THE UNITED STATES AND THE SOVIET UNION: A STUDY OF THE DIFFERENCES IN STEEL INTENSITY FROM 1950 THROUGH 1986

by

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ABSTRACT

The centrally planned economies consume significantly higher amounts of steel per unit of national income than other country groups. This study examines steel intensity of use (IOU) for the world's largest steel consumers, the United States and the Soviet Union, with the objective of explaining differences in the level and trend of steel intensity between the two countries.

The goods produced by an economy and the materials used to produce these goods influence the level and trend of IOU. During the study period, 1950 to 1986, the industrialization push in the USSR raised the share of steel-intensive sectors in the economy, and steel intensity rose. In the United States, the growing importance of the information processing and high technology sectors, which are not steel-intensive, caused steel intensity to fall.

More significant is the development of new technologies and materials that have reduced the quantity of basic steels required in manufacturing and construction. In the United States, such changes explain the sharp decline in steel intensity since the 1970s. In the USSR, reliance on outdated technology and designs has worked in concert with the increasing size of the industrial sector to keep steel intensity increasing over time.

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Chapter 1

INTRODUCTION

1.1 Overview

Intensity of use is defined as consumption of a metal, mineral, or energy divided by some macroeconomic indicator, usually gross domestic product (GDP). The concept was developed by several organizations, such as the Economic Commission for Europe (1959) and the International Iron and Steel Institute (1972), but is most often attributed to Wilfred Malenbaum, who in a series of articles and books, popularized and further developed the idea (see for example, 1978).

Intensity of use (IOU) originally was thought to reflect the level of economic development that a country had achieved. In underdeveloped countries undergoing rapid economic growth, IOU rises. As infrastructure is built and industrialization proceeds, IOU eventually levels off, and in advanced stages of economic development, it declines.

Other authors, such as Roberts (1986) and Tilton (1986), have noted that the focus on economic development alone, as represented by the level of per capita income, is insufficient to explain IOU. Other factors, such as materials substitution and technological change, can also affect the level and trend of IOU. These concerns between early

IOU theory and the new view have been amply explained in other literature, and will not be reiterated here.

What has been neglected in this research of the IOU concept, however, is a detailed study of the IOU in centrally planned economies (CPEs), such as the Soviet Union and the Eastern European countries. This is particularly unfortunate given that the level of IOU in CPEs is markedly different from that of developed and less developed countries.

Figure 1.1 shows crude steel IOU for the world and various country groups from 1960 through 1986. As one can readily see, IOU in the Council for Mutual Economic Assistance (CMEA-7), which is defined as the Soviet Union and members of the CMEA-6 (Bulgaria, Romania, Czechoslovakia, East Germany, Poland, and Hungary), is much higher than in other country groups. The extent of this difference is shown in Table 1.1, which shows an index of IOU for steel, with IOU for steel in the CMEA-7 equal to one hundred. In fact, the difference over time has been growing in the developed countries. CMEA-7 steel IOU in 1986 was more than three times the level of the developed countries; in 1960, CMEA-7 steel IOU was 1.8 times that of developed countries.

This phenomenon of higher IOU in the CMEA-7 is not confined to steel; other metals and even energy exhibit

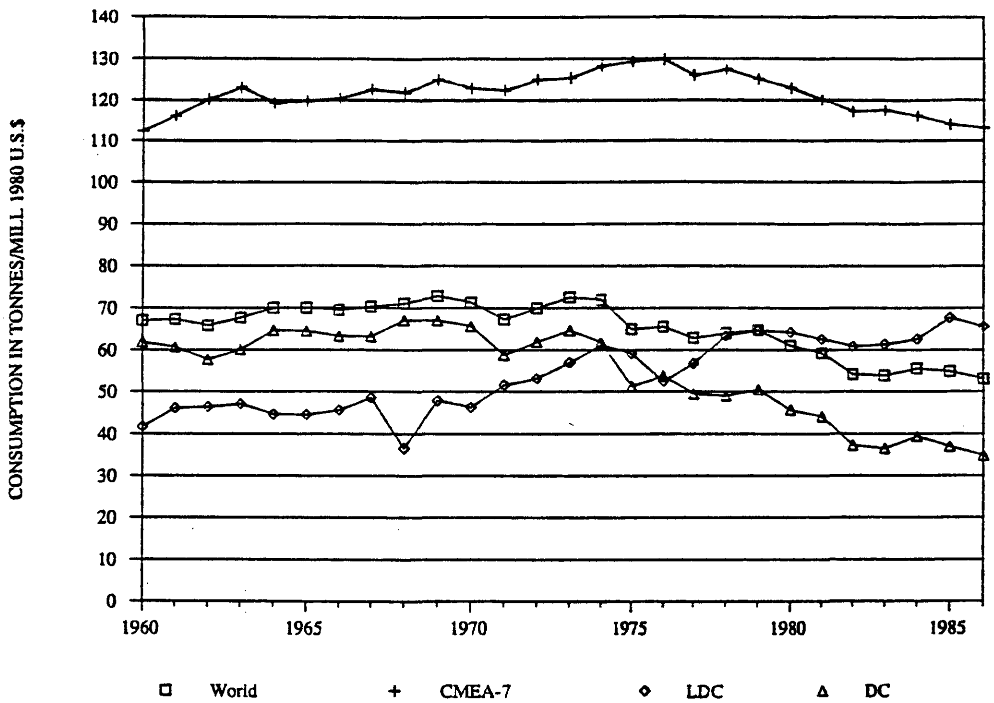

Figure 1.1 Intensity of Use of Crude Steel for Various Country Groups, 1960-1986

Sources: International Iron and Steel Institute. Statistical Yearbook, various issues.
The World Bank Data Tape, Update 1987.
CIA, 1982. USSR: Measures of Economic Growth and Development 1950-1980.
Tilton, J. E., (forthcoming). World Metal Demand: Past Trends and Future Prospects.

Table 1.1 CMEA-7 Steel IOU Relative to Other Country Groups

Year	World	LDC	DC
1960	59.7	37.1	55.1
1973	57.9	45.5	51.6
1979	51.8	51.7	40.5
1986	46.9	57.9	30.7

Source: International Iron and Steel Institute. Statistical Yearbook, various issues.
The World Bank Data Tape, Update 1987.
CIA, 1982. USSR: Measures of Economic Growth and Development 1950-1980.
Tilton, J. E. (forthcoming) World Metal Demand: Past Trends and Future Prospects, data appendix.

similar high levels of intensity relative to other country groups. While other analysts have commented on this difference in intensities, the reasons for the difference have not been subject to detailed investigation.

The difference in intensities raises a number of questions that will be investigated in the course of this study. Are differences in IOU really significant, and if so, what do they indicate? Is the primary reason for the differences the difficulties in obtaining comparable data, such as GDP or exchange rates? Would the inclusion of the metal contained in imported and exported products close the gap? How does the structure of the economy affect the level of IOU? Do centrally planned countries have a systemic bias towards industry that increases IOU relative to the developed Western countries whose economies have recently turned to less resource-intensive sectors? How have material substitution and resource-saving technologies affected IOU?

1.2 Survey of Related Studies

One of the first studies of CMEA intensities was conducted by the Economic Commission for Europe (1984). Using a modified intensity-of-use approach to study steel consumption across various country groups, the ECE had the ambitious task of explaining intensities of use worldwide. Specific countries were chosen for case studies to highlight various changes within countries, such as structural change and the development of new production technologies.

While the CMEA-7 countries are discussed by the ECE, a detailed study of the determinants of intensity of use, namely the material composition of products and the product composition of income, for individual countries was not conducted. More important, while the ECE mentions the higher steel intensity in the CMEA-7, it does not explore the reasons for this higher intensity. The ECE hypothesizes that the higher level of steel intensity is due to the larger share of industry in GDP in CPEs than other country groups, but they do not test this hypothesis or look for alternate explanations.

Dobozi (forthcoming) has made perhaps the most important contribution to the study of metal intensities in the centrally planned economies. Using econometric techniques, Dobozi attempted to identify the factors that determine metal consumption in the CPEs. His efforts to explain declining growth rates of IOU in these countries since 1979, however, are inconclusive. Dobozi cites the lack of disaggregated data as a possible explanation.

The second part of Dobozi's study was an investigation into the causes of higher IOU in CMEA countries. Dobozi used econometric methods to separate out the effects of the economic system from those of economic policy and the environment in which the economic system operates. According to Dobozi (forthcoming),

> The economic system is understood as a set of mechanisms, rules and institutions for decision making and the implementation of economic decisions. . . . Policies within the system are those economic decisions that seek to change outcomes without changing the underlying economic system. The environment of the economic system includes the level of economic development, natural resource endowments, the size of the economy, the stock of human and physical capital, random events, etc.

His purpose was to test the hypothesis that higher intensities in the CMEA were caused by the economic system itself. Although he did find some evidence of overconsumption of materials, he also acknowledges the difficulty of separating out the role of the economic system and economic policies in determining metal consumption.

Given the research to date, there is room for a more detailed examination of the reasons for higher intensities in the centrally planned countries, relative to other country groups.

1.3 Purpose and Scope

This study examines the consumption and intensity of use of crude steel for two major industrial and military superpowers: the United States and the Soviet Union. The purpose is to discern why the level and trend of IOU has differed so significantly between these two. As Figure 1.2 indicates, considerable differences exist between the level and trend of IOU for crude steel that require explanation.

The period of study is 1950 through 1986. Consistent macroeconomic data series for these years are available for both countries, and examining 1950 to 1986 avoids periods of growth not representative of the average. For example, the Soviet economy was devastated by World War II, and most Soviet observers feel that economic growth was unusually high immediately after the war. Inclusion of this period would make the recent economic slowdown seem more severe. Another reason is that up until Stalin's death in 1953,

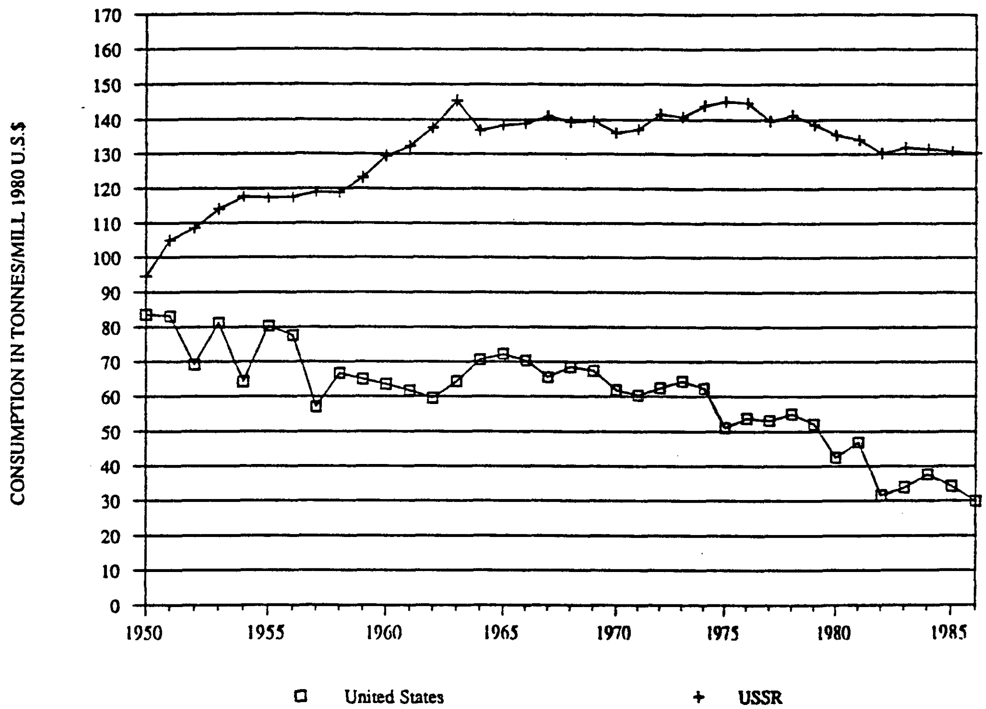

Figure 1.2 Crude Steel Intensity for the United States and the USSR, 1950-1986

Sources: International Iron and Steel Institute. Statistical Yearbook, various issues.
Kravis, Irving B., et al., 1982. World Product and Income: International Comparisons of Real Gross Product.
World Bank Data Tape, Update 1987.
CIA, 1982. USSR: Measures of Economic Growth and Development 1950-1980.
CIA, annual. Handbook of Economic Statistics, various issues.

there was little published data by the Soviet Union available to Western analysts, making the decade of the 1940s still partly a mystery.

Figures 1.3 and 1.4 show the two components of IOU, consumption and GDP, for both countries. Annual average growth rates for GDP, steel consumption, and steel IOU are shown in Table 1.2. In the USSR, both consumption and GDP show a relatively steady linear trend until about 1978 when the growth rates slowed markedly. The drop in the growth rate of consumption was larger than the slowdown in GDP growth, and hence steel IOU started to decline significantly after that for the first time.

In the United States, the break in steel consumption and GDP growth occurred earlier than in the USSR, about 1973. Although steel IOU had been declining throughout most of the period between 1950 and 1986, the larger downturn in consumption relative to GDP after 1973 caused the decline in IOU to accelerate between 1973 and 1986. The USSR surpassed the United States in steel consumption in the mid-1970s. GDP has been consistently higher in the United States than in the USSR, and the gap has been widening over time.

The United States and the Soviet Union were chosen for this study because they are the largest consumers of steel in the world, so the large and growing gap in IOU between

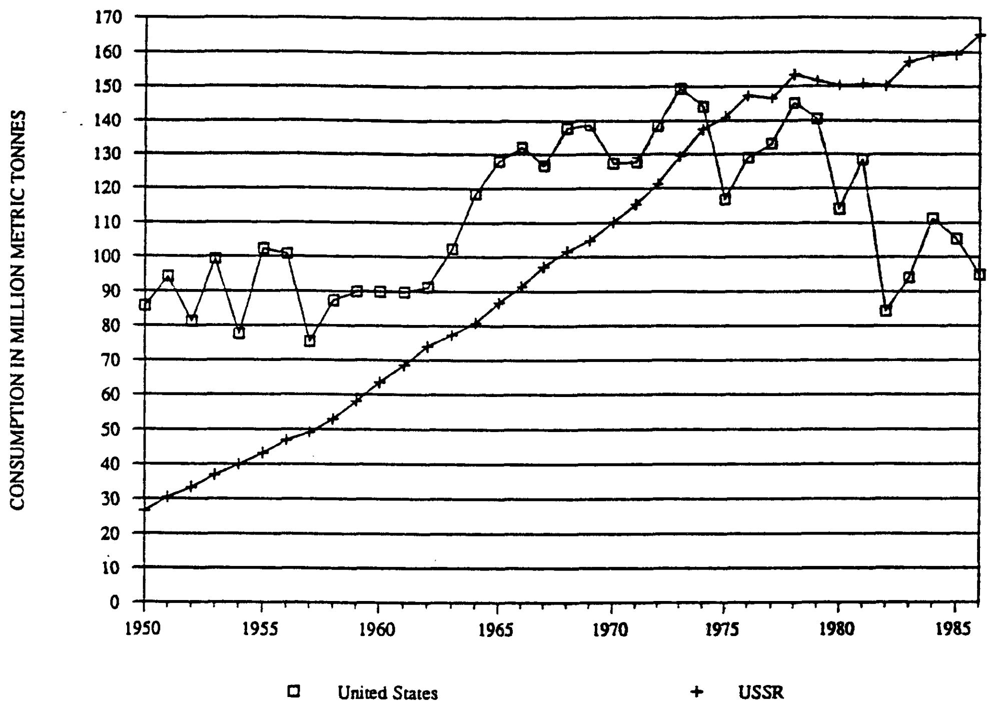

Figure 1.3 Consumption of Crude Steel in the United States and the USSR, 1950-1986

Source: International Iron and Steel Institute. Statistical Yearbook, various issues.

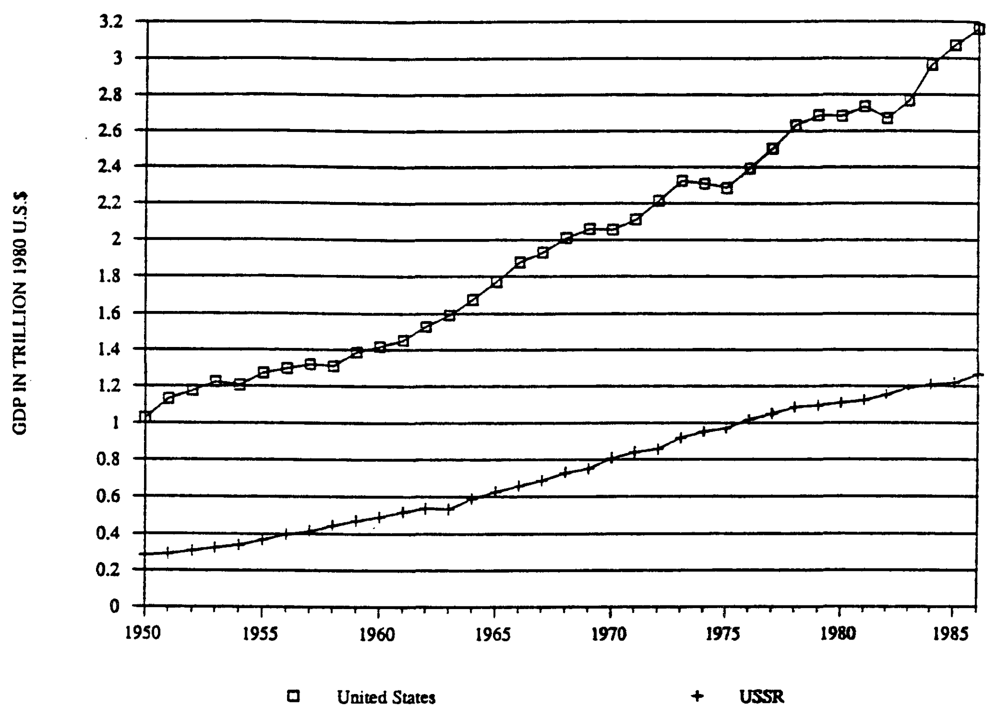

Figure 1.4 Gross Domestic Product in the United States and the USSR, 1950-1986

Source: Kravis, Irving B., et al., 1982. World Product and Income: International Comparisons of Real Gross Product.
World Bank Data Tape, Update 1987.
CIA, 1982. USSR: Measures of Economic Growth and Development 1950-1980.
CIA, annual. Handbook of Economic Statistics, various issues.

Table 1.2 Annual Average Growth Rates for GDP, Crude Steel Consumption, and Crude Steel IOU for the United States and the USSR, 1950-1986

	Annual Average Growth Rates (%)					
	USSR			UNITED STATES		
Years	GDP	Steel Consump	IOU	GDP	Steel Consump	IOU
1950-55	5.3	10.1	4.9	3.7	1.4	2.3
1955-60	5.7	6.9	1.5	2.1	-3.8	-5.9
1960-65	4.6	6.0	1.4	4.6	7.7	3.1
1965-70	5.0	4.7	-0.2	3.0	0.6	-2.5
1970-75	3.9	5.2	1.3	2.8	0.0	-2.8
1975-80	2.6	1.3	-1.3	3.6	0.6	-3.0
1980-86	2.1	1.6	-0.6	2.7	-2.4	-5.1
1950-86	4.3	4.9	0.6	3.2	0.9	-2.3

Sources: International Iron and Steel Institute. _Statistical Yearbook_, various issues.
Kravis, Irving B., et al., 1982. _World Product and Income: International Comparisons of Real Gross Product_.
World Bank Data Tape, Update 1987.
CIA, 1982. _USSR: Measures of Economic Growth and Development 1950-1980_.
CIA, annual. _Handbook of Economic Statistics_, various issues.

these countries is important to examine. Their size and importance in the world economy also makes data availability less of a problem than in smaller CPE and developed countries.

1.4 Outline

To determine why the Soviet Union's steel IOU differs so markedly from that of the United States, the following issues are examined.

Chapter 2 examines whether the higher steel IOU of the USSR relative to the United States is due to data limitations, and whether IOU is an appropriate measure for intercountry comparisons. The collection and interpretation of Soviet data is discussed to see whether distortions or misinterpretation of Soviet data is the cause of the higher intensities. Problems of doing intercountry comparisons are discussed because the economic structure of the United States differs radically from the USSR.

Potential adjustments to the IOU calculations are explored in chapter 3. Purchasing power parity and market exchange rates are discussed to see how they influence the level and trend of IOU. Indirect steel trade, defined as the metal content of semi-finished and finished steel goods, is examined to see if exclusion of this data in traditional measures of consumption accounts for the differences in intensities.

Chapter 4 looks at how changes in the product composition of income, or how changes in the intersectoral and intrasectoral structure of economies, have influenced the level of IOU. Disaggregated macroeconomic data are used to examine whether the higher USSR steel IOU can be explained by the larger size of its industrial sector. Traditional determinants of demand, such as government policy and consumer tastes and preferences, are also examined to see how they have influenced these sectoral changes.

Changes in the material composition of product are reviewed in chapter 5. Input-output tables are used to construct coefficients that evaluate the role of technological changes and material substitution in determining the level and trend of steel IOU. Important developments in the United States and the USSR that have influenced the degree of material substitution and technological change are also discussed, with the purpose of explaining the input-output study results. The chapter concludes with how shortages and reindustrialization policies in the USSR, as well as prices, have influenced the level and trend of IOU.

The final chapter summarizes the major conclusions from each section and presents implications of the study.

Chapter 2

LIMITATIONS OF CONSUMPTION AND GDP DATA

One potential explanation for the higher IOU in the USSR is that problems in collecting and interpreting data used in the IOU calculations are to blame. This chapter evaluates several potential problems in the calculation of IOU. This chapter examines how the two parts of IOU, consumption and GDP, are calculated, to see whether current methods of estimation are responsible for differences in the level and trend of steel intensity.

2.1 Calculation of Consumption

The International Iron and Steel Institute (IISI), which is the source of consumption figures in this study, defines apparent consumption of crude steel as production, plus imports, less exports.[1] This definition is used by most organizations, but since it is calculated indirectly, it is subject to error.

For example, production is measured as tonnes of crude steel, but exports and imports are measured as tonnes of semi-finished and finished steel products. Exports and imports must therefore be converted to their crude steel

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1. Crude Steel is rough shapes, such as slabs, blooms, and billets.

equivalent (CSE), since there is some scrap generated in the production of these exported and imported steel products. One would want to exclude the scrap generated in the production of exported steel products from consumption, and include the scrap generated in the production of imported steel products. The IISI assumes that 30% of the crude steel used to produce finished and semi-finished steel products for export or import is lost as scrap.

Accounting for this scrap alone is not sufficient, however, since it does not allow for differing yields between countries.[2] For example, the use of continuous casting results in a high yield because hot metal from the blast furnace is cast directly into crude steel shapes. When continuous casting is not used, hot metal is first cast into ingots, which are then heated and rolled into crude steel shapes. Ingots often must be cropped before rolling to ensure better surface quality, resulting in a lower yield.

Consequently, the IISI adjusts the 30% assumed scrap loss by another coefficient designed to take these differing yields into account by assuming a 17.5% savings with continuous casting over ingot production. The final equation to

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2. Yield is a measure of the amount of crude steel obtained from hot metal produced in the furnace during steelmaking.

convert the semi-finished and finished steel products to CSE is then:

$$CSE = \frac{P * 1.3}{1 + (0.175 * \%CC)}$$

where P = product in semi-finished or finished form to be imported or exported, in tonnes
%CC = proportion of crude steel production that is continuously cast

The purpose of the formula is to adjust the 30% assumed scrap loss downward to account for the higher yields achieved with continuous casting. The higher the proportion of continuous casting, the lower the scrap coefficient. Adjusted imports (in CSE) are then added, and adjusted exports subtracted, from production figures to obtain apparent consumption.

