The more familiar approach is to use econometric models, which represent an economy with a system of equations. By estimating the parameters of these equations, one can identify the regularities in historical data. These models can then be used with relatively high accuracy for short-run forecasting scenarios, which assume that historical trends will continue. In contrast, optimal control models employ optimizing techniques that depend mainly on data for the year from which a projection begins rather than upon historical trends. They are relatively useful for long-run scenarios that allow for major departures from historical trends, such as those that are the primary concern of this report.\(^2\)

Consider an application of a simplified version of the model to a simple economy consisting of only two goods, consumption and defense, and having only a single time period. The model would calculate the set of all possible outputs of consumption and defense for the economy. The model's optimizing technique would then be used to find the subset of possible outputs where it is impossible to produce more of one of the two outputs without producing less of the other. This is a portion of the boundary of the set of all possible points.

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\(^1\)Hopkins et al., 1982.
\(^2\)While the Hopkins-Kennedy model employs historical trends far less than econometric models, such as SOVMOD (Green and Higgins, 1976), it does use them to some extent. The most important instance concerns what we assume for the rate of total factor productivity growth for the Soviet economy during the rest of the decade. All models of the Soviet economy that the authors are aware of make assumptions concerning this rate of growth by judgment which is influenced substantially by historical trends. The impact of alternative assumptions concerning total factor productivity growth are examined in Section X in some detail.
known technically as the production possibility frontier. For this simple case, it would be our tradeoff curve between consumption and defense.

The Soviet economy is well known for its many inefficiencies. The model, loosely speaking, takes these into account by assuming that inefficiencies in the economy in the initial year of a projection persist throughout the period covered by the projection. These inefficiency assumptions act as constraints on the optimization process used by the model to find a tradeoff curve. Total factor productivity is an exception to this rule. It is allowed to increase in an exogenously determined fashion.

THE CORE OF THE MODEL

It is useful to describe the core of the HK model separately from a number of special features that will be summarized in later sections of this report.

The model has 21 sectors, each of which produces a different good in accordance with a sector-specific translog production function. Labor and two types of capital, structures and machinery, are the inputs to the production functions. In addition to labor and capital, in order to be able to produce a unit of output, each sector requires a certain amount of each of the goods in the economy as intermediate input. These amounts are given by an input-output matrix which changes with time. Consumption and defense are defined to be certain aggregates of the outputs of the 21 sectors. Projections are made for a number of years, usually for the period 1980 to 1990. At the beginning of the first year, each sector is assumed to have an initial amount of each of the two types of capital. This is what will be available for productive purposes during the first year.

A solution to the model is a set of outputs of defense and consumption (one value of each for each year of the projection) that is feasible, given the resources and constraints that are relevant to Soviet decisionmakers. The optimizing procedure finds the boundary of the set of all such solutions, which gives us the desired tradeoff curve.

The purpose of the initial group of decisions that decisionmakers must make in the model during the first year (to generate a feasible solution) is to determine the value of the share of the labor supply that will be allocated to each sector. Once the labor shares are determined, the model uses the exogenously specified labor supply and the estimated production functions to determine outputs. Some of these outputs come from the investment goods sectors.
The second group of decisions that decisionmakers must make in the model in the first year is to determine the value of the share of investment goods to be allocated to each sector. This determination yields the amount of capital associated with each sector for the second year. This procedure is then repeated for the second and each succeeding year until the end of the period of interest. The result is a feasible solution to the model.

The set of all possible solutions to the model—the set of all possible outputs of defense and consumption—can be generated from the set of all possible decisions that decisionmakers can make. Optimal control techniques are used to find the boundary of this set and, hence, the desired tradeoff curve.

THE SECTORS

The first 18 of the 21 sectors of the HK model are concerned with producing the economic or material product portion of the economy. The energy portion of the economy was disaggregated somewhat more than usual because of its particular importance in this study. Sectors 19 and 20 cover defense. The last sector consists of the remainder of the economy, which is primarily military services. The 21 sectors are:

1. Ferrous metallurgy
2. Nonferrous metallurgy
3. Machine building metal working
4. Forest products
5. Soft goods
6. Processed foods
7. Construction materials
8. Coal and peat
9. Oil
10. Gas
11. Electric power
12. Chemicals
13. Paper and pulp
14. Construction
15. Agriculture and forestry
16. Transportation and communication
17. Trade and distribution
18. Industry not elsewhere classified (NEC) and other branches
19. Procurement
20. Nonprocurement defense
21. Other
For the 1980–1990 projections, military personnel payments, which are part of the nonprocurement defense sector, are assumed to remain constant in real terms at their 1980 level. This assumption implies that, for any given rate of growth of total defense spending, the average rate of growth of the nonpersonnel portion of defense spending will be higher than the rate of growth of total defense spending.

THE DATA FOR THE CORE OF THE MODEL

Our earlier report describes much of our data; here we briefly discuss the data concerning the core of the model, with emphasis on data that are new since the earlier report. Data concerning subjects other than the core of the model, such as foreign trade, energy, and various scenarios, are discussed in the remainder of the text. These discussions also emphasize data not covered in the earlier report.

A key set of data required by the model is an input-output table for the economy. We employ tables in producers prices that were constructed by Guill from data originally gathered by Treml and associates. These tables cover 1959, 1966, and 1972. In order to derive input-output tables for the in-between years, we interpolate logarithmically. Since input-output data for years after 1972 are not available, we employ for these years the same table as for 1972.3

The net output of the economy is also a key set of data. This is required by the model for the initial year of a projection. CIA estimates have been revised by Pitzer since our project’s 1982 report.4 They remain in a fairly aggregated form. They were disaggregated by weights calculated by Greenslade.5

Given the net outputs and the input-output table (which gives, among other information, the amount of the two types of capital required to produce a given unit of output for each sector), the level for the initial year of each type of capital associated with each sector can be calculated. The production function parameters are calculated primarily from the input-output data by a method discussed in detail in our project’s 1982 report.6

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3Guill, 1982.
4Pitzer, 1982.
5Greenslade, 1976.
6Hopkins et al., 1982.
Few input data are needed for the years after the base year in the projections. These are mainly for the labor supply\textsuperscript{7} and the rate of technological progress.\textsuperscript{8}

\textsuperscript{7}Our estimates of the labor supply are adjusted to reflect an efficiency superiority of 27 percent of Slav as compared with non-Slav workers. See Hopkins et al., 1982, for a discussion of this calculation and related issues.

\textsuperscript{8}Section X discusses the rate of technological progress.
III. THE BASE CASE FOR THE CIA WORLD

The dominant view among experts on the Soviet Union is that the "CIA world" is correct. This section examines our base case for the "CIA world." Section XI discusses the base case for the Rosefielle-Lee and Birman "worlds," and compares them with that of the CIA and with each other.

To be more specific than heretofore, by "CIA world" we mean the CIA's view of the economic history of the Soviet Union and the future implications of this view and of other data that the CIA believe to be generally correct. The CIA view, with regards to history, is well embodied in data series and qualitative accounts that have been published by the CIA and others. While there are differences of opinion in the agency, periodic data revisions, and the like, there is little divergence of opinion concerning the past. Such is not the case with regard to the future.

For instance, within what we have defined to be the "CIA world" there is a debate as to what the rate of growth of Soviet total factor productivity will be during the 1980s. In our CIA base case we assumed that it will be the same as it was in the 1970s (according to CIA data). Daniel Bond and Herbert Levine (the major figures behind SOVMOD, the best-known econometric model of the Soviet Union) have argued that the low rate of Soviet total factor productivity growth of the late 1970s (according to CIA data) was a fluke, and that it is reasonable to assume that in the 1980s it will resemble the substantially higher rate of an earlier period of Soviet history.1 On the other hand, the CIA itself has argued that the late 1970s was not a fluke, and that the growth rate in the 1980s will be a good deal smaller than we estimate in this report.2 These disagreements produce sharply different tradeoff curves between consumption and defense, as will be seen in Section X of this report where the issue is discussed in detail. The issue is brought up here to demonstrate that there is ample room for controversy within what we have defined to be the "CIA world." As a reminder that the "CIA world" does not exactly represent the views of any particular author, but rather the generic views of a group, we have placed the term "CIA world" in quotation marks throughout this report. This was also done for similar reasons, which are further

1 Bond and Levine, 1981.
discussed in Section VI, for the terms "Rosefielde-Lee world" and "Bir-
man world."

Figure 1 depicts the tradeoff curve between consumption and
defense relevant to our base case projection for the "CIA world"
1980-1990. Note how the tradeoff curve acts as a boundary for the
feasible rates of growth for consumption and defense. We calculate the
tradeoff curve as follows: We selected a given annual rate of growth of
defense spending. We then used the HK model to calculate, for this
rate of defense growth, a maximum discounted sum of consumption for
the decade. This sum was then converted into an equivalent average
annual rate of growth of consumption. The model we used to make the
calculations for Figure 1 was not the core of the HK model described in
the previous section, but the full HK model, which includes the various
special features concerning foreign trade, weather, the energy sectors,
etc., which are described in later sections of this report. The model
determines investment endogenously, subject to certain constraints
that are described in our 1982 report.

Fig. 1—CIA base case projection: 1980-1990
The rate utilized by the model to discount consumption was found by first estimating the rate that was implicitly used by the Soviet economy for the period 1960–1975. It was then assumed that this rate would be employed for the 1980s as well. (See our 1982 report for information on how this rate was calculated for 1960–1975 and on related historical verification tests of the model.)

It is useful to compare the predicted performance of the Soviet economy for the 1980s with the actual 1970s experience. In Figure 1 the 1970s experience according to CIA data is represented by a data point that lies outside the area bounded by the tradeoff curve. Thus, our base case predicts that the Soviets will not be able to accomplish during the 1980s what they did during the 1970s. The main reason for this is the substantial drop in the growth rate of the labor force, which was 1.8 percent during the 1970s and is expected to be only 0.4 percent during the 1980s. Additional minor factors that are incorporated in the HK model include the accelerating cost increases for obtaining energy raw materials, such as oil, and the expected increase during the 1980s of the rate of increase of non-Slavs in the labor force, who are less efficient than Slavs.

The HK model predicts that the rate of growth of capital will continue its long-run falling trend during the 1980s. This is because the rate of return on capital has been falling due to a rising capital output ratio. The HK model predicts that eventually the rate of return and the corresponding capital output ratio will become stable as it has been for some time in most nations of the industrialized West.

The expected fall in the growth rate of capital has a negative impact on the expected rate of increase of output. Despite this, the overall effect is a favorable shift in the tradeoff curve of Figure 1. This is because of an effect that more than counteracts the unfavorable impact on the tradeoff curve of the fall in the rate of growth of output—namely, that the lower growth rate of capital results in a lower percentage of output being invested, which in turn means that more of a given output is available for consumption and defense. This result, of course, depends on the fact that we are considering only a ten-year time period. Longer time periods would tend to make the impact of a fall in the growth rate of capital less favorable to the tradeoff curve.
Soviet foreign trade is of particular interest to American policymakers because of the possibility of placing restrictions on such trade and, hence, of pressuring the Soviets toward desired policies. It is also possible for the West to penalize the Soviets for undesirable behavior by following policies concerning foreign trade, and subjects closely related to foreign trade, which increase the costs of maintaining—not to mention expanding—the Soviet empire of client states. The Reagan administration has placed increased emphasis on such possibilities.

