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Intelligence Report

Rubles for Research: Trends in Soviet R&D Expenditures

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CENTRAL INTELLIGENCE AGENCY
Directorate of Intelligence
November 1967

INTELLIGENCE REPORT

Rubles for Research: Trends in Soviet R&D Expenditures

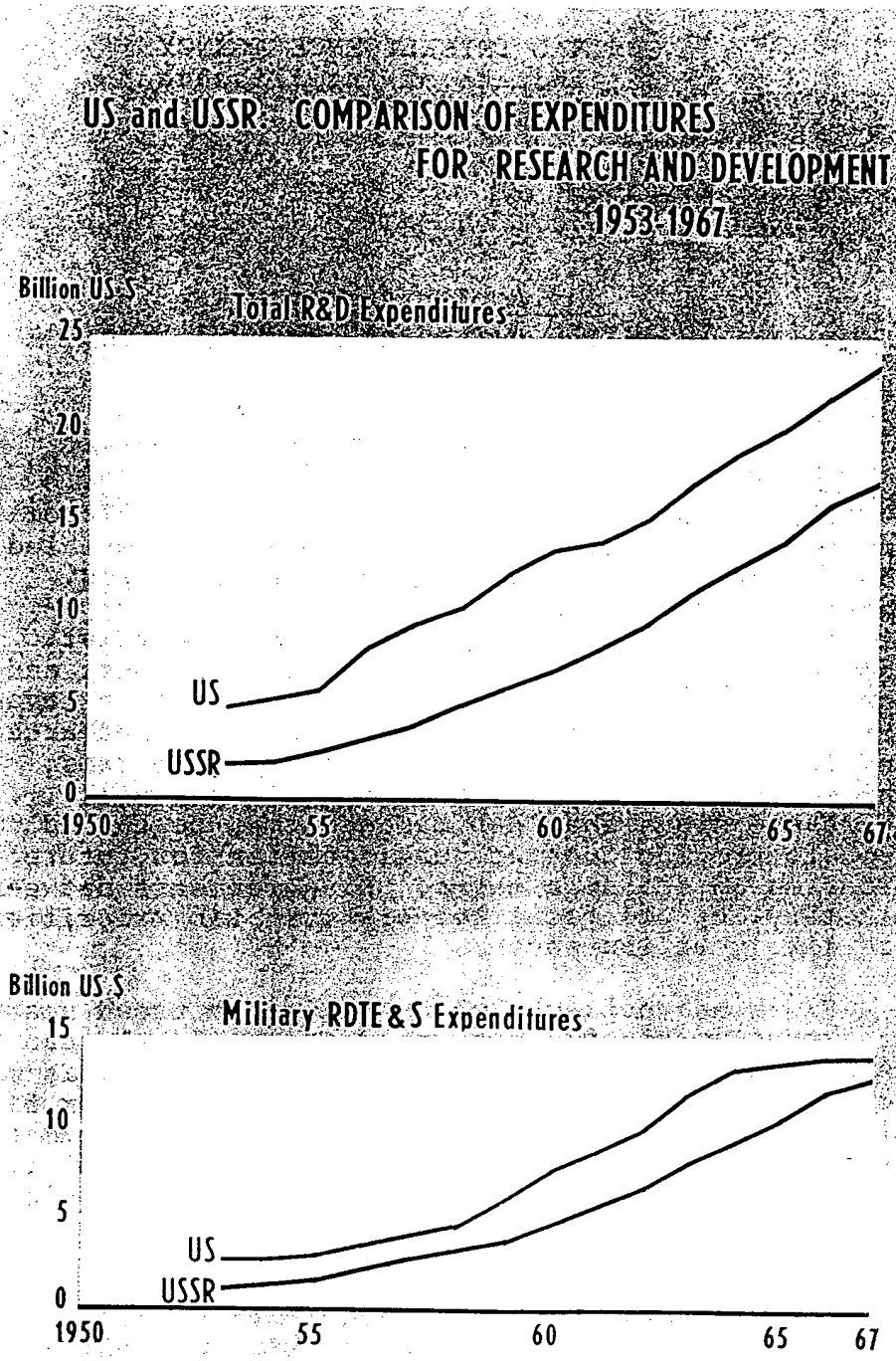
Summary

Throughout the postwar period Soviet science has been nurtured under conditions which have led to increasing claims against scarce resources. The combined effects of intense cold war competition, the pre-eminence of science in Marxist thought, expansion of technological horizons, and generally favorable rates of economic growth have stimulated rapid increases in scientific research and development and space (total R&D) programs. While many of these conditions still prevail, there are signs that R&D managers may be called upon to provide greater justification for future programs in economic terms. Disagreements between military and political leaders over R&D priorities are likely to increase.

