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Estimating Military Hardware Production from Soviet Industrial Data

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ESTIMATING MILITARY HARDWARE PRODUCTION FROM SOVIET INDUSTRIAL DATA

INTRODUCTION

1. The Soviet Union nas not published details of its expenditures on national defense since the 1930s. National income and budgetary data released by the Soviet government since World War II have provided only one summary figure for Defense, and published data on industrial production have not explicitly included the output of the defense industries. There have been large, unexplained residuals in official Soviet budgetary and national income data, however, and authoritative Soviet statements have suggested that defense expenditures are included in apparently civilian budgetary and national income accounts.

2. Western interest in determining the size and trend of Soviet defense spending originally stemmed from the issues of Soviet military capability during the post-World War II period. In the late 1960s the question of using financial data to monitor an arms control agreement heightened the interest in establishing the magnitude of Soviet defense expenditures.

3. A report prepared by the Stanford Research Institute (SRI) in 1968 for the Arms Control and Disarmament Agency surveyed the feasibility and explored the methodologies to be used in monitoring an arms limitation agreement from financial reporting.[1] This report developed several defense-related residuals in an attempt to estimate Soviet military hardware procurement. The estimates in the SRI report (the work of William T. Lee) gained additional exposure when Professor William R. Kintner introduced them at the hearings of the Joint Economic Committee of the Congress in 1969.[2] Then, in 1970, a compendium of papers submitted to the Joint Economic Committee contained a report on "The Technological Base of Soviet Military Power" in which Michael Boretsky presented his estimates of military hardware production, which were also derived from residual Soviet industrial data. More recently, a 1971 SRI publication[3] included an update of Lee's estimates, and in 1973 a group of SRI economists and consultants presented

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2. *The Military Budget and National Economic Priorities: Hearings of the Joint Economic Committee, 91st Congress, Part 3. The Economic Basis of The Russian Military Challenge to the United States*, Washington, 1969, UNCLASSIFIED.

3. W.T. Lee, *Soviet National Security Expenditures and Economic Growth in the 70s: Problems and Prospects*, Stanford Research Institute, July 1971, UNCLASSIFIED.

Note: Comments and queries regarding this publication are welcomed. They may be directed

estimates attributed to Lee in a paper prepared for the Joint Economic Committee of the Congress.[4]

4. This publication assesses these attempts to estimate the production or procurement of defense hardware from official data on the machine building and metalworking (MBMW) branch of industry. The reasonableness of the basic assumption of the Lee and Boretsky studies – that production of defense hardware is included in official MBMW data – is examined first. Then, the validity of estimates made by Lee, presently at General Electric - TEMPO, Center for Advanced Studies, and Boretsky, of the US Department of Commerce, is assessed. In a final section, the lessons learned from the review of the work of Lee and Boretsky are applied to determining residual machinery output in 1959, 1966, and 1967.

PRINCIPAL FINDINGS

5. Several estimates of Soviet military hardware production have been based on a widely accepted proposition – that Soviet data on the MBMW sector of the economy include the output of the defense industries. Soviet sources as well as Western analysis of Soviet data support this proposition. Thus, defense production should be obtainable as a residual of MBMW output after subtracting estimates of non-defense production.

6. Published Soviet data on MBMW output, however, do not permit a straightforward determination of defense production by subtraction of non-defense output. Western analysts have tried to use Soviet data on total machinery production and the purchases of machinery for civilian uses to obtain defense purchases as a residual. Data on neither production nor purchases can be used without adjustment because they are reported in different prices, and Soviet descriptions of economic data are so imprecise that substantial error remains in any adjustment. Moreover, Soviet data collected for specialized purposes – foreign trade or interindustry analyses – must be introduced into the calculations because of the paucity of published Soviet data on uses of machinery. Reliance on such data, compiled from different statistical systems and in different prices, weakens the estimates to an uncertain degree. Also, published Soviet growth indexes, which contain well-known sources of possible upward bias, must be used. The use of such indexes, of course, will distort trends in the residual. Finally, in using data on production and purchases to derive residual machine building (MB) purchases, Western analysts must deal with the time lag between production and sale.

7. Two quite different calculations of an MBMW residual show in sharp relief the inconclusiveness of the residual technique. In a 1968 SRI publication, William T. Lee estimated Soviet procurement of military hardware by a residual calculation. Michael Boretsky in 1970 presented a series of military hardware

4. Robert W. Campbell, M. Mark Earle, Jr., Herbert S. Levine and Francis W. Dresch, *Methodological Problems Comparing the US and USSR*, Joint Economic Committee of the Congress, A Compendium of Papers, 27 June 1973, UNCLASSIFIED.

residuals that resembled Lee's residuals conceptually, but whose values were substantially different from the Lee estimates. Indeed, Lee and Boretsky derived quite different values for each of the important steps of the residual process – the calculation of (1) gross value of output of MB, (2) final output of MB, and (3) the presumed military residual left after civilian uses are deducted from the final output of MB, as follows:

	Billion 1955 Rubles			
	1958		1965	
	Lee	Boretsky	Lee	Boretsky
Gross output of machine building	19.5	17.4	48.6	42.5
Final output of machine building	14.6	10.8	33.1	23.8
Residual	5.0	1.8	15.4	6.3

8. Lee ran afoul of most of the pitfalls cited above. He mixed data prepared for specialized interindustry studies with other data prepared for the Soviet Central Statistical Administration (CSA) without reconciling the two sets of data for differences resulting from (1) the accounting concepts used (CSA data include some non-machinery production, but does not include all machinery produced) or (2) the prices used (retail prices versus factory or producer prices). In estimating the trend in his defense-related residual, moreover, Lee did not use Soviet growth indexes where their application seemed appropriate – as in estimating a time series for the gross output of MB and for consumer durables – and instead created his own indexes. Lee also erred in subtracting all unfinished production from annual gross output of MB instead of merely the change, and in failing to deduct MB shipments to other industries, which are not counted as "final" output. His separate estimate of Soviet research-and-development expenditures is also suspect because (1) he did not include social security payments in production costs, and (2) his assumption that MBMW employment data exclude all R&D workers is open to question.

9. Michael Boretsky employed a methodology similar to Lee's in obtaining his estimate of Soviet spending on military and space programs. Boretsky derived a measure of total machinery output in the economy for a single benchmark year. The estimates for other years were then made using the CSA index of MBMW output, which includes some non-machinery output and which does not include all machinery output. Moreover, the gross value of output for MBMW which Boretsky used in 1959 is inconsistent with the values of MBMW output reported in Soviet sources.

10. Boretsky eliminated indirect taxes and trade-distribution markups from producer and consumer durables to put machinery production and civilian purchases on the same price basis, but his adjustments were incorrect. He also used data that included imports in order to make estimates from data that did not include

imports. Although Boretsky recognized that he had to subtract interindustry uses of machinery in deriving his residual (unlike Lee), he used arbitrary estimates of the growth of such uses between 1959 and 1965 that led to substantial errors. Finally, Boretsky bridged gaps in Soviet data with other estimates – as in his treatment of the machinery components of investment and working capital – which weaken the reliability of the residual.

11. Both Lee and Boretsky argue that even if their defense-related residuals of MB output are wrong, the errors are not large and the trend in the residuals is valid. The Lee and Boretsky estimates of annual growth between 1958 and 1965 in the defense-related residuals are nearly the same – 18% and 19%, respectively. Both rates far exceed the average annual growth in the gross value of output of MB for the same period – 14%. They also far exceed the trend of arms procurement estimated by US analysts inside or outside the government. In addition, erratic year-to-year fluctuations in the Lee-Boretsky results are too drastic to be plausible. A careful analysis of their procedures reveals that the gaps in data affecting the trend of the residuals are as serious as those affecting its base year value. To derive a respectable time series, the following data (presently unavailable to Western analysts) would be necessary at a minimum:

a. an index of interindustry uses of machinery, including double-counting within the machinery sector;

b. measures of the effect of overpricing of new machinery products on the values used in the residual calculations;

c. measures of changes over time in the ratio of production classified on a "commodity" basis to production classified on an "establishment" basis;

d. price indexes for machinery output and its various uses, so that residual values can be calculated from consistent data;

e. values for the non-machinery component of investment and for changes in inventories of machinery; and

f. reasonably accurate coefficients to convert foreign trade in machinery into domestic prices.

12. In an attempt to apply the lessons learned from the review of Lee and Boretsky, residuals were calculated independently for 1959, 1966, and 1967. In each case, remaining uncertainties as to key parameters outweighed the effects of improvements in procedure. To show, for example, the error embodied in such estimates, a band of plausible residuals was sketched out for 1967. The possible outcomes ranged from 3.9 billion to 18.3 billion rubles.