To a lesser extent, Western policies can also affect the values of certain foreign-trade-related parameters (such as the future prices of major imports and exports). The impact of differing values for these parameters on the Soviet economy is of interest. Our analysis of foreign trade covers this in Sections V and VII. In addition, certain foreign-trade-related parameters are also related to the topics covered in later sections and have been discussed there. For instance, the discussion concerning the price of oil in the “CIA world” is contained in Section VIII, the section on Energy. We are indebted to Gregory Grossman and Ronald Solberg for creating the initial versions of some of the foreign trade scenarios that we shall be examining.

This section analyzes, for the “CIA world,” issues concerning the impact on the Soviet economy of increased Soviet foreign aid in general, Soviet aid to prevent default in debt-ridden Eastern European countries in particular, credit extended from the West to the Soviets, and alternative values for the relative efficiency of imported and domestically produced capital. Section V discusses the implication for foreign trade in the “CIA world” of various scenarios concerning gold, agriculture, and weather. Section VII extends the discussion of Sections IV and V to the Birman and Rosefeldt-Lee “worlds.”

A brief description of the foreign trade part of the HK model is useful for understanding what follows. There are three endogenous variables that involve trade between the Soviet Union and the industrialized West: Soviet oil exports, Soviet agricultural imports, and Soviet MBMW (machine building metal working) imports. In the last half of the 1970s, oil represented over 40 percent of Soviet exports to the

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1Grossman and Solberg, 1983.

2See Hopkins et al. for a more detailed discussion of the foreign trade aspects of the model, including a mathematical description.
West. The combined value of agricultural and MBMW imports was over 50 percent of the total imports from the industrialized West. The remainder of trade is handled exogenously. There are also parameters that can be altered according to the dictates of the scenario being investigated that measure the amount of net credit extended by the West to the Soviets, and the relative efficiency of imported and domestically produced Soviet capital.

INCREASED FOREIGN AID

In this scenario it is assumed that the Soviet Union will increase the level of foreign aid as compared with the base case for their various client states around the world. Such an increase might come about because of deteriorating economic or military conditions in one or more of their client states. It is also possible that the Soviets will decide to escalate existing military conflicts in an attempt to obtain a victory quickly (e.g., Afghanistan), and also to embark on new foreign adventures aimed at opportunistic targets that are not currently apparent.\textsuperscript{4}

The Western allies in general and the United States in particular have certain policy options which, if exercised, could easily induce the Soviets to increase their foreign aid and, thus, heighten the pressure on their economy. For example, the United States could increase its aid to resistance movements in areas controlled by Soviet-backed states, such as Afghanistan, Cambodia, Ethiopia, Angola, Mozambique, and Nicaragua. This option deserves careful attention since it is likely to cost the Soviets much more to counter such aid than it would cost the West in economic terms (although possibly not in political terms) to supply it. It might be possible to use against the Soviets what we learned in Vietnam the hard way. Another policy option that could lead to increased Soviet aid is to change trade and credit policy in ways that are harmful to the economies of Soviet client states.

For our purposes we have modified the increased foreign aid scenario of Grossman and Solberg to be compatible with our model. They assumed an "entirely arbitrary figure" of 2 billion 1985 dollars as the increase in foreign aid for 1985, the only year that they are concerned with.\textsuperscript{5} We take for our model the also arbitrary figure of 1.4 billion 1980 dollars per year for 1983 and later years of the decade.

\textsuperscript{3}Gardner, 1981.
\textsuperscript{4}This scenario has been adapted for use in the HK model from a scenario developed by Grossman and Solberg, 1982.
\textsuperscript{5}Grossman and Solberg, 1983.
The results are shown in Figure 2. The tradeoff curve between consumption and defense for the increased foreign aid scenario has shifted inward compared to the tradeoff curve for the base case. At every level of the average annual rate of growth of consumption for the 1980s decade the average annual rate of growth of defense is lower.

Our comparison of the two curves in Figure 2 uses a two-dimensional figure of merit. For some purposes it is useful to summarize the difference between two tradeoff curves by a one-dimensional figure of merit—that is, a single number, but attempting to describe the difference between two curves such as those in Figure 2 by a single number gives rise to some ambiguity. We have elected somewhat arbitrarily to measure the difference between a pair of curves in this study in terms of the difference in the rate of growth of defense spending at a 2.667 percent rate of growth of consumption. This 2.667 percent is the rate that will occur, according to our base case for the "CIA world," if defense spending in the Soviet Union increases at the CIA projected
rate of 4.5 percent. It is actually a little more complicated, since we are not looking merely at the differences in the rate of growth of defense between a pair of curves, but rather at the cumulative effects that this difference in defense spending has over the decade. To be precise, we measure the difference in defense spending in 1990 that would occur if in both cases consumption grew at 2.667 percent per year over the decade. For Figure 2 this difference and, hence, our figure of merit is 3 percent. This is small compared with the results for most of this study's comparisons.

OPENING THE UMBRELLA

Not included as part of our increased foreign aid scenario is the possibility that, over the remainder of this decade, the Soviets may “open the umbrella”—that is, help some of their Eastern European satellites to repay their debts. The Eastern European debt situation by 1982 was critical in a number of states, most notably Poland where default was a genuine possibility. More recently, this threat has eased somewhat due to a combination of falling interest rates and efforts in these nations to favorably shift the export-import balance. However, it is possible that the situation will become critical once again, particularly in Poland, at some point during the remainder of the decade. If it does, the Soviets may choose to prevent default (or at least lessen the costs of the austerity measures that some of their satellites would otherwise be forced to pay) by “opening the umbrella.” This, in the Soviet’s eyes, might be worthwhile to prevent unrest in their satellites. Such unrest might be more costly and dangerous to them than the costs of “opening the umbrella.”

From a policy standpoint it would probably be desirable for the West if the Soviets did help their Eastern European satellites to pay their debts. This would increase pressure on the Soviet economy, forcing their tradeoff curve to move inward. The West might be able to do this by increasing economic pressure on the satellite nations by such means as placing further restrictions on new loans to them.

Following the Grossman and Solberg “opening the umbrella” scenario, we have assumed that the Soviets would accept responsibility for repaying one-third of the interest on the debt of their Eastern European satellites for the remainder of the decade. This amounts to roughly $1.8 billion per year in 1980 dollars.

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6CIA, 1981a.

7Grossman and Solberg, 1983. The $2 billion figure comes from their August 1982 draft. In the final 1983 paper they actually used $3 billion. This change occurred too late to be incorporated into the calculations for this report.
Figure 3 compares the base case and the "opening the umbrella" scenarios. The difference between the two curves in terms of our figure of merit is 4 percent, which means that if in both cases consumption grew at an average annual rate of 2.667 percent, then by 1990 Soviet defense expenditures would be 4 percent lower than in the base case—again a small difference compared with many of those to be discussed.

Fig. 3—Opening the umbrella

CREDIT

In the previous scenarios, Western policy could affect the Soviet economy only indirectly and uncertainly by pressuring Soviet planners to allocate increased amounts of resources to help their client states. But there is a more direct policy tool: reducing the amount of credit that is given to the Soviets by the West.

Our base case assumes that the amount of net credit extended by the West will be 2.2 billion 1980 dollars per year for the rest of the decade—the average amount granted in the period 1973–1981.8

8Net credit is the amount of funds loaned to the Soviets by the West above the amount sent by the Soviets in the form of loans and payments on existing debts to the West.
We also have low- and high-credit scenarios. The low scenario assumes that no net credit is extended to the Soviet Union for the remainder of the decade. The high scenario assumes, rather arbitrarily, a value for net credit that is twice the value used in the base case. It is possible to restrict credit even further than is assumed in the low scenario by halting not only net lending, but also some portion of the lending required to roll over the existing Soviet debt. However, we believe that such an extreme scenario is too unlikely to warrant being used for our "low" scenario.

Figure 4 depicts the tradeoff curves between the average annual rates of growth of consumption and defense in the 1980s for the high- and low-credit scenarios. The difference between the two curves in terms of our figure of merit is 10 percent, which is higher than in the previous comparisons but still small compared with many of the scenarios to follow.

Figure 4 also shows a tradeoff curve which is for a scenario labeled "low composite credit." This scenario assumes that the low-credit, increased foreign aid, and "opening the umbrella" scenarios occur.

![Fig. 4—Credit related issues](image-url)
simultaneously. Such an eventuality is plausible because a decision by
the West to further restrict trade with the Soviets could easily and log-
ically be accompanied by a decision to restrict trade with the Soviet
client states, and, perhaps in the case of a few nations, to increase
Western aid to anti-Communist resistance movements. The low com-
posite scenario results in a loss to the Soviets of $3.2 billion per year in
1980 dollars for the rest of the 1980s as compared with a gain of $2.2
billion in the base case scenario, and $4.4 billion in the high scenario.
The figure-of-merit difference between the low composite and high
scenarios is 17 percent. This is the difference in defense spending in
1990 between the two scenarios, assuming an average annual rate of
growth of consumption in both scenarios of 2.667 percent.

THE RELATIVE EFFICIENCY OF IMPORTED
VS. DOMESTIC CAPITAL

Most experts on the Soviet Union believe that the efficiency of capi-
tal imported by that nation is higher than the efficiency of capital that
is produced domestically, because of the West’s superior technology
and quality control. Estimates of the relative efficiency of imported as
compared with domestically produced capital vary widely, from a value
of 1 estimated by Weitzman to a value of 10 according to Green and
Levine.⁹ Our base case assumes a value of 1.5.

Figure 5 depicts the contrasting effect on our tradeoff curve of using
values of 1 and 10 for relative capital efficiency. Note that the gap
between the two curves widens as we move from low to high rates of
defense growth. This occurs because, at low rates of defense growth
(and consequently high rates of consumption growth), the fraction of
imports that are agricultural goods as opposed to capital goods is rela-
tively large. Thus, the impact of higher relative capital efficiency on
the curve is small. The opposite occurs when the growth rate of
defense is high and capital imports are relatively large.

While the main reason for examining the differences between
scenarios with high and low relative capital efficiency is uncertainty
over the current value of relative capital efficiency, there is also a
second reason: Relative capital efficiency can, to some extent, be
affected by Western trade policy. By placing relatively severe restric-
tions on high-technology goods that the Soviets wish to import, which
have high values of capital efficiency compared with their Soviet coun-

Fig. 5—Relative capital efficiency

terparts, the aggregate relative capital efficiency of imported as compared with domestically produced capital can be reduced.\textsuperscript{10}

THE INTERACTION OF CREDIT-RELATED ISSUES AND RELATIVE CAPITAL EFFICIENCY

We can take a combination of the scenarios discussed in the previous two subsections as a measure of the importance of foreign-trade-related issues. Figure 6 compares the combined low composite credit

\textsuperscript{10}The impact on the Soviet economy of the current value of relative capital efficiency being 10 as compared to 1 is shown in Figure 5. If the current value is 10, the impact on the economy of reducing this to a value of 1 by placing restrictions on foreign trade would be somewhat different from that depicted in Figure 5. The size of this difference would depend on such factors as the rate at which relative capital efficiency was reduced.
plus capital efficiency = 1.0 scenario with the combined high credit plus relative capital efficiency = 10.0 scenario. The difference between the two curves is substantial. In terms of our figure of merit it is 66 percent.