Financial outlays, which provide a broad measure of trends in resources devoted to total R&D, can be estimated with fair confidence through analysis of Soviet budgetary data. Total expenditures for all civilian and military R&D and the space program rose from about $2 billion (in equivalent US terms) in 1950 to more than $17 billion in 1967 (see Table 1).

Note: This report was produced solely by CIA. It was prepared by the Office of Strategic Research and coordinated with the Office of Economic Research, the Office of Scientific Intelligence, and the Foreign Missile and Space Analysis Center.

Figure 1



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Most of this increase occurred in the military and space--including civilian space--programs (military RDTE&S), where expenditures rose from about $1 billion in 1950 to almost $13 billion in 1967.

Between 1950 and 1960 the growth rate and level of expenditures for Soviet military RDTE&S were roughly the same as those for equipping and operating either the strategic offensive or strategic defensive forces. Since 1960, largely as a result of the burgeoning space program, expenditures for military RDTE&S have grown at a substantially greater rate than those for the strategic forces, and by 1967 had reached a level about the same as that of the combined expenditures for equipping and operating both of the strategic forces.

Growth in Soviet outlays for total R&D have roughly paralleled trends in comparable US activity, although the USSR has devoted less total resources to R&D than has the US (see Figure 1). In both countries scientific efforts have received steadily increasing shares of available resources. In 1955, for example, expenditures for military RDTE&S accounted for about 6 percent of total Soviet military and space expenditures, and in 1965 for some 25 percent. Comparable figures for the US show a rise from 8 percent to 28 percent. Rates of growth have slowed somewhat in recent years in both countries, partially, at least, because investment in facilities in some of the larger programs has passed through its most expensive stage.

While the downturn in the growth rate has not been as sharp in the USSR as in the US, it appears that new economizing measures now are being considered by Soviet leaders. There is increasing evidence that the Soviet appetite for resources for R&D--which during the 1950's was publicly noted with unqualified pride--now is being subjected to more careful scrutiny. By about 1965 this new concern for the economic use of the research ruble had become fully documented. From military as well as civilian leaders and from scientists as well as economic planners has come recognition that greater efficiency is needed in the use of the scientific and technological resources of the country.

The calls for more effective economic control of R&D have been influenced to some extent by the very complexity of managing a program which has attained the present size of the Soviet R&D effort. At the same time, however, pressures on scarce technological resources generated by currently expanding strategic military programs and programs to stimulate economic growth have probably raised other considerations of at least equal importance. There is no indication that plans to develop more effective management for R&D reflect a judgment that potential military or economic gains from technology are diminishing.

Soviet budgets are published only on an annual basis and what little direct evidence of future funding trends exists is limited to generalized statements by scientific planners and other Soviet officials. Such statements often represent pleas of special interest groups rather than government policy. Under these circumstances projections of Soviet R&D expenditures seem particularly hazardous. A simple extrapolation of the general trend would suggest a rate of some 10 percent a year during the next few years, and there have been protagonists of even higher rates. On the other hand, expenditures grew by only about 6 percent in 1967. The general revision of Soviet wholesale prices that took place in 1967 will be reflected in 1968 expenditures. Preliminary analysis indicates that the net effect will be to increase moderately the cost of R&D inputs. While a 10.8-percent increase in expenditures is planned for 1968, the growth in real terms is probably somewhat less. It seems likely that actual growth will fall within the range of 5 to 10 percent a year over the next few years.

Funds from the Soviet State Budget for R&D are channeled through several accounts. The major single source is the allocation for science in the Social-Cultural category. Within this total the funds labeled "all-union expenditures for science" are believed to contain most of the financial support for military RDTE&S. Additional military RDTE&S funds appear to originate in the budget

category called Financing the National Economy. The Defense category probably contains very little funding for military RDTE&S other than the pay and maintenance costs of military personnel working directly in military RDTE&S programs. It is believed that the science funds allocated to the republics through the State Budget are used almost exclusively for civil purposes, as are most of the R&D funds that originate within industrial organs, exclusive of military industry.