Theoretically, the IISI method of calculating consumption should provide a good estimate of actual consumption. There are, however, several problems with the IISI method. The most obvious problem is the use of a standard scrap coefficient of 30%, since it assumes every country has at most a 30% scrap loss. If a country is more inefficient than the average 30% scrap generation, then consumption is overestimated because the calculated CSE of exported steel products will be lower than actual CSE. Furthermore, this scrap coefficient can vary over time and between countries as technology or products manufactured changes.

A different problem arises for imported steel products. IISI uses the %CC for the importing country, rather than for the exporting country, to adjust the scrap coefficient. The IISI practice can be defended as being simpler and more practical than trying to determine the trading partners for every country, since trading partners can change frequently and the data on partners are sometimes not available.[3] However, if the importing country has a smaller %CC than its trading partners, this can again overestimate consumption, since calculated CSE will be greater than actual CSE for imports.

Table 2.1 shows the IISI consumption and adjusted consumption figures for the USSR to illustrate the effects of such data problems. For reasons that will be explored in later chapters, the USSR is assumed to have a higher scrap coefficient than the average, around 45%. Also, the USSR trading partners, mainly the Federal Republic of Germany and Japan are highly efficient producers of steel, and make

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3. Another reason for keeping coefficients constant across countries and time is to keep data internationally comparable, so that imports and exports are measured in similar ways. For more discussion of these issues, see the Economic Commission for Europe (1984).

Table 2.1 **Comparison of Consumption Figures for the USSR**
(in thousand metric tons)

Year	(1) %CC	(2) Produc	(3) Exp	(4) Imp	(5) Adj Exp 30% scrap	(6) Adj Exp 45% scrap	(7) Adj Imp IISI
1976	8.1	144,805	7,503	9,532	9,618	10,727	12,218
1977	8.3	146,655	7,387	7,326	9,466	10,558	9,387
1978	9.5	151,436	7,368	8,932	9,422	10,509	11,422
1979	10.3	149,087	7,407	9,409	9,459	10,550	12,015
1980	10.7	147,931	7,184	9,064	9,168	10,225	11,567
1981	12.2	148,517	7,089	8,921	9,023	10,064	11,355
1982	12.6	147,153	7,575	10,083	9,635	10,747	12,825
1983	12.4	152,511	5,320	9,055	6,769	7,550	11,521
1984	12.4	154,200	5,473	9,285	6,964	7,767	11,814
1985	13.3	154,500	5,500	9,300	6,987	7,794	11,815

Notes: (1) Proportion of domestic production that is continuously cast, IISI, Table 5.
(2) Domestic production of crude steel, IISI, Table 2
(3) Exports of semi-finished or finished steel products, IISI, Table 7
(4) Imports of semi-finished or finished steel products, IISI, Table 8
(5) col. (3) times a factor of 1.3/(1+0.175c), where c = col. (1)/ 100
(6) col. (3) times a factor of 1.45/(1+0.175c), where c = col. (1)/ 100
(7) col. (4) times a factor of 1.3/(1+0.175c), where c = col. (1)/ 100

Sources: **International Iron and Steel Institute, 1986. Statistical Yearbook.**
Scherer, John L., ed. USSR Facts and Figures Annual, various issues.

(continued)

Table 2.1 (continued)

Year	(8) Adj Imp case 1 85% CC	(9) Adj Imp case 2 50% CC	(10) Cons IISI	(11) Adj Con 45% scr 85% CC	(12) Adj Con 45% scr 50% CC	(13) % dif C11 & C10	(14) % dif C12 & C10
1976	10,787	11,395	147,406	144,865	145,472	-1.7	-1.3
1977	8,291	8,758	146,577	144,388	144,855	-1.5	-1.2
1978	10,108	10,677	153,436	151,035	151,604	-1.6	-1.2
1979	10,648	11,248	151,644	149,185	149,785	-1.6	-1.2
1980	10,257	10,835	150,330	147,963	148,541	-1.6	-1.2
1981	10,096	10,664	150,849	148,548	149,117	-1.5	-1.2
1982	11,411	12,053	150,343	147,817	148,459	-1.7	-1.3
1983	10,247	10,824	157,263	155,208	155,785	-1.3	-0.9
1984	10,508	11,099	159,050	156,940	157,532	-1.3	-1.0
1985	10,524	11,117	159,328	157,231	157,824	-1.3	-0.9

Notes:
(8) col. (4) times a factor of 1.3/(1+0.175c), where c = .85
(9) col. (4) times a factor of 1.3/(1+0.175c), where c = .5
(10) apparent consumption, IISI, Table 10
(11) col. (2) plus col. (8) minus col. (6)
(12) col. (2) plus col. (9) minus col. (6)
(13) [col. (11) - col. (10)] / col. (10)
(14) [col. (12) - col. (10)] / col. (10)

extensive use of continuous casting. Two scenarios of continuous casting are assumed: one with the trading partners having an average of 85% of their crude steel exports produced by continuous casting, and a second, more conservative scenario where this average is 50%.

Even with a grossly inefficient steel industry and with highly efficient trading partners, the difference between the IISI consumption figures and the adjusted consumption figures is less than 2%. Therefore, the calculation of consumption does not appear to be the cause of differences in steel IOU between the United States and the USSR, particularly given the potential margin for error in these calculations.[4]

2.2 Physical Units and Value

Some authors (Considine, 1987 and Humphreys, 1987) have faulted the IOU concept for focusing on consumption in physical units rather than on the value of that consumption. Their concern is a valid one, but as Tilton and Radetzki (forthcoming) have pointed out, it is a problem that plagues most demand studies, not just IOU.

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4. For countries in which trade in steel products assumes a much larger role than it does in the USSR and there are also large differences in efficiency, the differences between IISI consumption and adjusted consumption could be significant.

Steel is valued by consumers for many attributes, and each consumer obtains a certain utility from steel products purchased. As the quality of steels produced rises, the value of steel consumed should increase, since price is a proxy for value in competitive markets. In the absence of competition however, market prices can change for reasons other than favorable changes in quality, so even this measure is flawed.

Considine's study is important because it suggests that the use of tonnes rather than value overestimates the fall in steel consumption, and hence steel IOU in the United States in recent years. Because of the difficulties in performing such value studies, Considine only evaluated a limited number of sheet and strip products between 1970 and 1985, so one cannot apply these results across all steel products. His study is useful, however, because it suggests a partial explanation for the difference in steel IOU between the United States and the USSR. Between 1970 and 1985, the annual average growth in tons was 1.1% for these products, and the growth in value was 1.8%. Assuming that Soviet steel quality did not increase similarly (see chapter 5), then this might account for some of the difference in the level of steel intensity, and could affect the U.S. trend as well.

In any case, prices are unlikely to reflect IOU trends for centrally planned economies such as the USSR. In a market economy, prices dictate the quantity demanded of products, but in a centrally planned economy, prices do not serve the same purpose of rationing demand and often bear little resemblance to what is happening in the marketplace. Value studies such as Considine's would serve little purpose in explaining the behavior and level of steel IOU in the USSR, and therefore will not be explored further.

2.3 Collection and Interpretation of Soviet Data

Despite General Secretary Gorbachev's recent policy of "glasnost," problems of obtaining statistics continue to plague Soviet researchers. By Western standards, there is a dearth of information, and what data are released must often be reworked before they can be used. This section discusses some of the problems that can arise, such as problems of interpretation, bias, and the unavailability of data.

Problems of interpretation arise when a researcher examines data superficially and then attempts to make comparisons between countries. For example, the focus on heavy industry development in the USSR could lead a researcher comparing the size of the industrial sector to that of other industrialized countries to conclude that the economy is attaining a high level of economic development relative to others. Many Soviet researchers feel that although certain sectors of the Soviet economy have developed well, this does not indicate that all Soviet citizens are well off (see for example, Schroeder, 1983 and Winiecki, 1988).

In addition, sectoral definitions can differ widely between countries. For example, Soviet electric power output includes total power generated, gross of amounts used or lost in generation, so the figure must be adjusted before comparing with the U.S. electric power output, which excludes intraplant usage and losses (Campbell, 1959).

Bias is introduced when Soviet accounting techniques overestimate the importance of a sector. For example, the official Soviet index of industrial output uses a gross value method rather than a value-added method to construct the index. The result is double-counting of intermediate goods, as well as the inclusion of material costs which tends to increase the importance of material-intensive sectors (Heymann, 1959). In reference to steel consumption, IISI statistics are used without adjustment. Steel is not considered to be a strategic metal by the USSR, so reported statistics should not be subject to gross manipulation for political reasons.

Unavailability of data is perhaps the largest problem facing Soviet researchers. When data is not supplied at all, it must be estimated by experts. For example, the Soviet measure of national output is net material product (NMP), rather than the GDP published by market economy countries. In keeping with the Marxist-Leninist philosophy that services are nonproductive, their value is excluded from NMP estimates, but is included in GDP. Therefore, Soviet experts must impute the value of services to obtain comparable statistics. Such problems, while troubling, have been faced by every Soviet analyst and are not unique to this study. Since it is beyond the scope of this study to calculate new statistics, this study assumes that such estimates are reasonable.

The figures used in this study have been adjusted by Soviet analysts, primarily the U.S. Central Intelligence Agency (CIA). Despite the potential error involved in recalculating these statistics, they are the best available. It should be noted that CIA data is used by many Soviet analysts, including ones in the USSR and Eastern Europe, since they are considered to be the most reliable.

2.4 Intercountry Comparisons

Comparison of two different countries gives rise to index number problems and problems caused by differences in the economic system and policies. This section evaluates each of these problems for their probable effect on the level and trend of steel intensity.

2.4.1 The Index Number Problem

Published statistics that compare Soviet and U.S. measures of national output often present data in both dollars and rubles, as well as a geometric mean between the two. Comparisons in dollars or rubles alone yield different results. This "index number problem," as it is known in the literature, is not unique to comparisons between the U.S. and USSR.

According to Edwards, Hughes, and Noren (1979),

> Ruble and dollar comparisons yield different results, and neither provides an unambiguous measure of the difference in GNP. . . . The dollar comparison implies that the U.S. could shift to the Soviet pattern of output and still produce the same value as before. Thus, the dollar comparison at best measures the relative ability of the two countries to produce the Soviet mix of output. The quantitative result that the dollar comparison favors the USSR and the ruble comparison favors the U.S. implies, not surprisingly, that each country is better equipped to produce its own pattern of output.

To avoid such problems, some analysts advocate using the geometric mean between the two exchange rates. According to the CIA (1985), valuation in dollars or rubles are equally correct, and the geometric mean is not necessarily more valid, although it is often used when one number is required. Others, such as Becker (in Edwards, Hughes, and Noren, 1979), feel that the geometric mean has no significance of its own, and so its use should be avoided. This study uses comparisons in constant U.S. dollars where possible, since the author agrees with Becker's assessment.

2.4.2 Comparisons of Centrally Planned and Market Economies

Winiecki (1988) provides an excellent summary of some of the major fallacies that occur in analyses of centrally planned and market economy countries. Winiecki argues that looking at per capita GDP rather than at per capita consumption (defined as the value of services, nondurable, and durable goods that are consumed by households) can make average Soviet citizens appear to be enjoying a higher standard of living than they actually are. Focusing on quantity of goods produced or consumed, and ignoring their quality, further exacerbates this problem.

Campbell (1959) notes that one must keep the characteristics of the individual economies in mind when making comparisons. For example, labor productivity in the Soviet Union is low relative to other nations, so that one might assume that Soviet labor is inefficiently used. However, the Soviets have an abundance of labor, but not capital, so this forces labor productivity to fall as the size of the workforce increases.

2.5 Summary

This chapter dealt with various issues that might influence the level and trend of steel IOU. The first section examined whether the indirect calculation of consumption could artificially inflate Soviet statistics. Rough calculations show the differences between the IISI measures of consumption and the adjusted measures of consumption are not significant, but suggest that this difference might become more important if the volume of trade increases.

The measurement of steel consumption in physical units rather than value also was examined. The purpose of such value-weighted studies is to show changes in quality, which can act to decrease the absolute tonnages of steel required. Considine's study of U.S. sheet and strip steels suggested that consumption in tonnes may have overestimated the decline in U.S. steel intensity in recent years, and argued for the use of value instead. But because prices can change for reasons other than quality, and prices in the USSR do not reflect value, such an approach was not deemed to be appropriate for this study.

The next section examined the problems of obtaining and interpreting Soviet data. Although estimation of Soviet macroeconomic data by Western experts is troubling, this estimation by itself is not a likely explanation for the total difference in the level of steel intensity between the United States and the USSR, given the size of these differences. In addition, Soviet leaders have also noted that their material intensity is higher than other countries, so official Soviet statistics also confirm this discrepancy (Rumer and Vatkin, 1987).

The final section highlighted the difficulties of comparing countries with different economic structures. Analysts must be careful in their interpretation of statistics so that they take into consideration the characteristics of the economy. For example, one might conclude that the higher steel IOU of the Soviet Union reflects inefficient use of steel. However, intensity of use reflects the influence of a number of factors, each unique to an economy. This study examines in detail changes in economic structure, materials use, and technology to determine the underlying reasons for this difference in intensities.

Chapter 3

ADJUSTMENTS TO INTENSITY OF USE

This chapter evaluates the effect of various adjustments to IOU to determine if they are helpful in explaining the differences in IOU between the United States and USSR. The first section examines the conflict between the purchasing power parity approach and the market exchange rate approach in converting GDP data to a common currency. The following section evaluates whether consumption of crude steel is too narrowly defined. Indirect trade in steel, inventories, and secondary metal consumption are also discussed.

3.1 Purchasing Power Parity and Market Exchange Rates

Gross domestic product (GDP) in rubles was converted to U.S. dollars in this study using weighted-average market exchange rates, as reported by the CIA. Market exchange rates are determined by the supply and demand for a country's currency, which is influenced by a number of variables such as government monetary and fiscal policies or speculation.

USSR market exchange rates present additional problems for the analyst, since the ruble is not convertible, so "market" exchange rates do not exist. The Soviet government publishes several exchange rates, but most analysts agree that these "market" exchange rates are "arbitrary, notional rates without much economic content or practical significance" (Marer, 1985b). In 1961, the USSR set new official exchange rates, based on Soviet estimates of the purchasing power of the ruble against the U.S. dollar (Marer, 1985a). These exchange rates changed little until 1972, after which ruble/dollar exchange rates were pegged to movements of the U.S. dollar in the international market, despite sometimes significant differences between Soviet and U.S. inflation rates.

Since market exchange rates may not represent the true purchasing power of a currency, the use of market exchange rates could lead to overestimation or underestimation of GDP, and thus affect the level of IOU. The following section explores whether differences in the level of IOU between the United States and the USSR can be explained by the use of market exchange rates rather than purchasing power parity (PPP) rates.

3.1.1 Purchasing Power Parity Rates

PPP rates are determined by detailed studies of the prices of similar goods and services in economies. One of the most comprehensive PPP studies was the International Comparisons Project (ICP), conducted by the United Nations and the World Bank (see Kravis, et al., 1982). These authors found that market exchange rates underestimated the true purchasing power of domestic currencies for low income countries because of the high degree of nontraded goods and services in these countries. The more insulated a country is from imported goods, the more domestic and world prices can differ from each other. The result is that purchasing power of the domestic currency can vary greatly from the market exchange rate, since market exchange rates only reflect prices of tradable items.

For centrally planned countries such as the USSR, this theory is particularly significant, since these economies are somewhat autarkic. In addition, domestic prices are centrally planned and usually are set to achieve political goals rather than reflect economic scarcity of the item, as in market economy countries.

Several PPP studies of centrally planned economies have been conducted in recent years. Marer (1985a, 1985b) extended the ICP study for the USSR and Eastern Europe. Similar studies have been conducted by the CIA (Edwards, Hughes, and Noren, 1979 and CIA, 1985) and the Federal Republic of Germany (in Marer, 1985b).

Because PPP studies are very expensive and time-consuming to conduct, the results of studies are often extrapolated to obtain PPP rates for other years. For example, the CIA extrapolated their PPP rates on a study conducted in 1976 of 250 consumer goods, 245 machinery and equipment items, and 277 construction goods. The methods for such extrapolations have been subject to debate and several methods have been used. According to Edwards, Hughes, and Noren (1979), the reliability of such extrapolations depends on several factors: 1) the representativeness of the base year of average price conditions, 2) the length of time between the base year and the extrapolation year, and 3) the validity of proxies used for unpublished or unusable data.[5]

One problem encountered in doing the PPP study itself is locating comparable goods or services to contrast. Both the ICP and CIA studies refer to the difficulty in finding goods of similar quality and design. Schroeder and Edwards (1981), who conducted the consumption goods study for the CIA, remarked:

> [T]he price ratio for refrigerators is based on comparing the typical Soviet one-door, 7-cubic-meter capacity unit with a small (9-cubic-meter) apartment size unit not at all typical of the sales mix in the United States. For sewing machines, the typical Soviet model was judged a copy

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5. For discussion of extrapolation methods commonly used, see Marer (1985a), Wolf (1982), and Kurtzweg (1987).

of an old Singer model of the 1920s.

In order to compensate for such variances in quality, actual market prices were sometimes adjusted for these differences in quality, or the differences were simply noted and no adjustment was made.

Because of these problems, some authors have rejected the PPP studies. For example, Winiecki (1988) criticized the ICP study, saying its results bias GDP upward. He feels that lack of comparability because of inferior quality or nonavailability is a serious problem to successfully overcome. Another problem is the use of "official" Soviet prices, since they might not be close to "true" market prices. For example, shortages are rampant in the USSR, and goods needed are often purchased on the black market, so that the "official" price may not truly reflect the price actually paid on average. Other problems, such as differing utility value due to differences in quality, selection, or the additional costs of queuing also make the official prices not representative of actual prices.

The results of Marer's 1980 PPP study for the USSR are presented in Table 3.1. GDP in 1980 rubles, as estimated by the CIA, are converted using the weighted-average market exchange rate (the one used in this study), and three PPP rates determined by the Marer study. Of the PPP rates,

Table 3.1 Soviet GDP Using Different Exchange Rates

Year	(1) GDP 80 rubles bill	(2) GDP 80$ CIA mkt X, bill	(3) GDP 80$ low PPP bill	(4) GDP 80$ best PPP bill	(5) GDP 80$ high PPP bill	(6) GDP 80$ commerc X, bill
1950	183.1	282.2	469.6	345.5	223.3	610.4
1951	188.7	290.8	484.0	356.1	230.2	629.2
1952	199.9	307.9	512.4	377.1	243.7	666.2
1953	210.3	324.0	539.2	396.7	256.4	700.9
1954	220.3	339.4	564.8	415.6	268.6	734.3
1955	239.2	368.6	613.3	451.3	291.7	797.3
1956	259.2	399.4	664.6	489.1	316.1	864.0
1957	268.9	414.4	689.6	507.4	328.0	896.5
1958	289.5	446.1	742.3	546.2	353.0	965.0
1959	306.2	471.8	785.2	577.8	373.4	1020.7
1960	318.3	490.4	816.1	600.5	388.2	1060.9
1961	336.2	518.1	862.2	634.4	410.0	1120.8
1962	348.9	537.5	894.5	658.2	425.4	1162.8
1963	345.0	531.6	884.6	651.0	420.7	1150.0
1964	383.0	590.1	982.0	722.6	467.1	1276.6
1965	406.8	626.9	1043.2	767.6	496.1	1356.1
1966	427.5	658.8	1096.2	806.7	521.4	1425.1
1967	447.3	689.2	1146.8	843.9	545.5	1490.9
1968	474.3	730.8	1216.1	894.9	578.4	1580.9
1969	487.8	751.7	1250.9	920.5	594.9	1626.1
1970	525.4	809.6	1347.2	991.3	640.7	1751.3
1971	545.8	841.1	1399.5	1029.9	665.6	1819.4
1972	556.1	856.9	1425.9	1049.3	678.2	1853.7
1973	596.5	919.2	1529.6	1125.5	727.5	1988.5
1974	619.8	955.1	1589.3	1169.5	755.9	2066.1
1975	630.1	970.9	1615.7	1188.9	768.4	2100.4
1976	660.1	1017.2	1692.7	1245.6	805.1	2200.5
1977	681.3	1049.7	1746.8	1285.4	830.8	2270.8
1978	704.7	1085.8	1806.9	1329.6	859.4	2349.0
1979	710.3	1094.5	1821.3	1340.2	866.2	2367.7
1980	720.2	1109.7	1846.6	1358.8	878.3	2400.6
1981	729.5	1124.1	1870.6	1376.5	889.7	2431.8
1982	749.2	1154.5	1921.1	1413.7	913.7	2497.5
1983	773.2	1191.4	1982.6	1458.9	942.9	2577.4
1984	784.8	1209.3	2012.3	1480.8	957.1	2616.0
1985	791.1	1218.9	2028.4	1492.6	964.7	2637.0
1986	821.2	1265.3	2105.5	1549.3	1001.4	2737.2

(continued)

Table 3.1 (continued)

Notes:
(1) converted from 1970 rubles to 1980 rubles using indices in CIA, 1982.
(2) weighted-average exchange rate in CIA, 1985 = 0.649R/$
(3) low end PPP from Marer, 1985 = 0.39R/$
(4) best point estimate from Marer, 1985 = 0.53R/$
(5) high end PPP from Marer, 1985 = 0.82R/$
(6) Soviet commercial exchange rate = 0.30R/$

Sources: CIA, 1982. USSR: Measures of Economic Growth and Development 1950-1980.
Marer, Paul, 1985. "Alternative Estimates of the Dollar GNP and Growth Rates of the CMEA Countries" in East European Economies: Slow Growth in the 1980's. vol. 1, p. 133-193.
CIA, 1985. Handbook of Economic Statistics.

"best" represents the most likely point estimate, and "low" and "high" represents the range of likely estimates for PPP resulting from Marer's regression results. Calculation of GDP using the Soviet government market exchange rate for commercial goods is also presented.

Results for GDP vary widely, depending on the choice of converter, and this increases or decreases the level of steel IOU accordingly. A higher estimate of GDP decreases steel intensity, as is the case with the Soviet commercial exchange rate, and a lower estimate of GDP increases steel intensity. In all cases, IOU calculated using the commercial exchange rate is significantly smaller than when other converters are used. Using the commercial exchange rate, Soviet steel IOU was 46% of IOU calculated using the weighted-average exchange rate reported by the CIA, 77% of IOU using the "low" PPP rate, 57% of IOU using the "best" PPP rate, and 36% of IOU using the "high" PPP rate.

Although the choice of converter can influence the level of steel IOU, the difference between the U.S. and USSR levels of IOU are still significant. Table 3.2 shows an index of USSR steel IOU, with the U.S. level of IOU equal to one hundred. Even if one used the commercial exchange rate, which most analysts regard as too optimistic, Soviet steel IOU was still two times the U.S. level by the late 1980s.