13. The prospects for using residual output of MB to determine Soviet expenditures on military hardware are therefore dim. While some of the estimative and accounting errors in the work of Lee and Boretsky can be corrected, data are still insufficient and Soviet explanations of their national statistics still too vague to enable estimates to be made with confidence. Crude estimates will continue to be needed in calculating the residual. Moreover, a small percentage error in such crude estimates made at high levels of aggregation – e.g., in deducting metalworking output from total gross output of MBMW -- can lead to a very large percentage error in the much smaller, supposedly defense-related residual. In short, the data and information gaps are too formidable with present information to produce either a plausible value or trend of military-space hardware output from Soviet data on the MBMW sector of industry.

DISCUSSION

The Basic Assumption -- Defense Production and National Economic Accounts

14. Western efforts to use Soviet national accounts to obtain estimates of defense spending assume that these accounts include defense expenditures. The rationale for this assumption is as follows: Soviet national accounting practice follows the Marxist division of economic activity into spheres of material and non-material production. Accordingly, the Soviets claim that their statistics on "national income" include only material production – the production of tangible goods, as opposed to the production of intangible services. Moreover, *all* material production is presumed to be in Soviet national income. As a result, the production of uniquely military hardware (missiles, ships, tanks, etc.) is therefore assumed to be included in the sphere of material production and in official Soviet data on national income.

15. The Soviet statistical construct "national income" apparently does include only material product. The derivation of this construct in the Soviet statistical yearbooks and other Soviet sources includes ***consumption*** and ***accumulation***, subtotals which are consistent with other Soviet data on retail sales of material products and capital investment.

16. In addition, the assumption that *all* material production is included in published Soviet national income data seems acceptable. The CSA could compile Soviet economic data net of defense production. But this argument would imply that the CSA keeps two sets of national accounts and withholds the set including defense production from publication. Most Western observers have concluded that the CSA does not maintain two such sets of books, but rather simply does not publish sensitive, defense-related data.[5] Hence, the existence of large, unexplained residuals in Soviet data and the occurrence of apparently irreconcilable data.

5. For example, see Abraham S. Becker, *Soviet National Income 1958-64*, University of California Press, 1969, p. 157, UNCLASSIFIED.

17. Soviet descriptions of the contents of national accounts and the administrative subordination of the defense industries to the MB ministries suggest that defense hardware production is included in MBMW, the USSR's largest industrial branch. Major support for this supposition comes from the list of MBMW industries enumerated in the forms used for drawing up the seven-year plan (1959-65).[6] In this classification, shipbuilding, a branch of MBMW, includes warships, and another branch designated "defense industry" includes MBMW enterprises for the "production and repair of military equipment and munitions, including all aircraft plants but excluding naval shipyards, and specialized plants for the production of instruments and electronics." In the classification, it is also noted that general explosives and some nuclear materials for military use are included in the chemical industry. Except for shipments to stockpiles, these materials should be embodied in the final output of the warhead assembly plants included in MBMW.

18. That the published Soviet data on gross value output (GVO) of MBMW do, indeed, include output of military hardware is supported by the behavior of the MBMW index in the immediate post-World War II years. The output of MBMW fell by 34% during 1945-46. This sudden decrease (compared with a 29% increase during 1940-45) probably reflects the drop in military-related production as the economy retooled for civilian production.

19. Thus the published MBMW index almost certainly includes the production of military hardware. Insofar as the reported gross outputs are consistent with the published growth indexes, values for the GVO of MBMW would also include the value of military hardware. If the GVO of MBMW includes output of the defense industries, it should then be possible to estimate -- at some level of accuracy -- the production or procurement of uniquely military products of MBMW by subtracting the value of civilian production from total MBMW production.

Lee's Estimate of a Machinery Purchases Residual

20. A Stanford Research Institute report by William T. Lee in 1968 analyzed the possibilities of financial verification of Soviet military expenditures.[7] One of the approaches to verification used in that study was a machinery purchases residual (MPR) that has also appeared in subsequent SRI publications:

> Military space procurement of durables (hardware) is estimated as a residual in the final value of output of the Soviet machine building and metalworking industries.[8]

6. Gosplan, *Formy i pokazeteli k sostayleniyu proyekta perspektivnogo plana razvityya narodnogo khozyaystva SSSR na 1959-65 gody*, Moscow 1959. Since this publication was approved, additional official classifications have included defense industries in their descriptions of the MBMW branch: Gosplan, *Metodicheskiye ukazaniya*, Moscow, 1969, pp. 719-20; and V.I. Guryev, *Klassifikatsiya otraslevy narodnogo khozyaystva SSSR*, Moscow 1971, p. 112.

7. [illegible], *op. cit.*

8. W.T. Lee, *Soviet National Security, op. cit.*

A paper prepared by several SRI economists and consultants for the 1973 compendium of the Joint Economic Committee of the Congress also included estimates of total defense spending attributed to Lee.[9]

21. The methodology that Lee used was based on official Soviet growth indexes of the output of the MBMW sector. These indexes contain well-known sources of possible bias – new product pricing[10] and changing amounts of double-counting[11] – which can distort trends. The first step in the methodology, after converting the indexes into values, called for the subtraction of the GVO of metalworking (including repair) from the GVO of MBMW in 1950-65. The result is a series of GVO for MB which are then adjusted for double-counting and changes in unfinished production to estimate the final output of the MB branch. The final output series represents output available for investment, consumption, export, and defense. Lee subtracts his estimates of producer and consumer durables from final output to obtain the residual. This residual, which is assumed to be defense-related production, grows from 790 million rubles in 1950 (10% of the GVO of MBMW) to 15.4 billion rubles in 1965 (25% of the gross output of MBMW).

22. The purpose of this section is to evaluate Lee's methodology in some detail. Table 1 presents each step, and the discussion which follows considers these steps under three general headings: (a) the derivation of the GVO of MB from the GVO of MBMW; (b) the derivation of the value of the final output of MB; and (c) the subtraction of producer and consumer durables to derive a military hardware residual.

Derivation of the Gross Value of Output of Machine Building

23. Lee found official Soviet estimates of the GVO of MBMW in 1955 prices for 1955, 1958, 1960, and 1965 and calculated values for other years by means of the Soviet index of growth in MBMW gross output. Next, he subtracted annual estimates of output of the metalworking sectors (metal articles and capital repair) to obtain the gross output of MB.

24. The time series for the GVO of MB, which Lee estimates by this methodology, contains many errors which together result in an overstatement of the value of the GVO of MB ranging from 270 million rubles in 1955 to 2 billion

9. Robert W. Campbell, *et. al., op. cit.*

10. In any constant price growth index, the introduction of new products for which no base year price is available distorts the calculated growth index. In the Soviet case, this distortion is accentuated by the use of "temporary" prices for new products. These temporary prices are based on limited production runs and overstate the price which would apply after the product enters series production. The result is an upward bias in the growth index.

11. Increasing specialization within the MBMW branch results in an increase in the sale of subassemblies. Since each sector of the industry counts the value of these subassemblies in its calculation of gross output, their value is entered twice in the total gross output of the branch (first as the output of the sector which produced them and second as part of the gross output of the sector which incorporated them in a final product).

Table 1

Lee's 1968 Estimate of Machine Building Residuals[1]

Billion Rubles in 1955 Prices

	1950	1953	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Gross value of output of the MBMW sector	7.87	12.7	17.4	20.0	22.6	25.5	29.6	34.0	39.16	45.1	51.0	55.9	61.0
Minus													
Metalworking	0.96	1.48	2.0	2.2	2.4	2.64	2.90	3.17	3.47	3.81	4.17	4.57	5.01
Capital repair	1.76	2.16	2.49	2.74	3.0	3.32	3.75	4.18	4.61	5.24	5.84	6.57	7.36
Equals													
Gross value of output of machine building	5.15	9.06	12.91	15.06	17.20	19.54	22.95	26.65	31.08	36.05	40.99	44.76	48.63
Minus													
Unfinished production	0.53	1.028	1.52	1.81	2.10	2.38	3.18	3.22	3.79	4.33	4.38	5.77	6.23
Interplant transfers[2]	0.55	1.04	1.59	1.86	2.27	2.57	2.97	3.98	4.91	6.34	7.69	8.19	9.33
Equals													
Final value of output in the machine building sector	4.06	6.99	9.79	11.40	12.84	14.59	16.80	19.45	22.38	25.38	25.53 (28.92)[3]	30.80	33.07
Minus													
Producer durables	2.97	3.16	4.58	5.94	7.18	8.36	9.21	9.39	10.14	11.08	12.355	14.059	15.189
Consumer durables	0.300	0.600	0.87	0.98	1.12	1.27	1.39	1.53	1.68	1.85	2.04	2.24	2.48
Equals													
Machine building residual	0.79	3.23	4.34	4.48	4.54	4.96	6.20	8.53	10.56	12.45	14.13 (14.52)[3]	14.50	15.40

1. W.T. Lee & Sally Anderson, *Potential of Economic Data for Verification of an Arms Control Agreement with the USSR*, 16 February 1968.
2. The value series for interplant transfers does not appear in the source cited. The values were calculated by the methodology presented in the source by subtracting the estimate of unfinished production from the gross output and multiplying the result by the percentage indicated for that year, as follows:

1950	12%	1960	17%
1953	13%	1961	18%
1955	14%	1962	20%
1956	14%	1963	21%
1957	15%	1964	21%
1958	15%	1965	22%
1959	15%		

3. The 1963 values for the final output and the machine building residual were apparently miscalculated in the source cited. The correct values, based on Lee's methodology, are given in parentheses below the values found in the source cited.

rubles in 1965. Specifically, Lee failed to recognize the differences between the commodity-based Soviet data used in their input-output (I-O) table[12] and the establishment-based data used in other Soviet reporting systems; he subtracted turnover taxes[13] and trade and distribution markups and transportation costs in the metalworking industries from MBMW which did not include such markups; and he ignored a published Soviet index of growth in MB and created an index of his own.