Table 1

USSR: Estimated Expenditures for Research and Development a/
1950-70

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
	Billion Rubles																				
Total R&D																					
High estimate																			8.2	9.0	9.9
Best estimate	1.0	1.1	1.1	1.2	1.4	1.6	1.8	2.2	2.6	3.0	3.4	4.0	4.5	5.1	5.6	6.1	7.0	7.4	8.0	8.6	9.2
Low estimate																			7.8	8.2	8.6
Of which:																					
Military RDTE&S																					
High estimate	0.6	0.6	0.7	0.8	0.9	1.0	1.2	1.5	1.8	2.0	2.4	2.9	3.2	3.8	4.3	4.7	5.5	5.8	6.5	7.2	8.0
Best estimate	0.5	0.6	0.6	0.7	0.8	1.0	1.2	1.4	1.7	1.9	2.3	2.7	3.1	3.7	4.1	4.5	5.2	5.5	6.0	6.4	6.9
Low estimate	0.5	0.5	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	2.0	2.3	2.6	3.1	3.5	3.8	4.4	4.7	5.0	5.3	5.6
	Billion US $																				
Total R&D																					
High estimate																			18.9	20.8	22.8
Best estimate				2.4	2.7	3.1	3.7	4.4	5.3	6.3	7.3	8.6	9.9	11.5	12.9	14.1	16.2	17.2	18.4	19.8	21.2
Low estimate																			18.0	18.8	19.8
Of which:																					
Military RDTE&S																					
High estimate				1.5	1.7	2.0	2.5	3.0	3.6	4.2	5.1	6.1	7.1	8.6	9.9	10.9	12.6	13.4	14.9	16.6	18.4
Best estimate				1.4	1.6	1.9	2.4	2.9	3.5	4.0	4.9	5.8	6.8	8.2	9.5	10.4	12.0	12.7	13.8	14.8	16.0
Low estimate				1.2	1.4	1.6	2.0	2.5	2.9	3.4	4.1	5.0	5.8	7.0	8.0	8.8	10.2	10.8	11.5	12.2	12.8

a. See the Appendix for derivation of these data. Ruble figures have been converted to dollars on the basis of comparative wage costs and material and overhead costs in 1955 and in 1965. The resulting dollar figures should be viewed only as rough indicators of magnitude because of the uncertainty associated with this conversion.

I. Introduction

This report is an analysis of Soviet funding for research and development, with emphasis on financial support to military and space research. It covers the period 1950-67, with projections to 1970. Overall trends in Soviet financial support for military research and development, including space programs, are estimated and compared with approximately corresponding US data. All of the monetary data reflect current prices.

The analysis is addressed particularly to those specialized readers concerned with the cost of the Soviet military effort or the direction of Soviet science. For this reason, the evidence considered and the supporting methodology are unavoidably detailed. The discussion of the complexities of definition and measurement of R&D activity, the inherent uncertainties involved, and the methodology of the estimate, however, are kept for the most part to the Appendix.

The abbreviated term for all Soviet research and development used in this report--total R&D--includes basic and applied research, component and systems development, and final testing and evaluation of new designs, as well as all costs of space programs. The term military RDTE&S refers to that portion of total R&D which is primarily military, plus all of the space program.

Gaps in information and problems of monetary comparability continue to limit the precision of estimates of total funding levels for Soviet R&D. While actual expenditures could be somewhat higher or lower, estimated trends in overall growth are probably not markedly different from the actual trends as seen by Soviet leaders. Moreover, since the analysis of Soviet activity and the comparisons with the US that are presented in this report are concerned exclusively with costs of inputs, trends in R&D outlays assume greater significance than the actual spending levels. There are no appropriate measures of efficiency in the use of R&D resources in either country that would permit meaningful economic valuations of the output of R&D efforts.

The numerical findings in this report represent a special case among the military-economic estimates published by this Agency. This analysis differs from analyses of other components of Soviet military expenditures in that it is based very heavily on openly published Soviet financial data rather than on computations of the expenditure implications of observed and estimated military programs. Alternative intelligece sources--such as information on Soviet scientific manpower, R&D facilities and test ranges, and the RDT&E cost implications of developed and deployed weapons systems--have not yet yielded results adequate for an independent measure of total current Soviet programs or to permit precise insight into Soviet decision priorities in many sectors of military RDTE&S. This stems primarily from a lack of sufficient and accurate information on basic and supporting research and on applied R&D projects in their early stages.

Despite uncertainties in the details of Soviet statistical categories relating to definitions and concepts of R&D compared with those used in the US, broad comparability in coverage between the two sets of data is believed to exist. In general, higher levels of confidence may be associated with estimated trends in Soviet spending than with absolute levels of expenditure at a particular point in time. The ruble measures are probably a reasonably accurate reflection of the costs of committed resources as the Soviet planner sees them.

The findings of this study have intelligence utility in three important ways. First, they permit--in conjunction with estimates of costs of Soviet forces and deployed weapons systems--a measure of total military related activity in the USSR. Second, they permit conclusions on Soviet acceptance of heavy burdens against future, and often uncertain, payoffs in the strategic arena. Finally, they provide a base measure of total Soviet resources devoted to military RDTE&S against which further improvements in analysis--including estimating and summing more disaggregated levels of activity--can be judged. This report has been prepared and published in response to the needs of the intelligence community for a study that addresses these limited--but important--objectives.