There is some ambiguity concerning how to define a measure of the importance of foreign trade. Our measure, given above, includes the effects of credit, of Soviet foreign aid, and of the possibility of "opening the umbrella," as well as uncertainty concerning the value of the efficiency of imported as compared with domestically produced capital. More narrowly as well as more broadly defined measures could have been used. For example, it could be argued that the effects of uncer...
tainty in relative capital efficiency should have been excluded. On the other hand, it could be argued that the impact of price uncertainty for key imports and exports such as oil, gold, and agricultural products over the remainder of the decade should have been included. Many of these issues will be addressed in what follows.
V. FOREIGN TRADE PART II: GOLD, AGRICULTURE, AND WEATHER

This section examines the impact on our Soviet consumption vs. defense tradeoff curve for the 1980s of uncertainty in the prices of two goods that play a major role in Soviet trade: gold and agricultural products. We also examine the impact of poor weather. Weather, of course, affects Soviet agricultural production and imports.

GOLD PRICE

In recent years the price of gold on the world market has been highly volatile. For example, the real price increased by a factor of 1.43 in 1979 and an additional factor of 1.76 in 1980, and then fell by a factor of 1.45 in 1981. Predicting the price of gold for the remainder of the decade is an uncertain matter then. Our base case assumes that the real price will stay at its current level. We also have low and high gold price scenarios, in which we assume that in 1990 the real price will be a factor of two higher or lower (twice as high or one-half as high) than in the base case. A factor of two was chosen mainly by judgment. For the years 1983–1990 the price-uncertainty band, bounded by what is assumed for the high and low scenarios, is assumed to increase at a constant percentage rate until it reaches the factor of two levels of uncertainty for 1990. The uncertainty band was assumed to grow with time because the level of uncertainty concerning any parameter tends to increase as we project farther into the future.

The recent history of gold production in the Soviet Union is much less volatile than the price history. A simple regression was run to determine the rate at which output has been increasing since the United States went off the gold standard in 1967. We assume that during the 1980s production will continue to increase at this rate, and that gold sales will increase from their 1981 level at the same rate. The result of these and our price assumptions is that the value of Soviet gold sales in 1990 in terms of 1980 dollars will be between $1.6 and $4.7 billion depending on the extent to which the high and low gold price scenarios are correct.

Figure 7 depicts the effects of the high and low gold price scenarios for the 1980s. The difference is small. Assuming for both scenarios a growth rate of consumption of 2.667 percent, the difference which we have taken to be our figure of merit is 10 percent.
AGRICULTURAL PRICES

Agriculture has long been a major problem area for the communist economy of the Soviet Union. In recent years, the Soviets have chosen to alleviate the impact of this on Soviet consumption by heavy imports. High import prices are therefore a burden on the Soviet economy.

The United States being a leader in agricultural exports, and a predominant portion of agricultural exports to the Soviet Union coming from countries generally friendly to the United States (Argentina being a recent, notable, and debatable exception), there is the potential for the United States to influence the world market in ways that are detrimental to the Soviet Union. Our grain embargoes are examples of past attempts to do just that. Future embargoes would be dramatically more effective if undertaken jointly by the United States and other major exporting nations. The United States can also influence the world market in other ways. For instance, although the fact has excited little comment, our current policy of encouraging farmers to grow less so as to keep agricultural prices higher not only benefits the
United States farmer but also, via the world market, is detrimental to the Soviet Union.

For our base case, we assumed that the real price of agricultural goods would remain constant for the remainder of the decade. We also specified high and low agricultural price scenarios. These assume, on the basis of a 95 percent confidence interval calculation, that real prices in 1990 are a factor of 1.4 higher or lower, respectively, than in the base case. The prices for our high and low scenarios in the years between 1983 and 1990 were assumed, as in the case of the high and low gold price scenarios, to diverge starting in 1983 at a constant rate until 1990 when they differ by a factor of 1.4.

Figure 8 shows the tradeoff curves for the 1980s decade for the high and low agricultural price scenarios. Note that the gap between the two curves widens as we move from high to low rates of defense growth. The reason is that at low growth rates of defense, and hence, high growth rates of consumption, substantially greater amounts of agricultural goods are imported. Thus, the impact of differences in agricultural prices is larger because agricultural imports are larger. The difference between the high- and low-price scenarios in terms of our figure of merit is 22 percent.

WEATHER

The eight years of 1975 through 1982 were years of poor weather in the Soviet Union—so consistently poor that there is now at least some suggestion that what is currently thought to be normal weather may be overoptimistic. This subsection compares a normal and a poor-weather scenario.

The HK model handles weather in a special fashion. In the base case it is assumed that weather takes on its normal average values for every year relevant to our projection. For departures from that scenario, such as our poor-weather scenario, our optimization and other procedures (discussed in Section II) become more complicated. We first optimize as in the simpler procedure, subject to the assumption that weather is normal in each year of the decade. This optimization

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1The 95 percent confidence interval was calculated from real corn price data for the period 1960-1980. Corn is by far the dominant grain in imports and grain comprises about half of all agricultural imports in 1960. The first step is calculating the confidence interval was to find the change in real prices for succeeding periods of length equal to the time remaining in this decade (i.e., for intervals beginning in 1960, 1961, 1962, etc.). Assuming a normal distribution, we then calculated the 95 percent confidence interval for the 1990 price. The boundaries of this confidence interval were then taken to be the values of the 1990 price for our high and low scenarios.
Fig. 8—Agricultural prices

gives us a set of inputs for the agricultural sectors for the first year. Next, change in the weather is taken into account for the first year by adjusting the output of the agricultural sector to a higher or lower value while leaving the inputs to this sector unchanged. Weather is assumed to affect the economy through its effects on agricultural output only. Once the nature of the weather-adjusted economy at the end of the first year is determined, the model is reoptimized for the remainder of the period, subject to the constraint that weather in the remaining years is normal. Then, weather for the second year is taken into account and we reiterate. In general, it is assumed that decision-makers do not know what the weather will be until it occurs. Consequently, they make decisions knowing what the weather has been up to
the point at which the decision is made, under the assumption that future weather will be normal.2

The weather pattern assumed to occur for the remainder of the decade in our poor-weather scenario was determined as follows. Green has calculated what agricultural output would have been had the weather been normal for the 1955–1977 period.3 We have extrapolated his results to cover the period 1978 to present. This gives us the deviations by year in agricultural output between what could be expected and what actually occurred. From the six years between 1975 and 1980 (a period of particularly poor weather), we selected a sufficiently large number of the worst weather years to generate a weather pattern that we essentially assume (in the poor-weather scenario) will occur twice in the remainder of the decade.

Figure 9 compares the resulting poor-weather and base case (normal-weather) scenarios. The difference in terms of our figure of merit is small, 15 percent.4

THE INTERACTION OF AGRICULTURAL PRICES AND WEATHER

The previous two subsections examined the independent impacts of agricultural prices and weather, the two also interact. The Soviet Union accounts for a large fraction of the world market for agricultural goods. Poor Soviet weather harms the Soviet economy in two ways: The country has to import more agricultural goods, and the resulting increased demand on the world market drives up the price for such goods.

Figure 10 shows four tradeoff curves representing the results for all possible combinations of high and low agricultural prices and normal and poor weather. The innermost and the outermost curves represent what happens when the worst and best of these combinations occur. In terms of our figure of merit, the difference is a substantial 64 percent.

Also note that the difference between the high and low curves is greater for the poor-weather pair than for the normal-weather pair. This is because when there is poor weather, agricultural imports are

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2For additional information on how the HK model deals with differing weather scenarios, see Hopkins et al., 1982.
3Green, 1979.
4Hopkins et al., 1982, contains more information concerning the difference between a base case scenario and a poor-weather scenario (both scenarios being slightly different from the ones used here).
Fig. 9—Weather

Fig. 10—The interaction of agricultural prices and weather
higher and, hence, the importance of the price at which these goods are sold is greater. In terms of our figure of merit, the differences between the curves for each pair are 35 percent and 22 percent, respectively.
VI. THE BASE CASES FOR THE THREE WORLDS

Having explored the “CIA world” in some detail, this section extends our analysis to the Birman and Rosefielde-Lee “worlds.” The first step is to build base case scenarios for those two “worlds” and then compare them with the base case for the “CIA world.”

Igor Birman argues that the Soviet economy is currently smaller, with a larger defense share and slower technological growth, than the CIA believes. Steven Rosefielde and William Lee argue that the Soviet economy is currently larger, with a larger defense share and faster technological growth, than the CIA believes. In some sense, Birman argues that the Soviet economy is less dynamic than the CIA maintains, while Rosefielde and Lee argue the opposite. Which of these views is correct has more impact on our growth rate of consumption versus growth rate of defense for the 1980s tradeoff curve than any other issues addressed by this study.

As Section III emphasized in explaining how the model deals with the “CIA world” the term “world” as used here refers to a particular view of economic history, and to its implications for the future, as determined by the authors of this study. Thus, as was pointed out in Section III, the CIA base case predictions for the 1980s are not the same as those made in our base case. This is mainly because examination of the past Soviet record according to their estimates and other information, has led the CIA to conclude that the dramatic drop in the growth rate of Soviet total factor productivity in the last half of the 1970s is likely to persist through the 1980s, whereas we believe it is more reasonable to assume a higher rate reflecting the average for the entire 1970s decade. Other analysts looking at the same historical data have drawn still other conclusions. For example, Daniel Bond and Herbert Levine (the keepers of SOVMOD) have argued that the rate will be even higher.

In the case of the Birman and Rosefielde-Lee “worlds,” the situation is more uncertain. All of the reasons why experts disagree on the implications for the “CIA world” in the 1980s, given the assumption that the historical picture painted by Birman or Rosefielde-Lee is correct, are at least as strong for these worlds.

And there are further complications. Although Birman and Rosefielde-Lee have made numerous statements on the issues, they have not produced a comprehensive, quantitative picture in the sense
that the CIA has. Nor are their historical views as detailed and complete as those of the CIA, which is not surprising since they cannot command the CIA's research funds and other resources. Consequently, the predictions we make here for the Birman and Rosefeld-Le-Lee "worlds" may differ in detail from what Birman and Rosefeld-Le-Lee themselves believe will happen. This is particularly true with regard to predictions they may make in the future concerning aspects of the 1980s Soviet economy upon which they have thus far been silent. As a reminder that the authors have contributed, to some extent, to the definitions of each of the three worlds, we have placed in quotation marks the names of the worlds wherever they appear in this report.

While it is a mistake to ignore the above caveats, it is also a mistake to place undo emphasis on them. The HK model with differing data inputs and a few minor changes is capable of representing accurately all three worlds. This is indicated in part by the historical verification tests described in our 1982 report. These involved making projections from the base year of 1960 to 1975 and then comparing the results with what actually happened according to the history of the world in question.

Before we enter into a more detailed discussion of the base cases of the Birman and Rosefeld-Le-Lee "worlds," it is of interest to explain why we chose these for study instead of some other alternatives to the "CIA world," and to examine briefly why the authors of these three worlds come to such different conclusions. While probably no two experts on the Soviet economy agree on all issues, the vast majority of these disagreements are sufficiently small that they can be encompassed by what we have defined to be the "CIA world." There are roughly, and to some extent debatably, two opposing bodies of thought in which there is a significant amount of current interest. These are what we have built the Birman and Rosefeld-Le-Lee "worlds" from.2

The "Birman world" is based on Igor Birman's views; it is also representative of the views of Soviet emigres in general. Birman was a professional economist in the Soviet Union and has written prolifically on the Soviet economy since coming to the United States. Much more than do the CIA and Rosefeld-Le-Lee, Birman and the emigres generally base their arguments on their experiences in the Soviet Union and

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1. Hopkins et al., 1982, gives the results of historical verification tests for the CIA and Rosefeld-Le-Lee "worlds." Similar tests with equally good results have been performed for the "Birman-like world."