Commodity-Establishment Problem

25. The values for GVO of MBMW that Lee uses are compiled by Soviet statistical agencies on an "establishment" basis. The GVO of MBMW – the sum of the value of output of all enterprises whose primary production is machinery, metal articles, or machinery repair work – does not include machinery produced as a secondary product in other branches of the economy. These data do include, however, the value of non-machinery products produced in MBMW. Commodity-based data, on the other hand, classify data into similar product groups. Thus, machinery produced outside the MB industries would be included with the

12. An input-output table is a tool of economic analysis which depicts the flow of goods and services between productive units as a matrix.
13. The turnover tax is a discriminatory indirect tax on trade turnover levied chiefly on consumer goods.

machinery output of MB industries, but the non-machinery output of MB industries would not be included. To convert GVO of MBMW from an establishment basis to a "commodity" basis, non-MBMW production must be removed from the establishment output and MBMW-type production carried out elsewhere must be added. Two Soviet authors have stated that in 1959 commodity-based gross output of MBMW was 92% of the establishment-based gross output.[14] This was the result of removing the 14.5% of the establishment-based gross output that represented non-MBMW products and adding secondary MBMW output equal to 6.5% of the establishment-based gross output. In 1959 the commodity-based gross output of MBMW can be calculated as 27.2 billion rubles. Lee's establishment-based value of 29.6 billion rubles, therefore, overstates the gross output and the resulting residual by 2.4 billion rubles.

26. Because the commodity-establishment adjustment involves both an addition and a subtraction, the possibility that it varies over time is enhanced. The net adjustment for 1959 is the only one known; the commodity-establishment adjustments for other years have not been published. The inability of a Western researcher to make the proper commodity-establishment adjustment over time is another stumbling block in this type of methodology.

Purchaser vs Producer Prices

27. The Soviets have never released data on the value of output of the MB branch of MBMW. To reduce his MBMW series to MB output alone, Lee subtracts the gross outputs of the metalworking and repair sectors available in the 1959 I-O table. But the gross outputs in the Soviet I-O tables are in purchaser prices, and hence are not comparable with the gross outputs reported in constant enterprise (producer) prices. Therefore, when Lee fails to adjust the 1959 GVO of metalworking for the turnover tax collected and the transportation, trade, and distribution costs incurred in marketing the product, he is subtracting from MBMW gross output a value that is at least 500 million rubles too large.

Incorrect Index for Metalworking GVO

28. Although an index of metalworking output exists for all years between 1958 and 1965,[15] Lee used only 1959 and 1965 values – derived from the "differential" between the MBMW and MB indexes reported in the Soviet statistical yearbooks – and assumed that the index grew at a constant rate in the intervening years. This index was applied to a 1959 base value for three MW sectors from the I-O table, that include sanitary engineering equipment which may not be in

14. Ya. M. Shvyrkov, *Klassifikatsii otraslei v narodnokhzyaystvennom plane*, Moscow, 1965, pp. 32, 40. UNCLASSIFIED.

A.N. Efimov and L. Ya. Berri, eds., *Metody planirovanitya mezhotraslevykh proportsii*, Moscow, 1965, p. 81, UNCLASSIFIED.

15. TsSU, *Narodnoye khozyagstvo SSSR v 1965 godu*, Moscow, 1966, p. 194, UNCLASSIFIED.

metalworking. This procedure distorts the trend in the GVO of MW that Lee estimates between 1958 and 1965 and therefore distorts the residual.

The Problem in Capital Repair

29. The index of "production of repair work", which is part of MBMW, is published in the Soviet statistical yearbooks, but Lee could find no ruble value for a benchmark. Instead, he used the commodity-based gross output for "repair of all machinery" from the 1959 I-O table as his benchmark and applied the establishment-based growth index to this value to generate a ruble series for "production of repair work." The coverage of the two repair branches is not comparable and the differences go beyond the commodity-establishment adjustment. The establishment-based gross output of "production of repair work" is about 400 million rubles less than the value Lee used for the benchmark output.[16] This means the residual is understated by this amount in 1959.

The Indexes for MBMW and MB

30. The establishment-based GVOs which Lee estimated for 1950 and 1953 may be in error on their own account. The GVO of MBMW is based on a constant-price index published in official yearbooks. The price weights of this index have changed over time as the Soviets have linked constant-price segments together. The prices used have been 1949-51 current wholesale prices in 1950-51; constant 1 January 1952 prices in 1952-55; constant 1 July 1955 prices in 1955-67; and constant 1 July 1967 prices in 1967-73. The error introduced by the use of different price weights cannot be determined but could be sizable, particularly for 1950. In addition, any extension of the series beyond 1967 could also generate sizable errors. Lee's procedure for converting the published MBMW index into value terms resulted in overestimates for the value of MBMW output in all years except 1955 and 1958. The overestimates ranged from 200 million rubles in 1956 to 600 million rubles in 1964 and were the result of using the Soviet values of GVO in 1960 and 1965 (which were published with two-digit accuracy) as the base for the index rather than the 1955 and 1958 Soviet values (which were published with three digit accuracy).[17] The sum of Lee's errors in estimating the GVO of MB can be seen in Table 2, where Lee's series and the index derived from it are compared with a series based on the official index. The indexes grow quite differently in several years, and the value error resulting from errors in estimating the GVO of MB grows from 270 million rubles in 1955 to almost 2 billion rubles in 1965.

Derivation of the Value of Final Output of Machinebuilding

31. In moving from the GVO of MB to an estimate of the value of final output of MB, it is necessary to subtract the changes in the amount of unfinished

16. The weights implied by the growth indexes of GVO of MB, GVO of metalworking, and GVO of repair suggest that the value of repair in 1958 is 3 billion rubles.

17. The 1955 and 1958 values, when projected at the rate indicated by the official index, produce values for 1960 and 1965 which round to the values published by the Soviets for these years.

Table 2

Comparison of Lee and Official Soviet Machine Building Indexes and Values

	Indexes		Values (Billion Rubles)			
	Lee[1]	Official[2]	Lee[1]	Corrected Lee[3]	Official[4]	Error[5]
1955	66.1	64.4	12.91	12.91	13.18	-0.27
1956	77.1	75.1	15.06	14.86	15.37	-0.51
1957	88.0	87.4	17.20	17.00	17.88	-0.88
1958	100.0	100.0	19.54	19.54	20.46	-0.92
1959	117.5	115.5	22.95	22.65	23.63	-0.98
1960	136.4	134.0	26.65	26.35	27.42	-1.07
1961	159.1	155.5	31.08	30.72	31.82	-1.10
1962	184.5	180.0	36.05	35.65	36.83	-1.18
1963	209.8	204.5	40.99	40.49	41.84	-1.35
1964	229.1	223.4	44.76	44.16	45.71	-1.55
1965	248.9	245.0	48.63	48.13	50.10	-1.97

1. Table 1.
2. *TsSU, Narodnoye Khozyaystvo SSSR v 1967 godu*, Moscow, 1967, p. 256, UNCLASSIFIED.
3. Values in Table 1 corrected for Lee error in estimating GVO of MBMW.
4. The 1958 value for MB was derived from official Soviet growth indices for MB, two metalworking sectors, and repair. Values for other years estimated from the index in Column 2.
5. Corrected Lee value less official index value series.

production and the value of transfers between enterprises. Lee, however, overestimates unfinished production and underestimates interindustry transfers. The net result is an overstatement of final output by 2.3 billion rubles in 1959 that is then carried down to the residual.

The Treatment of Unfinished Production

32. Because MB gross output includes the increase in the value of unfinished production during the year, Lee makes adjustments to exclude such changes. In doing so, however, he overestimates the necessary adjustments by from 2 billion to 6 billion rubles in 1959-65. In 1959 the gross output of MB from Table 1 is 22.95 billion rubles, from which Lee subtracts 3.18 billion rubles, the total cost of unfinished production on hand at the end of the year. He should have subtracted only 800 million rubles, the difference between the value of unfinished production at the end of 1958 and the end of 1959. Similarly, Lee should have subtracted only 40 million rubles in 1960 instead of 3.22 billion rubles. By 1965 the overstatement of this adjustment amounts to 5.8 billion rubles.