II. Soviet Expenditures for R&D

A. Sources of Funds

There are three main sources of funds for R&D in the USSR: the allocation labeled "science" in the Social-Cultural category of the consolidated State Budget, allocations from other sections of that budget, and extrabudgetary sources such as industrial enterprises (see Figure 2).

The largest of these sources--typically over 70 percent of the total--is the explicit science allocation. Within this allocation, the all-union portion (central government account) has steadily become more dominant, accounting for 88 percent of the total by 1965. The all-union science budget supports the Soviet Academy of Sciences, scientific institutes "engaged in work of a theoretical nature," and "other works of national importance." 1/* The budgets of the union republics support their subordinate academies of science and other scientific organizations that are in large part concerned with R&D of local interest.

The budget category called Financing the National Economy (FNE) is estimated to be the source of about 10 to 15 percent of R&D funds. Although there is adequate evidence to tie the R&D funds to the FNE category of the budget, the evidence does not permit a precise measurement of their magnitude. The Soviets lump FNE funds for R&D with funds provided by enterprises under the label "other sources." 2/ Nonbudgetary enterprise funds are believed to constitute an additional 10 to 15 percent of estimated total R&D expenditures.

Finally, the defense allocation contains personnel-related expenditures for military manpower assigned to R&D activities. These costs are almost certainly not included in the announced Soviet expenditures for science. They are derived independently and are believed to represent a relatively minor portion of the estimated total.

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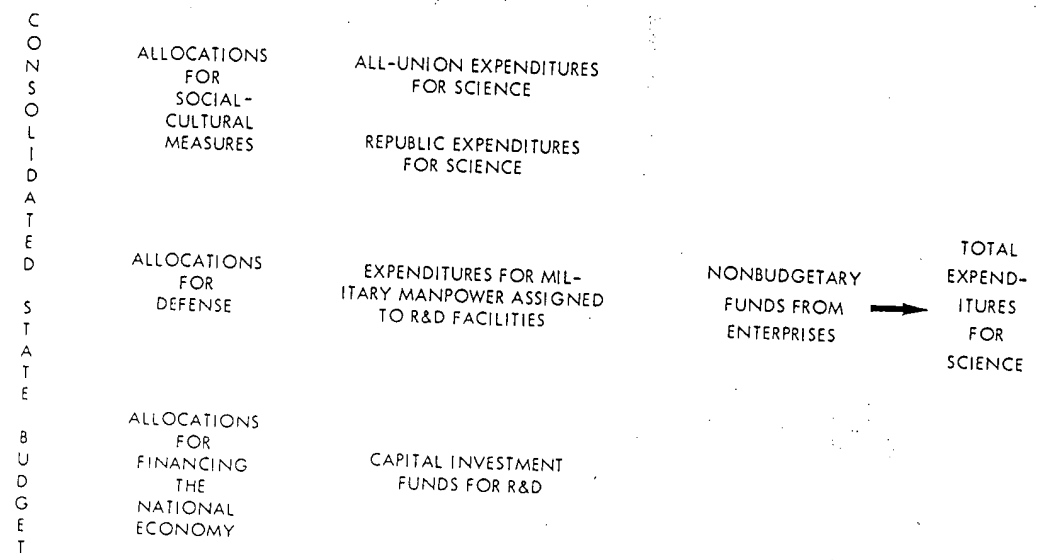
* *Sources are referenced in this manner throughout the report and are given in Section III of the Appendix.*

Figure 2

USSR: SOURCES OF FUNDS FOR SCIENCE



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B. Estimated Total Expenditures

The estimate of the growth in Soviet expenditures for total R&D for the period 1950-67, by source, is summarized in Figure 3.* The data are extrapolated to 1970 on the basis of current trends. The growth of these expenditures averaged more than 12 percent a year during 1950-67, as these funds expanded from one billion rubles in 1950 to 7.4 billion rubles in 1967. From 1953 to 1961 growth averaged 16 percent; since 1961 annual increases have ranged from 6 to 15 percent, averaging 11 percent for the period.

The estimated Soviet budgetary outlays for R&D rose from less than 2 percent of the consolidated State Budget in 1953 to more than 5 percent in 1967. Although definitional and measurement problems make the relationship imprecise, Soviet expenditures for R&D are currently about 3 percent of GNP--about double the share of 1953 GNP.

It seems reasonable that such trends cannot continue indefinitely. Growing awareness of the expanding requirements of R&D programs has brought demands by prominent Soviet planners for more study and research on the economic implications of R&D activity. Despite the decline in the rate of growth for Soviet R&D expenditures in recent years, annual increments to R&D expenditures are still substantial, and the latest data give little indication that a ceiling has been reached.