2. One exception to this is the possibility of creating "artificial" worlds which are not championed by any particular Soviet expert. These could be used to explore certain aspects of the Soviet economy which are of interest. For example, what are the implications of a world where defense spending is extremely large—say 25 to 30 percent of GNP—but which is otherwise like the "CIA world."
their intuitive feel for the way that system works. Their arguments are much more of a qualitative nature. The essence of their claims is simple: They have lived under both systems and "know" that the relative position of the Soviet as compared to the American economy is much less favorable while the share of defense spending is much larger than the CIA estimates indicate.  

The data utilized by the CIA and Rosefielde-Lee "worlds" do not come from the qualitative views of emigres; most of it, with one major exception, ultimately comes from published Soviet sources. Differences arise between the worlds because the relevant estimates rely on different Soviet data sources and involve different adjustments to correct for such problems as missing and distorted data. While there are differences between Rosefielde and Lee, these are small compared to those between the CIA, Birman, and Rosefielde-Lee taken together. This is why we have combined Rosefielde and Lee's views into one world.

The major exception mentioned above concerns the CIA estimate of defense spending. Instead of relying on Soviet data the CIA utilizes techniques whereby the physical outputs of different types of goods are estimated from intelligence and other non-Soviet data sources. These outputs are then aggregated using prices for weights. This method requires a great deal of information; much of it is classified and is therefore beyond the powers of either Birman or Rosefielde and Lee.  

Rather than entangle ourselves in arguments over which of these procedures is best, we concentrate here on deriving the implications of the three worlds; Section IX presents a new approach for comparing the worlds.

To move from making projections for the "CIA world" to making them for either the Birman or the Rosefielde-Lee "world," the main changes that are required are as follows. The base year for the projections for the different worlds needs to be specified in some detail. Particularly important are the size of GNP and defense spending. The rate of growth of total factor productivity for the period to be projected needs to be specified. (Labor-force growth is noncontroversial and is taken to be the same for all three worlds.) An appropriate discount rate for each world must be assumed. This was determined for each of the worlds by finding the discount rate that best fit the period

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3For an example of the nonquantitative way in which the emigres frequently justify their position, see Birman, 1980. For more information on Birman's viewpoints see Birman, 1980, and Subcommittee on Oversight, 1980.
1960–1975 and then assuming that this discount rate would also be relevant for the 1980s.\textsuperscript{5}

Of the three worlds, the "Birman world" is by far the least well specified by its creator. Further, Birman's views are often expressed in only a qualitative instead of a quantitative fashion, and occasionally are somewhat contradictory. As a consequence, some relatively strong assumptions were made concerning the nature of the "Birman world." Because of the strength of these assumptions, we label what is actually analyzed in this study the "Birman-like world" rather than simply the "Birman world."

Birman has argued that per capita Soviet GNP is about one quarter that of the United States, while the Soviet share of defense spending is in the neighborhood of 20 percent.\textsuperscript{6} This implies that Soviet GNP is about 60 percent of what the CIA maintains it is,\textsuperscript{7} and that the defense share is about 50 percent larger than the CIA believes.

We derive our estimate of the growth rate of total factor productivity for the "Birman-like world" of the 1980s from Birman's statement that labor productivity will probably cease to grow.\textsuperscript{8} This implies that the rate of growth of output will equal the growth rate of the labor force, which has been noncontroversially estimated from existing demographic data. The growth rate of total factor productivity was derived from this with the help of the HK model, which calculates the growth rate of capital endogenously.

The approach for the "Rosefield-Lee world" is somewhat different. Detailed historical data are available only from estimates made by Lee for 1960–1975.\textsuperscript{9} These were used to calculate the growth rate for the "Rosefield-Lee world" of total factor productivity for this period.\textsuperscript{10} It was assumed that the difference in total factor productivity growth between these estimates and our estimates for the same period for the "CIA world," 2.6 percent, would remain the same for later years. This

\textsuperscript{5}See Hopkins et al., 1982.
\textsuperscript{6}Birman, 1980.
\textsuperscript{7}Pitzer, 1982.
\textsuperscript{8}Birman, 1982. His statement refers specifically to the 1981–1985 period. His writings in general imply that the rate of growth of labor productivity will not increase in the second as compared to the first half of the decade.
\textsuperscript{9}Lee, 1979.
\textsuperscript{10}More precisely, the rates of growth for output were obtained from Lee, 1979. Labor force and capital growth rates were taken to be the same as in the "CIA world." The former is noncontroversial. The latter (along with our assumption that the 1980 capital stock of the Rosefield-Lee and CIA "worlds" was the same) was verified as reasonable through private communications with Steven Rosefield at the conference on The Soviet Economy and Military Spending, February 1, 1983, at the Georgetown Center for Strategic and International Studies, second conference in the USIA Conference Series on The Soviet Union in the 1980s.
is sufficient to calculate a value for GNP in 1980 that is roughly 30 percent higher than the CIA value. The share of defense spending for 1980 was calculated to be one quarter larger than in the CIA case by extrapolating the growth rate of defense and nondefense spending for the 1970–1975 period and then proportionally reducing the resulting figures so that their sum is consistent with our result for Soviet GNP in 1980.

Figure 11 shows the relevant tradeoff curves for 1980–1990 for the base cases of the three worlds. The most obvious point to be made is one that has been mentioned before: that there is a tremendous difference between the curves—larger than any other effect that we shall examine in this study. Somewhat less obvious is that, in a loose sense, the slope of the CIA curve is steeper than that of the other two curves. This is due to the higher relative shares of defense as compared with consumption in the Birman-like and Rosefield-Lee “worlds.”

The full extent of the differences in the three worlds is not captured by the base case curves of Figure 11 because the calculations for these curves ignore the differences in the size of the three economies in 1980. A comparison that takes these into account is useful for answering questions like the following. Consider the perspective of an analyst who is studying the economic potential of the Soviet Union during the next decade. Assume that, because of new information, he suddenly discovers that Rosefield and Lee were right all along, and then asks himself the question, how does this change my perspective? In order to find the answer, the analyst would make a new Rosefield-Lee projection similar to the one in Figure 11, except that this time, instead of

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11 For this calculation, capital and labor force growth rates were obtained as described in footnote 10 of this section.

12 The data for the 1975 defense and nondefense levels of spending and for calculating the rates of growth of these variables for the 1970–1975 period are from Lee, 1979.

13 Additional data and assumption inputs that were used to build the Birman-like and Rosefield-Lee “worlds” include the following. The levels of investment and consumption for 1980 were obtained for the “Birman-like world” by dividing the nondefense fraction of GNP into these two components using the assumption that the ratio of investment to consumption is the same as for the “CIA world.” For the “Rosefield-Lee world” the value of investment and consumption for 1980 was found by extrapolating Lee’s 1975 values (taken from Lee, 1979) to 1980 by a procedure analogous to that used in the text above to extrapolate Lee’s 1975 value of defense to 1980. For both the Birman-like and Rosefield-Lee “worlds,” the net outputs of the 21 sectors for 1980 were found by assuming that the ratio of net output of a given sector that is used for consumption in the economy is the same for all three worlds. Similarly, for the portions of net output of each sector that are used for investment and defense, the 1980 capital stock for each of the worlds is the same. As mentioned earlier in the text, the labor supply is also the same. Given the result (which the model calculates) that the labor and capital shares are nearly the same for the three worlds, then the levels of total factor productivity in 1980 will differ nearly proportionately to the levels of GNP for the different worlds.
using Rosefielde-Lee data for the base year, CIA data would be used. To be more precise, the analyst would generate a “normalized” Rosefielde-Lee curve by adding to the coordinates of every point on the Rosefielde-Lee curve the average annual rates of growth of consumption and defense required to make up the difference over a ten year period between the 1980 consumption and defense values for the CIA and the Rosefielde-Lee “worlds.” The resulting “normalized” base case projection for the “Rosefielde-Lee world” is compared in Figure 12.

14 For example, consider the point where the Rosefielde-Lee curve intercepts the X axis. The coordinates of this point represent an average annual growth rate of 7.18 percent for consumption and 0 percent for defense. In 1980 consumption is 25 percent higher and defense 64 percent higher in the “Rosefielde-Lee world” than in the “CIA world.” This difference can be made up over a ten year period starting from the 1980 CIA position by average annual rates of growth of 2.26 percent for consumption ((1.25)\(^{1/10}\) = 1.0226) and 5.04 percent for defense ((1.04)\(^{1/10}\) = 1.0504). Adding these rates of growth to those represented by the coordinates of the Rosefielde-Lee curve point in question, we obtain, for the coordinates of the corresponding normalized point, 9.44 percent (7.18 + 2.26 = 9.44) for the average annual rate of growth of consumption, and 5.04 percent (0 + 5.04 = 5.04) for the average annual rate of growth of defense.
with the CIA base case projection, and with a similarly defined “normalized” base case Birman-like projection. The curves are dramatically farther apart than were the nonnormalized base cases compared in Figure 11, thus further emphasizing the tremendous difference between the three worlds.

Fig. 12—Normalized base case projections for the three worlds
VII. FOREIGN TRADE AND THE THREE WORLDS

This section examines for the Birman-like and Rosefield-Lee "worlds," a number of key issues concerning foreign trade that were analyzed in Sections IV and V for the "CIA world." We also make comparisons between the three worlds. The topics that we look at in depth are credit, the price of gold, agricultural prices, the relative efficiency of imported vs. domestic capital, and the interaction of credit-related issues and relative capital efficiency.

CREDIT

It is instructive to compare our high and our low composite credit scenarios for each of the three worlds. Our high-credit scenario assumes that the Soviets will obtain a net extension of credit from the West of 4.4 billion 1980 dollars per year ($2.2 billion more than in the base case) for the remainder of the decade. Our low composite scenario is a combination of three scenarios: our low-credit scenario, where we assume that the Soviets will obtain no net credit from the West; our increased Soviet foreign aid scenario; and our "opening the umbrella" scenario, where we assume that the Soviets will decide to help some of their Eastern European client states by partially paying some of the high costs of the debts that they owe to the West. The total monetary impact of our low composite scenario is a net loss of $3.2 billion per year.\(^1\)

Figure 13 depicts three pairs of tradeoff curves. Each pair represents our high scenario and our low composite scenario for one of the three worlds. Note that the difference between the members of a pair of curves decreases as we move outward (to the northeast) from the origin of the graph. The difference is largest for the "Birman-like world," intermediate for the "CIA world," and smallest for the "Rosefield-Lee world." The reason for this effect, which we label the "size" effect, is that (as discussed in Section VI) the size of GNP in the base year (1980) is smallest for the "Birman-like world," intermediate for the "CIA world," and largest for the "Rosefield-Lee world." Since the difference in dollars between the high and low composite scenarios

\(^1\)See Section IV for additional discussion of our credit scenario.
is the same for each world, the impact when measured in percentage terms, as in Figure 13, is largest for the smallest economy, etc. There are policy implications for these results. Restrictions on credit and possible actions taken by the West that lead to increased Soviet foreign aid or the "opening of the umbrella" will have a larger impact if the "Birman-like world" is more correct than the "CIA world," and a smaller impact if the "Rosefield-Lee world" is more correct.

GOLD PRICE

We have taken, as our high and low gold price scenarios, cases where the price of gold is assumed to be a factor of two greater or smaller in 1990 than in the base case.²

As is shown in Figure 14, the difference between these two scenarios is largest for the "Birman-like world," intermediate for the "CIA

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²See Section V for additional discussion of our gold price scenario.
world," and smallest for the "Rosefielde-Lee world." This is not surprising. It is due to the size effect, which was defined above.