Interindustry Deliveries

33. Lee estimates that transfers between machinebuilding enterprises as a percentage of the gross output of machinebuilding vary from 12% to 22% in the period 1950-65. These figures are based on fragmentary MBMW data for the years 1955, 1956, and 1959, which indicate that the rate was constant in that period and "accounted for no more than 15% of MBMW GVO."[18] Lee notes that "the most precise figure available is 13% to 14% for 1959 which is based on data from the interindustry matrices."[19] Nevertheless, Lee uses a figure of 15% for the year 1959. The percentages which appear in Table 1 are based on this single observation and Lee's notions as to the direction of change. Lee believes that intraindustry deliveries have increased as a proportion of total output because the proportion of material purchases in MBMW prime costs has risen.

34. The intraindustry data used by Lee was taken from the published, incomplete version of the 1959 matrix which omitted two MB sectors.[20] The percentages of interplant transfers in the completed version of the table are: 16.4% for MBMW and 15.7% for MB. Both percentages exceed the 15% limit inferred by Lee from the data in the published table. Data from the I-O table, however, should not be directly used in making this adjustment because of the commodity-establishment problem and because input-output data reflect purchaser prices rather than producer prices. The net effect of these differences would be a 12.4% correction for double-counting in 1959, instead of the 15.7% implied by the input-output table.

35. The error in calculating interplant deliveries based on the incorrect ratio would have been significant (nearly 500 million rubles in 1959) if Lee had not subtracted far too much unfinished production from gross output before applying the percentage of interplant transfers. Because changes in unfinished production almost certainly were included in gross output when the base year percentage was calculated, this procedure led to an understatement of interplant deliveries. Because of these errors, the error in the value derived by Lee for interplant deliveries in 1959 is small. In other years, however, the error is large – an overestimate of 1 billion rubles in 1965.

36. Lee also failed to take account of deliveries of MB enterprises to other sectors of the economy. This value is available for 1959 (3.4 billion rubles) and for 1966 (7.7 billion rubles) from the reconstructed Soviet I-O tables.[21] This correction alone would reduce the Lee residual from 6.2 billion to 2.8 billion rubles in 1959. This oversight is partly offset by errors in estimating deliveries among MB enterprises and in handling the value of unfinished production. Thus, for 1959, Lee does not deduct the 3.4 billion rubles of interindustry deliveries, but he

18. , *op. cit.*, p. V-128.
19. *Ibid.*
20. This was not clearly stated in the source that used but can be deduced from a comparison of the data in the source with the published table.
21. Vladimir Treml, et. al., *The Structure of the Soviet Economy: Analysis and Reconstruction of the 1966 Input-Output Table*, New York, 1972.

subtracts 2.4 billion rubles more than he should have in the adjustment for unfinished production.

Subtraction of Producer and Consumer Durables

37. The final steps in the derivation of a machinery purchases residual are the subtraction of estimates of deliveries of producer and consumer durables. In making these estimates, Lee adjusts the producer durables component of investment for imports but not for its non-machinery element or for the trade, distribution, and transportation charges, which are also included. The chief problem in Lee's treatment of consumer durables is that he accepted an estimate for a single year (1955) and relied on arbitrary growth rates with no link to Soviet data to generate his series.

The Producer Durables Adjustment

38. Lee uses the value of equipment included in published data on capital investment to estimate domestic production of producer durables. Lee notes that Soviet investment data include (1) some non-machinery products, (2) imports, and (3) trade, distribution, and transportation costs. All three elements should be removed to derive domestic production of producer durables in producer prices. However, Lee removes only the surplus of imports over exports, converted to domestic prices. This procedure removes imports from the investment data and implicitly includes exports in the producer durable category so that these two components of final use are subtracted together. Lee explains his failure to remove the other elements by stating that these "adjustments are purposely not made in an attempt to keep the producer durables entry conservatively on the high side so as not to exaggerate the military/space residual."[22] Lee acknowledges that the difference between producer and purchaser prices overstates the value of equipment in capital investment by "almost 10%" according to a Soviet source. In addition, non-machinery products may account for at least 5% of equipment data. According to these crude factors, Lee may have understated his residual by 1.4 billion rubles in 1959 and 2.5 billion rubles in 1965.

39. Lee assumes zero lag between production and purchases of both producer and consumer durables. However, if this year's purchases include part of last year's production, the resulting residual represents neither output nor purchases of military/space hardware.

The Consumer Durables Adjustment

40. Lee calculates the output of consumer durables by inflating a CIA estimate of consumer durables purchased in 1955 by 25% to account for the items not included in the CIA sample and then moves this value over time at the rate of growth of the GVO of MBMW in 1955-58 and at a constant 10% per year thereafter. Lee rejects the CIA growth index for consumer durables because it does

22. [illegible], *op. cit.*, p. V-135.

not include consumer electronics. Neither of the growth rates that Lee uses can be supported as indexes of growth in consumer durables. For at least a five-year period (1959-63), he could have used the comprehensive official index of deliveries of consumer durables.[23] For the entire period he could have derived an index from sales data available yearly in the statistical handbooks for consumer durables.

Summary

41. The methodology which Lee used to derive his estimates incorporated most of the pitfalls in Soviet data that were cited at the outset. In his attempts to estimate some of the missing Soviet data, he committed a number of errors. He mixed input-output data with other data prepared for the CSA without (1) first estimating total machinery output in the economy by removing non-machinery production from the CSA data and including machinery produced outside the MBMW branch or (2) removing turnover taxes and trade distribution markups from the input-output and Soviet investment data. In confronting the trend problem, moreover, Lee did not use Soviet indexes where their application seemed appropriate – as in estimating a time series for the gross output of MB and for consumer durables – and instead created his own indexes, often with no basis in fact. Lee also erred in subtracting all unfinished production from gross output of MB instead of merely the change, as even Western accounting practice would do, and in failing to deduct MB shipments to other industries. Lee's inflation of the CIA estimate of the value of consumer durables in 1955 to obtain a base-year estimate for consumer durables is a crude adjustment for the omission of consumer electronics from the CIA sample.

42. Finally, Lee seems to estimate the value of his residual without conducting sensitivity tests on his estimates. Estimates made at very high levels of aggregation in the data, such as in the value of metalworking, for example, may have a small percentage error, but the ruble equivalent of that error can be a large percent of the residual -- that is, the error of 980 million rubles which Lee made in estimating the machinery component of MBMW is only 3.3% of the value of MBMW, but it is 16% of the residual value of machinery which Lee shows for 1959.

Lee's Estimate of Research and Development Expenditures

43. Lee's 1968 study also presented a calculation of the value of research and development (R&D) expenditures included in MBMW output. This estimate was based on the following hypothesis: the gross output of R&D projects is included in the published value of MBMW output, but MBMW employment statistics do not include R&D personnel.[24]

23. TsSU, *Narodnoye khozyaystvo SSSR v 1964 godu*, p. 589. The published index, based on Soviet input-output work, grows at 8.4% per year in 1960-63 while Lee's index increases at 10% per year. The former is generally accepted as an accurate measure of consumption of consumer durables.
24. The hypothesis had been examined in an earlier work

44. The procedure can be illustrated by a simple formula:

$$\text{GVO of MBMW} - \left(\frac{\text{MBMW employment x average wage in MBMW}}{\text{Labor payments as percentage of cost}} + \text{MBMW profits} \right) = \text{The value of R\&D}$$

Gross output excluding R&D is thus defined as cost plus profit and is subtracted from the official Soviet gross output value (see Table 3). The difference is labeled

Table 3

Lee Estimates of the Value of Soviet Research and Development

Billion Rubles in 1955 Prices

	1955	1959	1960	1961	1962	1963
Official Soviet GVO of MBMW	17.52	29.6	34.0	39.16	45.10	51.0
Lee estimates of costs plus profits	15.5	25.33	29.16	33.22	36.97	41.95
Residual (GVO of R&D institutions)	2.02	4.27	4.84	5.94	8.13	9.05
Final output of R&D (70%-85% of residual)	1.41-1.72	2.99-3.63	3.39-4.11	4.16-5.05	5.69-6.91	6.34-7.69

the R&D component of MBMW. Since the residual represents gross output, Lee adjusts it to exclude unfinished production and intraindustry use so as to obtain an estimate of "R&D final output." Although the methodology appears straightforward, the residual obtained can be questioned on several points:

(1) Social security payments were not included in Lee's wage calculation but are part of the wage portion of Soviet cost data. Inclusion of these estimates alone would reduce the residual in 1959 by 2.1 billion rubles.