Expenditures in 1967 were only about 6 percent above 1966. A planned increase of 10.8 percent has been announced for 1968. 3/ However, a general revision of wholesale prices took place in

* *In this connection, R&D data contained in the recently published Strana Sovetov Za 50 Let (Fifty Years of the Soviet Nation) and Science Policy and Organization of Research in the USSR, by Unesco, have not been used for this analysis because of inconsistencies explained in Section I, C, of the Appendix.*

Figure 3

USSR: GROWTH OF ESTIMATED EXPENDITURES FOR RESEARCH AND DEVELOPMENT BY SOURCE OF FUNDS 1950-1970

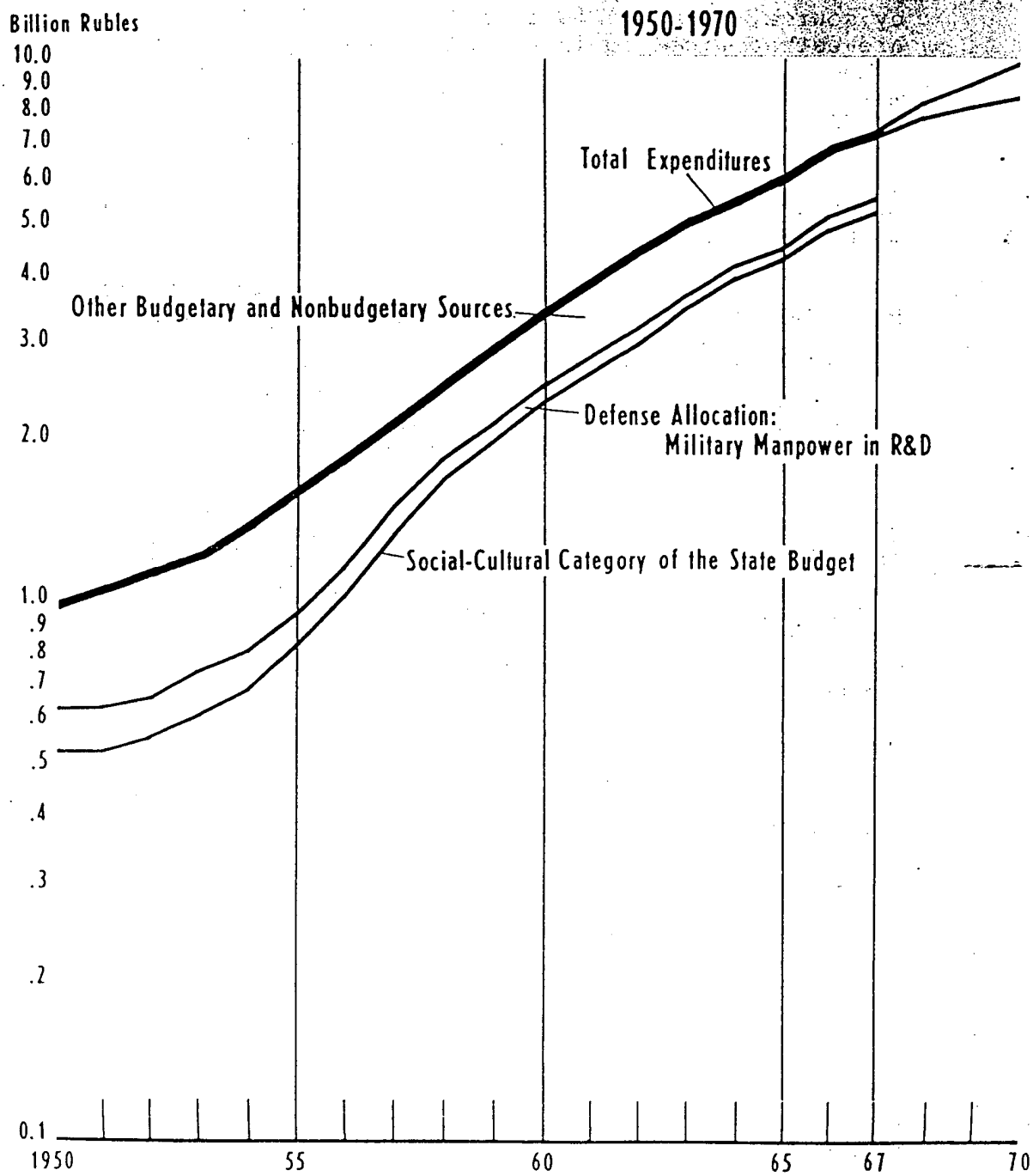

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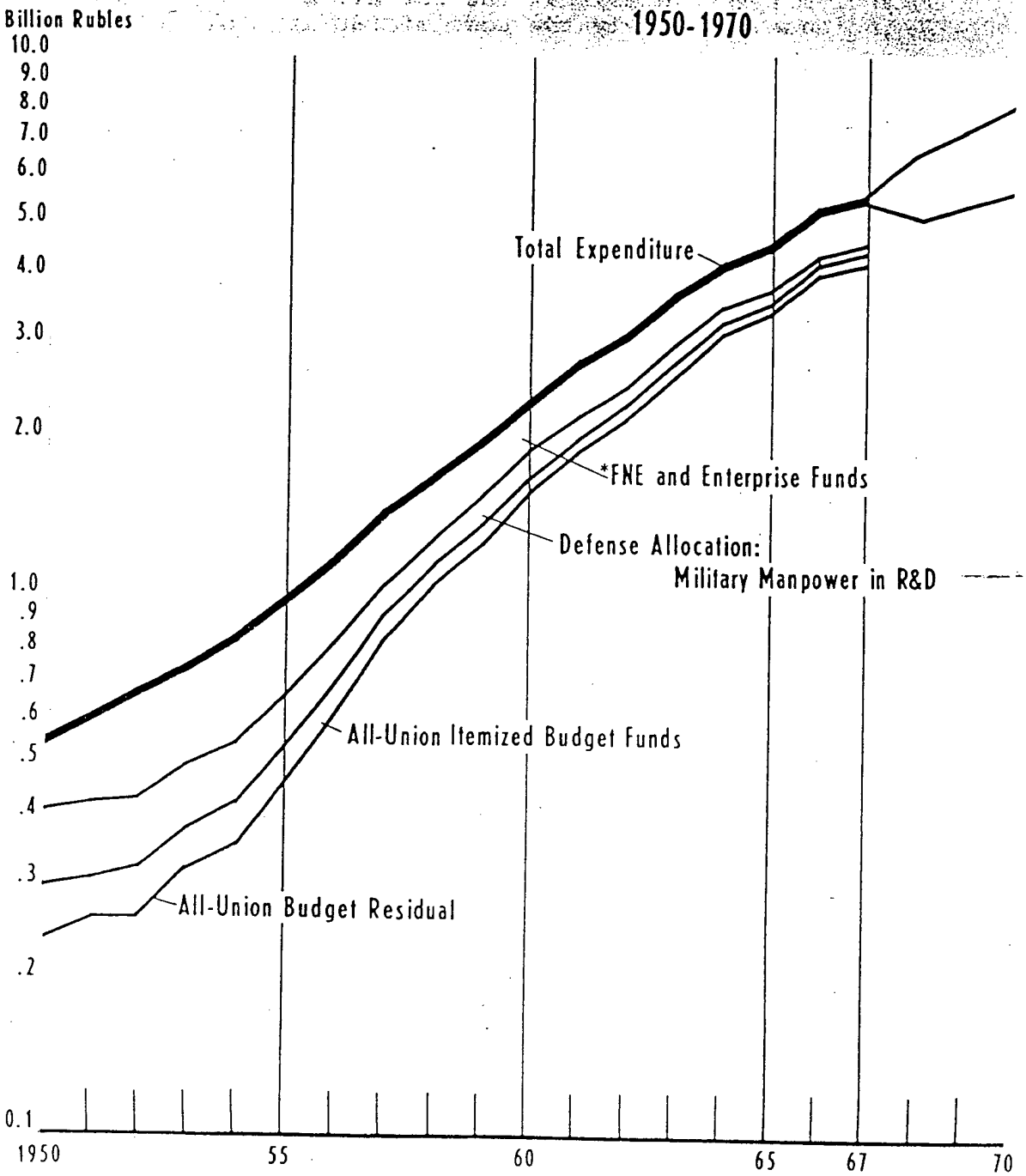
Figure 4

USSR: GROWTH OF ESTIMATED EXPENDITURES FOR MILITARY RDTE&S, BY SOURCE OF FUNDS 1950-1970



*Financing the National Economy Category of the State Budget

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the Soviet Union in 1967, and these changes will be reflected in 1968 expenditures. Preliminary analysis indicates that the net effect will be to increase moderately the cost of R&D inputs.

In constant prices the planned increase in expenditures is probably somewhat less than 10.8 percent. Through 1970 we estimate that an average rate of between 5 and 10 percent will occur. The lower limit represents a continuation of the decline in growth and a leveling off at about the expected rate of growth for GNP; the upper limit represents more nearly a continuation of the rates of growth of recent years.