AGRICULTURAL PRICES

Our high and low scenarios for agricultural prices involve 1990 prices that differ from those of the base case by a factor of 1.42 higher or lower, respectively.\(^3\) Figure 15 depicts tradeoff curves for each of these scenarios for each of the three worlds. The two curves for each of the worlds are similar in the sense that they diverge as one moves from high to low rates of growth of defense. There are also some interesting differences between the pairs of curves. Compare the three pairs of curves where they intersect the X axis. The distance between the two curves of each pair is intermediate for the "Birman-like world," smallest for the "CIA world," and largest for the "Rosefielde-Lee world." This pattern, where for once the "CIA world" occupies a

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\(^3\)See Section V for additional discussion of our agricultural prices scenario.
nonintermediate position, is the result of the combined effects of two factors that operate in opposing directions. The first is the size effect, which explains why the difference between the Birman-like curves is larger than the corresponding CIA difference.

The second factor explains why the difference between the Rosefielde-Lee curves is the largest. It concerns the nature of the agricultural sector. Before harvesting, storage, and processing, the level of agricultural outputs (for which there are good data) is assumed to be the same for all three worlds in 1980. However, the efficiency at which food is converted into what is actually consumed by humans differ greatly between the three worlds. It is lower for the "Birman-like world," higher for the "Rosefielde-Lee world," and intermediate for the "CIA world." These levels of consumption are the net outputs of the agricultural sector for the three worlds. As mentioned in Section VI, they differ in 1980 by the same proportions as consumption.

Fig. 15—Agricultural prices for the three worlds
In 1980 the level of agricultural imports is the same for the three worlds. The worlds with the larger GNPs happen also to have higher growth rates and hence higher decade average GNPs. They also have agricultural imports that are growing as a share of agricultural consumption. The reasons for this are as follows. Agricultural imports are the difference between agricultural outputs and consumption. The worlds with higher GNP growth rates happen to have higher consumption growth rates (for a given growth rate of defense). Further, the worlds differ less in their growth rates of agricultural outputs than they do in their growth rates of consumption. This is because the agricultural sector has as inputs not only labor and two types of capital, like the other sectors, but also land, which is fixed in supply and the same for all three worlds. It follows that the larger the GNP of a world, the larger the growth rate of agricultural imports, and hence the greater the impact on the economy of fluctuations in agricultural prices. If this were the only effect, the impact of fluctuations in agricultural prices would be the largest for the "Rosefielde-Lee world," intermediate for the "CIA world," and smallest for the "Birman-like world." But because of the opposing force of the size effect, we obtain the results shown in Figure 15.

The United States (particularly if we acted in concert with some of the nations generally considered to be our friends) can significantly influence the world market for agricultural goods. As can be seen in Figure 15, the effect would be larger for the "Birman-like world" than for the "CIA world," and larger yet if the "Rosefielde-Lee world" is correct.

THE RELATIVE EFFICIENCY OF IMPORTED VS. DOMESTIC CAPITAL

The experts disagree over the value of the ratio between the efficiency of capital that the Soviet Union imports from the West and the efficiency of capital that it produces domestically. We shall compare the cases where this ratio, which we refer to as relative capital efficiency, is equal to 10 and to 1. The value for our base case is 1.5.4

Figure 16 shows three pairs of tradeoff curves, one for each world. The two curves in each pair represent a relative capital efficiency value of 10 and 1, respectively. Note that the curves in each pair diverge as the growth rate of defense spending increases. This is because at relatively high levels of defense spending and consequently low levels of

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4See Section IV for additional discussion of our relative capital efficiency scenario.
consumption, there is a relatively large amount of capital imports compared with other imports such as agricultural goods. Thus, the importance of differing relative capital efficiency increases for all worlds as the growth rate of defense spending increases.

The Birman-like curves, as compared with the CIA curves in Figure 16, are farther apart and diverge less as the rate of growth of defense spending rises. This is due partly to the size effect and partly to the fact that each world has the same supply of land. Thus, the larger a world's GNP the larger the growth rate of agricultural imports. Since all worlds have the same level of agricultural imports in 1980, it follows that the “Birman-like world,” with its low GNP, will have on average during the decade lower agricultural imports and hence more room for capital imports. This is particularly true at low rates of growth of defense spending; hence, the slower divergence of the Birman-like relative to the CIA curves as defense spending rises.

Fig. 16—Relative capital efficiency for the three worlds
The Rosefielde-Lee curves in Figure 16 are closer together than for the other worlds because of both the size effect and the relatively heavy imports of agricultural goods. Only at fairly high rates of growth of defense spending do the curves begin to diverge. This divergence arises in part because, in the "Rosefielde-Lee world," the growth rate of procurement is expected to be substantially larger than the growth rate of total defense spending. (See Appendix A for further discussion of this aspect of the "Rosefielde-Lee world.") Procurement (essentially weapons production) has as one of its key inputs the output of the MBMW (machine building metal working) sector. The other major form of output of this sector is capital goods. We then have the following causal chain. A high growth rate of defense spending implies an even higher growth rate of procurement spending, which implies a high demand for the use of MBMW output in weapons production, which implies little MBMW output available for capital production, which implies a high demand for capital imports and, hence, an increase in the importance of the relative efficiency of foreign as compared with domestic capital.

It is clear from Figure 16 that Western policies aimed at reducing the capital efficiency of Soviet imports by placing restrictions on high-technology goods, etc., will be more effective if the "Birman-like world" is more correct than the "CIA world" and least effective if the "Rosefielde-Lee world" is correct. The same can be said about placing restrictions on the quantity of capital imports. It is also evident that, for all three worlds, restrictions of this type are more deleterious to Soviet economic prospects if the Soviets decide to embark on relatively high rates of defense growth.

THE INTERACTION OF CREDIT-RELATED ISSUES AND RELATIVE CAPITAL EFFICIENCY

The preceding makes it easy to predict the outcome if we combine the high credit and high relative capital efficiency scenarios of the last two subsections and compare the result with a combination of the low composite credit and low relative capital efficiency scenarios for each of the three worlds. This is done in Figure 17. The curve indicates the impact of foreign trade on the economy in the special and somewhat arbitrary sense discussed in Section IV. From Figure 17 the obvious point to be made is that foreign trade is substantially more important for the "Birman-like world" than for the "CIA world," and of relatively little importance for the "world" of Rosefielde-Lee.
Fig. 17—The interaction of credit-related issues and relative capital efficiency for the three worlds
VIII. ENERGY

Oil is the key facet of the Soviet energy picture. This is because of the large size of the sector and the prevailing uncertainties with regard to the level of oil production and (especially recently) its price for the rest of the decade. Strategic and political considerations are also associated with oil, such as Western dependence on Middle Eastern supplies, which lie close to the Soviet Union. These interact with more parochial Soviet issues and, hence, make Soviet oil issues of particular concern to the West.

This section examines issues concerning oil supply and price for the three worlds. There is a high and a low oil price scenario. These are compared in the context of the three worlds. Several variant scenarios concerning oil prices are presented. These include one where OPEC collapses and another that involves a large, sharp, price fluctuation. The price issues are examined in some detail for the “CIA world.” We then explore, for some of these issues, the impacts in the context of the Birman-like and Rosefield-Lee “worlds.” Finally, we analyze the interaction of supply and price for the three worlds.

The Hopkins-Kennedy model incorporates a number of special features concerning its energy sectors (coal and peat, oil, gas, and electric power) that have not been previously discussed. This is partly because of the importance of energy to the Soviet economy, partly because of the special interest that Western analysts have in this subject, and partly because (unlike the other sectors) coal and peat, oil, and gas are subject to resource exhaustion effects that are too important to be ignored. These effects are handled by treating resource exhaustion as a form of negative technological change. It is assumed that the production functions for the three relevant energy sectors become less efficient at a rate of 2 percent per year. All else being equal, this effectively increases the cost of producing these types of energy. The HK model incorporates the effects of these cost increases by allowing for the substitutions of other goods for coal and peat, oil, and gas, in both production and consumption. (For the details of how this is done and more information concerning the modeling of the energy sector in general, see our 1982 report.)

1The 2 percent figure was determined by Richard Nehring, a noted expert on Soviet energy, and given to us in private communications.
OIL SUPPLY FOR THE THREE WORLDS

In the HK model the amount of Soviet oil produced per year is determined by assumption. This is a means of taking into account the fact that oil production depends not only on the amount of inputs of capital, labor, and intermediate goods, but also upon the amount of oil reserves.\(^2\) We have defined a high and a low oil supply scenario as having a growth rate of plus or minus 1 percent as compared with the base case starting in 1985.\(^3\) These numbers take into account uncertainties in the amount of oil that will be pumped from existing fields. They do not include the much harder to predict uncertainties concerning the discovery of new oil fields.

The high and low oil supply scenarios are compared in Figure 18 for the “CIA world.” There is a moderate difference between the two curves. In terms of our figure of merit (the difference in the level of defense spending in 1990 assuming a 2.667 percent growth rate of consumption in both scenarios), this difference is 29 percent.

The difference between the paired curves for each of the worlds falls as we move from left to right in Figure 18. This is due to the size effect. Oil supply is thus more important for the “Birman-like world” than for the “Rosefelde-Lee world,” with the “CIA world” occupying an intermediate position.

OIL PRICE

In the last few months before the results of this project were committed to paper, there was a great deal of excitement because of disagreements among the OPEC countries over what action OPEC should take in response to a worldwide recession-induced glut in the supply of oil. These disagreements were so severe that there was serious talk of OPEC collapsing. At a minimum, the price that OPEC members would decide upon charging in the near term (not to mention the rest of the decade) was highly uncertain.

In this hazardous climate for making predictions, we chose to examine several widely varying scenarios concerning the price of oil. The base case assumes that the world economy will make a good recovery from the current recession. This will lead to a strong increase in

\(^2\)The amounts assumed for oil production by year in terms of millions of barrels per day were, for 1983–1990: 12.10, 12.10, 12.04, 11.96, 11.81, 11.69, 11.25, and 10.55, respectively. These figures have been updated since our 1982 report. They were provided in private communications by Richard Nehring. See Hopkins et al., 1982, for further discussion.

\(^3\)This assumption was made at the suggestion of Richard Nehring.
demand for oil, which will allow OPEC (which it is assumed will not collapse) to force substantial increases in the real price of oil over the decade at the equivalent of an average annual rate of 2.85 percent. This is about the growth rate that energy experts expected at the beginning of this decade.\textsuperscript{4}

We have also defined "high," "muddle through," and "OPEC collapse" scenarios, which will be compared below. The high scenario assumes a very strong recovery from the current recession or, alternatively, difficulties with supply such as might be caused by a guerrilla war in one of the more substantial oil-exporting nations. Qualitatively, the high scenario assumes that, for the first few years of the decade, prices will change in accordance with history and that prices will soon begin to increase such that the overall effect for the decade is

\textsuperscript{4}The 2.85 percent figure was specifically derived as the "most likely" estimate by the U.S. Department of Energy. See U.S. Department of Energy, 1980.
equivalent to a 5.0 percent average annual increase in the real price of oil.\textsuperscript{5}

The muddle-through scenario assumes that, after some bickering, OPEC will reach an agreement to charge a new lower price of $29 per barrel in 1983 dollars and that this price will be maintained for the rest of the decade. Finally, the OPEC collapse scenario assumes that in 1983 the organization disintegrates and that as a consequence the price of oil falls to $16 per barrel in 1983 dollars for the remainder of the decade. It is worth noting that this price of $16 per barrel is a debatable result of what would occur given an OPEC collapse. The actual result depends to a considerable extent on hard-to-predict political decisions of such nations as Saudi Arabia concerning such matters as how much oil they should produce. Our value of $16 was selected as the midpoint of a range from $12 to $20 estimated in a recent article by Tussig.\textsuperscript{6}

Figure 19 compares the high, base case, muddle through, and OPEC collapse scenarios. There is a substantial difference between the two scenarios that differ the most, the high and OPEC collapse scenarios. In terms of our figure of merit this is 42 percent.