(2) The estimate of employment begins with published data on the number of workers in MBMW. To obtain total employment, Lee uses the fragmentary data on the number of engineers and support staff in MBMW that were then available. Although Lee allows for a high and low estimate of employment, and averages the result, figures for total employment data that were published later indicate the actual employment for 1955 to be 50,000 men higher than Lee's highest estimate for that year, while the actual employment for 1960 was 60,000 men lower than his low estimate for 1960. The estimates for other years would be similarly distorted, and the actual figures indicate a much flatter trend in employment than implied by Lee's estimates.

(3) In calculating the share of labor costs in total costs, Lee adds 70% of what the Soviets designate as "other costs" in their cost breakdown

for MBMW. While it is true that these costs are partly labor and partly material costs, the "other cost" category is a catchall including costs that are difficult for the Soviets to assign to labor or material cost categories. The labor component of "other costs" would not be included by the Soviets in calculating the annual wage bill. Therefore, when Lee adds 70% of "other costs" in deriving a labor cost percentage, the total costs are understated. An overstatement of the residual results.

(4) On the basis of Lee's hypothesis that MBMW data do not include R&D personnel, if the industrial gross output of scientific organizations is added to branch gross output, then employment data should also include the workers in these establishments. While inconsistencies in Soviet reporting techniques are numerous, a direct statement from a Soviet source confirming Lee's hypothesis on the exclusion of R&D personnel would be necessary for most Western analysts to accept an inconsistency as gross as that which he is assuming. What Lee may have rediscovered is an inconsistency between the prime cost data and the gross output data, which may or may not be related to R&D production.

Boretsky's Estimate of a Machinery Purchases Residual

45. Michael Boretsky presented a residual for machinery purchases, which he equated with military hardware procurement, in a 1970 article.[25] His methodology, as set out in Table 4, can be summarized as follows:

Table 4

Boretsky's Estimate of the Residual Final Value of Output[1] in Machine Building

Billion Rubles in 1955 Prices

	1958	1959	1962	1963	1965	1967	1968
1. GVO of MBMW, establishment basis	....	27.60	....	....	....	....	....
2. GVO of MBMW, commodity basis	....	25.39	....	....	....	....	....
3. GVO of MB, commodity basis	....	20.06	....	....	....	....	....
4. Extrapolation of the 1959 benchmark value for GVO of MB	17.37	20.06	31.27	35.51	42.53	54.06	60.62
5. Intraindustry uses in MB	2.62	3.21	5.94	7.14	10.21	13.57	15.52
6. Value of intermediate products sold to sectors other than MB	3.94	4.49	6.69	7.49	8.49	10.33	11.34
7. Value of final output of MB	10.81	12.36	18.64	20.88	23.83	30.16	33.76
8. Value of consumer durables	1.45	1.60	2.14	2.39	2.88	3.90	4.57
9. Value of producer durables (less imports)	6.92	7.29	9.89	10.99	13.49	15.39	16.74
10. Value of inventories	0.27	0.33	0.51	0.50	0.50	0.78	0.84
11. Exports	0.31	0.45	0.47	0.57	0.65	0.82	0.93
12. Residual (Military and Space Programs)	1.85	2.68	5.62	6.42	6.31	9.28	10.69

1. Boretsky, *op. cit.*, pp. 227-229 UNCLASSIFIED.

25. Michael Boretsky, "The Technological Base of Soviet Military," 91st Congress, *Economic Performance and the Military Burden in the Soviet Union*, Washington, D.C., 1970, p. 189-231.

(1) The GVO for MBMW (establishment definition is estimated for 1959 in 1 July 1955 prices by means of the official indexes of GVO growth and a Soviet-reported figure of 24 billion rubles for 1958;[26]

(2) This value is reduced to a commodity-based estimate using the 1959 commodity-establishment ratio previously discussed (0.92);[27]

(3) The MB portion of this output is estimated by using the MB-MBMW relation in the reconstructed 1959 I-O table (0.79);

(4) The benchmark value estimated in step (3) is extrapolated to other years in the 1955-68 period by means of the official Soviet index of MB growth;

(5) Intraindustry use in each year is estimated as a changing share of the estimates made in step (4);

(6) The value of intermediate products sold to non-MB sectors is determined from the 1959 I-O table and the share of this value in total MB;

(7) The value of the final output of MB is derived by subtracting the estimates of steps (5) and (6) from the estimates of step (4);

(8) Private and public consumption of durables are estimated from Soviet data on retail trade sales;

(9), (10) Soviet data on investment in fixed capital and inventories are used to adjust the series for producer durables;

(11) Estimates of exports and imports are made and exports are subtracted from final output while imports are subtracted from producer durables;

(12) The residual remaining is identified as "military and space programs."

46. Boretsky's methodology is superior to Lee's in its treatment of commodity-establishment conversions, turnover taxes, and trade and distribution costs. However, it still employs benchmark estimates which are moved forward and backward through time by inappropriate official indexes or by his own rough estimates of growth.

26. This is not the methodology described by Boretsky in his paper. His methodology does not produce the value he uses. The methodology described above does result in the GVO that Boretsky has for 1959.
27. See paragraph 25.

Derivation of the Gross Value of Output of Machine Building

47. Like Lee, Boretsky first had to derive a GVO of MB from the GVO of MBMW. Boretsky's estimate of the GVO of MBMW, however, is in error, as is the division of MBMW output between MB and MW. While aware of the commodity-establishment problem, Boretsky nevertheless used the official Soviet, establishment-based index of growth in MB.

The Value of the GVO of MBMW

48. Boretsky's derivation of a 1959 base year value of MBMW gross output (establishment basis) is unclear. The value of MBMW output in 1959 that Boretsky starts with is 27.6 billion rubles. But this value is not the result of the methodology that he sets forth and is 2 billion rubles less than Lee's estimate.[28] Moreover, Boretsky's estimate of 27.6 billion rubles is inconsistent with other Soviet data for this time period. Unofficial Soviet sources report the GVO of MBMW in 1958 as 25.5 billion rubles,[29] a value which is consistent with the growth index and other values published by the Soviets for the years 1955, 1960, and 1965.[30] Application of the reported increase of GVO of MBMW in 1959 to the 25.5 billion ruble figure for 1958 yields 29.3 billion rubles for 1959, which is close to the value of 29.8 billion rubles that can be calculated using Boretsky's stated methodology. Boretsky's GVO for MBMW in his benchmark year, therefore, is understated by at least 1.7 billion rubles.

The Division of MB and MW Output

49. To derive the GVO of MB, Boretsky calculates the ratio of MB to MBMW in an early reconstruction of the Soviet I-O table for 1959[31] and applies the ratio to his estimate of the GVO of MBMW on a commodity basis (line 3, Table 4). In doing so, he is on shaky ground:

a. The data of the early I-O reconstruction were based on a GVO that included imports, whereas the adjusted establishment data to which Boretsky applies the ratio cover domestic output only;

b. The I-O data include turnover tax, trade and distribution costs, and transportation costs, whereas the adjusted establishment data to which the ratio is applied are in enterprise wholesale prices;

28. In his article, Boretsky indicates that this value was calculated as a percentage of the gross output of industry for 1959, the percentage coming from a Soviet source. But application of this methodology produces an estimate of 29.8 billion rubles (0.21 x 141.7 billion rubles).

29. A.N. Gavrilov, *Sovremenoye sostoyaniye napravleniye razvitiya teknologii mashinostroyeniya i priborostroyeniya*, Moscow, 1960, p. 304.

30. The 1955 figure of 17.4 billion rubles is from *Pravda*, October 18, 1961; the 1960 figure of 34 billion rubles is from *Materialy XXII-S'EZDA KPSS*; the 1965 figure of 61 billion rubles is from *Materialy XXIII-S'EZDA KPSS*, Moscow, 1966.

31. Vladimir G. Treml, *The 1959 Soviet Intersectoral Flow Table*, Research Analysis Corporation, November 1964, p. 93.

c. The I-O data are in 1959 prices and the adjusted establishment data are in July 1955 prices.

50. Boretsky's estimate of the GVO of the MW sectors (including repair) in 1959 is 5.33 billion rubles. The value based on the reconstruction of the 1959 I-O table adjusted to producer prices, is 5.99 billion rubles. Thus, the sum of Boretsky's errors is a 660 million ruble underestimate of GVO of MW.

The Growth Index for Machine Building

51. To calculate MB output for years other than 1959, Boretsky used the published index for establishment-based GVO of MB, thus implicitly assuming that the commodity and establishment GVOs grow at the same rate. Because this is unlikely,[32] the GVO of MB so derived can not be relied on to generate accurate values for a commodity-based residual.

Derivation of the Value of Final Output of MB

52. Adjustments to derive the value of final output of MB from the GVO of MB center on the elimination of interindustry and intraindustry uses of output.