C. Science Funds for Military and Space

Published Soviet data for the period 1950-60 yield several clues which make it possible to derive the aggregate level and to identify the trend of military RDTE&S outlays. Relevant sources of funds for military RDTE&S are primarily the all-union allocation for science from the Social-Cultural section of the consolidated State Budget and, secondarily, funds from the Defense and FNE categories of the budget and from enterprises of the defense industries.

1. All-Union Allocation for Science

It has been clear for some time from budgetary and related analysis that the all-union allocation for science has been the major source of funds for Soviet R&D of national interest. Given the strong Soviet orientation toward military RDTE&S, the large and rapidly growing all-union allocation has been viewed as the major source of funds for these programs. One Soviet source clearly associates science expenditures with the development of ballistic missiles and the space program. 4/ There was, however, little information which would permit quantification of the amount devoted to military and space purposes.

A statistical handbook published in 1958 provided the first real clues on military RDTE&S. A substantial amount of accounting detail

was included in this book on the Social-Cultural category of the consolidated State Budget for the period 1950-57. 5/ This handbook revealed the existence of a large and rapidly growing residual in the all-union science account. This residual was about 50 percent of the total allocation in 1950 and more than 60 percent by 1957. There has been no further publication of such detailed information. Although the precise nature of this residual cannot be determined, it is believed to encompass much of the funding for the nationally important R&D programs--such as atomic research, missile development, and the space program (see the Appendix).

Another part of the science allocation is also believed applicable in order to parallel more closely the US definition of military RDTE&S. This part--covering such activities as mathematical research and basic physical, psychological, physiological, and medical research--comes from the itemized portion of the science allocation and is estimated to be roughly one-third of it. These activities are carried out by institutes of the Academy of Sciences and the Academy of Medicine and are comparable to certain basic research activities financed by the US Department of Defense, some of the more public aspects of space research administered by the National Aeronautics and Space Administration, and unclassified research funded by the Atomic Energy Commission.

2. Other Sources

The total expenditures for science announced by the USSR have always contained a nonbudgetary element that was added to the consolidated State Budget allocation. Prior to 1958 these other funds were referred to as "enterprise funds," and they were thought to cover unclassified industrial R&D that was financed by setting aside a portion of the gross revenue of plants or industries. Specifically excluded from published announcements were large-scale appropriations for capital investment from accounts for Financing the National Economy (FNE) as well as research performed by teaching faculties at universities. 6/

The 1959 edition of the Soviet Statistical Handbook published for the first time data labeled as expenditures for science from the "budget and other sources." The new figures for selected earlier years (1950, 1953, 1956) were substantially higher than the science expenditures previously announced. 7/ The handbook showed no adjustment for that portion of science expenditures from the Social-Cultural category of the budget, therefore, clearly expenditures previously excluded had been added to enterprise funds to arrive at a new total for science. A more complete description of the coverage of the term "budget and other sources" appeared in the 1960 and subsequent editions of the handbook and indicated that the addition represented capital investment in facilities financed from the FNE budget category. 2/ Analysis of historical data reveals this new source to be another rapidly growing series (see the Appendix) suggesting that most of these funds were allocated to the construction of military RDTE&S facilities. We estimate that military and space programs received about three-quarters of these funds.

Wage, maintenance, and other support costs for military personnel assigned to R&D activities are also included in the estimate of military RDTE&S. The Defense category of the budget is almost certainly the source of funds for such costs. About one-fourth of the enterprise funds are also believed to support military RDTE&S programs. Soviet sources indicate that enterprises under the jurisdiction of the ministries of the defense industries follow generally the accounting and pricing procedures in commercial industry. Their prices for military hardware include certain additions above cost, including a planned profit, and they make deductions from revenues for special funds. 8/ Available evidence suggests that profits of the enterprises of the ministries of defense industries account for about 25 percent of all enterprise profits (see the Appendix). On this basis we estimate that the defense industry supplies a similar share of enterprise funds for science.

The estimate of the growth in Soviet expenditures for military RDTE&S for 1950-67 and extrapolations of current trends through 1970 are shown in Figure 4. The funding levels ascribed to the several sources are also identified. These expenditures are estimated to have increased from about one-half billion rubles in 1950 to about five and a half billion rubles in 1967. Between 1950 and 1967 the average annual rate of growth was nearly 15 percent. Between 1950 and 1960 the rate of growth and the level of expenditure were roughly the same as those for equipping and operating either the strategic offensive or strategic defensive forces. Since 1960, expenditures for military RDTE&S have grown at a substantially greater rate than those for the strategic forces, and by 1967 had reached a level about the same as that of the combined expenditures for both of the strategic forces.