We can conclude from this that a lower price for oil is important to the West, not only because of its direct favorable impact on our economies, but also because it is significantly deleterious to the Soviets.

An interesting issue is the extent to which a sharp fluctuation in the price of oil (other things, including the average price of oil, being equal) would affect the Soviet economy. We have made an exploratory probe into this issue by comparing two scenarios in Figure 20: the muddle-through and the fluctuation scenario.

The latter scenario assumes that OPEC muddles through 1983 with a $29 per barrel price for oil and, then, as a result of some internal conflict, collapses, bringing the price of oil down to $16 for 1984. Further, it assumes that this collapse is followed by a sudden drop in the supply of oil due, for example, to a situation similar to the early stages of the Iran-Iraq war, and, as a consequence, that OPEC is able to regroup and drive the oil price up to $42 per barrel for 1985. Finally, it is assumed that the situation normalizes, after which OPEC returns to the muddle-through path and, as a consequence, charges $29 per barrel for the period 1986 to 1990.

\textsuperscript{5} This rate of growth is the same as was used for the high scenario in U.S. Department of Energy, 1980.

\textsuperscript{6} Tussig, 1982.
From the preceding we note that the average price in the fluctuation scenario is the same as for the muddle-through scenario. The year for which the price is $16 is balanced by the year for which it is $42, giving an average of $29, which is the same price that the muddle-through scenario has for every year. Thus, the only difference between the scenarios is the sharp price fluctuation in 1984–1985.7

In Figure 20 we see the result of comparing these two scenarios. While the tradeoff curves are different, the difference is so small that when both curves are graphed they are indistinguishable from one another.

The obvious conclusion is that an oil price fluctuation would not be of much importance to the Soviet economy. However, this conclusion needs to be qualified, which is why we labeled the exercise pictured in

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7All prices in this and the immediately preceding paragraph (unlike most of the rest of this report) are in terms of 1983 dollars. The fluctuation scenario actually has an average price which is different, but negligibly so, from the average for the muddle-through scenario. This is because the level of oil exports for 1984 is not the same as it is for 1985.
Figure 20 as an exploratory probe. The model was not designed with the idea of examining sharp fluctuations of this type in mind. For instance, it is assumed (except in the scenarios involving poor weather) that planners at the beginning of the decade have full knowledge of what will occur, including what the world price of oil will be by year. Thus, the costs imposed by the unexpected are not included in this evaluation of the costs of oil price fluctuations. It is possible to modify the model to deal more completely with these issues (for example, along the lines of the modifications that were made to deal with unexpected weather developments), but we did not do that for this report.

OIL PRICE FOR THE THREE WORLDS

Figure 21 extends the preceding “CIA world” analysis for the high and OPEC collapse scenarios to the other two worlds. As can be seen, the impact of the oil price difference decreases rapidly as one moves outward from the origin toward the northeast. The impact on the

![Diagram](Image)

Fig. 20—Oil price fluctuation
"Birman-like world" is substantially greater than the impact on the "CIA world" which, in turn, is substantially greater than the impact on the "Rosefield-Lee world."

This result is partly due to the size effect, but is much stronger than can be explained by the size effect alone. What is occurring is that Soviet oil consumption is greater at higher levels of GNP, and hence less oil is available to export. Lower exports reduce the value to the Soviets of higher oil prices. Thus, any influence that the United States can exert to lower oil prices has an impact on the Soviet economy, the size of which depends greatly on which world is correct.

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6The economies of the three worlds, though differing in the efficiency with which they use oil, consume and export the same amounts of oil in 1980. However, the worlds with larger GNPs in 1980 are also the worlds that grow faster in terms of GNP and in terms of consumption for a given growth rate of defense spending. These higher growth rates in turn imply higher growth rates for domestic oil consumption, and thus lower growth rates for oil exports. Consequently, the worlds with larger GNP values also have smaller average levels of oil exports over the decade.
THE INTERACTION OF OIL SUPPLY AND PRICE FOR THE THREE WORLDS

To explore the interaction between oil supply and price, we created two scenarios that combine, on one hand, our high oil supply and high oil price scenarios, and, on the other hand, the low oil supply and OPEC collapse scenarios. A positive correlation between oil supply and price is to be expected because the Soviets are likely to pump oil faster from existing fields when the price is high. The results, shown in Figure 22, are about what one would expect from the preceding work. Fluctuations concerning oil are of far greater importance in the "Birman-like world" than in the "Rosefinde-Lee world," and are of intermediate importance to the "CIA world."

Another point is worthy of comment. If one closely compares, for the "Rosefinde-Lee world," the low oil supply tradeoff curve of Figure 18 with the low supply curve of Figure 22, then one finds that the latter curve represents a situation that is better for the Soviets for all but the highest rates of growth of defense spending. In other words, if

![Graph showing the interaction of oil supply and price for the three worlds.](image-url)
the supply of oil is low, then a low instead of a high oil price is what the Soviets desire. How can this be so? The answer is that in these low oil supply cases, after exporting oil for the first part of the decade, the Soviets begin to import it, and the costs of these imports over the decade to the economy are greater than the value of the exports.
IX. WHICH OF THE THREE WORLDS BEST REPRESENTS REALITY?

As we have mentioned several times, the most important issue in this report is which of the three worlds is correct. We have utilized a shadow price methodology to make a comparative test of the three worlds. The results, while by no means definitive, shed important new light on this question.

The shadow price of a commodity is its true value to an economy. It takes into consideration, among other factors, all constraints on an economy, such as the labor force, the state of the economy's technology, and the extent to which factors of production and outputs can be substituted for each other in production and consumption. It may differ from actual prices because these can be set by fiat or distorted for various reasons such as taxes. In a perfectly competitive economy, shadow prices and actual prices are equal. By calculating the shadow price of a good, we determine its true price—its true undistorted value to the economy.

We have utilized the Hopkins-Kennedy optimal control model to calculate the shadow prices for oil for each of the three worlds for the 1970–1980 decade. According to economic theory, the Soviet oil shadow price should track the world price for oil with a lag of some size. This is particularly true given the extensive connection via foreign trade between Soviet domestic oil and the world oil market.

During the 1970–1980 period there was a 500 percent increase in the real price of oil, primarily due to the 1973 oil crisis. Thus, the real shadow price of oil should have increased in this period. Economically, this should come about because the increased world price for oil would make it more profitable for the Soviets to export oil. This, in turn, would lead the Soviets to save domestic oil at home by conservation programs which would drive the shadow price upward.

According to available qualitative information, the Soviets did initiate conservation measures in response to the dramatic changes in the international market during this period, but the priority and extent of these efforts were small compared with what was done in most Western nations. In the correct world, while the shadow price will eventually fully adjust to changes in the world market price, the extent

\[1\text{More precisely, a shadow price will be equal to the marginal value of a commodity to an economy. The average value may differ.}\]
to which this adjustment occurred in the 1970s should be small. Thus, the correct world should have a shadow price that rose during this period, but only by a small amount compared with the world price.

For several reasons, we chose the Soviet oil sector as the one to which to apply our shadow price methodology. First, compared with other sectors, there is little controversy concerning the level and quality of output. Second, the sector is relatively large and important to the Soviet economy. Third, something happened during the decade (the explosion in the world market price for oil) that should have a measurable impact on the economy—in this case, an increase in the shadow price of oil. Finally, the measured value of this impact is likely to be different for each of the worlds, and hence can be used to distinguish between them.

The results of employing our shadow price methodology are shown in Table 9.1. For the Rosefielde-Lee and CIA “worlds,” the shadow price increased during the decade by 92 percent and 32 percent, respectively. Both of these figures are in line with our expectations and hence tell us little concerning which world is correct.

The results for the “Birman-like world,” however, are qualitatively different. The change in the shadow price is actually negative! It drops 16 percent. If this is to be believed, then changes in the Soviet economy moved in the direction opposite to that in the world market, despite the enormous size of these changes and despite the fact that the oil sector is closely tied to the world market by trade. It is difficult to find any rationale for such a result. We conclude that, while not conclusive, this is significant evidence against the “Birman-like world.”

Two qualifications are needed. First, these shadow price results need to be considered preliminary. Though the authors feel that the results are unlikely to be qualitatively in error, it is possible that data uncertainties are the cause for finding that there is a drop in the shadow price for the “Birman world.” What is needed is to estimate (confidence interval) upper and lower bounds for the shadow prices. This could not be done without more resources than were available in

Table 9.1


<table>
<thead>
<tr>
<th>World Type</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosefielde-Lee world</td>
<td>92%</td>
</tr>
<tr>
<td>CIA world</td>
<td>32%</td>
</tr>
<tr>
<td>Birman-like world</td>
<td>-16%</td>
</tr>
</tbody>
</table>
this project. Second, the test we are employing is primarily a dynamic test that compares various growth rates. As such, it indicates that there are serious questions concerning the assumptions in the “Birman-like world” about the growth rate of total factor productivity and, hence, the growth rates of consumption and defense, which are the focus of this report. The results indicate that the actual rate of growth of total factor productivity is probably higher than in the “Birman-like world” and that the tradeoff curve between consumption and defense is probably more favorable for the Soviets. However, the results say little about the static aspects of the “Birman-like world.” They are not, for instance, relevant in a significant sense for the issue of what the size is of the current Soviet GNP.

2Calculating a confidence interval would be difficult because it requires that the model have several degrees of freedom in order for the usual procedures to work which is not the case here. This problem is not unsolvable. It does, however, require a substantial effort in order for it to be solved.
X. TECHNOLOGY AND COMPLEX COMPOSITE SCENARIOS

Uncertainty over the rate of total factor productivity growth during the 1980s has the largest impact on the average annual rate of growth of consumption vs. the average annual rate of growth of defense trade-off curve of all the "CIA world" issues examined in this study. This section addresses issues concerning technology. It also discusses two sets of scenarios that are composites of a large number of the scenarios discussed earlier. The first set examines some of the implications of possible Western policies aimed at imposing costs on the Soviet Union. The second postulates two extreme composites: one in which virtually everything that has been discussed goes right for the Soviets, and the other in which virtually everything goes wrong. These are then compared with the base case for the Birman and Rosefielde-Lee "worlds."

TECHNOLOGY

We have defined high, low, and base case technology scenarios. Our base case assumes that the growth rate of Soviet total factor productivity will be 0.1 percent, the same as it was in the 1970s. The high scenario assumes a rate of 0.94 percent—about what is called for by the eleventh five-year plan, which covers the first half of the 1980s. Since there is no reason to believe that the Soviets will do better during the second half of the 1980s, and given the Soviet history of failure to meet productivity goals in earlier plans, it is reasonable to take this as a high scenario. The low scenario was selected somewhat arbitrarily by taking into account the position of the base case and high scenarios as well as the predictions of others, particularly the CIA and the SOV-MOD team of Daniel Bond and Herbert Levine. We chose a rate of −1.00 percent.