Intraindustry Uses of MB in 1959

53. Boretsky calculates the intraindustry use of MB as 16% of sales in 1959 by multiplying the ratios of (a) interindustry use to GVO (0.394) and (b) intraindustry use to interindustry use (0.417), both derived by Soviet authors from the 1959 I-O table. This apparently straightforward calculation contains three errors which together produce a net overstatement of this adjustment equal to 280 million rubles in 1959.

a. The ratios that Boretsky assumes are calculated from data on MB were demonstrated in Vladimir Treml's reconstruction of the Soviet I-O table to be based on data for all MBMW;[33]

b. Boretsky assumed that the ratios were calculated from the same table and could therefore be used together. But the ratio of interindustry use to GVO (0.394) was calculated from a table in producer prices (net of turnover tax and transportation and trade costs) while the ratio of intraindustry use to interindustry use (0.417) was based on a table in purchaser prices;

c. The ratio of interindustry use to GVO (0.394) was based on total domestic consumption. Boretsky knew that gross output in this calculation excluded exports, but he did not realize that imports had been added and that the adjustment made was a net foreign trade (imports

32. See, for example, Vladimir G. Treml, *et. al., Structure*, pp. 123-146, UNCLASSIFIED.
33. Vladimir G. Treml, *op. cit.*, Vol. II, pp. 100-101, UNCLASSIFIED.

minus exports) adjustment rather than a subtraction of exports. According to Boretsky's own estimates of the foreign trade balance, his adjustment is overstated by 300%.

54. All these errors affect the accuracy of his calculation, and the percentage of intraindustry use should be rejected. The value of intraindustry sales of MB in 1959 in producers prices is 2.93 billion rubles. Boretsky's estimate is 3.21 billion rubles, an overstatement of 280 million rubles.

Intraindustry Uses of MB in 1965

55. Boretsky estimates intraindustry use of MB in 1965 by increasing the 1959 intraindustry percentage use by a factor of 50%. This factor was based on what he believed were ***expost*** data from the 1965 Soviet I-O table. The 1965 table, however, was an ***exante*** planning table whose price base is unknown; the ratios derived from it represented planned (or expected) changes in interindustry relationships, not actual changes.[34] Also, the data from which the increase was calculated were based on material costs rather than GVO. Only if the ratio of material costs to gross output did not change during 1959-65 would the change in the ratio based on material costs reflect the change in the ratio based on gross output. Comparison of the 1959 and 1966 IO tables shows that this was not the case. The value for 1965 is therefore of questionable realiability, and the values interpolated for 1958-68 are even less reliable because there is no reason to assume a uniform trend in the rate of change in intraindustry use. Intraindustry use of MB in 1966 in producer prices is 9.37 billion rubles. Boretsky's value for 1965 is 10.21 billion rubles. After adjusting for price differences, Boretsky's 1965 estimate is overstated by about 1 billion rubles.

Interindustry Deliveries in 1959

56. To derive MB interindustry deliveries to other branches in 1959, Boretsky multiplied the GVO of MB by 0.224, an adjustment factor derived by subtracting the share of intraindustry uses of MB (0.16) from the interindustry-use ratio (0.394 reduced to 0.384 to allow for the exclusion of exports). As noted above, this factor was based on data for total MBMW in 1959 producer prices (with the net foreign trade balance added). Boretsky applied this ratio, adjusted only for exports, to MB measured in 1955 prices. The value derived by Boretsky (4.49 billion rubles) is 1 billion rubles higher than the value in the 1959 Soviet I-O table, thus understating the residual by at least this amount.

Interindustry Deliveries in 1960-68

57. To estimate sales of MB to other sectors of the economy, Boretsky cites a Soviet statement that "In 1965 the proportion (relative importance) of repair in the overall volume of machine building output declined by almost 9% in

34. The distribution is significantly different from that of the 1966 table. See Vladimir G. Treml, *et. al., Structure, op. cit.*, pp. 402-404, UNCLASSIFIED.

comparison with 1958. In the current 5-year period this proportion will decline by 10% more." Boretsky applies these declining ratios to his estimate of interindustry use in 1959. In so doing, Boretsky assumed analogous trends in sales of MB to other productive sectors and in the proportion of repair in MB output.

58. The declining proportion of repair, however, has little to do with interindustry use of MB. The repair GVO referred to in the Soviet statement is the gross output of specialized enterprises whose primary function is repair. The relative weight of purchases by these enterprises from the MB sector (part of interindustry use) would be influenced by the declining share of repair in gross output of MBMW. However, changes in current and capital repair performed by enterprises on their own equipment and MB sales to other sectors of subassemblies and tools would not be reflected in the declining share in total MBMW output of repair enterprises. The magnitude of the error is indicated by an examination of the data in the 1966 Soviet I-O table. According to the Boretsky projection, sales of MB to sectors other than MB were 19.6% of gross output in 1966, and in the reconstructed I-O table for that year they were 16.8% of gross output. The error amounts to 1.3 billion rubles in the year 1966.

The Subtraction of Producer and Consumer Durables

59. The final step in deriving a residual value of MB final output is the subtraction of estimates of producer and consumer durables. Here, Boretsky overestimated the turnover taxes and used an average value for investment in his benchmark year that probably understates investment. His inventory series is also weak. As a consequence, the residual is overstated. Boretsky also assumes a zero lag between production and purchases of producer and consumer durables. If a lag exists between the purchases data and the output data, then the residual calculated is neither the purchases nor the output of military and space hardware.

Producer Durables: Equipment and Inventories

60. The machinery investment data used by Boretsky can be criticized on a number of points. Boretsky cites the Soviet statistical yearbooks for his gross investment data, but the 1968 yearbook that he cites does not have data in the form in which it appears in Boretsky's paper. Investment in 1958-60 (key years in the Boretsky calculations) is not given separately but as part of a five-year aggregate figure for the period 1956-60. The value used by Boretsky for 1958 appears to be a simple average of the five-year total. The margin for error in such a calculation is sizable: when the same method was applied to the total for 1961-65, a period for which separate yearly values are available in a later yearbook, the average annual investment is 200 million rubles greater than the actual value for 1963.

61. Boretsky does not show his calculation of investment values for the year 1959. However, if his source and methodology are used, the value for 1959 investment appears to be understated. Given the value of investment in 1961 and

his estimate for 1958, the value of investment in 1959 would have been at least 9 billion rubles, whereas the gross investment value implicit in Boretsky's net value is 8.78 billion rubles.[35]

62. Boretsky derived a series for investment in inventories of MB products by assuming that working capital grew at the same rate as gross output. Using a single published value of 10 billion rubles for 1960 to generate a series for working capital in MBMW, he assumed that 80% of this working capital was the working capital of MB – probably on the basis of gross output of MB as a proportion of GVO of MBMW. Working capital is then divided into inventories and unfinished production with the help of the published percentage distribution of working capital. Because this percentage distribution is available only for recent years, he had to estimate it for the earlier years in his series (1958-64). His values for investment in inventories are the yearly changes in these derived series for inventories and unfinished production.

Consumer Durables: Private and Public Consumption

63. Boretsky uses Soviet data on private and public consumption in 1958-63 to estimate the value of consumer durables. In the conversion of the data from retail prices to enterprise wholesale prices, the turnover tax and the cost margins for retail trade, distribution, and transportation must be removed.

64. In removing the turnover tax, Boretsky uses a turnover tax rate of 45% for the entire period.[36] This rate, a crude weighting of many individual rates, appears to be high on the basis of other sources of information: Vladimir Treml estimates a rate of 33% in the reconstruction of the 1959 Soviet I-O table, and the 1966 I-O table has an implicit rate of 37.4% for MB.[37] In addition, the turnover tax collections from MBMW in 1959 and 1964 are known: 1.1 billion and 1.5 billion rubles, respectively. These values are equal to the Boretsky estimates for just MB, indicating that the Boretsky values are overstated by about 25%.[38]

65. Boretsky's estimates of the retail trade margins and transportation costs are based on their share in total material costs in MBMW for 1959 and 1965. The use of this overall MBMW ratio for private and public consumption is wrong because retail margins and transportation costs are not distributed proportionally among either the MBMW sectors or among the various final demand and interindustry uses. Boretsky's adjustment for retail margins and transportation costs combined in 1965 is 5.1% of retail trade sales. The implicit rate calculated from the 1966 I-O table in producer prices was close to 10%. He has therefore understated these charges by almost 50%.

35. Net investment of 7,292 million rubles plus imports of 608 million rubles divided by 0.9.
36. Turnover tax rate from Phillip Hansen, *The Consumer in the Soviet Economy*, London, 1968, p. 116, UNCLASSIFIED.
37. Vladimir G. Treml, *et. al, Conversion of Soviet Input-Output Tables to Producers Prices; The 1966 Reconstructed Table, BEA*, Foreign Economic Reports No. 1, Washington, D.C., 1973, UNCLASSIFIED.
38. Based on the distribution of the turnover tax, in the 1966 I-O table (producer prices) between the MB and MW sectors.