Table 3.2 Index of Soviet Crude Steel IOU Compared to U.S. Levels of Crude Steel IOU (US = 100)

Year	IOU using CIA mkt X	IOU using low PPP	IOU using best PPP	IOU using high PPP	IOU using commerc X
1950	109.7	65.9	89.6	138.6	50.7
1951	121.9	73.3	99.5	154.0	56.4
1952	151.2	90.8	123.4	190.9	69.8
1953	134.9	81.1	110.2	170.5	62.4
1954	175.6	105.5	143.4	221.8	81.2
1955	148.9	89.5	121.6	188.1	68.8
1956	147.2	88.4	120.1	185.8	68.0
1957	151.4	91.0	123.6	191.3	70.0
1958	199.7	120.0	163.1	252.3	92.3
1959	189.1	113.7	154.5	239.0	87.4
1960	197.9	118.9	161.6	250.1	91.5
1961	207.7	124.8	169.6	262.5	96.0
1962	224.7	135.0	183.5	283.9	103.9
1963	219.8	132.1	179.5	277.7	101.6
1964	188.6	113.3	154.0	238.3	87.2
1965	187.0	112.4	152.7	236.3	86.4
1966	192.4	115.6	157.1	243.1	88.9
1967	209.6	126.0	171.2	264.9	96.9
1968	198.0	119.0	161.7	250.1	91.5
1969	202.5	121.7	165.3	255.8	93.6
1970	214.7	129.0	175.3	271.3	99.2
1971	222.3	133.6	181.5	280.8	102.7
1972	223.7	134.4	182.7	282.7	103.4
1973	217.6	130.8	177.7	274.9	100.6
1974	229.0	137.6	187.0	289.4	105.9
1975	282.8	170.0	231.0	357.4	130.7
1976	267.5	160.8	218.5	338.0	123.7
1977	263.6	158.4	215.3	333.1	121.9
1978	256.2	154.0	209.2	323.7	118.4
1979	266.4	160.1	217.6	336.6	123.2
1980	319.5	192.0	260.9	403.7	147.7
1981	290.3	174.4	237.1	366.8	134.2
1982	416.6	250.3	340.2	526.1	192.6
1983	389.4	234.0	318.0	493.0	180.0
1984	351.5	211.2	287.0	444.1	162.5
1985	380.0	228.4	310.3	480.2	175.7
1986	432.5	259.9	353.2	546.5	199.9

Source: IISI, Statistical Yearbook, various issues.
Table 3.1

For the same time period, the most likely PPP point estimate places Soviet steel IOU at 3.5 times as high as the U.S. level, while the weighted-average exchange rate places Soviet steel IOU at over 4 times as high as the U.S. level. The overall trend of Soviet steel IOU, which shows the difference between the Soviet and U.S. levels increasing over time, does not change regardless of the choice of converter, since rubles were converted at a constant ratio over all years.

3.2 Consumption Versus Absorption

This study chose to use apparent consumption of crude steel as the numerator for intensity of use, which includes production of crude steel plus net imports of semi-finished and finished steel products. Since crude steel is used as a raw material by firms, a potentially important segment of the market is ignored, that of indirect steel trade. Indirect trade in steel is defined as trade of products that contain steel, but are not classified as semi-finished or finished steel products. Examples include the importation of an automobile or the exportation of construction machinery. Adding indirect steel trade to apparent consumption yields absorption.

Humphreys (1987) has remarked that the stage at which consumption is measured will affect IOU. Although this might be true if a country is a heavy exporter or importer of steel-containing products, metal absorption is not necessarily a more appropriate estimator of demand than consumption. In addition, little data is usually available about indirect trade, so reported consumption is often the only measure available to the investigator.

Two other factors that may influence the level of IOU include inventories of semi-finished and finished steel products and secondary metal consumption. Both of these factors will be examined in the final portion of this section on steel absorption.

3.2.1 Indirect Trade

Although little data on indirect trade is usually available, for steel we are fortunate that the IISI has conducted special studies in this area (1982 and 1985). For selected countries, the IISI multiplied the weight of steel-containing products by a coefficient that reflects the steel content for each product as well as the scrap usually generated in the production of these products. The result is the weight of steel needed to manufacture the finished product, or finished steel weight. The results then need to be converted to crude steel equivalent, using the formula presented in chapter 2.

The coefficients were originally developed in the early 1960s, and have not been changed since then, despite changes in technology and material substitution. IISI (1982) reports:

> [T]he retention of out-dated coefficients was not as misleading as it would seem, due to the crucial role of manufactured product weight in the estimation process. If a product was downsized, then its total weight probably would also drop, and this reduction would thus automatically be transmitted to the steel weight imputed. The same would be true of substitution, either of steel by aluminum or plastics, or of ordinary steel by stronger steel alloys. Typically, a lighter finished product would result; and in consequence a less weight of steel would be allocated in the indirect trade statistics. Of course . . . the employed weight of aluminum or plastics would be incorrectly allocated as steel weight; but given the comparative lightness of these substitute materials, the error would be less serious than it would first appear to be.

The retention of the same coefficients also helped to maintain comparability over time.

Imports and exports of indirect steel for 1979 and 1982, two of the detailed study years, are shown in Table 3.3. It is important to note that exports were not reported for the USSR by IISI. Since imports are added to consumption and exports are subtracted, the exclusion of exports for the USSR makes absorption for the USSR higher than it should be. This could be significant since exported items from the USSR are generally heavier than their Western

Table 3.3 Indirect Trade for the United States and USSR

Category*	1979exp	1979imp	1979 I-X	1982exp	1982imp	1982 I-X
Intmed Goods						
U.S.	109.6	863.6	754.0	78.6	652.2	573.6
USSR		30.4			31.6	
Power Gen Mach						
U.S.	81.3	422.4	341.1	492.5	464.8	-27.7
USSR		9.5			10.7	
Process Mach						
U.S.	12.1	339.2	327.1	1,280.0	256.2	-1,023.8
USSR		60.3			168.2	
Other Mach						
U.S.	2,649.5	435.7	-2,213.8	935.0	510.3	-424.7
USSR		179.4			191.0	
Elec Mach						
U.S.	446.3	223.0	-223.3	400.6	257.6	-143.0
USSR		45.5			49.2	
Agric Mach						
U.S.	642.8	400.3	-242.5	430.3	228.3	-202.0
USSR		11.1			16.6	
Rolling Stock						
U.S.	67.7	403.4	335.7	71.2	122.8	51.6
USSR		37.9			50.0	
Pass Cars						
U.S.	1,046.7	3,045.6	1,998.9	434.5	2,820.0	2,385.5
USSR		2.0			0.7	
Comml Vehicle						
U.S.	810.8	1,764.0	953.2	450.8	1,614.9	1,164.1
USSR		7.2			32.2	
Auto Parts						
U.S.	2,563.0	1,527.0	-1,036.0	1,508.8	1,225.8	-283.0
USSR		20.4			34.2	
Dom Appl/Mach						
U.S.	165.1	73.6	-91.5	137.3	103.9	-33.4
USSR		0.3			0.4	
Other Manufact						
U.S.	984.2	725.5	-258.7	869.6	1,040.7	171.1
USSR		93.7			69.8	
TOTAL ALL GROUPS: (excludes maritime)						
U.S.	9,579.1	10,223.3	644.2	7,089.2	9,043.2	1,954.0
USSR		497.7			654.6	

* all data in thousand metric tons finished steel weight

Source: IISI, various years. <u>Indirect Trade in Steel</u>.

counterparts (for reasons that will be explored later in this study), and since the USSR does export steel-containing products such as machinery and equipment.

As is apparent from Table 3.3, the USSR indirect steel imports are significantly less than for the United States. What is somewhat surprising is that exports of indirect steel tend to balance out imports of indirect steel for the United States, despite heavy imports of vehicles and related parts. U.S. exports of machinery, auto parts, and domestic appliances help to balance out the steel being imported. The overall impact of indirect trade on IOU for the United States and the USSR is presented in Table 3.4. Although inclusion of indirect trade increases IOU slightly in both countries, an index of IOU with the United States equal to one hundred shows that the indirect trade does little to explain differences in the level of IOU between the United States and the USSR. The conclusions drawn, however, are somewhat restrained owing to uncertainty surrounding the coefficients and the exclusion of exports for the USSR.

If the USSR was a heavy exporter of steel-containing products, then exclusion of these products could be significant. According to official Soviet statistics (in CIA, 1985), in 1979, the value of machinery and equipment, consumer goods other than food, and miscellaneous goods (as-

Table 3.4 Consumption and IOU Excluding and Including Indirect Steel Trade

	Consumption in thousand metric tons, CSE		Crude Steel IOU tons/million 1980 U.S.$		Index of IOU, US=100	
	1979	1982	1979	1982	1979	1982
United States						
excl indirect	140,407	84,319	52.0	31.3	100	100
incl indirect *	141,220	86,737	52.3	32.2	100	100
USSR						
excl indirect	151,644	150,343	138.6	130.2	266	416
incl indirect *,**	152,280	151,176	139.1	131.0	266	407

Notes:

* calculated by multiplying finished steel weight by factor of 1.3/(1+0.175c) to convert to CSE and adding to consumption

** includes only imports (exports not reported)

Sources: IISI. Statistical Yearbook, various issues.
IISI. Indirect Trade in Steel, various issues.
World Bank Data Tape, Update 1987.
CIA, 1982. USSR: Measures of Economic Growth and Development 1950-1980.
CIA, annual. Handbook of Economic Statistics, various issues.
Kravis, Irving B., et al., 1982. World Product and Income: International Comparisons of Real Gross Product.

sumed to be steel-containing) exported by the USSR was $26.2 billion, while the value of imports in these same categories was $35.1 billion. In 1982, the USSR was also a net importer in these categories.

In machinery and equipment, a heavily steel-intensive sector, the value of imports was 1.9 times higher than exports in 1979, and 2.4 times higher in 1982. Although Soviet machinery exports are often lower in quality, and consequently value, than machinery that is imported, it is still unlikely that the USSR exports more steel in indirect trade than it imports, despite the heavier weight of its machinery relative to Western countries.

3.2.2 Inventories

The calculation of apparent consumption used by the IISI does not include the metal contained in inventories of semi-finished or finished steel products. Additions to inventories should be excluded from consumption, while subtractions should be included, since they are part of current consumption. Unfortunately, data on inventory movements are not reported for the CPE countries and even for many OECD countries.

In market economy countries, inventories of metal tend to change over the business cycle. New technological changes, such as better inventory control, may act to decrease the level of inventories held over time. In general, however, studies conducted where such data was available, such as Radetzki's study on invisible copper stocks (1977), suggest that such changes are not very significant in terms of overall consumption over the long term. In applying Radetzki's results to copper intensity of use for OECD countries, Tilton (forthcoming) concluded that "changes in invisible stocks do not appear to alter greatly the trends and patterns in intensity of metal use."

In centrally planned countries, the effect of the business cycle on inventories is less certain. Presumably, metal production is based on the plan, and if correctly predicted, the supply of metal will equal the demand. If an error in planning occurs, then overproduction or underproduction could cause inventories to accrue or shortages to develop.

However, constant shortages have created an environment where high inventories are the norm in the USSR, plus there is frequent stockpiling of spare parts and even imported equipment (Rumer, 1984). Such inventories insulate firms against production stoppages, which can prevent them from fulfilling their production plans. Since no data are published about these inventories, it is impossible to quantify how they have impacted steel intensity. Assuming that firms require a certain level of inventory in order to feel comfortable, inventory building could influence the level and trend of steel intensity, but only over the short term.

3.2.3 Secondary Metal Consumption

Steel scrap, or secondary metal, is composed of two general types, old and new. Old scrap refers to scrap present in machinery, buildings, and automobiles, for example. New scrap includes scrap generated in the production process, and consists of two types, prompt industrial and home scrap. The IISI definition of crude steel includes all secondary metal consumed, excluding home scrap (Tilton, forthcoming). Home scrap is scrap metal that is produced and reused by the same production facility.

Inclusion of new scrap in consumption results in double counting if the scrap is produced and recycled in the same year. This new scrap is not consumed in the true sense, since it ends up on the shop floor rather than being embodied in steel-containing products. Old scrap, however, when recycled, should be added to consumption since it is used to produce new goods.[6] According to Tilton (forthcoming), since new scrap should be excluded from consumption,

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6. For further discussion on this issue, see Hutchison and Tilton, 1988.

the inclusion of new scrap "tends to overestimate the intensity of steel use at the final stage of consumption." Tilton's calculations for the United States show that removal of all new scrap would decrease steel IOU by 15% in recent years.

Ideally, data would be available that accurately reports the amounts of new steel scrap for both the United States and the USSR, but it is not. If the Soviet Union generates an abnormally high amount of new scrap relative to the United States, then inclusion of this scrap could explain part of the difference in the level of steel IOU.

According to the Rumer and Vatkin (1987), the 1985 Soviet statistical yearbook, *Narodnoye Khozyaystvo SSSR*, reported that the share of steel wastage in total steel consumption was 22% for the machine building and metal working (MBMW) sector, and has been at this level since 1960. Rumer and Vatkin report even lower coefficients of steel utilization: for forgings, the coefficients of steel utilization are 0.33 to 0.38; for stampings, 0.44 to 0.52; for the automobile industry, 0.70; for machine tools, 0.60; and for chemical machine building, 0.70. These coefficients suggest that some segments of Soviet industry produce up to 67% scrap, which if recycled, should be removed from consumption to avoid double-counting.

Unfortunately, complete data on scrap production or utilization is not available, and what little data exists are often poorly defined or sketchy, so one cannot quantify just how much new scrap might be included in the apparent consumption figures. Still, the data suggest a significant amount of new scrap generated. Since the MBMW consumes 40% of the steel used in the USSR (CIA, 1982b), and using the Soviet yearbook's data on wastage (which seems low given the utilization coefficients reported earlier), this implies 14.5 million tons of new steel scrap generated in the MBMW sector alone in 1986.

There is an additional element to this problem, however. New scrap should be excluded from consumption only if it is actually recycled, otherwise there is no double-counting. In the United States, most new scrap is recycled. According to the CIA (1982b), despite Soviet concerns about the huge amounts of scrap generated, some of this scrap never gets recycled:

> The lack of success in collecting more scrap metal seems to stem primarily from shortages of equipment to sort scrap metal and shortages of labor, especially skilled engineers. Soviet commentaries indicate that scrap-sorting procedures are slipshod. . . . [S]crap collection is poorly coordinated and ineffective because of the diffusion of responsibility for collection among many ministries for which the assignment is an unwelcome sideline. Some Soviet studies suggest that the amount of scrap "irretrievably lost" amounts to

> from 10 to 20 million tons per year in the machine-building and metalworking sector alone.

Unfortunately, Soviet statistics do not differentiate between new and old scrap, so it is dificult to say how much of the 10 to 20 million tons is new scrap, if any.

Another problem is that metal cuttings are not easily recycled. Fine cuttings and dust are difficult to collect, and are poor furnace feedstock due to their size. In addition, cuttings tend to oxidize quickly, so they often must be refined before processing in a furnace. The implication is that some of these cuttings may never get recycled, and therefore should remain in consumption figures.

Given the significant volulmes of new scrap apparently generated, if new scrap that gets recycled is included in consumption figures, then USSR consumption figures may be artificially high. Even so, this point may be moot from the Soviet point of view, since the greater the wastage, the more steel must be manufactured, and the greater cost to the nation.

3.3 Summary

This chapter evaluated various adjustments to steel IOU that might explain the USSR's higher level of steel IOU relative to the United States. An examination of PPP rates rather than market exchange rates showed that the choice of converter did affect the level of IOU; however, the level of Soviet IOU using weighted-average exchange rates was within the range of estimates using PPP rates. Regardless of the choice of converter, Soviet IOU was still significantly higher than the U.S. level in the latter part of the period examined. Weighted-average exchange rates are therefore deemed adequate to convert rubles into U.S. dollars for this study, particularly given the problems in obtaining accurate PPP rates.

When indirect trade was included in the consumption figures, IOU increased slightly for both countries, but did little to explain the differences in intensities between the two countries. The lack of indirect export data for the USSR is cause for some concern in interpretation of these results, but trade data indicate that the USSR was a net importer of steel-intensive items, such as machinery and equipment. Inclusion of export data would therefore help to decrease IOU somewhat, but not enough to explain differences in the level of IOU.

Inventories were also not very helpful in explaining the high level of Soviet IOU. Though no data was available for either the United States or the USSR for steel, the effect of inventory changes are generally short-term, and should not significantly affect the level of IOU over the longer run.

The final section provided the most useful information in explaining differences in the level of IOU. The inclusion of new scrap in consumption artificially inflates IOU statistics for both countries. In the USSR, the significant volumes of new scrap generated could help explain the higher level of IOU in this country, assuming that this is recycled and then included in consumption figures. However, since the amount of new scrap recycled is not reported, it is impossible to adjust consumption appropriately.

The results suggest that the higher IOU of the Soviet Union is due in part to the higher levels of scrap generated in the production and fabrication of steel and steel-containing products relative to the United States. The steel that is not recycled should remain as part of consumption. Although consumption, and hence IOU, is higher at present, the success of scrap reduction programs now in place in the USSR could help reduce IOU somewhat in the future.

Chapter 4

CHANGES IN THE PRODUCT COMPOSITION OF INCOME

4.1 The Traditional View of Intensity of Use

According to early intensity-of-use literature, differences in the level of IOU could be attributed to differences in the level of economic development, which caused changes in types of goods produced. Tilton (1985) further developed the concept by arguing that IOU was determined not only by changes in the mix of goods produced in an economy, which he termed the product composition of income, but also by changes in technology and the materials used to produce these goods, which he termed the material composition of product.

This chapter looks at the first component of IOU, the product composition of income, to see whether differences in economic structure can explain differences in the level of IOU between the United States and USSR.

4.2 The Role of Intersectoral Shifts

If certain sectors of an economy, such as industry, are large relative to another economy, this could cause differences in the level of IOU between the two countries. According to Tilton (forthcoming), the sectors with the highest IOU traditionally are capital equipment, construction, consumer durables, and transportation. If these sectors were a larger part of GDP than other less resource intensive sectors, one would expect a correspondingly higher IOU.

There has been much discussion about large Western developed countries, such as the United States, entering the "post-industrial" era. During this era, such countries are assumed to switch from the domination of industry to the domination of services in the economy. Services are assumed to be less resource-intensive than industry by most economists. Roberts (1985) tested this assumption by examining input-output data for the United States, and concluded that services were less resource intensive than other sectors, such as durable goods.

The assumption of low resource intensity for all services, however, has been challenged by some economists. Vogely (1986) and Auty (1985) have suggested that some services, such as those provided by government, may in fact be resource-intensive. Many previous studies have analyzed economic sectors in the aggregate, without focusing on how the composition of these sectors has changed over time. For that reason, this study will examine changes within economic sectors as well as the sectors in aggregate, to better test how secular changes have influenced the level and trend of IOU.

4.2.1 GNP by End Use

The following sections break down Gross National Product (GNP) into consumption, investment, government, and net exports. The concept of GNP, rather than GDP, will be used in this section since the national account breakdowns for each country are based on GNP.[7] The difference between GNP and GDP will be reported for the United States where data are available. For the USSR, there is very little difference between the GNP and GDP, so the terms are used interchangeably (Marer, 1985b).

4.2.1.1 Intersectoral Shifts in the United States

Since 1950, the United States has undergone some interesting changes. Table 4.1 shows the proportion of GNP devoted to various end uses for the United States from 1950 through 1986. The shares of both durable consumer goods and services increased, while nondurable goods fell as a percentage of GNP during this period. A study by Roberts (1985) obtained similar results with a longer study period.

Table 4.2 shows average annual growth rates for selected sectors between 1950 and 1986. Durable goods, surprisingly, shows the highest growth rates during this period,

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7. The difference between GNP and GDP equals income paid to foreign sources, such as net interest payments on debts owed to foreigners.

Table 4.1 U.S. GNP by End Use, 1950-1986

Sector	% of GNP					
	1950	1960	1970	1980	1985	1986
CONSUMPTION	61.9	61.2	62.5	63.5	65.8	66.7
Durable Goods	7.0	6.1	7.0	8.0	10.2	10.8
Nondurable Goods	30.6	29.0	27.3	25.0	24.4	24.7
Services	24.4	26.1	28.2	30.5	31.2	31.3
INVESTMENT	19.7	15.8	15.9	16.1	17.7	17.4
Fixed Investment	17.6	15.3	15.6	16.3	17.5	17.0
Structures	4.3	4.5	4.5	4.2	4.0	3.4
Prod Dur Equip	5.9	5.0	6.4	7.7	8.4	8.2
Residential	7.5	5.8	4.7	4.5	5.0	5.5
GOVERNMENT	19.1	24.2	23.6	19.4	20.2	20.4
Defense			7.4	5.2	6.4	6.6
NET EXPORTS	0.4	-0.3	-1.3	1.9	-3.1	-4.0
Other*	-1.1	-0.9	-0.7	-0.9	-0.6	-0.5
TOTAL GNP	100.0	100.0	100.0	100.0	100.0	100.0
-Foreign Income	0.5	0.7	0.7	1.7	1.0	0.8
TOTAL GDP	99.5	99.3	99.3	98.3	99.0	99.2

* Statistical discrepancy

Sources: U.S. Department of Commerce, 1986. The National Income and Product Accounts of the United States, 1929-82.
U.S. Department of Commerce. Survey of Current Business, various issues.

Table 4.2 U.S. GNP by End Use, Annual Average Growth Rates, 1950-1986

Sector	Average Annual Growth Rate, %			
	1950-55	1955-60	1960-65	1965-70
CONSUMPTION	3.4	2.7	4.2	3.8
Durable Goods	3.6	0.4	7.0	4.3
Nondurable Goods	3.1	2.2	3.2	3.0
Services	3.8	3.9	4.6	4.5
INVESTMENT	0.6	0.2	7.0	1.1
Fixed Investment	2.8	0.7	6.3	2.2
Structures	5.4	0.7	5.2	1.7
Prod Dur Equip	1.9	-0.5	8.5	3.7
Residential	1.8	1.7	5.0	0.7
GOVERNMENT	7.8	2.5	3.6	3.3
Defense				
GDP	3.7	2.1	4.6	3.0

Sources: U.S. Department of Commerce, 1986. The National Income and Product Accounts of the United States, 1929-82.
U.S. Department of Commerce. Survey of Current Business, various issues.

(continued)

Table 4.2 (continued)

Sector	Average Annual Growth Rate, %			
	1970-75	1975-80	1980-85	1986
CONSUMPTION	2.8	3.2	3.4	4.3
Durable Goods	4.8	3.9	7.8	8.4
Nondurable Goods	1.4	2.5	2.3	3.8
Services	3.5	3.7	3.0	3.3
INVESTMENT	1.6	6.4	5.2	1.0
Fixed Investment	2.1	6.3	4.2	0.0
Structures	-0.3	6.2	0.7	-13.5
Prod Dur Equip	5.2	7.6	4.5	0.0
Residential	0.0	4.3	7.0	11.8
GOVERNMENT	0.3	1.4	3.0	4.0
Defense	-6.1	1.3	6.5	6.0
GDP	2.4	3.4	2.7	3.0

suggesting that saturation has not yet occurred, as one might expect in a service economy. The rising share of durable goods suggests a rising level of IOU, since durable goods, such as cars and large household appliances, are traditionally steel-intensive.

In the investment sector, fixed investment has declined from the higher post-war level of 17.6% of GNP in 1950 to 17.0% in 1986. Structures and residential construction are mostly responsible for this decline, since purchases of producers' durable equipment increased from 5.9% of GNP in 1950 to 8.2% in 1986, despite erratic growth rates for the entire sector. Since producers' durable equipment is traditionally the most steel-intensive segment, this increase in share should also indicate a rising IOU over time.

The share of government purchases in GNP has fluctuated widely since 1950. The limited series available for government purchases of defense goods, traditionally a steel-intensive segment, also shows wide fluctuations in its share of GNP. However, the stronger growth in the 1980s of defense goods would indicate a rising steel intensity during this decade for this segment as well.

Overall, the examination of these broad sectors would predict an increasing level of steel intensity for the U.S. since the 1950s. Instead, as discussed in previous chapters, steel IOU has fallen significantly in the United States. Since another dynamic must be at work, these broad sectors will be disaggregated further in an attempt to explain the difference in trends. First, however, the same sectors are examined for the USSR to determine how their size differs from the United States.

4.2.1.2 Intersectoral Shifts in the USSR

The Soviet Union shows a significantly different economic structure than the United States. Table 4.3 shows the proportion of GNP accounted for by selected end-use sectors between 1950 and 1985.[8] Consumption accounts for a lower percentage of GNP (53.3% in 1985) than for the United States (65.8% in 1985), as well as declining growth rates over time, as indicated by Table 4.4. This is exactly the opposite of the U.S. consumption trends. The only segment of consumption to show strong growth was consumer durables. Although durable goods are traditionally the most steel-intensive sector, in 1980 they were only 6.8% of Soviet GNP, compared to 8% in the United States.