The resulting three curves are shown in Figure 23. Note, as advertised, the enormous difference between the curves for T.F.P. (total factor productivity) of 0.94 percent and −1.00 percent. The CIA has projected that total factor productivity will grow in the 1980s at a rate roughly similar to the disastrous last half of the 1970s.¹ If plotted in Figure 23, the resulting curve would lie about midway between the base

¹Rowen, 1982, and Bond, 1983.
case and low scenarios.\textsuperscript{2} The corresponding curve for Bond and Levine would lie a little better than one third of the distance from the base case to the high scenario\textsuperscript{3}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{technology_graph.png}
\caption{Technology}
\end{figure}

\textsuperscript{2}More precisely, this statement refers to a curve generated by the HK model employing a rate of total factor productivity growth equal to that which occurred according to CIA data in the last half of the 1970s. The actual CIA curve would be quantitatively different in ways not relevant to the discussion here.

\textsuperscript{3}More precisely, we obtained this result by noting (see Bond and Levine, 1981) that the rate of T.F.P. growth, being used by Bond and Levine for their SOVMOD base case, was assumed to be equal to the rate for the 1968-1978 period. We then calculated the T.F.P growth rate for this period using the same data series as was used for our other T.F.P. calculations for consistency reasons (this result differs from the T.F.P. figure utilized by Bond and Levine, presumably because they used different data). Finally, this rate of T.F.P. growth was employed in the Hopkins-Kennedy model to get the relevant curve. If the Bond and Levine data and SOVMOD model could somehow be used to generate an equivalent curve, it would be somewhat different. It would also be difficult to compare it in a meaningful way with our results.
In Figure 23 there is also a point representing constant per capita consumption and the CIA expected rate of growth of defense spending. Note that if the T.F.P. = -1.00 percent scenario comes about, then this is sufficient (without postulating additional difficulties for the Soviet Union as reflected in some of the other “low” scenarios discussed in this report) to make it impossible for the Soviet economy to reach this point or even come reasonably close to it. This would result in serious economic difficulties for the Soviet Union.

THE IMPACT OF ALTERNATIVE COST-IMPOSING POLICIES

Consider our base case tradeoff curve and then ask what would be the impact on this curve, and hence the Soviet economy, of adding, one after another, unfavorable scenarios that we have examined in the preceding parts of this report. Further, let us perform this exercise by taking the scenarios in roughly descending order from those whose probability of occurrence Western policies could most easily to those which it could least easily influence. The main purpose is to shed some light on the economic costs to the Soviets of various actions that the West might take.

A couple of caveats are in order. The West cannot cause most of the scenarios to occur merely by making policy decisions; it can only push the Soviets in the desired direction or otherwise increase the probability of such events. For instance, the West cannot force the Soviets to have a low rate of growth of total factor productivity, but it can make it more difficult for the Soviets to improve their technology and, hence, push the Soviets in that direction. Second, we are ignoring the costs to the West of undertaking various actions. These two caveats taken together imply that plausible Western policies would not be able to exert anything close to the total impact of some of the scenarios about to be discussed. Further, a study that was primarily aimed at evaluating the impact of alternative cost-imposing policies would be structured differently, the obvious approach being to define various plausible policies and then directly analyze their impacts. This was not done here because the primary focus of this project was different. Despite these caveats, the results provide useful insights.

The results are presented in terms of a large number of tradeoff curves in Figure 24. The outermost (and, hence, most favorable for the Soviets) is the CIA base case scenario. Moving inward toward the origin and, hence, to successively less favorable (for the Soviets) scenarios, we first come to the low-credit scenario, which we have seen
before. Of those scenarios that we have analyzed, it is the easiest and most realistic to bring about through Western actions. The West need only place a moratorium on additional credit to the Soviet Union over and above what is necessary to roll over the existing debt. Even this, however, would not be easy to achieve. It would require a favorable Western consensus to be effective. In terms of our figure of merit, which is the difference in the level of Soviet defense spending in 1990 between two scenarios (in this case, the low credit and base case scenarios), assuming a 2.667 percent rate of growth of consumption for both scenarios, the loss to the Soviets would be 5 percent.

The low composite scenario has also been seen before. This adds to the low-credit scenario an annual cost of $3.2 billion due to increased Soviet foreign aid and an assumed "opening of the umbrella" by the Soviets to help their Eastern European client states repay their Western creditors. Western actions could substantially increase the likelihood that this scenario will occur, but not with the same confidence of success as in the case of the low-credit scenario. Examples of
such actions include increased aid to Afghan guerrilla forces and restricting new loans to Eastern Europe. The resulting figure-of-merit loss to the Soviets caused by moving from the base case to this scenario is 13 percent.

Additional actions could be taken by the West to promote a composite scenario, the components of which are the low composite credit, low relative capital efficiency, and low gold price scenarios. Relative capital efficiency could be reduced from the base case value of 1.5 toward the low scenario value of 1 by placing increased restrictions on high-technology exports to the Soviets. The change of relative capital efficiency from 1.5 to 1 causes only a small fraction of the effect on the tradeoff curve that is shown in Figure 24. The change to the low gold price scenario, which involves a drop in 1990 prices by a factor of two, explains the rest of the effect. The United States could promote this change through sales from its gold stockpile, the intent being to depress the market price of gold. The figure-of-merit difference between the base case and the low composite credit + low relative capital efficiency + low gold price scenario is a loss of 18 percent.

Suppose we next add the high agricultural price scenario to the foregoing list of calamities for the Soviet economy. This involves the assumption of an increase in the price of agricultural goods by a factor of 1.42 in 1990 compared with the base case. The probability of this occurring could be enhanced by using U.S. agricultural market power, preferably in conjunction with other friendly major agricultural exporters, to increase prices by reducing supplies. The change between this and our base case scenario in terms of our figure of merit is 36 percent.

Next add the OPEC collapse scenario to the preceding. We have as a result the following composite scenario: low composite credit + low relative capital efficiency + low gold price + high agricultural prices + OPEC collapse. The OPEC collapse scenario involves a fall from the $34 (1983 prices) per barrel level that existed at the beginning of 1983 to the $16 (1983 prices) per barrel level for the remainder of the decade, while the base case assumes an average annual increase in real dollars of 2.85 percent per year. The United States, in possible conjunction with other Western powers, could pursue a number of policies to promote the dissolution of OPEC. These all have other benefits and costs (which may be prohibitive), which are not discussed here. They cover the spectrum from simply reducing demand for OPEC oil by increasing oil taxes and promoting alternative forms of energy to direct military action aimed at seizing key oil fields. The relevant figure-of-merit loss to the Soviet economy is 48 percent.

The last composite scenario to be discussed adds to the immediately preceding composite scenario, the low technology scenario, where total
factor productivity growth over the decade is assumed to average -1 percent per year instead of the base case value of 0.1 percent. Of all the preceding scenarios, this is probably the most difficult for the West to drive the Soviets a substantial distance toward, but some progress in that direction can be achieved even with only those scenarios already presented.

A reduction in the amount of technologically sophisticated goods that the Soviets import for almost any reason would be harmful to their technological development. Most of the preceding scenarios would tend to promote such an effect by reducing the total amount of goods that the Soviets could afford to import. An exception is the low relative capital efficiency scenario, which does little to affect the total amount of goods imported. Instead, it tends to reduce their sophistication. A second possible exception is the high agricultural price scenario. While this scenario does involve a reduction of total imports, there is also a substitution effect away from the higher priced agricultural goods toward the technically more sophisticated capital goods, which could be the dominant effect. Fewer technologically sophisticated imports give the Soviets less opportunity to learn new technologies and, hence, slows their technological growth. In general, the effect on technological growth of the scenarios discussed in this study is a secondary impact of these scenarios which, until now, we have ignored.

In Figure 24 the impact of adding the low technology scenario to the composite of unfavorable (for the Soviets) scenarios is dramatic. At the 2.667 percent growth rate of consumption, the resulting tradeoff curve falls off the graph.

From the foregoing it is reasonable to conclude that Western cost-imposing policies might substantially damage the Soviet economy, but the evidence is too circumstantial and preliminary to draw anything like a firm conclusion. It appears, however, that the subject might be a fruitful area for further research.

COMPARISON OF EXTREME CIA COMPOSITE SCENARIOS WITH THE BASE CASE BIRMAN-LIKE AND ROSEFIELD-LEE SCENARIOS

It is instructive to define an extreme low and an extreme high composite scenario for the “CIA world.” The extreme high scenario consists of the following component scenarios: low composite credit, low relative capital efficiency, low gold price, high agricultural prices, OPEC collapse, low technology, and low oil supply. This is identical to
the last scenario discussed in the previous subsection (and represented in Figure 24 by the curve closest to the origin), except that the low oil supply scenario has been added. The extreme high composite scenario is approximately the mirror image of the extreme low scenario, whose component scenarios are: high credit, high relative capital efficiency, high gold price, low agricultural prices, high oil price, high technology, and high oil supply. As can be seen in Figure 25, there is a dramatic difference between the tradeoff curves for the two scenarios.

Note the two points in Figure 25 representing, respectively, the 1970s experience according to CIA data, and the point of constant per capita consumption and expected rate of growth of defense spending. The extreme high scenario is dramatically better for the Soviets than what they experienced in the 1970s. The extreme low scenario would
be a truly great disaster for them. They would not be able to maintain the CIA projected 4.5 percent rate of defense spending growth and a constant per capita level of consumption. In fact, it would be impossible to obtain even a positive rate of growth for both consumption and defense. Figure 25 also contains the tradeoff curves for the Birman-like and Rosefielde-Lee base cases. The extreme composite curves are not much farther apart than these. Indeed, if the normalized tradeoff curves for the base cases for these worlds (shown in Figure 12) were drawn, instead of the usual unnormalized tradeoff curves, then they would be substantially farther apart than the extreme "CIA world" cases. These considerations demonstrate once again the importance of the issue of which of these worlds is correct.
XI. CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

Let us summarize the major findings of this study. We have found by comparing high and low scenarios, etc., for various economic parameters that credit, weather, and the price of gold have a relatively small impact on the tradeoff curve between the average annual growth rate of consumption and the average annual growth rate of defense for the 1980s. The impact for agricultural prices is substantial. This is also true for credit when it is augmented by such scenarios as increased Soviet foreign aid, opening the umbrella, and, in particular, uncertainty concerning the efficiency ratio of imported to domestic capital. Issues concerning oil supply and prices are also of substantial importance. Within the "CIA world," technology is of dramatic importance. Only the extreme composite scenarios are more important, and this has much to do with the fact that they contain the technology scenarios as components.

With regard to the Birman-like and Rosefield-Lee "worlds," the difference between their base cases is dramatic. This is doubly true if we compare their normalized base cases instead of the usual unnormalized base cases. Foreign trade, broadly defined to include not only credit-related and relative capital efficiency issues, but also the effects of gold prices, agricultural prices, oil prices, etc., tends to have larger effects on the "Birman-like" than the "Rosefield-Lee world." The major exception to this is agricultural prices. Our shadow price methodology has produced preliminary evidence that is unfavorable for the "Birman-like world." It is difficult to believe that the effective price of oil to the Soviet economy fell during the 1970s decade while it was skyrocketing on the world market. This result suggests that the dynamic aspects of the "Birman-like world" are not correct and, hence, the growth rate of total factor productivity and the tradeoff curve between consumption and defense growth rates are much more favorable for the Soviets than is assumed in the "Birman-like world." The static aspects of the "Birman-like world," such as the argument that GNP is substantially lower than the CIA believes, were not tested in any significant sense by our shadow price approach and could be correct.