Foreign Trade

66. Values for imports and exports are published by the USSR in foreign prices converted to rubles at the official exchange rate. Boretsky's conversion of these values to domestic prices is based primarily on his estimated dollar-ruble ratio of 2.75. This ratio is generally believed to be high.[39] If it is high, then Boretsky has understated the domestic price of exports and imports. Because imports exceed exports, this procedure would understate the residual.

67. The Boretsky foreign trade calculations are suspect on other counts:

a. He failed to take into account machinery products classified as cultural goods: therefore, not all machinery and equipment traded are included in his totals;

b. The domestic price of an exported good excludes turnover tax, whereas the domestic price of an import includes turnover tax. Therefore, the conversion ratios of foreign to domestic prices can not be equal (as Boretsky assumed) for exports and imports;

c. Foreign trade prices used by the East European countries are calculated on the basis of "world prices" for commodities traded. Despite the differences observed by Boretsky between these prices and the US prices, it is doubtful that world prices of MB products average only 80% of US domestic prices.

Summary

68. Michael Boretsky used a methodology similar to Lee's in obtaining his estimate of Soviet spending on "military and space programs." Unlike Lee, Boretsky derived a measure of total machinery output in the economy, but for only one year. The estimates for other years were made using the official Soviet index of MBMW output which includes some non-machinery output but which does not include all machinery output. Moreover, the GVO for MBMW which Boretsky used in 1959 is inconsistent with the value of MBMW outputs reported in other Soviet sources.

69. Boretsky eliminated turnover taxes and trade distribution margins from producer and consumer durables to put machinery production and civilian purchases on the same price basis, but his adjustments were incorrect. He also used data that included imports to make estimates from data that did not include imports. Although Boretsky recognized that he had to subtract interindustry uses in deriving his residual (unlike Lee), he used arbitrary estimates of the growth of interindustry uses between 1959 and 1965 that led to substantial errors. Finally, Boretsky bridged

39. Nove, *op. cit.*, UNCLASSIFIED.

gaps in Soviet data with other estimates – as in his treatment of the machinery components of fixed investment and working capital – which weakened the reliability of the residual.

Can the Residuals be Trusted?

70. The Lee and Boretsky estimates have been reviewed in detail – often on quite technical points. A more important criticism is that any estimate of this kind encounters too many imponderables to justify a firm calculation of a magnitude as important as production of "military and space hardware." Calculations of machinery residual still produce inconclusive results, even when the calculations can build on the Lee and Boretsky studies and have the benefit of more recent information. Some object lessons are described below.

A 1959 Residual

71. The year 1959 is one of the most promising for a residual estimate because the Soviets prepared their first I-O table for that year. Vladimir Treml and his associates have reconstructed the 1959 I-O table on the basis of a great deal of research. This reconstructed table offers a seemingly unmatched opportunity to derive a residual for military-related machinery.

72. But not all of the reconstructed table can be used. The GVO of the Soviet MBMW sector of industry compiled on an establishment basis was reported as 25.5 billion rubles in enterprise wholesale prices in 1958. A value for 1959 can be estimated by using the announced growth of 15.1% for MBMW in 1959. Converting the result to a commodity basis (by multiplying by the commodity-establishment ratio of 0.92 for 1959) provides a value of 27.0 billion rubles.[40] This value in enterprise *wholesale prices*, however, exceeds the Treml estimate of 26 billion rubles, which is in *purchasers' prices*. Since the 1959 I-O table was exploratory, something could have been excluded in its preparation. Moreover, the announced GVO of 25.5 billion rubles for 1958 (establishment definition) is consistent with other Soviet data. Therefore, we begin with the establishment-based figure and convert it to a commodity basis before bringing the I-O data to bear on the residual problem (Table 5).

73. The reconstructed 1959 I-O table reports data for the GVO of metalworking and repair (6.65 billion rubles), total interindustry deliveries by MB (6.54 billion rubles), and consumption of MB products (2.69 billion rubles). These values include turnover taxes and trade distribution markups. The sum of these three items must be subtracted from the GVO of MBMW. But these deductions are too large because they are valued in purchasers' prices. Therefore, 1.21 billion rubles for turnover taxes and 1.31 billion rubles, representing distribution markups, must be added at this stage of the calculation.[41] The remainder – 13.64 billion

40. In enterprise wholesale prices of 1 July 1955.

41. Except for turnover tax collections, these data are from the reconstructed Soviet I-O table for 1959 (see Treml *et. al., op. cit.*). Turnover tax collections are from S.V. Borovik and N.A. Plashchinskiy, *Obrazovaniye fundy proizvodstvennogo nakopleniya v promyshlennosti*, Minsk, 1972, p. 179, UNCLASSIFIED.

Table 5

Residual Machinery Output, 1959

	Billion Rubles in 1955 Prices
GVO of MBMW, commodity basis[1]	27.00
Less	
Gross value of MW and repair output (PP)[2]	6.65
Total interindustry uses deliveries by MB[2]	6.54
MB output used for consumption[2]	2.69
Plus	
Turnover taxes on MBMW output	1.21
MBMW trade-distribution markups	1.31
Equals	
Deliveries of machinery to fixed investment, machinery exports, and deliveries to other uses[2]	13.64
Less	
Machinery component of investment	8.96
Machinery exports	1.20
Plus	
Machinery imports	1.38
Equals	
Residual MB deliveries[1]	4.86

1. Enterprise wholesale prices.
2. Purchasers' prices.

rubles – represents output used for investment, exports, and other purposes such as defense and additions to inventories of machinery.

74. Investment and net exports of machinery are not identified in the reconstructed I-O table. Indeed, Soviet investment data for 1959 are incomplete and include distribution charges and some investment in furniture, plumbing, and the like. The value for investment originating in MB shown in the tabulation is the sum of (1) the published value of state investment in machinery and other equipment, (2) collective farm investment in machinery and equipment (derived by subtracting the value of construction and other types of investment from total collective farm investment) and (3) a deduction of 5% (Boretsky's factor) to allow for equipment such as furniture that did not originate in MB.

75. The determination of the domestic value of Soviet exports and imports is uncertain because they must be converted from foreign trade prices to domestic prices. There is little reason to choose among the several conversion ratios that Western researchers have developed; the tabulation uses the values of imports and exports from the 1959 I-O table as reconstructed by Vladimir Treml and associates.

76. The residual of 4.86 billion rubles includes production of military hardware and any items unaccounted for in the calculation of the residual. For

example, the residual certainly includes changes in inventories and machinery losses.[42] More important, it may well include the value of capital repair performed by MB enterprises on their "own account."[43]

77. The residual also reflects any errors made in estimating the various values used in the tabulation. The primary source of error is the commodity-establishment ratio. Although published by the Soviets for 1959, the ratio was based on sample survey data and may therefore be incorrect. It is impossible to quantify this uncertainty. Price differences undoubtedly are another source of error. Gross output of MB is reported in 1955 prices; the I-O data are in 1959 prices. Although it has often been assumed that average MB prices did not change in 1956-59, this remains an assumption and a possible source of error.

78. The overall error in the Lee and Boretsky estimates is further illuminated by a comparison with the 1959 residual from Table 5. This residual is 2.18 billion rubles larger than Boretsky's estimate and 1.34 billion rubles lower than Lee's estimate.

A 1966 Residual

79. The CSA put a second I-O table together for 1966. The quality of the research reflected in this table is believed by Western experts to be vastly superior to that supporting the 1959 table. The full table, like the 1959 table, was reconstructed by the Research Analysis Corporation. Thus, 1966 is another vintage year for the calculation of residuals, although the procedure followed is somewhat different from that used in finding a 1959 residual (Table 6).

Table 6

Residual Machinery Output, 1966

	Billion Rubles in 1966 Enterprise Wholesale Prices
Value of final output of MB	25.48
Less	
MB output used for consumption	3.36
Machinery component of investment	16.65
Machinery exports	1.37
Plus	
Machinery imports	1.76
Equals	
Residual MB deliveries	5.86

42. These are losses not included in material expenditures for production and compensated from national income. They include losses from cancellations of construction projects. These are determined by the amount of the expenditure up to the discontinuation of the projects, plus expenditures for dismantling the unfinished project, and minus the value of salvaged materials.

43. Capital repair conducted "in house" should have been removed from MB with the commodity-establishment adjustment. The Soviets are ambiguous in their description of this adjustment, however, and state conclusively only that such repair was reported as part of the repair sector in the 1966 I-O table.

80. The methodology, shown in Table 6, uses data on final output and consumption directly from the reconstructed portions of the 1966 Soviet table in producers' prices (enterprise wholesale prices).[44] Hence, difficulties arising from converting establishment-based data to commodity-based data are avoided while turnover taxes and trade distribution margins have been removed from both the value of MB output and the value of deliveries of MB output to consumption.