The investment sector shows the most dramatic differences from the United States. In 1950, USSR investment

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8. Since Soviet economic data does not conform to Western accounting methodologies, these data have been reconstructed by the CIA to allow comparisons to be made (CIA, 1982a).

Table 4.3 USSR GNP by End Use, 1950-1985

Sector	% of GNP, 1980 U.S.$-based				
	1950	1960	1970	1980	1985
CONSUMPTION	59.3	57.0	53.6	53.1	53.3
Durable Goods	1.2	3.2	4.1	6.8	
Nondurable Goods	35.7	33.8	30.0	26.7	
Consumer Services	22.4	20.0	19.5	19.6	
INVESTMENT	16.6	28.3	33.0	38.5	41.0
New Fixed Invest	13.4	22.2	26.0	28.9	30.8
Mach & Equip	4.0	7.1	10.2	15.5	
Constr/Other	9.4	14.9	15.8	16.1	
Capital Repair	3.1	6.1	7.0	10.1	
GOVERNMENT	19.7	13.8	13.4	10.2	9.4
Defense*					
Lower Bound	13.8	9.9	11.5	11.8	15.0
Upper Bound	24.0	13.4	13.8	15.0	17.0
Other**	4.4	0.9	0.0	-1.8	-3.7
TOTAL GNP	100.0	100.0	100.0	100.0	100.0

* defense expenditures are not included in government as in the United States, but instead are part of other categories (based on CIA estimates)
** statistical residual

Sources: CIA, 1982. USSR: Measures of Economic Growth and Development, 1950-80.
CIA, annual. Handbook of Economic Statistics.
Kurtzweg, Laurie, 1987. "Trends in Soviet Gross National Product" in Gorbachev's Economic Plans, vol. 1.

Table 4.4 USSR GNP by End Use, Average Annual Growth Rate, 1950-1985

Sector	Average Annual Growth Rate, %			
	1950-55	1955-60	1960-65	1965-70
CONSUMPTION	5.1	5.7	3.6	5.3
Durable Goods	19.5	11.7	4.9	9.4
Nondurable Goods	5.7	6.1	2.7	5.7
Services	4.0	4.9	5.1	4.4
INVESTMENT	10.6	10.2	6.4	5.7
New Fixed Invest	10.6	9.6	5.8	6.1
Machinery & Equip	10.0	11.8	10.4	7.1
Construction/Other	10.8	9.9	4.7	6.2
Capital Repair	11.2	12.9	9.2	4.0
GOVERNMENT	2.0	1.1	5.1	2.9
Defense*				
Lower Bound	1.1	-3.5	6.6	4.6
Upper Bound	4.7	-0.9	8.5	5.0
TOTAL GNP	5.3	5.7	4.6	5.0

* some 1980-85 figures are based on CIA estimates, no raw data available

Sources: CIA, 1982. USSR: Measures of Economic Growth and Development, 1950-80.
CIA, annual. Handbook of Economic Statistics.
Kurtzweg, Laurie, 1987. "Trends in Soviet Gross National Product" in Gorbachev's Economic Plans, vol. 1.

(continued)

Table 4.4 (continued)

Sector	Average Annual Growth Rate, %		
	1970-75	1975-80	1980-85
CONSUMPTION	3.5	2.7	2.0
Durable Goods	10.4	5.8	4.0
Nondurable Goods	3.5	2.5	1.7
Services	3.5	2.9	2.5
INVESTMENT	5.7	4.0	3.1
New Fixed Invest	5.0	3.5	3.2
Machinery & Equip	8.4	6.3	4.6
Construction/Other	4.9	1.6	2.6
Capital Repair	8.4	5.9	3.5
GOVERNMENT	2.1	-0.4	1.1
Defense*			
Lower Bound	3.9	2.7	1.5
Upper Bound	4.2	3.6	2.0
TOTAL GNP	3.9	2.6	2.1

* some 1980-85 figures are based on CIA estimates, no raw data available

accounted for 16.6% of GNP, and a comparable 19.7% of GNP in the United States. By 1985, however, USSR investment accounted for 41% of GNP, while U.S. investment had fallen to 17.4% of GNP.

Furthermore, the level of fixed investment in GNP in the USSR is very high (30.8% in 1985) relative to the average Western industrialized country (20%) (Ofer, 1987). Until 1975, Ofer estimates that the USSR capital stock doubled in size every 8 to 9 years, growing at an average annual rate of 8% to 9.5%. Since 1976, the growth rate has moderated somewhat, from 6% to 7%, but is still "very high" compared to international standards. Producers' durable goods (machinery and equipment), the most steel-intensive segment of investment, was double the U.S. level in 1980. The wide disparity between U.S. and Soviet investment levels seems the most likely explanation for the divergence in steel IOU between these two countries so far.

There are, however, some differences in what is included in the investment sectors of the United States and the USSR. In the United States, defense-related spending is included as a part of government expenses. In the USSR, however, defense spending is not reported as a separate item, so estimates must be made by intelligence experts. Instead, defense-related spending is "hidden" in other categories, in investment in particular (CIA, 1982a).

Unfortunately, how much of investment is devoted to defense spending is not known with certainty. In the machinery sector, for example, Becker (1987) estimates that 50% of output was devoted to military goods between 1971 and 1975, 62% between 1976 and 1980, and 58% between 1981 and 1985, depending on how the sector is defined. The close relationship between the civilian and military sectors of industry makes such distinctions difficult. Despite these problems, whether such spending is military- or civilian-related does not abrogate the traditional steel intensity of investment compared to other sectors.[9]

As a share of GNP, military spending accounts for a much higher percentage of GNP in the Soviet Union (15% to 17% in 1985) than in the United States (6.6% in 1985). Even if the percentage of GNP devoted to defense spending in the United States is included in investment spending to attempt a crude comparison of the Soviet and U.S. definitions of this sector, USSR investment is still significantly higher than that of the United States. In 1985, for example, USSR investment would still be 1.7 times the U.S. level of in-

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9. Military investment goods rely more on high technology materials than do civilian investment goods. The importance of this will emphasized in chapter 5.

vestment as a percentage of GNP.

Soviet investment also includes a subsector called "capital repair" that the United States does not use. In the United States, machinery repairs are expensed rather than capitalized. In the USSR, capital repairs are assumed to increase the productive life of machinery, and hence are capitalized. These capital repairs have become a significant part of total investment, accounting for over 25% of the total sector, and 10.1% of GNP in 1980. Most Soviet analysts, however, feel that despite increasing expenditures on capital repairs, not all of these expenditures truly increase the productive life of machinery as assumed (Harris, 1987; Edwards, Hughes, and Noren, 1979; Cohn, 1987).

One might assume that repairing rather than replacing machinery would lower steel intensity. This may not be the case however, for several reasons. Although new machinery does not have to be built to replace the old machinery, repairs absorb a significant portion of Soviet resources. According to Cohn (1987), capital repairs have absorbed 10% of the total industrial labor force and over 33% of the stock of machine tools. More importantly, repairing old machinery results in the retention of obsolete, often steel-intensive technology.

4.2.2 GNP by Sector of Origin

A second method of examining the sectoral makeup of an economy is by breaking down GNP into the sectors that produce the goods and services, rather than into the sectors which consume those goods as the end-use method does. This breakdown provides additional insights into differences between the U.S. and Soviet economies.

Table 4.5 presents sector of origin data for the United States and Table 4.6 presents similar data for the USSR for selected years between 1950 and 1986. Like investment, the shares of industry and construction in GNP in the USSR are high and growing over time, while in the United States these shares are much lower and have been declining steadily since 1950. Taken together, the share of construction and industry in GNP grew from 27.1% in 1950 to 42.3% in 1986 in the USSR. In the United States, however, the share of construction and industry in GNP fell from 35% to 29.6% during this period.

The intersectoral differences between the United States and the USSR become even more striking when agriculture is examined. Although the share of agriculture has fallen in both the United States and the USSR since 1950, in the USSR agriculture continues even today to generate a significant portion of GDP (19.6% in 1986). In 1986, the proportion of

Table 4.5 U.S. GDP by Sector of Origin, 1950-1986

Sector	% of GDP, 1982 U.S.$						
	1950	1955	1960	1970	1980	1985	1986
INDUSTRY	27.6	28.2	26.2	26.7	25.6	25.6	24.9
Mining	6.1	6.2	5.7	5.6	4.3	3.6	3.1
Manufac	21.5	22.1	20.5	21.1	21.2	22.0	21.8
CONSTRUCT	8.4	9.0	9.9	7.0	5.2	4.6	4.7
AGRI/FISH	5.4	4.7	4.1	2.9	2.4	2.6	2.6
SERVICES	58.5	58.1	61.1	63.7	66.5	67.2	67.8
Transp/ Commun	6.6	5.9	5.6	6.0	9.4	9.1	9.0
Coml Svc*	25.2	25.3	27.3	28.7	30.8	31.6	32.0
Cons Svcs/ Util**	12.5	12.0	13.6	14.8	16.8	18.8	19.3
Govnt***	14.1	15.0	14.5	14.2	12.2	11.2	11.1

Notes:

* commercial services: finance, insurance, real estate, and trade.
** consumer services and electricity, gas, and sanitation services
*** government and government enterprises

Sources: U.S. Department of Commerce, 1986. The National Income and Product Accounts of the United States, 1929-82.
U.S. Department of Commerce. Survey of Current Business, various issues.

Table 4.6 USSR GDP by Sector of Origin

Sector	% of GDP, 1982 U.S.$						
	1950	1955	1960	1970	1980	1985	1986
INDUSTRY	22.5	23.8	26.3	30.1	34.1	34.5	34.3
CONSTRUCT	4.6	5.6	6.9	6.9	7.7	8.1	8.0
AGRICULTURE	37.4	36.6	33.8	28.2	19.6	18.8	19.6
SERVICES	35.5	34.0	33.0	34.8	38.6	38.7	38.1
Transp/ Commun	3.2	4.9	6.3	8.9	11.2	11.5	11.5
Coml Svcs*	4.2	4.7	5.2	5.8	6.7	6.3	6.2
Consumer Svcs**	15.3	14.5	14.1	13.4	13.5	13.9	13.7
Govnt***	12.8	9.9	7.4	6.7	7.2	7.0	6.7

Notes:

* commercial services: trade and credit services
** housing, other consumer services, and utilities
*** military personnel, other, science, and administrative services provided by government

Sources: CIA, annual. Handbook of Economic Statistics.
Kurtzweg, Laurie, 1987. "Trends in Soviet Gross National Product" in Gorbachev's Economic Plans, vol. 1.
MacEachin, Douglas and RADM Robert Schimitt, 1987. "Gorbachev's Modernization Program: A Status Report" in Allocation of Resources in the Soviet Union and China--1986.
Schroeder, Gertrude E., 1987. "USSR: Toward the Service Economy at a Snail's Pace" in Gorbachev's Economic Plans, vol. 2.

agriculture in GNP in the USSR was 3.6 times that of the United States in 1950, the year with the highest U.S. shares during the study period. According to Ofer (1987), the normal share of agriculture in GNP for industrialized countries is between 4% and 12%.

In the service sector, which is more broadly defined than the consumer services segment in consumption, both the United States and the USSR posted gains in share since 1950. However, the U.S. service sector has been growing faster than the USSR over time, and has remained its largest sector by far. In 1950, 58.5% of U.S. GNP was generated by the service sector; by 1986, this share had grown to 67.8%. USSR services generated only 35.5% of Soviet GNP in 1950 and 38.1% in 1986.

In summary, the sector of origin data shows that the economic structure of both the United States and the USSR has changed since 1950. In the United States, industry's declining share of GNP is the result of a 50% drop in the mining sector's share between 1950 and 1986. The share of manufacturing remained relatively unchanged, suggesting a steady trend of steel intensity. The share of construction in GNP has dropped because of falling shares of both residential and commercial construction. Taken together with the significant rise of services in aggregate, the data suggest a slight decline in steel intensity.

In the USSR, the substantial increase in industry and construction came at the expense of agriculture. The significant increase in industrial activity suggests some reasons for the increasing level of steel IOU over time.

Still, despite these changes in the size of the aggregate sectors themselves, changes in the composition of these sectors over time could lead to different conclusions. The following sections disaggregate these economic sectors to see if changes in the composition of these sectors can explain these differences.

4.3 The Role of Intrasectoral Shifts

Although aggregate sectors may have been traditionally steel-intensive, secular changes in the composition of these sectors can change steel intensity. For example, increased reliance on high technology goods often decreases metal intensity because these goods rely on alternate materials or new steel alloys that provide greater strength, thus reducing total weight and the steel content of the goods.

The most steel-intensive sectors of the economy are traditionally durable producer and consumer goods, which include transportation equipment and construction. The National Income and Product Accounts (NIPA) for the United States provide several useful disaggregations of these sectors. Less information is available for the USSR, owing to limitations described earlier, but data are presented where possible.

4.3.1 Consumer Durable Goods

Consumer durable goods include automobiles and trucks, furniture, appliances, and other goods such as boats, aviation equipment, and recreational equipment. In the United States, the bulk of this sector consists of motor vehicles, and has since 1950. In 1985, motor vehicles and parts accounted for 45% of consumer durables purchases. New vehicles accounted for 69% of motor vehicles and parts purchases, with the remainder split about evenly on used vehicles and parts (U.S. Department of Commerce, 1988). According to Eggert (forthcoming), the U.S. motor vehicle industry accounts for 20% of total steel consumption, making it an important sector for examination.

In the USSR, the composition of consumer durables has changed over time, but automobiles remain a much smaller proportion of this sector than in the United States, and this proportion has been decreasing over time. The CIA (1982a) describes the situation as follows:

> During much of the postwar era, the growth of consumer durables output has outpaced producer durables--partly because it started from an extremely low base. . . . In the 1950s consumer

> durables production was so primitive that products such as kitchen utensils and small electrical appliances accounted for the bulk of the growth. In the 1960s larger appliances--televisions, refrigerators, and washing machines--began to drive consumer durables output. Early in the 1970s output of automobiles sold to consumers also began to grow rapidly. In the past few years, however, the growth of automotive production has tailed off, and consumer durables growth has approached that of producer durables.

Part of the reason for lower automobile purchases in the USSR is governmental restrictions on private ownership, as well as the low priority accorded to the sector by the government. According to Welihozkiy (1979), in 1960, only 1 in 424 persons owned a motor vehicle in the USSR. By 1980, ownership of motor vehicles increased to 1 car per 35 persons, or 2.9% of the USSR's population. In contrast, 69% of the U.S. population owned a motor vehicle in 1980 (Eggert, forthcoming). Welihozkiy also estimated that the USSR car inventory in 1980 was approximately equal to the U.S. level in 1920; at current growth rates, the USSR car inventory in 1990 would be equal to the U.S. inventory of 1925.

Table 4.7 shows the how the composition of consumer durables has changed in the USSR from 1950 to 1979. Despite large gains in precision instruments (timepieces and other instruments, such as telephones) since 1950, metalwares still held the largest share in 1979, 28.9%. Automobiles accounted for only 15.7% of this sector in 1979, compared to

Table 4.7 Composition of Consumer Durables in the USSR

Sector	% of consumer durables, 1970=100				
	1950	1960	1970	1975	1979
Total Cons Dur	100.0	100.0	100.0	100.0	100.0
Electrotech Eq	17.8	15.8	12.3	9.2	7.5
Precision Instr	3.9	10.8	15.0	19.8	27.5
Pumps/Compres	2.4	6.8	7.3	6.5	6.1
Light Industry	2.1	0.9	0.6	0.6	0.5
Motor Vehicles	24.6	20.4	18.1	17.2	15.7
Metalwares	42.2	34.4	34.3	30.2	28.9
Cable Products	7.1	11.0	12.5	16.5	13.8

Sources: CIA, 1982. USSR: Measures of Economic Growth and Development, 1950-1980.

24.6% in 1950. Overall, there has been some shift to high technology items, and the composition suggests that the steel intensity of this sector should be lower than in the United States. Therefore, the higher level of Soviet IOU must be due to the composition of other sectors.

4.3.2 Producers' Durable Equipment

Producers' durable equipment (PDE) seems a much more likely candidate for explaining the large differences in the level of IOU between the two countries. In 1950, this sector accounted for 4% of USSR GNP and 5.9% of U.S. GNP, but in 1980 this sector accounted for 15.5% of USSR GNP and only 8.2% of U.S. GNP. Table 4.8 presents a breakdown of U.S. producers' durable equipment from 1950 through 1986. The most significant change occurred in the information-processing subsector, which grew from 6.5% to 45.4% of the value of this sector between 1950 and 1986, primarily from gains in computers and communications equipment. Information processing is the least steel-intensive sector of PDE, relying on high technology materials instead. The shares of industrial, transportation, and other equipment all fell significantly, so that shares in 1986 were 60% or less of the 1950 share of PDE. Therefore, despite the growth of the PDE sector in total share in GNP, the overall steel intensity should have fallen, because high technology items were responsible for this growth, and because steel-intensive industrial and transportation equipment declined in importance.

The USSR shows a somewhat different pattern of change in the producers' durable equipment sector from the United States. Table 4.9 shows the share of various types of equipment in producers' durable goods between 1950 and 1979. As in the United States, precision instruments, which include high technology items such as timepieces and computers, increased from 1.7% to 20.1% of the total category. Similarly, the share of most types of industrial, transporta-

Table 4.8 Breakdown of U.S. Producers' Durable Equipment

Sector	% of total, 1980=100					
	1950	1960	1970	1980	1985	1986
PROD DUR EQUIP	100.0	100.0	100.0	100.0	100.0	100.0
Information Proc	6.5	11.5	14.5	26.7	43.5	45.4
Ofc Mach/Comput	1.9	2.9	2.0	8.3	26.8	28.4
Commun Equip	2.4	5.9	8.2	11.4	9.4	9.7
Instruments	2.0	2.2	2.5	3.4	3.5	3.8
Photocopy	0.3	0.5	1.7	3.6	3.8	3.6
Industrial Equip	31.8	35.7	34.5	27.6	19.2	18.4
Fabr Metal Prod	3.0	3.3	5.0	4.5	2.5	2.3
Engines/Turb	2.2	2.1	2.2	0.8	0.5	0.4
Metalwork Mach	5.8	7.2	7.9	7.0	4.4	4.3
Other M & E	16.7	17.2	14.2	11.1	8.4	8.3
Electrical	4.1	5.9	5.2	4.2	3.3	3.0
Transport Equip	30.4	25.3	23.7	20.3	19.3	18.6
Other Equipment	31.3	27.4	27.3	25.3	18.0	17.6
Furniture/Fixt	3.9	5.0	4.3	4.0	4.1	4.2
Tractors	6.1	3.2	3.6	2.9	1.5	1.4
Agri Mach*	7.0	4.8	5.1	4.1	1.7	1.6
Construct Mach*	4.2	4.2	4.5	4.0	2.8	2.8
Mining/Oil Mach	2.8	2.2	1.9	2.4	0.9	0.6
Service Ind Mach	3.8	3.8	3.6	2.6	2.3	2.3
Elec Equip nec**	1.4	1.0	1.1	1.7	2.1	2.1
Other	2.1	3.1	3.1	3.5	2.7	2.8

* excluding tractors
** "nec" means not elsewhere classified

Sources: U.S. Department of Commerce, 1986. _The National Income and Product Accounts of the United States, 1929-82_.
U.S. Department of Commerce. _Survey of Current Business_, various issues.

Table 4.9 Breakdown of USSR Producers' Durable Equipment

Sector	% of producer durables, 1970=100				
	1950	1960	1970	1975	1979
TOTAL PROD DURABLES	100.0	100.0	100.0	100.0	100.0
Precision Instru	1.7	5.6	9.4	14.3	20.1
Industrial Equip	53.8	54.5	58.1	56.7	54.0
Forge Presses	0.3	0.8	0.7	0.8	0.8
Elec/Power M&E	2.8	3.3	2.3	1.8	1.4
Machine Tools	2.0	2.9	3.0	3.0	3.2
Electrotech M&E	9.3	9.8	9.2	8.0	6.5
Pumps/Compressors	0.6	1.9	2.5	2.5	2.4
Hoist/Crane Eq	2.6	1.9	1.9	1.6	1.3
Repair Mach	24.9	24.6	29.6	29.8	29.4
Misc Ind M&E*	11.3	9.4	8.9	9.2	8.8
Transportation Eq	15.6	18.6	13.7	13.9	12.1
Railroad/Other	8.5	11.7	6.3	5.8	4.6
Motor Vehicles	7.1	6.9	7.4	8.1	7.5
Other Equipment	28.9	21.3	18.7	15.1	13.8
Other n.e.c.**	7.4	6.3	5.6	2.6	2.3
Agric M & E	7.9	6.7	7.4	8.1	7.8
Construc M & E	2.8	2.1	2.0	1.8	1.4
Metallurg/Mine Eq	10.8	6.2	3.6	2.6	2.3

* includes log/paper machinery, light industry equipment, food industry equipment, sanitary engineering products, metalwares, and structural metals.
** includes casting machinery, tools and dies, construction material machinery, bearings, and abrasives.

Source: CIA, 1982. USSR: Measures of Economic Growth and Development, 1950-1980.

tion, and other equipment has fallen since 1950. Only forge presses, machine tools, pumps and compressors, motor vehicles, and repair machinery showed increased shares of producers' durable goods.

Several comments should be made at this point, however. According to Cohn (1987), forge presses and machine tools have also entered the realm of high technology items, so that one might assume that these products have become less steel-intensive as well. Another important point is that although the share of high technology items has increased and most other equipment has decreased in share, U.S. share of high technology items is much larger than that of the Soviet level. Finally, the decrease in share of industrial equipment in the USSR is considerably smaller than the drop recorded in the United States. Therefore, it would appear that there is some justification for a higher level of steel intensity in the USSR, based on the large and growing share of PDE in GNP, as well as the types of products manufactured by the United States.

4.3.3 Construction

The United States segregates construction into residential and commercial structures, both of which have declined in share since 1950. Residential structures use wood and other construction materials for frames, while commercial structures use steel and concrete, resulting in a higher steel intensity for the commercial sector. Through the decline in share of commercial structures alone, one may conclude that the steel intensity of this segment has declined in the United States.

Moreover, U.S. commercial structures built since 1950 contain less steel because manufacturing activities have changed, further reducing steel intensity. According to Rumer (1984), most industrial countries have changed to a "flexible shop" construction design, which allows quick and easy dismantling of buildings in order to expand or retool to accommodate new products or technologies. Such building designs widely use new, lighter construction materials, such as "light panels of aluminum, asbestos-cement, steel sheet with foam rubber insulation, glass-fiber slabs, and other light fillers" (Rumer, 1984).

The USSR has experienced changes in the types of construction being undertaken since the 1950s as well. Prior to the mid-1970s, the USSR relied on "extensive" development in Soviet parlance, which focused on the building of new plants and the expansion of existing plants to fuel economic growth. In the mid-1970s, however, declining rates of economic growth and a declining labor pool forced a change to "intensive" development, with the focus on reconstruction and modernization of plants rather than new construction and expansion. Reconstruction is believed to be less expensive than new construction by the Soviets, as well as less resource-intensive.

The extent of this change is shown by changes in the share of construction-installation and producer durables during this period. According to Cohn (1982), the share of construction-installation work in total fixed investment declined from 69.6% in the 1951-55 period to only 54.9% in the 1976-79 period, while the share of producer durables increased from 24.4% to 35.6% respectively. Another study (Leggett, 1987) shows that reconstruction grew at an average annual rate of 7% between 1981 and 1985, while expansion of existing enterprises fell by 0.4% and new construction grew by only 3%.