One fruitful subject for future research (discussed at length in Section X) would be the impact on the Soviet economy of alternative plausible Western policy options specifically aimed at imposing costs on the
Soviet Union. Such research would have a different orientation from this study. For example, instead of comparing the impact on the Soviet economy of a plausibly high and a plausibly low set of agricultural prices, the new study might ask: if we implement policy A, what would be the increase in the price of agricultural goods, and how much would this hurt the Soviet economy?

Another possible area for future work, which is of more immediate concern to the authors, is the construction of an optimal control model of Poland and its use to address various Polish issues as well as issues that concern the interaction of the Polish economy with the West and the Soviet Union. Poland is a particularly interesting nation for which to build an optimal control model because its future is highly uncertain and difficult to predict from historical behavior. This is the type of situation for which optimal control does best compared with other methodologies. Once a Polish model is built, it could be linked to the Hopkins-Kennedy Soviet model, creating a larger model. We would then be in a position to address such questions as what the implications are of various Western policies for the Polish economy for given Soviet policies, the implications of various Soviet policies for the Polish economy for given Western policies, the impact of various Soviet policies toward Poland on the Soviet economy, and how these impacts are altered by Western policies.

The model could also be used to study issues of concern to the Polish economy other than its relationship to the West and the Soviet Union, such as energy, technology, and the impact of alternative relationships between the government and the people. Will the people in the future work at reduced efficiency because of pro-Solidarity sympathies, etc.? If so, what will be the impact on the economy?

In the more distant future, but not as part of an initial effort, optimal control models could be constructed for the other nations of Communist Eastern Europe and linked to the Polish and Soviet models, so as to create a model that could address interactive questions relevant to the region as a whole.
Appendix A

THE IMPACT OF ALTERNATIVE MODEL SPECIFICATIONS

The Hopkins-Kennedy optimal control model of the Soviet Union was originally presented in Hopkins et al., 1982. The contract for the current research project calls for the investigation of a number of alternative model specifications. Some of these have been incorporated in the version of the model used in this report. The purpose of this appendix is to address the question of how much difference it makes if we use or do not use these changes. The answer is that, in general, the difference is small.

Below, we examine the effects of changing the number of sectors in the model; of employing a different approach to measuring the amount of capital that exists in the initial year from which we begin a projection; of not assuming that personnel expenditures will be constant for the remainder of the decade but instead will grow at the same rate as the rest of defense spending; and of not allowing procurement to grow at a different rate from the rest of defense spending.

THE NUMBER OF SECTORS

The Hopkins-Kennedy model has 21 sectors. This number was chosen somewhat arbitrarily, which gives rise to the question of whether it would make much difference in the results if the number of sectors were changed.

It obviously would if the number were greatly reduced to, say, 2 or 3. Then the interaction between the sectors would play such a great role in the model that adding or subtracting a sector (or for that matter, simply redefining what the sectors were) would substantially affect the results.

The more interesting question is what would happen if the number of sectors were increased substantially. To answer this question we developed a 32-sector HK model. This task was not difficult since the 21-sector model obtained all of its sectors, except for those dealing with
defense and the residual "other" sector that mainly covers services,\( ^1 \) by aggregating the 56 material product sectors of Treml et al.\( ^2 \) We simply divided some of the 21 sectors into pieces where each piece still represents one or more of the Treml sectors.

The disaggregating process was purposely done so as to favor disaggregating the MBMW (machine building metal working) sector more than the others. The reasoning for this is that MBMW plays a dominant role in weapons production, and hence it is particularly important to learn more about how this sector interacts with the rest of the economy.

Table A.1 has three columns. The first of these lists the 21 sectors of the HK model. The second lists the new sectors created by disaggregating some of the 21 so as to give a total of 32. The final column lists the numbers of the Treml sectors that were aggregated to create each of the sectors in the first two columns. These Treml numbers and detailed descriptions of each of the sectors they represent are given in Treml et al., 1976.

The tradeoff curves for the 21-sector and 32-sector HK models are shown in Figure A.1. As can be seen, the difference between the two curves is too small to be detected on the graph. This indicates that the number of sectors used in the model, given that the model has at least a number that is in the ballpark of 21, is not important.

**CAPITAL MEASUREMENT**

One input needed in the Hopkins-Kennedy model is the amount of capital that is associated with each sector for the initial year of a projection. Our procedure for obtaining this was to calculate, from data in Treml et al., 1976, the value added by capital for each sector. We assumed that the amount of capital associated with each sector was proportioned to this and then used information on the size of the total capital stock to obtain the amount of capital associated with each sector.

An alternative procedure is to utilize the Treml et al., 1976, estimates of the capital stock by sector. This has the advantage of being more direct, but creates a new problem that does not occur for the procedure actually used. The model also requires, as an input, value added due to capital for each sector. This was obtained in the alternative procedure by taking capital's share of output for the economy as a

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\(^1\)See Hopkins et al., 1982, for a detailed description of this aggregation process and other particulars concerning how the sectors were chosen.

\(^2\)Treml et al., 1976.
### Table A.1

<table>
<thead>
<tr>
<th>The sectors for the 21-sector HK model</th>
<th>The additional sectors for the 32-sector HK model</th>
<th>Treml sector numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ferrous metallurgy</td>
<td></td>
<td>1,2</td>
</tr>
<tr>
<td>2. Nonferrous metallurgy</td>
<td></td>
<td>1,2</td>
</tr>
<tr>
<td>3. Machine building</td>
<td></td>
<td>9-26</td>
</tr>
<tr>
<td>metal working</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1 Energy m&amp;e (machinery and equipment)</td>
<td>9,10</td>
</tr>
<tr>
<td></td>
<td>3.2 Other machinery</td>
<td>11,16,21-23</td>
</tr>
<tr>
<td></td>
<td>3.3 Instruments and chemical equipment</td>
<td>12,13,15</td>
</tr>
<tr>
<td></td>
<td>3.4 Construction m&amp;e</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>3.5 Transportation m&amp;e</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>3.6 Automobiles</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>3.7 Tractors &amp; agricultural m&amp;e</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3.8 Mining and metallurgical m&amp;e</td>
<td>14</td>
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<td></td>
<td>3.9 Other metal output</td>
<td>24,25</td>
</tr>
<tr>
<td></td>
<td>3.10 Repairs of m&amp;e</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>4. Forest products</td>
<td>34-36,38</td>
</tr>
<tr>
<td></td>
<td>5. Soft goods</td>
<td>40-43</td>
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<tr>
<td></td>
<td>5.1 Textiles</td>
<td>41</td>
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<tr>
<td></td>
<td>5.2 Other light industry</td>
<td>40,42,43</td>
</tr>
<tr>
<td></td>
<td>6. Processed foods</td>
<td>44-49</td>
</tr>
<tr>
<td></td>
<td>7. Construction materials</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>8. Coal and peat</td>
<td>3.7</td>
</tr>
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<td></td>
<td>9. Oil</td>
<td>4.5</td>
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<tr>
<td></td>
<td>10. Gas</td>
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</tr>
<tr>
<td></td>
<td>11. Electric power</td>
<td>8</td>
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<tr>
<td></td>
<td>12. Chemicals</td>
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<td></td>
<td>12.1 Chemical products</td>
<td>27-30,33</td>
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<td></td>
<td>12.2 Rubber</td>
<td>31,32</td>
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<td></td>
<td>13. Paper and pulp</td>
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<td></td>
<td>14. Construction</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>15. Agricultural and forestry</td>
<td>52-53</td>
</tr>
<tr>
<td></td>
<td>16. Transportation and communication</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>17. Trade and distribution</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>18. Industry not elsewhere</td>
<td>50,56</td>
</tr>
<tr>
<td></td>
<td>classified (NEC) and other branches</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19. Procurement</td>
<td>Not covered</td>
</tr>
<tr>
<td></td>
<td>20. Nonprocurement defense</td>
<td>Not covered</td>
</tr>
<tr>
<td></td>
<td>21. Other</td>
<td>Not covered</td>
</tr>
</tbody>
</table>
whole, and assuming that this is divided among the sectors in proportion to their capital stocks. The resulting value added, by capital by sector, is not the same as we obtain more directly from the procedure actually used. In particular, the value added by capital and labor no longer adds up to the total value of output, net of the value of intermediate goods inputs. This problem is solved by making the required adjustment in the amount of intermediate goods assumed to be utilized in the output of a unit of a particular good. Of course, this means the input/output coefficients are no longer what Tremil et al. estimated them to be. There is no obvious solution to this problem. It is the price paid so as to be able to use more direct capital stock estimates.

We do not believe that either procedure is better than the other. Both would give the same results if the Soviet economy actually had constant returns to scale for each of its sectorial production functions, and if the rate of return on capital were the same for all sectors. These assumptions are made by both of the procedures. In practice they are only roughly correct.
Figure A.2 compares the base case scenario with one that uses the alternative procedure to determine the capital stock for the initial period. There is a clear but small difference.

THE PERSONNEL CORRECTION

One of the changes made in the HK model since our 1982 report was to respecify the defense sector so as to assume, for our 1980 to 1990 projections, that the real cost of defense personnel remained constant instead of growing at the same rate as aggregate defense spending.

Figure A.3 explores the issue of how much impact this difference has on our consumption vs. defense tradeoff curves. The figure depicts the tradeoff curve for the "CIA world" base case scenario and for a scenario that is identical to the "CIA world" base case except that there is no personnel correction. As can be seen, the difference

![Diagram](image-url)
between the curves is too small to be detectable on the graph. The results for the Birman and Rosefieles-Lee "worlds" are similar.

THE PROCUREMENT CORRECTION

Another change in the HK model, (from the work reported in Hopkins et al., 1982) concerns procurement. Previously, it was assumed for the 1980–1990 projections that procurement would grow at the same rate as the rest of defense spending. The new procedure is to estimate roughly, for each world, a most likely rate of growth of procurement and of defense spending. It is then assumed that the ratio of these rates of growth will remain the same for all levels of the growth rate of defense covered in this study.

The impact of the new procedure is largest for the "Rosefieles-Lee world." Figure A.4 compares the Rosefieles-Lee base case scenario tradeoff curve with the tradeoff curve for the same scenario, except that no procurement correction was made. The difference between the two curves is small but noticeable.
The Hopkins-Kennedy model is undergoing continual development. If improved future versions of the model were used to redo the analysis in this report, there would be quantitative changes in the results. However, the authors feel that there would be few qualitative changes.
Appendix B

DATA IMPROVEMENTS AND UPDATES

The data used in this report differ somewhat from the data use in our 1982 report. These data changes have slightly altered the results for our CIA base case 1980–1990 projection as well as the results for some of the scenarios.

The changes in the CIA base case are mainly due to the use of data that have recently become available concerning the value of output and capital for the years 1960–1980. Previously, SOVMOD data (generously provided by Daniel Bond of Wharton Econometric Forecasting Associates) were used for these variables. In the current report, we employ newly released CIA data. In particular, we use output data from Pitzer, 1982, and capital data from Leggett, 1982. Our estimates of total factor productivity growth for 1960–1980 depend upon the numbers used for output and capital for this period. These total factor productivity numbers, in turn, played a key role in determining what we assumed would be the growth of total factor productivity in the 1980s and, hence, in determining of the base case tradeoff curve.

Other important data changes include the following: The new Pitzer, 1982, data were used for net outputs. The model requires such data for the initial year of a projection. Treml input-output data in terms of producers prices were used in this report instead of the less desirable purchasers price data of the 1982 report. This was because producers price data for all three years for which Treml and associates made their calculations (1959, 1966, and 1972) have only recently become available.¹ There were also data changes because another year has passed in the decade for which we are making predictions.

¹Guill, 1982.
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