81. Investment in machinery (16.65 billion rubles) is estimated by reducing the published value of investment in machinery and equipment by 10% – 5% to allow for non-machinery products (Boretsky's factor) and 5% for distribution charges (the average distribution charge on MB deliveries to final demand in 1966). Data on foreign trade in machinery from the Soviet foreign trade yearbook are converted to domestic prices by coefficients of 0.75 for imports and 0.80 for exports. These coefficients were developed by the Foreign Demographic Analysis Division of the US Department of Commerce as a result of research on the Soviet I-O tables.

82. Unfortunately, this new estimate of the residual is not as solid as it looks. Because a substantial difference was observed between the gross values of MBMW output calculated for 1959 from establishment-based data and from I-O data, the 1966 data should be tested for the same discrepancy. But the required information does not exist for 1966.[45] Moreover, the residual (a) is affected by all of the inevitable errors in reconstructing the MB portion of the 1966 I-O table and (b) includes losses and inventory charges.[46]

A 1967 Residual

83. To illustrate some of the pitfalls encountered in estimating residual machinery output for years when corollary I-O data are not available, an attempt was made to estimate a machinery residual for 1967 (Table 7). Because the underlying assumptions are so critical to the estimate of the machinery residual, the results are presented in terms of low, central, and high estimates. The central estimate is based on the best available point estimate for each value in the calculation of the residual. The high and low estimates use values in each of the steps that reflect a reasonable range of uncertainty. For the high estimate all of the values chosen tend to drive up the residual while for the low estimate the reverse is true. In addition, three different price deflators are used to permit comparison of the residual with that found for 1959.

84. The large differences in the estimates shown in Table 7 reflect difficulties in: (1) estimating the ruble value of commodity output of MB, (2) estimating interindustry deliveries of machinery, (3) converting foreign trade in machinery

44. Foreign Demographic Analysis Division, Department of Commerce, *Conversion of Soviet Input-Output Tables to Producers' Prices: The 1966 Reconstructed Table*, July 1973, UNCLASSIFIED.
45. For example, no ratio of commodity-based to establishment-based values has been reported, as it was in connection with the 1959 I-O table.
46. "In house" capital repair, however, seems to be excluded, in contrast to the 1959 residual.

Table 7

Alternative Estimates of the Machinery Output Residual in 1967

Billion Rubles in 1 July 1967 Prices

	Range of Estimates		
	Low	Central	High
GVO of MBMW, establishment basis	59.6	59.6	59.6
GVO of MBMW, commodity basis	54.8	59.6	63.2
GVO of MB, commodity basis	44.9	49.5	53.1
Less			
Interindustry use	18.0	18.8	19.1
Exports	1.9	1.5	1.1
MB output for consumption	3.7	3.7	3.7
Machinery component of investment	18.5	18.0	17.4
Plus			
Imports	1.5	2.0	2.5
Equals			
Residual MB deliveries (in 1967 enterprise wholesale prices)	4.3	9.5	14.3
Residual MB deliveries in 1955 prices, assuming:			
(1) 10% increase in prices, 1955-67	3.9	8.6	13.0
(2) no change in prices, 1955-67	4.3	9.5	14.3
(3) 22% decline in prices, 1955-67	5.5	12.2	18.3

from the foreign trade rubles in which it is reported to domestic prices, and (4) estimating consumption and investment data in enterprise wholesale prices.

85. Data published for the first time in 1973 permit a calculation of the GVO of MBMW in 1967 prices (59.6 billion rubles). A least-squares exploration of the relation between indexes of growth in the GVO of MBMW, MW, and capital repair can be used to estimate the share of GVO of MB in that of MBMW (83%). The analysis suggests a narrow margin of error of this estimate – from a low of 82% to a high of 84%.

86. There is no commodity-establishment ratio for any year other than 1959, nor is there reliable information about changes in this ratio over time. This ratio changes according to changes in the importance of production of non-machinery products by machinery enterprises and in the amount of machinery produced by non-machinery enterprises. Soviet policy has been to increase the degree of enterprise specialization. Because of the uncertainty about the success of this policy, three different assumptions about the 1967 ratio are used: (1) the ratio equals its 1959 value of 0.92, which implicitly assumes that the two components of the ratio did not change or experienced offsetting changes; (2) the ratio equals 1.0, which implies that the Soviet specialization policy was so successful that the

commodity- establishment problem has disappeared, and (3) the ratio equals 1.06, which implies that the Soviets succeeded in eliminating non-machinery output at machinery enterprises but could not reduce the relation between machinery produced by non-machinery enterprises and the production of MBMW enterprises. Although higher or lower ratios could be assumed for sensitivity testing, they would be even more arbitrary. But the higher the ratio, the greater would be the machinery residual.

87. Interindustry use is estimated as 38% of GVO, based on recently available data.[47] This share agrees closely with that embodied in the 1966 I-O table in producers' prices. Therefore, the range of uncertainty in Table 7 is limited to 40% for the low estimate and 36% for the high estimate.

88. Soviet imports of machinery in 1967 were 2.65 billion rubles in foreign trade rubles, while exports of machinery were 1.91 billion rubles. The best available ratios for converting these values to domestic prices are those used for the 1966 residual (0.75 for imports and 0.80 for exports). There is a great deal of uncertainty in these ratios.[48] A range for the low and high estimate is calculated by assuming an error of ±25% in the ratios.

89. The value of MB production allocated to consumption in 1967 was extrapolated from the 3.36 billion rubles in the 1966 I-O table (producers' prices) using the Soviet production index "household and cultural products." This index includes non-MB products but is dominated by consumer durables manufactured in MBMW.

90. After 1967 the machinery component of investment is reported in "delivered" prices of "1 January 1969" (19.9 billion rubles). Although these prices reflect the general price changes in mid-1967, the CSA claimed that average machinery prices changed very little. In any case, the 1969 prices are almost certainly closer to the true 1967 prices than the 1955 prices in which investment had been reported.

91. The average trade and transportation share of the value of final products calculated from data in the 1966 I-O table (5.0%) was used to remove these charges from the "delivered" price of investment. Non-machinery products are netted out using Boretsky's factor of 5% and allowing a 3% margin on either side for uncertainty.

92. The residual in 1967 prices has a range of 10 billion rubles, 5 billion rubles above and below the "central" estimate of 9 billion rubles. The low value of 4.3 billion rubles is less than the 1966 residual calculated in Table 6, while the high value is almost 2-1/2 times as large as the 1966 residual.

47. A. Lalayants, "Determining the Materials Intensity of Social Production", Moscow, *Planovoye khozyaystvo*, no. 2, February 1972, pp. 6-14. UNCLASSIFIED.

48. The ratios calculated for heavy industry products in the 1966 producers' prices table (FDAD, *op. cit.*) are 1.73 for imports and 1.25 for exports.

93. Converting residual output of machinery in a given year's prices to constant prices is essential to obtain results that are comparable over time. The official Soviet price index for MBMW declines by 22% between 1955 and 1967. In contrast, some Western (and some Soviet) analysts believe that machinery prices have actually been increasing.[49] Insofar as the residual represents military hardware, the appropriate deflator could be quite different from either the official or unofficial price indexes for MBMW as a whole. Therefore, the upper limit for price increases between 1955 and 1967 was arbitrarily limited to 10%. A lower limit to price changes was assumed to be the 22% drop in the official Soviet index for MBMW. No price change was taken to be a third alternative.

94. The values for residual MB output in 1967 (in 1955 prices), shown in Table 7, range from 3.9 billion to 18.3 billion rubles. Even the central estimate ranges from 8.5 billion to 11.9 billion rubles.

	Billion Rubles in 1955 Prices		
	1965	1967	1968
Lee	15.4	....	....
Boretsky	6.3	9.3	10.7
Table 7	....	3.9-18.3	....

The range in these values is more than enough to encompass the Lee estimate for 1965 and the Boretsky estimate for 1968.

95. The residual, calculated by comparing the 1959 estimate with the central estimate for 1967 (assuming no price change), increases at 8.7% per year, compared with the Lee estimate of 18% per year in 1959-65 and the Boretsky estimate of 17% per year in 1960-67. Their higher growth can be matched only by making the extreme assumptions involved in the highest estimate in 1955 prices.

96. The low level of reliability of present estimates of MB residuals seems apparent. A single answer is not possible, and the range of results obtained from reasonable sensitivity tests is too wide. These considerations, and the fact that residuals still contain non-defense elements of machinery production, demonstrate the inconclusiveness of the residual approach, given the existing state of the art and of the statistics.

49. See, for example, Abraham S. Becker, *Ruble Price Levels and Dollar-Ruble Ratios of Soviet Machinery in the 1960s*, RAND, R-1063-DDRE, January 1973, UNCLASSIFIED.