Whether this new intensive development strategy will be successful is uncertain. Rumer (1984) cites increasing tension between Soviet leaders and the ministries concerning this issue. Ministries have been pushing for new construction funds in order to meet their production quotas, since reconstruction has been proceeding slowly at many plants and disrupts production. It is also uncertain whether reconstruction is truly less expensive than new construction.

According to Rumer (1984):

> Standard designs are not used for reconstruction, the level of mechanization is much lower, and prefabricated components are used to a lesser extent. Labor expenditures in the reconstruction of automobile plants, for example, are 60 percent higher than in the construction of new plants. Expenditures of materials are higher by a similar amount. . . . Another not unimportant factor that contributes to the higher costs of reconstruction work and lengthens project completion times is the insufficient number of construction-installation enterprises undertaking such work because they have no material incentives to do it. Therefore, the reconstruction of buildings and structures is most often carried out by small-scale repair-construction divisions of the enterprises themselves.

Leggett (1987) notes that 25% of current construction projects were started 10 to 20 years ago, with the result that plants are often obsolete before brought on-line.

The major reason for the difficulty of reconstruction is the design of existing structures. Typical Soviet industrial designs rely on durable, prefabricated concrete structures with overhead bridge cranes, requiring heavy steel columns and supports that limit the ability to rearrange floor space (Rumer, 1984; Cohn, 1987). U.S. flexible shops rely on mobile transportation, such as conveyors and pneumatic systems, that result in considerable savings in cement, steel, and other materials relative to Soviet plants. According to Rumer (1984), Soviets use bridge cranes even when the product manufactured would ordinarily not call for such heavy equipment:

> Planning and design decisions on the part of construction for modern Soviet industrial buildings depend much more on the type of bridge crane adopted in the design than on the technology of production. For example, structures of shops producing enameled pots and pans that weigh no more than 2-3 kilograms differ very little in scale and weight from those of a rolled metal shop in a metallurgical plant.

4.4 The Role of Government Policy and Consumer Tastes and Preferences

In a typical market economy, both government policies and consumer tastes and preferences influence the demand for goods and services. In centrally planned economies such as the USSR, however, government policy dictates the type and quantity of goods and services produced; consumer tastes and preferences play a subordinate role.

Services and consumption goods account for a significantly smaller proportion of the Soviet economy than in the United States. According to Marxist philosophy, services are "nonproductive" sectors of the economy, and therefore not important to economic growth. Since the 1950s, the USSR has relied on the "productive" sector of industry to provide the bulk of economic growth, with the result that this sector appears "overgrown" relative to other developed countries.

The USSR's focus on supply rather than demand is also cited as a reason for the larger size of its industrial sector. According to Ofer (1987):

> While resisting the introduction of replacement equipment, plant managers overdemand investment funds, also as part of their effort to meet exacting production plans. Accumulated excess capacity can help meet production norms under conditions of frequent shortages due to equipment failures and supply interruptions, and can be used to produce unobtainable spare parts for oneself, albeit at high cost. Similar factors . . . lead to high investment in inventories. The long tradition of no charge or low charge for capital funds also contributes to excess demand.

Winiecki (1986) claims that these policies cause waste of material inputs and the disregard of material-saving innovations, with higher resource intensity the result. He also cites the Soviet policy of import substitution as another factor increasing the size of industry relative to other industrialized countries, which generally import goods if they can be produced cheaper or are of better quality than domestic goods.

One final factor that increases steel intensity in the USSR is the large amount of investment geared to the extraction and primary processing sectors, rather than the final stages of production. The current investment pattern is motivated by the Soviet desire for self-sufficiency in these raw materials and poor investment patterns in earlier years. According to Rumer (1984):

> A vicious circle has been created: the more

> resources that are diverted to maintain and develop the production of raw materials, the less that are allocated for the development of technology and the production of equipment; and the more technology lags, the greater the amount of raw materials that is expended per unit of output--the more the requirements for their production grow. And regardless of how much fuel, metal, and cement is produced, the gap between production and requirements does not shrink but grows. And instances of plants being idled due to lack of raw materials, fuel, and metal become more frequent. And construction stops because of lack of cement.

4.5 Summary

This chapter examined differences in the economic structure of the United States and the USSR. Examination of intersectoral shifts, or changes in the composition of broad sectors of the economy, show that the USSR has significantly larger shares of investment, industry, and construction than does the United States. The larger Soviet shares in steel-intensive sectors helps to explain the higher level of Soviet steel intensity relative to the United States. In addition, the share of these sectors in GNP has generally increased over time, rather than declining in share as they have in the United States. The result is an increasing trend of steel intensity in the USSR, and a declining trend in the United States.

Breakdown of these aggregate sectors shows that the proportion of high technology items increased over time in both countries, but that the United States produces significantly more of these products. In the consumer durables sector, automobile purchases are significantly less in the USSR, suggesting a lower Soviet steel intensity for this sector. In producers' durable equipment, the USSR produces a higher proportion of industrial equipment, suggesting a higher Soviet steel intensity for this sector. In construction, Soviet designs result in significantly heavier, material-intensive structures relative to the United States.

Despite these differences, the overall level of steel IOU seems much higher in the USSR than would be predicted given these differences in shares alone. In 1950, the year when the United States and the USSR had the most similar shares of industry and construction, the United States had a total of 36% of GDP generated by these sectors, with an economy-wide steel intensity of 83.6. In the USSR, industry and construction generated only 27.1% of GDP, but their economy-wide steel intensity was 94.6. In other words, with only 0.75 times the U.S. share in these steel-intensive sectors, USSR steel intensity was comparable to, but slightly higher than the U.S. level in 1950.

Furthermore, this difference in IOU has been widening over time. In 1986, USSR industry and construction was 1.4 times the U.S. level as a percentage of GDP, but steel IOU was 4.3 times the U.S. level. Obviously, the differences in the level of steel IOU between the USSR and the United States are not entirely explained by differences in the size and composition of these sectors over time. A brief assessment of Soviet government policies and the role of consumer tastes and preferences suggests a systemic proclivity for higher resource intensity. However, dissimilarity in the types of structures suggests an even stronger reason for differing steel IOU levels--the role of material substitution and technological change. This will be examined in the following chapter.

Chapter 5

CHANGES IN THE MATERIAL COMPOSITION OF PRODUCT

5.1 Overview

Despite the significant differences between the structure of the Soviet and U.S. economies, or the product composition of income, Soviet steel intensity is still much larger than one would expect. This chapter examines the second component of IOU, the material composition of product, to see whether changes in technology and material substitution can explain differences in the level of IOU between the United States and the USSR.

Although the traditional view of IOU hypothesized an inverted U-shaped pattern of IOU over time, this view also assumed a stable curve over time. However, Radetzki (1988) indicated that the original pattern of IOU can shift up or down over time as new technologies and materials are developed. As figure 1.2 suggests, U.S. and Soviet levels of IOU were somewhat comparable in 1950, but the differences have increased over time. Part of the difference has been explained by the large and growing share of industry in the USSR relative to the United States. If one country has undergone significant material-saving technological changes relative to the other since the 1950s, this could explain the remaining differences in the level and trend of IOU.

5.2 Input-Output Analysis

An input-output (I/O) table shows the flow of goods and services among sectors of the economy over time, usually one year. The entire table can be thought of as a system of linear equations. Matrix algebra is used to determine coefficients, that show how the use of inputs has changed relative to demand for final products.

Since metals are used as inputs by many industries, the study of I/O coefficients can show how metal use has changed over time. Various analysts have used I/O analysis to examine the effect of material substitution and technological change in the metal industries (Hwang, 1989; Myers, 1986; Roberts, 1985). Although I/O tables are generally constructed in value terms, the entries are assumed to represent changes in physical quantities as well (Leontief, 1986). Total coefficients represent the proportion of each dollar of final demand spent directly and indirectly on a given input. Theoretically, a decrease in a total coefficient for the steel industry indicates a decrease in the steel required to produce a good in another industry, such as boilers or automobiles.

Several problems can arise in interpreting these coefficients, as indicated by Hwang (1989). The most serious of these is that changes in the mix of goods produced by an industry, as well as changes in the types of steels used as inputs, could cause total coefficients to change. In the first case, changes in product mix would then be incorrectly interpreted as changes in material composition of product, assuming that each product requires a different quantity of steel. In the second case, differences in the values of steels used could cause changes in the total coefficient, even though the tonnage required remains the same. Although these and other problems may offset one another, the reader is cautioned to keep the above in mind when drawing conclusions.

Table 5.1 shows total coefficients and the percentage changes between 1963 and 1977 for major steel-consuming industries in the United States. The coefficients were converted to constant 1972 dollars to allow annual comparisons. Most categories show a substantial decrease in the total steel coefficient since 1963. The implication is that significant material substitution or technological change has occurred in these sectors since 1963, reducing steel requirements.

The Soviet Union has also published I/O tables. Tables were published for 1959, 1966, and 1972, but restricted thereafter by the Soviet government, apparently for national

Table 5.1 Total Coefficients for the United States for Major Steel-Consuming Sectors

Sector and Number	1972=100 *,**			
	1963	1967	1972	1977
Other Furniture and Fixtures (23)	0.16498	0.17522 (6.2)	0.1452 (-17.1)	0.14226 (2.0)
Metal Containers (39)	0.68114	0.62807 (-7.8)	0.4356 (-30.6)	0.38525 (-11.6)
Heating,Plumbing, and Structurals (40)	0.44376	0.44778 (0.9)	0.33116 (-26.0)	0.29577 (-10.7)
Stampings, Screw Mach Prod, and Bolts (41)	0.38660	0.42834 (10.8)	0.34917 (-18.5)	0.35122 (0.6)
Other Fabricated Metal Products (42)	0.32335	0.32905 (1.8)	0.26455 (-19.6)	0.26714 (1.0)
Engines/turbines (43)	0.19181	0.20402 (6.4)	0.2189 (7.4)	0.21591 (-1.4)
Farm/Garden M&E (44)	0.26936	0.27922 (3.7)	0.21988 (-21.3)	0.20020 (-8.9)
Construction, Mining, and Oilfield M&E (45)	0.28034	0.28515 (1.7)	0.22835 (-19.9)	0.26088 (14.2)
Materials Handling M&E (46)	0.21893	0.23045 (5.3)	0.2132 (-7.5)	0.19923 (-6.6)
Metalworking M&E (47)	0.17218	0.17171 (-0.3)	0.15809 (-7.9)	0.13921 (-11.9)
Special Ind M&E (48)	0.17922	0.17726 (-1.1)	0.15012 (-15.3)	0.13814 (-8.0)
General Ind M&E (49)	0.20636	0.21253 (3.0)	0.19982 (-6.0)	0.18093 (-9.5)

(continued)

Table 5.1 (continued)

Sector and Number	1972=100 *,**			
	1963	1967	1972	1977
Machine Shop Prod (50)	0.19491	0.17941 (-8.0)	0.1464 (-18.4)	0.12129 (-17.2)
Service Ind Mach (52)	0.19313	0.18196 (-5.8)	0.14125 (-22.4)	0.12336 (-12.7)
Elec Industrial Equip and Apparatus (53)	0.13971	0.11993 (-14.2)	0.11593 (-3.3)	0.09893 (-14.7)
Household Appliances (54)	0.21178	0.18903 (-10.7)	0.14575 (-22.9)	0.10779 (-26.0)
Electric Lighting and Wiring Equipment (55)	0.14364	0.13311 (-7.3)	0.10742 (-19.3)	0.09916 (-7.7)
Motor Vehicles, Parts, and Equipment (59)	0.26804	0.22246 (-17.0)	0.17616 (-20.8)	0.15156 (-14.0)
Other Transportation Equipment (61)	0.28384	0.24184 (-14.8)	0.1616 (-33.2)	0.13996 (-13.4)

Notes: * Numbers in parentheses under the coefficients represent percentage change from the previous year.

** Coefficients converted to constant dollars to allow comparisons between years. Deflators and method described in Appendix D.

Source: U.S. Department of Commerce. <u>Survey of Current Business</u>, various issues.
U.S. Department of Commerce, 1986. <u>The National Income and Product Accounts of the United States, 1929-1982</u>.

security reasons.[10] Even the published tables, however, must be reconstructed by Western Soviet analysts, since much data is missing or incomplete. According to Treml, Gallik, and Kostinsky (1977), up to 20% of the entries in the 1966 table had to be estimated for "nonproductive" sectors such as services.

Another problem is that the official government tables are in purchasers' prices, rather than producers' prices, which requires additional reconstruction. Most Western I/O tables are published in producers' prices, which include only direct costs of production plus profit, and are considered therefore to be representative of flows in physical quantities (Treml, Gallik, and Kostinsky, 1977). Purchasers' prices include producers' price data plus transportation and distribution costs, taxes, and customs duties, which are generally unrelated to the technology of production, and therefore can distort the coefficients.

Furthermore, a comparison of coefficients over time for the USSR presents problems, owing to differences in quality of the data or noncomparability of sectors between tables. The 1959 definitions of sectors were not consistent with

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10. Estimated I/O tables have been published since 1972 by various organizations, but were not disaggregated enough for the purposes of this study. See, for example, Gallik, D. M., et al. (1984) for an estimated 1977 table.

subsequent tables, and was not used in this study. The 1972 table grouped all metals together as one sector, including nonferrous metals and their ores. Despite aggregation, the small share of the ores sector in total metals and ores (generally less than 2%) should limit the degree of upward bias in the coefficients. Second, use of nonferrous metals is still limited in the USSR, which also limits upward bias of the coefficients. For example, 95% of the materials used in the Machine Building and Metal Working (MBMW) sector are ferrous (Rumer and Vatkin, 1987).

In Table 5.2, a comparision of the U.S. and USSR total coefficients is presented. Soviet coefficients were converted to constant 1972 rubles using coefficients presented in Treml and Guill (1977), and then converted to 1972 dollars using the 1972 exchange rate published by the CIA (1985). In all cases (where data was available), the Soviet coefficients increased by a significant margin between 1966 and 1972, while the U.S. coefficients declined during 1967 and 1972. Although individual sectors may use a larger proportion of nonferrous metals than the MBMW sector in general (to which most of the sectors listed in the table belong), the size of the increase suggests that this aggregation alone is not the cause. Furthermore, material-saving technological change and substitution of nonmetals for

Table 5.2 Comparison of U.S. and USSR Total Coefficients

	USSR, 1972=100				U.S., 1972=100		
No., Sector Name	1966	1972	% chg	No., Sector Name	1967	1972	% chg
39 Met Struct	0.767	0.850	10.8	40 Heat, Plumb, Struct	0.448	0.331	-26.0
37 Sanit Engr	0.380	0.589	55.0				
38 Metalwares		0.566					
7 Ind Met Pr	0.655	0.980	49.7	41 Stamp, Bolts	0.428	0.349	-18.5
15 El/Pow M&E	0.292	0.488	67.4	43 Engines, Turbines	0.204	0.219	7.3
34 Agric M&E	0.299	0.503	68.4	44 Farm, Gard M&E	0.279	0.220	-21.3
30 Constr M&E	0.208	0.346	66.4	45 Con,Mine, Oil M&E	0.285	0.228	-19.9
31 Con Mat M&E	0.258	0.427	65.7				
23 Mine/Met Eq		0.526					
29 Hoist M&E	0.225	0.380	68.6	46 Mat Hand M&E	0.230	0.213	-7.5
18 Mach Tools	0.141	0.235	66.3	47 Met Work M&E	0.172	0.158	-7.9
21 Tools&Dies	0.352	0.476	35.0				
19 Forge M&E	0.180	0.301	67.7				
28 Print M&E	0.092	0.230	150.5	48 Spec Ind M&E	0.177	0.150	-15.3
26 Lt Ind M&E	0.116	0.278	139.0				
27 Food M&E	0.211	0.418	97.6				
25 Paper M&E	0.213	0.352	65.7				

(continued)

Table 5.2 (continued)

	USSR, 1972=100				US, 1972=100		
No., Sector Name*	1966	1972	% chg	No., Sector Name**	1967	1972	% chg
35 Bearings	0.337	0.440	30.6	49 GenInd Eq	0.213	0.200	-6.0
20 Cast M&E		0.256					
68 Ind nec		0.143					
16 Electronics	0.124	0.397	221.3	53 Elec M&E	0.120	0.116	-3.3
				55 Light M&E	0.133	0.107	-19.3
33 Autos	0.189	0.374	97.3	59 Mot Veh, Parts	0.222	0.176	-20.8
32 Transp		0.384		61 Other Transp Eq	0.242	0.162	-33.2

Notes: * A description of the Soviet sectors is in Appendix E. Sector numbers listed for the USSR are from the 1966 table. Blanks indicate data was not available.

** A description of the U.S. sectors is in Appendix E. U.S. sector numbers are the same for both years. The U.S. published a 1967 table, not a 1966 table like the Soviets.

Sources: **U.S. Department of Commerce. *Survey of Current Business*, various issues.**
U.S. Deparatment of Commerce, 1986. *The National Income and Product Accounts of the United States, 1929-1982*.
Treml, Vladimir G., 1977. *Studies in Soviet Input-Output Analysis*.
Gallik, Dimitri M., Barry L. Kostinsky, and Vladimir Treml, 1983. *Input-Output Structure Structure of the Soviet Economy: 1972*.
CIA, 1985. *Handbook of Economic Statistics*.

metals would have caused a decline in the coefficient, resulting in an offsetting effect. It would appear, therefore, that the USSR did not undergo the same changes that the United States did during the period in question. The conclusions from changes in the Soviet coefficients are guarded, however, because of the uncertainty present.

An attempt is made to compare the U.S. and Soviet coefficients for similar sectors in Table 5.2 as well. Despite efforts to match the Soviet and U.S. sectors, differences still remain, the most similar being dissimilar product mixes. For example, the Soviet industrial metal products sector (No. 7 in 1966) includes steel wire, strip, rope, nails, electrodes, bolts, and rivets, but not the metal stampings the comparable U.S. sector (No. 41) includes. The result is that the industrial metal products coefficient is biased downward, while the electronics coefficient, which includes metal stampings, is biased upward.

Despite these problems, there are significant differences between the Soviet and U.S. coefficients. In general, Soviet sectors require more steel per unit of final demand than in the United States, as the larger Soviet coefficients indicate. For example, the Soviet industrial metal products coefficient was 1.5 times the U.S. level in 1966 and 2.8 times the U.S. level in 1972, even with stampings and other metal products not included.

The total coefficient comparisons over time suggest that technological change or material substitution has occurred in the United States, but one cannot separate the effects or identify the forces behind these changes. Similarly, the intercountry comparisons indicate that the USSR uses more steel to produce similar goods, but do not provide information beyond that. The following sections examine both material substitution and the technological changes in the United States and the USSR in detail in order to separate these efforts and to identify the reasons for differences in the level of steel IOU between the two countries.

5.3 Material Substitution

Material substitution can take many forms: substitution of one material for another is the most common, but new processes or designs which allow for the use of less material or eliminate the need for the material altogether are becoming just as important. How material substitution has affected the level and trend of steel intensity in the United States and the USSR since 1950 is examined in the following section. Subsequent sections discuss how technological change and price changes have influenced the degree of material substitution.

5.3.1 Material Substitution in the United States

The wide variety of new materials, such as new forms of aluminum, plastics, ceramics, stronger steels, and composites have created many options for the product designer. The U.S. automobile industry provides perhaps the best example of material substitution in steel.

Eggert (forthcoming) found that the motor vehicle share of total steel consumption fell from 21% in 1960 to 17% in 1985, and that the average weight of a car fell from 3,500 lb in the 1960s to less than 2,800 lb in the early 1980s. Prior to the mid-1950s, the share of aluminum in cars was less than 1% of total car weight, but by the end of the 1970s, the share was as high as 5%. Plastics and composite materials also increased their share, from 1% in the early 1960s, to 7% in the middle 1980s.

The steels used in car production changed as well. According to the ECE (1984), when the price of steel sheet dropped, its use in cars went up. Total car weight fell, however, because new steelmaking technologies have allowed for thinner, lighter sheet. Use of cold-rolled steels and alloys have created stronger steels, allowing further declines in total car weight (Eggert, forthcoming). New processes, such as stamping, drop-forging, and new machining techniques allowed carmakers to get more finished products out of each ton of steel purchased.

Other businesses are concerned with material-saving (and cost-saving) designs and processes. According to the ECE (1984), Olivetti Office Machines decreased the share of steel in total purchases of materials from 94% in 1971 to 71% in 1981 by substituting parts manufactured from metal powders instead of steel sheet, substituting stronger steels for ordinary carbon steels, and adopting new material-saving designs. Other important examples are found in the beverage container market where aluminum has virtually replaced tinplated steel (Demler, 1980) and in household appliances, where plastics, aluminum, and higher strength steels have replaced carbon steels in housings and other parts. This data indicates that material substitution is a likely explanation for the declining trend in steel intensity in the United States, at least in recent years.

5.3.2 Material Substitution in the USSR

In the USSR, interest in material substitution has increased in recent years. Shortages of steel, particularly rolled, sheet, and high quality steels, have caused concern and have heightened modernization efforts. Imports of specialty products, such as high strength pipe for the oil industry; cold-rolled steels for machine building, automobiles, and other consumer durable goods; tinplate for cans and packaging; and sheet for transformers and electric motors have become a large part of Soviet hard currency trade (CIA, 1982b).

The reasons for these shortages range from an overtaxed rail system, that cannot supply the required raw materials for steelmaking, to underinvestment in the processing segments of the steel industry. Existing facilities cannot keep up with the demand for specialty products or do not possess the technology needed to make these products. In general, the USSR produces very basic types of carbon steels and has only limited capacity to produce the higher strength steels common in the United States.

According to Harris (1987), the limited selection and low quality of available steels results in finished goods up to 25% heavier than similar Western products. In addition, distrust of steel quality causes designers to apply a "correction factor," resulting in the use of thicker and heavier steels to protect against metal failure. For example, Harris (1987) cited a Soviet survey of 432 pipe system designs which showed many used thick-walled pipe unnecessarily. The Soviets claimed that efficient use of pipe could save 370,000 tons of steel pipe annually.

Concerns about these shortages has led to a Soviet campaign to save ferrous metals. According to Soviet literature, the primary methods espoused for saving metal include greater use of stronger steels, such as cold-rolled sheet, and heat-treated and low-alloy steels; design changes; modernization of steelmaking technology; and the use of substitute materials such as ceramics, composites, plastics, and aluminum (Harris, 1987).

Soviet interest in the use of alternative materials and more complex steels is only of recent origin compared to the United States. For example, in 1983 the Soviet auto industry was just beginning to consider the use of low alloy steel and aluminum as a method of cutting overall steel consumption (Anufriev, 1983). As Harris (1987) indicated, recent Soviet articles are still discussing Soviet plans for using these materials, but there is little indication given as to when these plans will actually be implemented.

Low quality steels, the use of "correction factors," and the limited use of substitute materials helps to explain the higher Soviet total steel coefficients and steel intensity relative to the United States. In the USSR, material-saving plans and shortages of metal may help to explain the decline in steel intensity since the late 1970s. Many analysts feel, however, that the savings plans have not been as successful as hoped, and therefore have had limited impact on metal consumption (Harris, 1987; Rumer and Vatkin, 1987).

5.4 Technological Change

Technological change can be a driving force behind material substitution. Advances in computer technology, new metal processing techniques, and other innovations have revolutionized the U.S. metal industries and their customers' industries.

Continuous casting, described in chapter 2, is an important metal-saving technology. Up to 10% of the steel poured into ingots is lost in croppings before the ingots are rolled into semi-finished shapes, compared with only a 2% to 4% loss with continuously cast semi-finished shapes (ECE, 1984). Soviet sources estimate the metal savings may be even greater with continuous casting, from 10% to 15% (Parfenov, 1977). In 1975, 6.9% of Soviet crude steel production was continuously cast, compared to 9.1% in the United States (IISI, 1986). By 1985, 13.3% of crude steel was continuously cast in the USSR, compared with 44.4% in the United States. Despite Soviet interest in this technology, its adoption is proceeding slowly.

Soviet sources also cite a large amount of waste in the steel-consuming industries. Estimates range from 22% (Narodnoye Khozyaystvo SSSR, 1985) for the entire machine-building sector to as high as 67% in forgings (Rumer and Vatkin, 1987). The reasons for this wastage include reliance on outdated casting technologies, extensive use of metalcutting rather than metalforming technologies, and systemic factors which inhibit the adoption of new technologies. These problems are examined in the remaining sections.

5.4.1 Casting Technology

Casting refers to the process of making final products directly by pouring molten metal into a mold made of sand, metal, or other refractory materials. Casting techniques range from the green sand method to precision casting. In the green sand method, a moist sand mixture is compacted around a pattern, into which molten metal is poured. Precision casting refers to a family of techniques including vacuum molding, die casting, and lost wax casting, among others. In these techniques, molten metal is forced into a mold by pressure, centrifugal force, or other methods. The primary differences between precision casting and other casting methods are the higher quality of the mold and the fact that the molten metal is forced to completely fill the mold, resulting in a more accurate casting.

According to Premier Ryzhkov, 50% to 60% of the total weight of Soviet machinery in the early 1980s consisted of cast steels, making the machinery 2 to 2.5 times heavier than other industrialized countries (Rumer and Vatkin, 1987). Casting is an inexpensive and fast method of forming components, because it eliminates forging, rolling, stamping, and other methods of metal forming. Furthermore, modern casting techniques, such as precision castings, produce very little scrap. According to Eggert (forthcoming), cast automobile parts produce negligible scrap, compared to the use of steel sheet, which produces 30% to 35% scrap.

Between 80% to 90% of Soviet castings use outdated green sand method (Rumer and Vatkin, 1987). The green sand method is inexpensive and simple compared to dry sand, thermoset resin, or other permanent mold castings methods, plus the sand can be reused after use. The major disadvantage of the green sand method, causing its infrequent use in Western countries, is its lack of dimensional control resulting in large tolerances which require extensive machining. Another disadvantage is that moisture from the sand creates defects, inclusions, and cracks, that must repaired by welding (Bever, 1986). In addition, many Soviet castings are hand-molded, further increasing tolerances. According to Pashko (1976), hand-molded castings in the USSR result in 30% to 35% tolerances, compared to 18% to 25% for machinemolded castings.

Other factors that increase the cost and metal usage for the Soviets include the lack of standardization of cast parts, resulting in small production runs, and shortages of foundry equipment, limiting the ability of casting shops to take advantage of newer technologies like their Western counterparts (Rumer and Vatkin, 1987). Large production runs help save metal because the operators learn how to cut waste the more frequently the mold is used. Castings also tend to produce heavier components than other metal forming methods. For example, a cast-blast furnace valve body weighs 1,942 kg; one made of welded plate weighs 1,664 kg (ECE,1984).

The heavy Soviet reliance on castings and the casting method used results in higher metal consumption than in other countries. This wastage pushes the Soviets even farther from their metal-saving goals: in 1982 over 3 million tons of scrap was generated from machining castings, about 2% of total steel consumption (Zhugunusov and Troitskaya, 1982).

5.4.2 Metalforming and Metalcutting Technology

Metalforming refers to the shaping of products by forging, stamping, or other methods of deformation. Many techniques exist, the choice of which depends on desired cost and the characteristics of the finished product. Important metalforming methods include forging, which uses hammers or presses to shape the metal into the desired form; stamping, which bends metal sheet into forms such as automobile panels; and extrusion, which forces metal through a die. Metalcutting, on the other hand, refers to the use of machines, such as lathes, to sculpt a product out of a larger piece of metal.

Of the scrap generated in the MBMW sector, over 50% is from metal cuttings, but machining of castings is only partly responsible for this problem (Rumer and Vatkin, 1987). The bulk of this scrap comes from metalcutting techniques themselves. Metalcutting results in much higher wastage than metalforming techniques, since excess metal is removed in the form of chips and not all of these chips can be recycled. Modern metalforming technology includes cold-forming, drop-forging, precision forging, high-speed stamping, extrusion, and stampings of metal powders. Drop-forging saves 20% to 60% and cold-forming saves 40% to 60% over machining, and the resulting products are 25% to 40% lighter than their machined counterparts (ECE, 1984).

The Soviets, however, rely more on metalcutting than on metalforming to produce components. A study of the machine tool industry in 1977 showed that the USSR produced more than three times as many machine tools as the United States did, and two times as many metalcutting tools as the United States consumed (Grant, 1979).

Shortages of metalforming equipment are common in the Soviet machine-building sector, which claims that it cannot keep up with the demand because of a lack of steel products. Production needs also mandate more metalcutting than metalforming tools. The Soviet Union produces a higher proportion of military durable goods, which require more metalcutting techniques, while the U.S. produces more consumer durable goods, which are better adapted to metalforming (Grant, 1979). Soviet machine tools are also less sophisticated than their U.S. counterparts, which limits their adaptability to some applications and increases metal usage.

According to Grant (1979), in 1977 only 3% of Soviet metalforming tools were 3-axis, compared to 40% in the U.S. The remainder of the Soviet tools were 2-axis, compared to the U.S. 4-axis and 5-axis models.[11] In addition, few Soviet machine tools are numerically controlled (computer-operated, often abbreviated NC). Manual operation increases

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11. Axis refers to the type of movements a machine tool can make. The greater the number of axes, the greater the surface area that can be worked.

metal usage because the product is not as uniform and precise as those produced by NC technology. According to Hardt and Kaufman (1987), the Soviets lag 7 to 12 years behind the United States in NC machine tools, various computer applications, and flexible manufacturing systems.[12]

Although production of NC metalforming equipment has doubled in the past five years, the Soviets produce a maximum of 70 to 80 units annually, hardly enough to satisfy demand (Rumer and Vatkin, 1987). Shortages of equipment have led to increasing imports of NC technology, and have delayed the wider adoption of metalforming in the USSR. Although the Soviets acknowledge that metalforming is a more desirable technology, little progress is being made to change to these newer technologies. The implication is that steel consumption will continue to be higher than the United States because of the higher instance of metalcutting, lack of NC tools, and types of products manufactured in the USSR.

5.4.3 Systemic Factors

Despite the existence of new technologies, the Soviets have had difficulty with their implementation. Soviet

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12. Flexible manufacturing systems are a numerically-controlled transfer line of machine tools, that automatically transfer items to the next set of tools. They are especially well-suited for assembly line work, such as automobile manufacturing.

literature abounds with examples of long lead times from prototype development to implementation, lack of domestic innovation, and the inability of the Soviets to adapt foreign technologies to the domestic workplace. This section examines some of the reasons for this problem and how it has affected steel intensity.

One frequently cited reason for slow technological change in the USSR is improper management incentives. The focus on production goals causes management to be unwilling to install new technology, since it disrupts operations and since current equipment is already proven and familiar (Cohn, 1987; Kushnirsky, 1987; Amann and Cooper, 1982; Holliday, 1979). Soviet literature also places blame on Gosplan (the official Soviet planning agency) for unwittingly encouraging technology lags. For example, metallurgists are judged on tonnage produced, so they have been reluctant to produce the lighter, more efficient steel types demanded by industry (Parfenov, 1977).

There is also evidence that industry itself is not ready for a change in the types of metal used. Citing an article from *Sotsialisticheskaia Industriya*, Rumer and Vatkin (1987) stated:

> Gosplan's leading expert Ivan Pashko believes that in the first half of the 1980s the supply of flat rolled steel in the Soviet Union exceeded the

> demand for it from the machine-building sector because enterprises were not ready to use rolled metal instead of casting. The ministries demonstrate their eagerness to save metal through the use of high-quality rolled product and transmit requests for the production of this type of steel to the steel plants. However, the machine-building enterprises are not ready to use it and avoid receiving it.

Such problems also make the steel industry less willing to produce better quality metals, prolonging the use of heavier, less versatile steels.

Persistent shortages or unfilled orders force many companies to hoard inputs and make their own spare parts and components rather than order them elsewhere. This tendency for vertical integration, or "intraenterprise autarky" is another reason for the slow adoption of new materials and technology (Ofer, 1987). This behavior also increases steel consumption and consequently steel intensity.

Theoretically, the central planning system has the potential to be more efficient than market economies in developing new technology. In centrally planned systems, technology can be centrally developed according to nationwide needs, and there are no barriers to entry like patents that exist in market economy countries (Ofer, 1987). In practice however, the lack of competitive pressures, which stimulate many innovations in the United States, are a deterrent to domestic technology formation in the USSR.

Restrictions on the flow of information also inhibit technology development. Reliance on "innovation by order" has not created the environment for technological change that exists in other countries (Cocks, 1987). Research and development organizations are separate from the enterprises themselves, and therefore may not produce the types of technologies desired by the enterprises because of this lack of communication. In the past, military production facilities developed or had access to the latest technologies, and there was little transfer to the civilian sector, but this is changing under new guidelines issued by General Secretary Gorbachev (Ofer, 1987).

The result is extremely long lead times from development to implementation of new technologies, as well as an aging capital stock. Table 5.3 shows the average service life of various types of equipment in the USSR in the 1960s and in the United States in 1974. The Soviets keep machinery in place for much longer periods, and this has not changed much in recent years. The older the machinery, the more primitive the technology, which leads to higher metal consumption and burgeoning repair expenditures to keep these machines in operation. Soviet repairs divert money from new investments and are a reason for higher Soviet production of machine tools (Grant, 1979). Even reconstruction has not

Table 5.3 Average Service Life of Soviet and U.S. Capital Equipment in Various Industries

	Average Service Life, in years	
Industry	USSR 1961-1966	United States 1974
Chemicals	28	11
Machinery	26	8-12
Electric Power	39	18-20
Textiles and Apparel	28	9-14

Source: Poznanski, Kazimierz, 1985. The Environment for Technological Change in Centrally Planned Economies. World Bank Staff Working Paper No. 718.

enhanced the Soviet technological level as hoped. According to Rumer (1984):

> [N]ewly constructed enterprises have priority in receiving new, more productive equipment, and the replacement of equipment retired during reconstruction largely involved traditional and improved equipment. This new equipment in many instances has no technical or economic advantages over that which it replaces.

5.5 The Influence of Prices

Changes in prices have been traditionally assumed to be the driving factor behind material substitution. Tilton (1987) challenged this belief, noting that changing prices may be responsible, but only indirectly since they may influence the rate and direction of technological change.

His contention is supported by a U.S. Bureau of Mines study of the U.S. steel industry that found that the prices of substitute materials were only important in certain markets (pipes and tubes), and that 95% of carbon steel consumption was not sensitive to price changes of substitute materials (National Academy of Engineering, 1985). The study concluded that technological changes were far more important in determining changes in steel consumption.

Although the price of substitute materials may not influence steel consumption in the short run, they may hold true in the long run. Technological change comes about for a reason, and changes in the price of raw materials can be one reason. Over longer periods of time, changes in the price of raw materials can influence the types of new technology developed, which in turn influence the types of materials, such as steel, required. In this manner, price changes can influence steel consumption, and consequently steel intensity, but only over the long term.

In the USSR, price serves a different role than in market economy countries, but has influenced the level of technology as well as steel consumption nevertheless. Inflation has become a problem in some sectors of the Soviet economy, particularly in the machinery sector. According to Rumer (1984), the rate of inflation is double the rate of investment in some sectors.

One explanation for inflation in the industrial sector is pressure to innovate. Soviet guidelines will not allow price increases unless a product is "improved." In an effort to justify price increases, minor modifications are introduced which help the enterprise fulfill production plans (if based on dollar value of output), but add little actual value (Berry, 1982; Ofer, 1987; Kurtzweg, 1987). This introduces bias towards little to no innovation and against important innovations. For example, new machine tools cost four time more than those they are replacing, but are only 30% to 40% more productive (Cohn, 1979). The result is retention of older models using older technology, which prevents steel consumption and IOU from falling.

5.6 Summary

This chapter examined the influence of material substitution and technological change on steel intensity. Input-output analysis showed that total coefficients of steel decreased over time in the United States, and increased in the USSR. Since I/O coefficients largely reflect the effects of material substitution and technological change, the U.S. coefficients suggest material-savings through favorable changes and a declining steel intensity; the Soviet coefficients suggest the opposite. The level of the

Soviet coefficients also was greater than the U.S. level, suggesting that the USSR requires more steel to produce similar final goods than does the United States.

The study of material substitution supports the lower coefficients in the United States, since widespread usage of new materials and design changes have helped to decrease steel consumption, and consequently steel intensity. In the USSR, shortages of complex steels and alternative materials have limited the Soviets' ability to decrease steel content through the use of new materials, metalforming technologies, or design changes.

Other factors which compound the problem in the USSR include the use of correction factors, limited selection of metals, and the products manufactured. Correction factors increase consumption of steel to compensate for uncertain metal quality. Limited selection of steels cause product designers to choose steels of the wrong shape or weight, resulting in higher metal consumption because most of the steels end up on the shop floor in the form of cuttings.

Technological change has occurred more slowly in the USSR than in the United States. The Soviets' reliance on green sand casting increases final product weight and results in higher consumption than other techniques owing to machining losses. Shortages of metalforming equipment, which consume less steel, have thwarted Soviet efforts to decrease steel intensity as well. In addition, the Soviet focus on production goals encourages plant managers to delay introduction of unfamiliar technologies, and restriction of information discourages domestic innovation. Finally, inflation has confounded Soviet efforts to increase technological capabilities by favoring retention of older, less technologically advanced machinery and equipment.

Chapter 6

CONCLUSIONS AND IMPLICATIONS

The purpose of this study was to explain differences in the level and trend of steel intensity between the United States and the USSR from 1950 through 1986. In the early 1950s, U.S. and Soviet steel intensities were somewhat comparable, but diverged considerably in later years. U.S. steel intensity declined, particularly since the mid-1970s, while USSR steel intensity rose steadily until the late 1970s.

The structure of the economy, or product composition of income, provides one explanation for the higher Soviet level of steel intensity: the significantly larger share of industry and construction in GNP, relative to the United States. The substantial increase in the size of industry and construction since 1950 is a principal reason for the increasing Soviet trend of steel intensity as well.

The composition of these sectors has changed little in the USSR. Although there has been some growth of high technology industry and consumer services in the USSR, the size of these less steel-intensive sectors remains significantly smaller than similar U.S. sectors.

In contrast, although the size of the U.S. industrial sector has declined somewhat since 1950, the change in its composition is far more important in explaining the decline in steel intensity since 1950. Consumer durable goods account for a larger share of GNP than in earlier years, but producer durable goods and construction have shifted to far less steel-intensive segments. The rising share of information processing equipment and the shift to new flexible manufacturing techniques have significantly reduced steel requirements overall.

Differences in the size and composition of industry and construction over time provide only a partial explanation for the increasing trend and high level of USSR steel intensity relative to the United States. If the size of industry and construction alone determined the level of steel intensity, then in 1950 when these industries accounted for a much smaller proportion of GNP than in the United States, one would expect a correspondingly smaller level of steel intensity relative to the United States as well. Instead, as was discussed in chapter 4, Soviet steel intensity was comparable to, but slightly higher than the U.S. level, and the differences have widened significantly since then.

Examination of material substitution and technological change provide the solution to this puzzle. In the United States, new materials and design changes have allowed substantial savings in steel. These changes, motivated by the needs of consumers or by government policy (in the case of automobile fuel efficiency regulations), are an additional justification for the declining level of steel intensity in the United States, particularly since the mid-1970s.[12] New technologies, such as continuous casting, powder metallurgy, and precision casting and forging techniques, have also helped cut steel consumption considerably, as suggested by input-output data.

In the USSR, shortages of materials and equipment, combined with production incentives that delay the development and implementation of new technology, have limited the metal-saving potential of material substitution and technological change. Continued reliance on outdated technologies, such as metalcutting and green sand casting, have resulted in higher metal waste, and therefore higher steel consumption and intensity.

In summary, both product composition of income and material composition of products are responsible for the declining U.S. steel intensity since 1950. Both determinants caused steel intensity to fall over time; however, the

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12. Although many of these substitute materials existed prior to the mid-1970s, their use increased substantially after 1973 because of pressures created by rising fuel prices.

significant decline in input-output coefficients suggests that the material composition of product was responsible for the majority of the decline in U.S. steel intensity after the mid-1970s.

In the Soviet Union, the product composition of income is responsible for the increasing trend of steel intensity since 1950, and provides a partial explanation for the higher level of Soviet intensity as well. The material composition of product is responsible for the remainder of the differences in the level of steel intensity. Input-output data showed that the USSR requires a greater amount of steel to produce goods than the United States.

What is certain is the high and rising share of industry, combined with systemic factors that inhibit the rapid adoption of new technology, has kept steel intensity from falling as it has in the United States. The result is a progressively higher level of steel intensity over time when compared to countries pursuing different patterns of structural and technological change.

The prospects for further material substitution and technological changes in the United States are good, but the extent to which they will come at the expense of steel is uncertain. The steel industry has responded to its changing environment by providing stronger and lighter materials. In the USSR, current reforms may help save metal or increase the technological base, but only if incentives are given to enterprises to do so. According to Dobozi (forthcoming), some steps have been taken in this direction with the creation of production bonuses for metal saving. The declines in Soviet steel intensity since the late 1970s may be a sign that these reforms are helping somewhat, but given the wide disparity between Soviet resource intensities and other countries, much remains to be done.

This study suggests, however, that even if these metal-saving and technological development programs are successful, Soviet steel intensity will still be greater than the U.S. level. If the goal of the Soviet government is to have comparable levels of steel intensity, then current economic and political reforms must correct the propensity for high industrial and defense sector shares in GNP as well.

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APPENDIX A

GDP, STEEL CONSUMPTION, AND STEEL INTENSITY DATA

1950-1986

Table A.1 GDP, Steel Consumption, and Steel Intensity for the United States and the USSR, 1950-1986

CONSUMPTION IN THOUSAND TONNES, IOU=CONSUMP IN TONNES/MILL 1980$ GDP

	Soviet Union:			United States:		
YEAR	GDP mill80$	Cons	IOU	GDP mill80$	Cons	IOU
1950	282,171	26,681	94.6	1,026,172	85,750	86.2
1951	290,831	30,524	105.0	1,131,497	94,164	86.1
1952	307,938	33,448	108.6	1,175,547	81,225	71.9
1953	323,991	36,922	114.0	1,223,282	99,418	84.5
1954	339,408	39,948	117.7	1,206,485	77,569	67.0
1955	368,555	43,286	117.4	1,273,074	102,290	82.5
1956	399,391	46,956	117.6	1,298,355	100,761	79.9
1957	414,387	49,283	118.9	1,319,523	75,405	61.0
1958	446,068	52,997	118.8	1,310,953	87,408	69.0
1959	471,835	58,125	123.2	1,387,569	90,014	67.1
1960	490,421	63,520	129.5	1,417,564	90,014	65.4
1961	518,089	68,537	132.3	1,453,986	89,846	63.7
1962	537,519	74,020	137.7	1,530,259	91,240	61.3
1963	531,606	77,340	145.5	1,592,735	102,544	66.2
1964	590,109	80,767	136.9	1,677,235	118,386	72.6
1965	626,860	86,785	138.4	1,774,504	128,095	74.0
1966	658,752	91,498	138.9	1,878,973	132,137	72.2
1967	689,166	97,253	141.1	1,932,535	126,649	67.3
1968	730,773	101,813	139.3	2,012,150	137,751	70.4
1969	751,683	104,837	139.5	2,062,113	138,680	68.9
1970	809,553	110,234	136.2	2,056,029	127,304	63.4
1971	841,023	115,360	137.2	2,111,734	127,663	61.7
1972	856,863	121,240	141.5	2,215,259	138,410	63.2
1973	919,169	129,390	140.8	2,324,013	149,595	64.7
1974	955,074	137,550	144.0	2,308,330	144,120	62.9
1975	970,915	141,030	145.3	2,284,505	116,821	51.4
1976	1,017,169	147,406	144.9	2,394,201	129,044	54.2
1977	1,049,695	146,577	139.6	2,503,468	133,108	53.0
1978	1,085,810	153,436	141.3	2,633,561	145,150	55.2
1979	1,094,470	151,644	138.6	2,688,066	140,407	52.0
1980	1,109,676	150,330	135.5	2,683,867	113,990	42.4
1981	1,124,102	150,849	134.2	2,736,915	128,504	46.2
1982	1,154,453	150,343	130.2	2,669,384	84,319	31.3
1983	1,191,395	157,263	132.0	2,769,138	94,123	33.9
1984	1,209,266	159,050	131.5	2,963,078	111,343	37.4
1985	1,218,941	159,328	130.7	3,069,688	105,256	34.4
1986	1,265,260	165,122	130.5	3,163,101	94,872	30.2

(continued)

Table A.1 (continued)

Sources: International Iron and Steel Institute, _Statistical Yearbook_, various issues.
Kravis, Irving B., et al., 1982. _World Product and Income: International Comparisons of Real Gross Product_.
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APPENDIX B

U.S. MACROECONOMIC DATA, SELECTED YEARS

Table B.1 U.S. GNP by End Use, 1950-1986

in billion 1980 U.S. dollars

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
PERSONAL CONSUMP	638.9	652.1	671.9	698.9	716.2	760.9	783.3	800.4	811.5	851.9
Consumer Goods	387.4	391.1	401.8	418.6	424.8	455.8	464.4	471.0	470.8	493.9
Durables	72.0	66.6	65.1	71.5	72.7	86.4	82.8	82.4	77.5	86.4
Nondurables	315.4	324.4	336.7	347.1	352.1	369.4	381.6	388.6	393.3	407.5
Services	251.5	261.0	270.1	280.3	291.5	305.1	318.9	329.4	340.7	358.0
GR PRIV DOM INV	202.7	203.0	182.8	186.9	183.5	224.2	222.5	210.1	191.1	233.3
Fixed Invest	181.9	176.3	174.2	184.5	187.5	210.1	211.3	207.5	194.0	219.0
Nonresiden	105.5	112.1	111.1	119.2	117.0	128.5	136.5	137.1	122.5	130.7
Structures	44.1	47.2	47.9	52.1	54.3	58.0	63.1	62.9	59.0	60.1
Pr Dur Eq	61.2	64.7	63.0	66.8	62.5	70.3	73.0	73.9	63.0	70.3
Residential	77.5	64.9	63.7	66.0	71.3	82.6	75.5	70.9	72.4	89.6
Chg Bus Inven	20.9	26.6	8.6	2.4	-4.1	14.1	11.1	2.6	-2.9	14.2
GOVERNMENT PURCH	197.3	281.9	333.4	358.2	323.5	308.9	311.0	325.8	338.0	340.0
Federal	98.4	180.7	229.9	249.4	206.5	183.7	181.6	188.9	189.6	186.7
Defense										
Nondefense										
State and Local	98.4	99.5	101.1	106.1	115.0	123.6	127.8	135.3	146.9	151.9
NET EXPORTS	4.4	13.6	6.4	-2.5	2.3	0.0	4.0	6.5	-9.6	-16.9
Residual/Foreign	-17.2	-19.0	-18.9	-18.3	-19.1	-20.9	-22.4	-23.3	-20.0	-20.7
TOTAL GDP	1026.2	1131.5	1175.5	1223.3	1206.5	1273.1	1298.4	1319.5	1311.0	1387.6

Source: U.S. Department of Commerce, 1985. The National Income and Product Accounts of the United States, 1929-1982.
U.S. Department of Commerce. Survey of Current Business, various issues.

(continued)

Table B.1 (continued)

in billion 1980 U.S. dollars

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
PERSONAL CONSUMP	874.0	890.9	929.0	963.1	1017.0	1074.3	1128.8	1161.9	1221.2	1265.0
Consumer Goods	501.6	503.8	524.8	541.6	570.4	605.7	637.8	648.2	682.7	701.5
Durables	87.4	83.5	91.9	99.7	107.8	120.1	128.8	130.4	144.1	149.7
Nondurables	414.2	420.3	432.9	441.9	462.6	485.6	509.0	517.8	538.5	551.8
Services	372.4	387.1	404.2	421.4	446.6	468.6	491.1	513.7	538.5	563.6
GR PRIV DOM INV	224.8	223.6	249.1	265.0	281.3	316.7	337.0	323.1	338.1	354.1
Fixed Invest	218.1	217.3	235.1	250.7	267.7	295.0	305.2	298.3	319.9	332.3
Nonresiden	135.6	134.6	144.8	150.3	165.9	193.7	213.1	208.5	216.6	229.5
Structures	63.6	65.0	68.0	68.2	73.5	85.1	90.3	88.1	90.3	94.4
Pr Dur Eq	71.6	69.2	76.5	81.8	92.0	108.2	122.5	120.1	126.0	134.8
Residential	83.4	83.7	91.4	101.8	103.1	102.1	92.3	89.9	103.9	103.2
Chg Bus Inven	6.6	6.3	14.0	14.3	13.5	21.7	31.8	24.9	18.1	21.7
GOVERNMENT PURCH	345.2	365.2	384.2	393.1	402.5	416.4	455.4	492.7	510.9	505.5
Federal	186.0	196.3	210.2	208.9	205.9	206.0	230.8	256.6	261.0	249.2
Defense										
Nondefense										
State and Local	157.8	167.4	172.5	182.7	195.3	209.0	223.1	234.3	248.3	254.8
NET EXPORTS	-3.7	-2.5	-7.0	-1.8	5.5	-2.5	-12.8	-15.7	-27.7	-32.5
Residual/Foreign	-22.7	-23.1	-25.0	-26.7	-29.0	-30.4	-29.5	-29.4	-30.4	-30.0
TOTAL GDP	1417.6	1454.0	1530.3	1592.7	1677.2	1774.5	1879.0	1932.5	2012.2	2062.1

(continued)

Table B.1 (continued)

in billion 1980 U.S. dollars

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
PERS CONSUMP	1295.2	1335.7	1399.1	1466.8	1452.1	1483.5	1564.8	1634.2	1700.8	1737.9
Cons Goods	710.4	731.5	764.8	807.3	778.3	787.3	840.9	880.4	912.3	923.1
Durables	145.0	159.0	178.8	196.5	182.8	183.4	207.2	226.5	238.5	237.7
Nondurables	565.5	572.4	586.0	610.8	595.5	603.9	633.7	653.9	673.8	685.3
Services	584.8	604.2	634.3	659.5	673.8	696.2	723.9	753.8	788.5	814.8
GR PRIV DOM INV	329.2	361.9	401.6	449.5	415.4	330.8	391.4	449.9	497.9	496.4
Fixed Invest	322.2	344.9	382.9	414.9	386.6	341.8	372.3	424.8	466.2	483.5
Nonresiden	224.7	219.9	235.7	270.0	270.4	239.3	247.3	275.7	308.1	331.4
Structures	92.9	89.7	91.5	98.4	96.3	85.9	87.3	90.5	99.7	109.2
Pr Dur Eq	131.5	129.9	144.1	171.7	174.3	153.4	160.1	185.5	208.8	222.6
Residential	97.7	126.3	148.9	146.1	116.4	102.7	125.9	150.3	159.1	152.7
Chg Bus Inven	7.1	16.9	18.8	34.5	28.7	-11.0	19.1	25.1	31.8	12.9
GOVERNMENT PURCH	489.6	484.4	487.9	483.3	490.1	496.7	496.2	503.7	516.5	520.8
Federal	226.2	211.3	207.4	193.9	190.9	190.8	189.0	195.4	197.0	199.1
Defense			154.5	142.6	136.2	134.4	131.4	132.8	134.0	137.0
Nondefense			152.4	51.1	54.5	56.3	57.7	62.8	63.1	62.1
State/Local	262.3	272.3	279.9	289.0	298.9	305.7	306.9	307.9	319.3	321.5
NET EXPORTS	-27.9	-37.1	-46.0	-29.3	0.7	17.6	-10.2	-33.1	-25.0	3.4
Residual/Foreign	-30.0	-33.1	-27.4	-46.3	-49.9	-44.0	-47.9	-51.2	-56.7	-70.4
TOTAL GDP	2056.0	2111.7	2215.3	2324.0	2308.3	2284.5	2394.2	2503.5	2633.6	2688.1

(continued)

Table B.1 (continued)

in billion 1980 U.S. dollars

	1980	1981	1982	1983	1984	1985	1986
PERS CONSUMP	1733.3	1753.6	1776.3	1859.5	1949.7	2041.1	2128.7
Cons Goods	901.1	907.1	914.7	967.9	1026.6	1074.3	1129.7
Durables	219.3	223.7	225.4	252.5	288.2	316.7	343.4
Nondurables	681.8	683.4	689.3	715.4	738.4	757.6	786.3
Services	832.2	846.6	861.7	891.6	923.2	966.8	999.0
GR PRIV DOM INV	439.5	470.8	386.0	435.0	568.2	549.7	555.3
Fixed Invest	445.5	450.2	407.2	440.5	514.4	541.9	542.1
Nonresiden	322.7	336.3	312.1	307.4	361.8	385.9	368.6
Structures	113.9	124.4	119.8	106.3	120.2	125.0	108.1
Pr Dur Eq	209.0	211.9	192.1	201.2	242.0	261.4	261.3
Residential	122.5	113.1	94.0	133.5	152.8	155.9	174.3
Chg Bus Inven	-6.0	20.6	-21.1	-5.5	53.8	7.9	13.3
GOVERNMENT PURCH	530.5	538.4	548.7	554.9	579.4	625.2	650.2
Federal	208.1	218.8	229.9	231.9	245.1	274.8	281.1
Defense	142.8	150.4	161.6	172.6	182.2	197.8	209.7
Nondefense	65.4	68.5	68.2	58.9	62.5	76.7	70.8
State/Local	322.0	319.0	318.1	322.3	333.6	349.3	368.2
NET EXPORTS	53.1	46.0	24.5	-18.5	-78.2	-97.1	-128.0
Residual/Foreign	-72.6	-71.9	-66.1	-61.7	-56.1	-49.2	-43.1
TOTAL GDP	2683.9	2736.9	2669.4	2769.1	2963.1	3069.7	3163.1

Table B.2 U.S. GDP by Sector of Origin, 1950-1986

in billion 1982 U.S. dollars (1)

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
INDUSTRY (2)	330.5	369.1	379.6	404.4	379.8	419.6	427.2	428.8	392.5	432.1
Mining	72.8	80.8	81.5	84.3	83.3	92.0	96.5	96.2	89.1	94.1
Coal/Oil/Gas	68.5	76.2	76.9	79.6	78.8	86.7	90.9	90.5	83.8	88.6
Oth mineral	4.3	4.6	4.6	4.7	4.5	5.3	5.6	5.7	5.3	5.5
Manufacturing	257.7	288.4	298.2	319.9	296.6	327.7	330.6	332.5	303.5	338.0
Prim Met	39.4	47.1	42.0	48.4	37.7	46.3	45.7	46.2	35.1	38.8
Fabr Met	21.6	23.5	25.0	27.6	25.4	27.1	27.7	28.2	25.6	28.5
Mach, nonel	26.0	33.8	37.1	36.3	32.5	33.2	36.8	34.7	29.3	34.1
Electronics	8.7	10.3	12.6	13.1	11.8	12.7	13.8	14.3	13.4	16.2
Veh/Trans Eq	28.1	31.9	38.2	46.5	43.2	49.2	43.2	46.4	39.3	42.9
Instruments	3.8	4.6	5.3	5.8	5.7	6.1	6.4	6.2	6.2	6.9
Misc Dur Mfg	29.1	30.2	30.4	30.7	29.5	33.9	33.7	32.7	31.2	35.6
Chem prod	10.0	10.7	10.8	11.6	12.2	14.1	14.7	15.3	15.1	17.6
Pet/coal pr	11.6	12.1	12.2	12.7	12.7	14.0	14.4	14.0	14.3	16.1
Misc Nondur	79.4	84.2	84.6	87.2	85.9	91.1	94.2	94.5	94.0	101.3
CONSTRUCTION	100.0	110.9	115.9	119.9	124.8	133.3	142.7	142.4	147.5	160.4
Ind + Constr	430.5	480	495.5	524.3	504.6	552.9	569.9	571.2	540	592.5
AGR/FOREST/FISH	64.3	62.6	64.2	66.3	68.2	69.1	67.8	65.9	68.3	65.8
SERVICES	530.9	552.0	568.1	587.2	596.6	640.5	669.0	691.9	699.9	743.6
Trans/Comm:	79.4	86.5	84.7	85.3	80.6	87.7	91.2	91.6	86.6	91.1
Transport	69.4	75.3	72.9	72.3	67.3	73.1	75.8	75.0	69.4	72.7
Communic	10.0	11.2	11.8	13.0	13.3	14.6	15.4	16.6	17.2	18.4
All Others:	451.5	465.5	483.4	501.9	516	552.8	577.8	600.3	613.3	652.5
Trade	182.1	183.8	189.5	195.6	197.1	215.0	221.4	225.1	225.0	240.7
Fin/Ins/RE	119.7	126.4	134.7	142.2	149.5	160.2	168.8	178.3	184.5	195.9
Cons Serv	133.8	136.9	139.4	142.7	145.9	153.0	161.1	168.6	174.3	183.5
El/Gas/San	15.9	18.4	19.8	21.4	23.5	24.6	26.5	28.3	29.5	32.4
GOVERNMENT ENT	169.2	214.0	231.9	230.9	225.4	223.4	225.6	229.2	230.1	232.8
Residual	2.5	11.7	12.0	18.7	13.0	-0.4	-17.3	-18.5	-8.6	-15.6
TOTAL GDP (3)	1197.4	1320.3	1371.7	1427.4	1407.8	1485.5	1515.0	1539.7	1529.7	1619.1

(continued)

Table B.2 (continued)

Notes: (1) Reconstructed to match USSR categories
(2) Industry per National Income and Product Accounts (NIPA) less construction, agriculture, transportation, communications, trade, finance, and services
(3) NIPA GDP less sum of industry, construction, agriculture, transport,communications, trade, finance, services, and government

Source: U.S. Department of Commerce, 1985. The National Income and Product Accounts of the United States, 1929-1982.
U.S. Department of Commerce, Survey of Current Business, various issues.

(continued)

Table B.2 (continued)

in billion 1982 U.S. dollars

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
INDUSTRY (2)	432.8	435.0	466.4	499.8	531.1	571.8	613.1	616.7	646.5	665.5
Mining	94.2	95.6	98.1	102.2	105.7	109.4	115.0	120.2	124.7	128.9
Coal/Oil/Ga	87.9	89.5	91.9	95.9	98.8	102.2	107.3	113.3	117.2	121.1
Oth mineral	6.3	6.1	6.2	6.3	6.9	7.2	7.7	6.9	7.5	7.8
Manufacturing	338.7	339.4	368.3	397.4	425.4	462.5	497.9	496.6	522.0	536.7
Prim Met	38.0	36.3	38.7	41.7	47.0	51.0	54.4	51.0	50.8	51.3
Fabr Met	28.6	28.6	31.2	32.6	34.7	38.3	41.9	43.6	45.9	48.2
Mach, nonel	34.1	34.1	38.1	39.7	44.5	48.8	54.2	54.6	54.7	57.0
Electronics	16.9	17.9	20.1	22.1	23.3	27.8	32.1	33.3	34.8	37.3
Veh/Trans Eq	43.2	41.9	48.9	55.5	58.0	64.8	71.1	70.8	78.1	75.0
Instruments	7.2	7.0	7.8	8.2	8.4	9.7	11.1	11.6	12.6	14.0
Misc Dur Mfg	34.4	34.1	35.7	39.1	43.4	46.5	47.5	47.0	49.3	51.3
Chem prod	17.6	18.4	19.7	22.1	23.9	26.1	27.8	28.6	32.5	33.8
Pet/coal prod	16.6	17.2	18.6	19.1	19.6	20.7	21.1	21.0	21.6	20.7
Misc Nondur	102.1	103.9	109.5	117.3	122.6	128.8	136.7	135.1	141.7	148.1
CONSTRUCTION	163.1	165.1	172.5	177.5	185.9	193.7	194.4	190.7	190.2	183.6
Ind + Constr	595.9	600.1	638.9	677.3	717	765.5	807.5	807.4	836.7	849.1
AGR/FOREST/FISH	68.3	67.5	67.1	67.2	65.2	66.7	62.4	65.5	63.6	65.3
SERVICES	769.9	790.4	834.4	870.9	917.6	971.5	1025.7	1061.0	1115.0	1163.8
Trans/Comm:	93.1	93.5	107.9	103.4	107.2	116.4	126.3	127.8	134.4	141.7
Transport	73.6	73.1	86.1	80.1	82.5	89.6	97.0	96.3	100.5	104.3
Communic	19.5	20.4	21.8	23.3	24.7	26.8	29.3	31.5	33.9	37.4
All Others:	676.8	696.9	726.5	767.5	810.4	855.1	899.4	933.2	980.6	1022.1
Trade	245.4	247.7	263.9	273.8	290.7	309.8	326.5	335.3	354.8	361.7
Fin/Ins/RE	206.5	215.0	226.5	235.9	245.8	259.8	271.1	282.4	296.0	314.0
Cons Serv	190.2	197.7	207.7	217.4	230.7	240.4	253.9	265.2	274.7	287.8
El/Gas/Sanit	34.7	36.5	28.4	40.4	43.2	45.1	47.9	50.3	55.1	58.6
GOVERNMENT ENT	240.3	249.2	258.4	264.5	274.0	284.3	305.5	322.3	332.6	340.2
Residual	-20.3	-10.6	-13.2	-21.4	-16.7	-17.4	-8.6	-1.2	.0	-12.2
TOTAL GDP (3)	1654.1	1696.6	1785.6	1858.5	1957.1	2070.6	2192.5	2255.0	2347.9	2406.2

(continued)

Table B.2 (continued)

in billion 1982 U.S. dollars

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
INDUSTRY (2)	641.3	647.9	695.5	754.5	721.9	673.1	725.0	771.2	812.1	827.2
Mining	134.5	132.4	134.4	133.4	130.3	125.6	124.4	126.2	128.8	130.0
Coal/Oil/Gas	126.4	124.5	126.4	124.9	121.8	117.6	115.7	117.9	120.1	121.0
Oth minerals	8.1	7.9	8.0	8.5	8.5	8.0	8.7	8.3	8.7	9.0
Manufacturing	506.8	515.5	561.2	621.3	591.6	547.5	600.6	645.0	683.4	697.1
Prim Metals	46.8	45.6	48.7	57.8	58.8	44.0	46.0	46.1	50.5	49.8
Fabr Metals	44.1	42.3	46.8	52.1	47.5	41.8	47.1	50.3	52.5	54.9
Mach, nonelec	57.0	53.2	60.4	68.7	70.3	64.1	68.3	73.3	79.2	83.8
Electronics	34.4	34.5	38.3	43.9	40.9	37.6	41.5	49.5	56.6	60.2
Veh/Trans Eq	60.8	66.6	70.8	78.2	71.9	67.5	77.0	84.6	90.3	85.1
Instruments	12.3	12.4	14.0	15.3	16.2	16.1	17.0	19.0	20.4	22.5
Misc Dur Mfg	49.4	50.9	57.5	61.0	57.9	54.1	60.5	63.4	66.4	67.2
Chem prod	34.4	36.4	29.8	44.6	40.3	39.3	45.8	50.5	52.4	55.4
Pet/coal prod	23.8	25.2	24.5	25.7	25.1	25.1	27.0	28.9	29.1	28.9
Misc Nondur	143.8	148.4	170.4	174.0	162.7	157.9	170.4	179.4	186.0	189.3
CONSTRUCTION	168.0	162.7	166.7	170.4	162.3	149.4	158.1	165.1	176.7	173.5
Ind + Constr	809.3	810.6	862.2	924.9	884.2	822.5	883.1	936.3	988.8	1000.7
AGR/FOREST/FISH	68.8	70.6	70.9	70.3	69.7	73.1	71.5	71.6	71.8	76.1
SERVICES	1187.9	1233.8	1309.5	1387.9	1404.1	1419.5	1482.3	1553.8	1641.6	1694.1
Trans/Comm:	143.7	145.4	157.4	168.1	171.9	165.8	177.3	188.1	202.6	210.1
Transport	102.8	102.4	110.4	117.6	118.9	110.6	119.2	126.2	134.9	137.6
Communic	40.9	43.0	47.0	50.5	53.0	55.2	58.1	61.9	67.7	72.5
All Others:	1044.2	1088.4	1152.1	1219.8	1232.2	1253.7	1305	1365.7	1439	1484
Trade	367.6	385.7	414.8	437.0	426.2	433.1	454.4	479.2	502.4	511.7
Fin/Ins/RE	320.7	335.9	350.9	367.7	381.6	387.6	403.1	417.7	442.5	459.2
Cons Serv	295.7	302.4	320.0	340.2	347.5	352.4	367.7	388.4	411.9	429.8
El/Gas/Sanit	60.2	64.4	66.4	74.9	76.9	80.6	79.8	80.4	82.2	83.3
GOVERNMENT ENT	339.6	340.0	340.5	343.4	350.6	355.0	357.7	362.9	371.5	376.2
Residual	-6.5	9.1	1.8	-14.7	-15.1	-4.4	-0.9	-3.4	-0.7	-10.5
TOTAL GDP (3)	2399.1	2464.1	2584.9	2711.8	2693.5	2665.7	2793.7	2921.2	3073.0	3136.6

(continued)

Table B.2 (continued)

in billion 1982 U.S. dollars

	1980	1981	1982	1983	1984	1985	1986
INDUSTRY (2)	801.0	815.8	766.9	801.0	891.0	916.9	920.3
Mining	135.6	139.8	132.1	125.4	133.0	130.1	115.7
Coal/Oil/Gas	126.6	130.3	125.3	118.4	125.0	122.2	107.9
Oth minerals	9.0	9.5	6.8	7.0	8.0	7.9	7.8
Manufacturing	665.4	676.1	634.6	675.5	757.9	786.8	804.6
Prim Metals	46.4	48.2	35.3	30.0	34.7	34.2	34.3
Fabr Metals	52.5	52.2	46.3	48.9	55.8	56.8	56.7
Mach, nonelec	84.6	88.6	80.0	86.9	114.8	134.5	147.0
Electronics	62.7	64.3	61.8	66.2	77.3	79.7	80.3
Veh/Trans Eq	71.8	67.2	61.7	77.1	90.5	94.7	92.3
Instruments	21.8	23.7	22.6	23.2	25.4	24.7	25.2
Misc Dur Mfg	61.7	60.7	54.8	58.1	68.3	69.1	69.2
Chem products	50.1	53.5	55.3	59.6	60.0	59.1	64.1
Pet/coal prod	26.7	25.5	24.4	24.0	25.0	24.9	26.3
Misc Nondur	187.1	192.2	192.4	201.5	206.1	209.1	209.2
CONSTRUCTION	161.6	147.4	140.9	147.3	159.2	165.4	173.1
Ind + Constr	962.6	963.2	907.8	948.3	1050.2	1082.3	1093.4
AGRIC/FOREST/FISH	76.2	88.0	89.6	74.5	82.2	93.8	97.2
SERVICES	1700.7	1740.2	1733.6	1805.4	1919.9	2007.0	2091.0
Trans/Comm:	207.9	204.4	196.4	197.3	201.7	199	198.3
Transport	129.5	121.6	110.8	105.2	108.8	103.8	99.1
Communic	78.4	82.8	85.6	92.1	92.9	95.2	99.2
All Others:	1492.8	1535.8	1537.2	1608.1	1718.2	1808	1892.7
Trade	500.4	507.3	506.5	529.0	578.9	610.3	642.9
Fin/Ins/Re	464.3	474.2	475.1	489.0	506.6	524.3	537.6
Cons Serv	442.6	462.5	463.6	486.6	514.0	546.4	578.9
El/Gas/Sanit	85.5	91.8	92.0	103.5	118.7	127.0	133.3
GOVERNMENT ENT	382.7	385.3	383.9	387.4	392.1	400.8	407.9
Residual	9.5	16.9	-0.1	15.6	13.1	-2.0	1.4
TOTAL GDP (3)	3131.7	3193.6	3114.8	3231.2	3457.5	3581.9	3690.9

Table B.3 U.S. Breakdown of Consumer Durable Equipment, 1950-1986, selected years

in billion 1980 U.S. dollars

	1950	1960	1970	1980	1985	1986
TOTAL CONSUMPTION	636.4	872.4	1295.1	1736.3	2044.0	2131.1
Durable Goods	72.3	87.8	145.6	220.3	318.2	345.0
Motor Veh/Parts	36.2	43.1	64.4	90.9	144.0	154.5
New Autos	22.1	24.0	36.6	46.4	72.9	80.9
Used Autos	8.5	11.4	12.0	15.0	20.6	21.3
Other Vehi	1.0	1.0	4.4	12.3	25.8	26.4
Tires/Parts	3.6	5.2	10.6	16.7	24.8	26.1
Furniture/HH Goods	27.4	31.8	55.7	86.9	119.3	130.5
Other	8.4	12.6	25.5	20.8	54.4	59.6
Plane/Boat/Sport	1.9	3.8	8.7	17.2	23.1	25.7

Sources: U.S. Department of Commerce, 1985. _The National Income and Product Accounts of the United States, 1929-1982_.
U.S. Department of Commerce, _Survey of Current Business_, various issues.

Table B.4 Breakdown of U.S. Producers' Durable Equipment, 1950-1986, selected years

	1950	1960	1970	1980	1985	1986
NONRES. PROD DUR EQUIP	60.9	71.3	131.2	213.6	281.1	282.5
Information Processing	4.0	8.2	19.0	57.1	122.4	128.4
Office Mach/Computers	1.2	2.1	2.7	17.7	75.3	80.1
Communications Equip	1.4	4.2	10.7	24.3	26.6	27.4
Instruments	1.2	1.5	3.3	7.4	9.9	10.7
Photocopy & related	0.2	0.4	2.3	7.8	10.6	10.1
Industrial Equipment	19.4	25.4	45.3	59.0	53.9	51.9
Fabricated Metal Prod.	1.8	2.3	6.6	9.7	6.9	6.6
Engines and Turbines	1.3	1.5	2.9	1.7	1.4	1.2
Metalworking Mach	3.5	5.1	10.4	15.0	12.4	12.3
Other M & E	10.2	12.2	18.6	23.7	23.7	23.3
Electrical	2.5	4.2	6.8	9.1	9.4	8.5
Transportation Equipment	18.5	18.1	31.1	43.4	54.2	52.7
Other Equipment	19.0	19.6	35.8	54.0	50.6	49.6
Furniture & Fixtures	2.3	3.6	5.6	8.6	11.6	11.7
Tractors	3.7	2.3	4.7	6.2	4.1	3.9
Agricultural Mach *	4.3	3.4	6.7	8.7	4.9	4.4
Construction Mach *	2.6	3.0	5.9	8.6	7.8	7.9
Mining/Oilfield Mach	1.7	1.6	2.6	5.2	2.6	1.7
Service Ind Mach	2.3	2.7	4.8	5.5	6.4	6.4
Electr Equip n.e.c.	0.8	0.7	1.5	3.7	5.8	5.8
Other	1.3	2.2	4.1	7.4	7.5	7.8

* excluding tractors

Sources: U.S. Department of Commerce, 1985. <u>The National Income and Product Accounts of the United States, 1929-1982</u>.
U.S. Department of Commerce, <u>Survey of Current Business</u>, various issues.

APPENDIX C

SOVIET MACROECONOMIC DATA, SELECTED YEARS

Table C.1 Soviet GNP by End Use, 1950-1985

billions of 1980 U.S. dollars

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
CONSUMPTION	167.4	168.4	178.6	190.3	201.0	212.3	222.3	237.6	254.3	265.8
Cons Goods	104.3	103.5	111.2	120.5	127.8	135.0	142.3	154.1	166.3	172.8
Durables	3.5	4.2	4.9	6.3	8.1	8.8	9.5	11.6	12.6	13.7
Cons Svcs	63.1	65.0	67.4	69.9	73.3	77.3	80.1	83.5	88.1	93.2
INVESTMENT	46.9	55.8	56.0	64.7	69.4	84.2	95.8	106.9	118.7	131.8
New Fixed Inv	37.8	45.6	45.1	52.4	56.1	67.9	76.6	85.2	94.2	103.3
Mach & Eq	11.2	11.2	12.2	12.9	15.1	18.6	23.5	25.7	28.9	31.5
Constr/cap	26.4	30.5	34.1	37.3	41.4	45.9	48.7	53.2	60.1	67.8
Capital Repair	8.8	9.8	10.7	11.9	13.1	15.8	18.9	21.6	24.1	28.3
GOVERNMENT	55.5	55.5	60.6	58.1	58.4	62.4	70.6	63.1	66.6	68.8
Admin Svcs	22.3	22.3	22.3	21.4	19.9	17.8	17.4	16.5	16.7	16.3
Research & Dev	5.3	5.8	6.3	6.5	7.0	7.5	8.7	9.4	10.9	12.1
Outlays n.e.c.	27.6	27.2	31.1	29.4	30.5	34.5	40.7	34.7	36.7	38.1
TOTAL GNP	282.2	290.8	307.9	324.0	339.4	368.6	399.4	414.4	446.1	471.8

Sources: CIA, 1982. USSR: Measures of Economic Growth and Development, 1950-80.
CIA, annual. Handbook of Economic Statistics.
Kurtzweg, Laurie, 1987. Trends in Soviet Gross National Product." Gorbachev's Economic Plans, vol. 1.

(continued)

Table C.1 (continued)

in billions of 1980 U.S. dollars

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
CONSUMPTION	279.8	287.9	299.4	313.4	317.8	334.9	353.1	373.6	395.9	414.9
Cons Goods	181.5	184.8	190.8	199.5	197.6	208.4	220.7	234.8	250.5	263.4
Durables	15.8	15.8	16.9	16.9	18.3	20.4	22.8	24.9	27.4	29.8
Cons Svcs	98.3	103.0	108.5	114.0	120.3	126.7	132.8	139.0	145.8	151.7
INVESTMENT	138.7	154.3	160.7	148.1	182.7	199.7	201.4	209.1	222.7	237.0
New Fixed Inv	109.0	121.9	125.6	109.9	140.2	154.3	155.0	161.3	172.1	184.3
Mach & Eq	34.7	37.9	42.4	46.9	53.4	57.2	60.4	64.9	70.1	73.3
Constr/cap	73.2	76.4	80.3	83.3	86.9	93.6	97.4	106.5	112.3	117.8
Capital Repair	29.9	32.3	35.4	40.2	43.9	46.3	47.8	48.8	51.5	53.6
GOVERNMENT	67.7	72.4	74.3	66.9	85.6	89.4	98.4	101.0	106.5	98.4
Admin Svcs	16.1	15.9	16.3	16.3	16.9	18.0	18.9	20.1	21.4	22.5
Research & Dev	13.8	15.3	17.0	18.4	20.1	21.1	22.5	23.5	24.9	26.6
Outlays n.e.c.	36.6	39.3	39.8	33.4	46.6	48.5	54.3	55.1	57.9	50.0
TOTAL GNP	490.4	518.1	537.5	531.6	590.1	626.9	658.8	689.2	730.8	751.7

(continued)

Table C.1 (continued)

in billions of 1980 U.S. dollars

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
CONSUMPTION	434.2	449.8	460.5	479.5	497.5	517.1	528.6	544.1	560.0	575.6
Cons Goods	276.0	286.2	291.6	304.7	316.1	329.1	335.2	345.9	355.1	364.6
Durables	33.0	37.6	43.5	47.1	50.9	56.2	59.7	65.3	68.1	70.9
Cons Svcs	158.1	163.8	169.1	174.8	181.6	187.9	193.9	198.3	205.1	211.2
INVESTMENT	267.1	279.9	291.8	318.7	339.7	347.1	374.7	393.7	408.5	415.4
New Fixed Inv	210.6	217.9	224.7	243.0	258.1	266.1	286.2	298.9	308.3	312.5
Mach & Eq	82.3	86.8	93.9	100.9	111.2	125.4	137.6	145.3	157.5	164.2
Constr/cap	127.9	136.1	142.9	150.5	157.3	164.0	168.1	170.0	173.4	174.5
Capital Repair	56.4	62.8	68.6	78.0	84.4	82.9	91.1	98.4	104.2	107.3
GOVERNMENT	108.3	111.6	107.9	123.4	123.2	115.3	123.5	124.0	129.8	119.7
Admin Svcs	22.9	24.0	24.9	25.7	26.8	27.6	28.5	29.4	30.2	31.1
Research & Dev	29.1	31.0	33.4	35.6	37.3	39.0	39.5	40.7	42.1	43.8
Outlays n.e.c.	56.1	57.2	52.6	62.9	61.4	53.8	59.4	58.7	62.0	52.6
TOTAL GNP	809.6	841.0	856.9	919.2	955.1	970.9	1017.2	1049.7	1085.8	1094.5

(continued)

Table C.1 (continued)

	1980	1981	1982	1983	1984	1985
CONSUMPTION	588.8	600.6	606.6	618.7	636.6	649.4
Cons Goods	371.7					
Durables	75.5					
Cons Svcs	217.4					
INVESTMENT	427.8	448.3	466.7	484.4	489.8	500.0
New Fixed Inv	320.8	335.5	350.6	363.9	369.0	374.9
Mach & Eq	172.0					
Constr/cap	178.1					
Capital Repair	111.9					
GOVERNMENT	113.1	108.6	112.8	119.9	117.9	115.2
Admin Svcs	31.9					
Research & Dev	45.8					
Outlays n.e.c.	45.9					
TOTAL GNP	1109.7	1124.1	1154.5	1191.4	1209.3	1218.9

Note: blanks indicate that data was not available

Table C.2 Soviet GNP by Sector of Origin, 1950-1986, selected years

in billions of 1982 U.S. dollars (exchange rate=0.726 rubles/dollar)

	1950	1955	1960	1970	1980	1985	1986
INDUSTRY	60.4	81.7	118.6	220.1	324.8	361.2	374.8
Ferr Met		6.6	9.6	17.8	22.7	24.1	25.1
Nonferr Met		2.9	3.9	8.3	11.7	12.9	13.1
Fuel		7.4	11.8	21.8	33.5	35.5	37.2
Elec Power		3.4	5.8	14.6	25.6	30.6	31.7
Machinery		24.2	32.6	63.5	106.5	116.1	121.3
Chemicals		3.0	5.4	14.5	24.9	30.0	31.7
Constr Mat		4.0	8.0	14.2	19.4	20.9	21.9
Light Ind		9.1	12.1	18.9	24.1	26.0	26.2
Misc Ind		20.9	29.3	46.8	59.0	65.0	66.7
CONSTRUCTION	12.4	19.2	31.1	50.8	73.1	84.6	87.4
Ind+Constr	72.8	100.9	149.7	270.9	398.0	445.7	462.3
AGRICULTURE	100.5	125.5	152.2	206.3	186.5	197.2	214.2
SERVICES	95.4	116.6	148.8	254.8	367.7	405.7	416.4
Tran/Comm:	8.6	16.8	28.4	65.2	107.1	121.0	125.7
Transp	7.0	14.7	25.7	59.3	97.2	109.0	113.7
Commun	1.6	2.1	2.7	5.9	9.9	12.0	12.0
All Oth:	86.8	99.8	120.4	189.6	261.0	285.2	290.7
Trade	11.3	16.1	23.4	42.5	63.8	66.0	67.8
Cons Svcs	41.1	49.7	63.6	98.1	128.6	145.7	149.7
Govn't:	34.4	33.9	33.4	49.1	68.6	73.4	73.2
MilPers	16.4	16.5	14.0	19.8	23.8	25.2	25.1
Sci/R&D	2.1	3.1	5.9	12.4	19.1	21.0	22.9
Admin	15.8	14.4	13.5	16.8	25.7	27.3	25.1
TOTAL GNP	268.6	342.9	450.7	732.0	952.2	1048.7	1092.8

Sources: CIA, annual. Handbook of Economic Statistics.
Kurtzweg, Laurie, 1987. "Trends in Soviet Gross National Product." Gorbachev's Economic Plans, vol. 1.
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Table C.3 Breakdown of Soviet Consumer Durable Equipment, selected years, 1950-1979

in millions of 1970 rubles

	1950	1955	1960	1965	1970	1975	1979
Total Cons Dur	413.6	935.0	1534.8	2427.5	4148.2	7211.6	9297.8
Electrotech Eq	73.4	128.9	242.2	390.7	509.2	665.7	696.3
Precis Instr	16.3	54.2	165.1	287.4	622.8	1428.4	2555.8
Pumps/Compres	9.8	35.0	105.1	200.3	301.2	469.8	568.5
Light Ind Eq	8.5	10.2	13.1	16.5	25.3	40.7	50.7
Motor Vehicles	101.9	187.1	312.5	446.7	750.0	1237.4	1455.7
Metalwares	174.3	320.4	527.3	822.6	1423.2	2177.5	2685.4
Cable Products					516.5		

Source: CIA, 1982. _USSR: Measures of Economic Growth and Development, 1950-80_.

Table C.4 Breakdown of Soviet Producers' Durable Equipment, 1950-1979, selected years

in million 1970 rubles

	1950	1960	1970	1975	1979
Total Prod Durables	4094.3	12841.7	28651.8	43272.8	55298.0
Precision Instr	70.8	716.9	2704.1	6201.9	11096.8
Industrial Equip	2202.2	7003.5	16767.2	24525.8	29880.1
Forge Presses	13.0	105.2	200.7	324.7	465.2
Elec/Power M&E	113.9	419.2	671.2	791.1	790.3
Machine Tools	83.1	367.6	858.1	1310.0	1777.5
Electrotech M&E	381.4	1258.2	2645.0	3458.1	3616.8
Pumps/Compress	22.9	246.7	707.3	1103.2	1335.1
Hoist/Crane Eq	105.6	242.9	533.4	674.8	742.9
Repair Mach	1018.1	3160.3	8470.4	12875.0	16263.2
Log/Paper M&E	14.4	42.2	142.9	230.9	314.6
Light Ind M&E	110.0	168.7	326.8	525.2	655.3
Food Ind M&E	91.6	152.0	321.1	467.7	562.0
Printing M&E	7.4	21.7	39.1	47.1	61.3
Sanit Engr Prod	76.2	312.0	578.4	719.4	797.0
Metalwares	65.9	199.4	538.1	823.3	1015.3
Structural Met	98.6	307.3	734.7	1175.5	1483.6
Transportation Eq	638.4	2384.3	3937.2	6009.8	6688.5
Railroad/Other	349.7	1499.0	1812.6	2504.5	2564.8
Motor Vehicles	288.7	885.3	2124.6	3505.4	4123.6
Other Equipment	1183.3	2735.3	5357.9	6534.2	7631.1
Casting M&E				52.6	
Tools & Dies				605.9	
Constr Mat M&E				222.7	
Bearings				448.2	
Abrasives				170.8	
Agric M&E	322.0	854.7	2129.4	3485.6	4325.5
Construc M&E	114.5	270.2	574.8	770.7	762.7
Metlurg/Mine M&E	442.3	797.8	1039.9	1140.1	1262.5
Other	304.5	812.5	1613.8	1137.7	1280.4

Source: CIA, 1982. USSR: Measures of Economic Growth and Development, 1950-80.

APPENDIX D

DEFLATION METHOD FOR TOTAL I/O COEFFICIENTS

FOR THE UNITED STATES AND THE USSR

Derivation of the U.S. Coefficients in 1972 U.S. Dollars:

Table D.1 Conversion from Nominal Coefficients to 1972 Price Base for the United States

	1963nom	end use index	1967nom	end use index	1972nom	1977nom	end use index
Oth furn/fixt (23)	0.15212	75.6	0.14652	85.9	0.14520	0.16116	152.8
Metal Contain (39)	0.53772	88.3	0.49144	91.8	0.43560	0.39066	170.7
Heat/Pl/Struct (40)	0.35032	88.3	0.35037	91.8	0.33116	0.29992	170.7
Screw mach (41)	0.30520	88.3	0.33516	91.8	0.34917	0.35615	170.7
Oth Fab Met Pr (42)	0.25527	88.3	0.25747	91.8	0.26455	0.27089	170.7
Engines/turb (43)	0.19074	70.1	0.19514	75.1	0.21890	0.22501	166.1
Farm/Gard M&E (44)	0.24673	76.1	0.23540	85.2	0.21988	0.21686	159.8
Con/Mine/Oil M&E(45)	0.26954	72.5	0.25764	79.5	0.22835	0.25997	173.7
Mat Handl M&E (46)	0.21050	72.5	0.20336	81.4	0.21320	0.21514	160.3
MetWork M&E (47)	0.16067	74.7	0.14789	83.4	0.15809	0.15280	157.7
Spec Ind M&E (48)	0.17473	71.5	0.15758	80.8	0.15012	0.14536	164.5
Gen Ind M&E (49)	0.19841	72.5	0.18754	81.4	0.19982	0.19537	160.3
Mach Shop Prod (50)	0.15387	88.3	0.14038	91.8	0.14640	0.12299	170.7
Svc Ind Mach (52)	0.16181	83.2	0.15023	87.0	0.14125	0.14911	143.2
Elec Ind Mach (53)	0.11776	82.7	0.10123	85.1	0.11593	0.11602	147.6
HH Appliances (54)	0.15410	95.8	0.14888	91.2	0.14575	0.14611	127.7
Elec/Wire Eq (55)	0.12107	82.7	0.11235	85.1	0.10742	0.11629	147.6
Mot Veh/Parts (59)	0.21208	88.1	0.18138	88.1	0.17616	0.19549	134.2
Other Transp Eq (61)	0.23114	85.6	0.20705	83.9	0.16160	0.16789	144.3

Source: U.S. Department of Commerce. <u>Survey of Current Business</u>, various issues.

Notes:

All coefficients in Table 5.1 were converted to a 1972 price base using the following formula as suggested by Myers (1986) and Hwang (1989):

adj coeff = nom coeff * (end use index/steel index)

where:

adj coeff = coefficient in 1972 $
nom coeff = coefficient in nominal dollars
end use index = price index for end use industry
steel index = price index for steel industry

Steel coeffients used were derived from USBM (1985):

Iron Age Composite Index, 1972=100

1963	69.7
1967	71.8
1972	100.0
1977	173.1

Derivation of the USSR Coefficients in 1972 U.S. Dollars:

Coefficents already converted to a 1970 price base were obtained from a study by Treml and Guill (1977). These coefficents were then multiplied by generalized price indices found in the same study to convert to 1972 rubles. For all coefficients except Industrial Metal Products (which did not change between 1970 and 1972 according to Treml and Guill), the coefficient was multiplied by 1.03.

The 1972 CIA exchange rate was then used to convert rubles to U.S. dollars as done throughout this study.

APPENDIX E

DESCRIPTION OF INPUT-OUTPUT SECTORS

FOR THE UNITED STATES AND THE USSR

Table E.1 Description of U.S. I/O Sectors

Other furniture and fixtures (23):
wood, metal, and public building furniture; wood and metal partitions and fixtures; drapery hardware, blinds, and shades; furniture and fixtures n.e.c.

Metal containers (39):
metal cans, barrels, drums, and pails

Heating, Plumbing, and Metal Structural Products (40):
metal sanitary ware; plumbing fixture fittings and trim; heating equipment,except electric; fabricated structural metal; metal doors, sash, and trim; boiler plate; sheet metal work; architectural metal work; prefabricated metal buildings; miscellaneous metal work

Screw machine products and stampings (41):
screw machine products, bolts, nuts, rivets, washers; automotive stampings; crowns and closures; metal stampings n.e.c.

Other fabricated metal products (42):
cutlery; hand and edge tools n.e.c.; hand saws and saw blades; hardware n.e.c.; plating and polishing; metal coating and allied services; misc fabricated wire products; steel springs, except wire; pipe, valves, and pipe fittings; metal foil and leaf; fabricated metal products n.e.c.

Engines and turbines (43):
turbines and generator sets; internal combustion engines n.e.c.

Farm and Garden machinery (44):
farm machinery and equipment; lawn and garden equipment

Construction and Mining Equipment (45):
construction, mining, and oilfield machinery and equip

Materials handling machinery and equipment (46):
elevators and moving stairways; conveyors and conveying equipment; hoists, cranes, and monorails; industrial trucks and tractors

(continued)

Table E.1 (continued)

Metalworking machinery and equipment (47):
machine tools, metal cutting types; machine tools, metal forming types; special dies, tools, and machine tool accessories; power driven hand tools; rolling mill machinery; metalworking machinery n.e.c.

Special Industry machinery and equipment (48):
food products, textile, woodworking, paper industries, printing trades, and other machinery n.e.c.

General industrial machinery and equipment (49):
pumps and compressors; ball and roller bearings; blowers and fans; industrial patterns; power transmission equip; industrial furnaces and ovens; other n.e.c.

Machine shop products, miscellaneous, except electrical (50):
carburetors, pistons, rings, valves; other n.e.c.

Service Industry Machinery (52):
automatic merchandising machines; commercial laundry equipment; refrigeration and heating equipment; measuring and dispensing pumps; other n.e.c.

Electric Industrial equipment and apparatus (53):
instruments to measure electricity; transformers; switch-gear and switchboard apparatus; motors and generators; industrial controls; welding apparatus, electric; carbon and graphite products; other n.e.c.

Household appliances (54):
household cooking equipment, refrigerators, freezers, laundry equipment; electric housewares and fans; vacuum cleaners; sewing machines; other n.e.c.

Electric lighting and wiring equipment (55):
electric lamps; lighting fixtures and equipment; wiring devices

Motor Vehicles and Parts (59):
truck and bus bodies; truck trailers; motor vehicles and car bodies; motor vehicle parts and accessories

(continued)

Table E.1 (continued)

Other Transportation equipment (60):
ship and boat building and repairing; railroad equipment; motorcyles, bicycles, and parts; travel trailers and campers; mobile homes; motor homes; other n.e.c.

Source: U.S. Department of Commerce. *Survey of Current Business*, various issues.

Table E.2 Description of Soviet I/O Sectors

Industrial Metal Products (7,4):
steel wire, strip, rope; wire nails; metal cloth; welding electrodes; chains; springs; screws; bolts; keys; pins; rivets; other industrial hardware

Electric and power machinery and equipment (15,12):
steam boilers and boiler equipment; steam, gas, and hydraulic turbines and equipment; nuclear reactors for power generation; diesel engines and generators; other internal combustion engines (except auto, tractor, combine, and aircraft engines); steam engines; windmills

Electrotechnical (electronic) M & E (16,13):
electric motors and generators; transformers, rectifiers, and condensers; high- and low-voltage apparatus; electrical equipment for transportation facilities; electric furnaces; electric welding and electrothermal equipment; lighting equipment and fixtures; incandescent, fluorescent, mercury, arc, and special elecrtic lamps; wet and dry batteries; electric insulating materials and products; glass and ceramic insulators; electrical household appliances (except refrigerators)

Machine Tools (18,15):
all types of metalcutting and woodworking machine tools, including automatic and semi-automatic lines; sawmill frames

Forge-Pressing Machinery and Equipment (19,16):
power presses, hammers, shears, bending and riveting machines; automatic forging and stamping machinery

Casting machinery and equipment (20,17):
molding and casting equipment of all types, including automatic and semi-automatic casting lines

Tools and Dies (21,18):
cutting tools, dies, chucks, jigs, and other fixtures for metalworking and woodworking machinery; measuring tools; mechanics's tools; files; electric tools; woodworking tools; chain saws

(continued)

Table E.2 (continued)

Mining and Metallurgical Equipment (23,20):
blast furnace and steel smelting equipment; rolling mills and pipe mills; other equipment for ferrous and nonferrous metallurgy; oil refining equipment and apparatus; coal mining combines and other mine machinery; mine cars, lifts, and hoists; mine loading and unloading machinery; mechanical supports; ore concentration equipment; open-pit and strip mining equipment; peat mining equipment

Logging and Paper machinery and equipment (25,22):
log handling equipment, except tractors; equipment for production of pulp, paper, and cardboard, except chemical processing equipent; equipment for match industry

Light Industry machinery and equipment (26,23):
equipment for the knitting, sewing, footwear, leather, fur, textile, chemical fiber, cable, and glass industries; cotton ginning equipment; household sewing machines

Food industry machinery and equipment (27,24):
equipment for processing food products (including fish, meat, and milk); equipment for flour mils, grain elevators, and grain storage facilities

Printing machinery and equipment (28,25):
printing presses; typesetting machinery; other n.e.c.

Hoisting-transporting machinery and equipment (29,26):
cranes of all types (including mobile construction cranes); conveyors (stationary and mobile); elevators; container and packet handling equipment; cable car equipment; power winches, jacks, hoists, and lifts; escalators; other hoisting, loading, and transporting equipment

Construction machinery and equipment (30,27):
excavators, scrapers, graders, bulldozers, ditch diggers, suction dredges, snowplows, concrete and asphalt mixers, gravel processing equipment, pile drivers, power rollers, electric and pneumatic construction tools and other machinery for construction and road building

(continued)

Table E.2 (continued)

Construction material machinery and equipment (31,28):
equipment for the cement and lime making industries; equipment for the production of prefabricated concrete, asbestos-cement products, insulating materials, brick; crushing and grinding equipment; equipment for stone-working

Transportation machinery and equipment (32,29):
diesel, electric, and steam locomotives; railroad freight and passenger cars; subway cars and street cars; railroad braking, coupling, switching, signaling, and roadbed equipment; horsedrawn vehicles; ships and boats of all types,including fishing vessels and sport boats

Automobiles (33,30):
trucks, passenger cars, autobuses, trolleybuses, auto tractors and trailers; motorcycles, motor scooters, and bicycles; auto, motorcycle, and bicycle engines and components

Agricultural machinery and tractors (34,31):
tractors, including industrial and logging; tractor and combine engines and components; all types of agricultural machinery, including animal husbandry, and components

Bearings (35,32):
all types of roller and ball bearings, including those made of plastic, and appurtenances

Sanitary Engineering products (37,34):
heating and air conditioning apparatus and components; plumbing supplies and fixtures; sewer pipe; wood, coal, and gas stoves; other n.e.c.

Other Metalwares (38,35):
metal construction components (gratings, railings, stairways, doors, awnings, fireplace castings, other hardware); metal containers; shoemaker's, chauffeur's, and gardening tools; metal furniture frames and springs, metal beds; baby carriages; chains; anchors; wire screening; metal kitchen utensils, tableware, and

(continued)

Table E.2 (continued)

cutlery; razors and blades; metal lamps and lanterns; metal sporting goods, including guns and fishing tackle; knitting and sewing machine needles

Metal structures (39,36):
metal frames for buildings and structures; bridges; metal sheds and hangers; utility poles and masts; water towers

Industry n.e.c. (68,81):
printing and bookbinding; musical instruments and appurtenances; toys of all types, except rubber; pencils, pens, and ink; jewelry; buttons; art products of metal, wood, plaster, stone, bone, and other materials; commercial dyeing and dry cleaning; movie film printing and consumer film processing; water supply systems; prosthetic appliances; feather and down products; processed animal feeds

Source: Gallik, D.M., B.L. Kostinsky, and V.G. Treml, 1983. Input-Output structure of the Soviet economy: 1972. U.S. Department of Commerce, Bureau of the Census, Foreign Economic Report no. 18, Appendix B.