In 1955 military RDTE&S expenditures accounted for about 6 percent of total expenditures for all military and space activities. By 1965 this share increased to some 25 percent. This trend parallels the US experience where spending for military RDTE&S grew from about 8 percent to 28 percent of the total from 1955 to 1965.

III. Research and Development and Soviet National Policy

Recent public statements seem to indicate that the 1970 plan goals for R&D expenditures had not yet been established by July 1967, and that the relative proportions for military, civilian, and space efforts had not yet been determined. 9/ Articles in the Soviet press have discussed economic management themes and stressed the need for better decision criteria in R&D activity. Some influential spokesmen, including a high official in the administration of science, believe an accelerated effort in industrial R&D would be worthwhile even if it were at the expense of such other programs as capital investment. 10/

Some resources could be shifted within the R&D programs. Soviet articles have indicated there is waste in military RDTE&S programs which have been strongly pervaded by autarchy. Trimming these

programs would ease the budgetary pressure generated by expanding strategic programs and by the need to improve R&D in support of the civilian economy. The degree to which the military is likely to tolerate economizing at the expense of its R&D programs cannot yet be determined.

That this appears to be a subject of military concern at the present time is evidenced by recent arguments in the Soviet military press. The writers have stressed the need for unrelenting efforts to break "newer and newer barriers" and the potential vulnerability of modern weapons to technological breakthroughs. The reiteration of R&D themes at this time suggests some connection with resource allocation issues currently under consideration. These issues could contribute to tensions between military and political leaders over the next few years.

Current Soviet military doctrine holds that support of research and development is an essential function of the "modern military economy." A recent journal lists the three most important military functions of the economy as: covering the current consumption of the armed forces, increasing the stocks of arms, and, chiefly, renovating the material-technical base for combat by developing new forms of weaponry and by replacing the new with the newest.

This formulation brings the modernists in the armed forces and the economic planners to a common ground. It provides a justification for the economic development of "progressive industry," represented by such branches as chemistry, metallurgy, and electronics, and for the development of resources in support of science. It represents a recognition that R&D on military systems conceivably could be of decisive importance in a future conflict.

Expenditures for total R&D and for military RDTE&S--which have grown at significantly faster rate than the rise of GNP--are drawing closer attention from the planners. Among questions being raised are: payoff criteria--more research for every ruble spent; long-lead planning; the mix between basic and applied research; and the priority to be given individual product development projects. 11/

At the 23d Party Congress in early 1966 the president of the Academy of Sciences discussed trends in the new Five-Year Plan, although he was indefinite on major issues. For example, he simply noted that, "Questions of the scale of scientific research, of the improvement of its organization, of the increase in its effectiveness, and of the quickest possible application of its results are among the basic questions of the further development of the country." He had nothing further to say about the scale of effort during the plan period. Concerning the other issues, he did indicate that an effort would be made to improve the work of the design bureaus by encouraging "great scientists" to participate actively in carrying their ideas to fruition. He referred to efforts to improve incentives, and stressed efforts to concentrate the attentions of scientific workers and to avoid diffusion of work.

Following the party congress, a major statement by the government was issued defining the current mission of the State Committee for Science and Technology. 12/ The committee was charged with conducting a technical and economic appraisal of the level of development of science and technology in the economy and with developing and implementing means to increase technical progress. The committee was to work in close cooperation with the Academy of Sciences and with government bodies, to develop long-term plans and to help establish the priority of the development effort within the economy. The need for this review would explain the delay in presenting a long-term plan for science.

There have also been proponents of acceleration of R&D activity seemingly related primarily to civilian R&D. In this context Academician Trapeznikov, deputy chief of the State Committee for Science and Technology, early in 1967 stressed the importance of competitive development, including increases in the allocation of resources to developmental engineering. 10/

Another article appearing in September 1966 also made a strong plea for increases in civilian R&D--setting the 1970 target on the basis of a growth rate averaging 16 to 20 percent. By the author's calculation, the plan in 1967 should be for expenditures of 7.5 billion to 8.5 billion rubles (actual expenditures were 7.2 billion rubles), and he recommended that the forms of financing should be made more flexible in order to stimulate activity in desired fields. According to the author, salaries are too low either to keep the necessary scientific personnel within industry or to attract new personnel. 13/

On balance, the tenor of the literature and the array of organizational points of view involved in recent writing suggest that decisions on future funding levels for Soviet R&D and space programs are being widely discussed. Moreover, both civilian and military programs seem to be facing a strong impetus to cull out projects not likely to be profitable and others considered unnecessarily duplicative. Gosplan chief Baybakov specifically referred to this effort in his presentation of the 1967 plan. 14/

APPENDIX

This appendix reviews some of the more technical problems involved in the development of data on expenditures for R&D for the US and the USSR. Section I covers the concept of R&D and the related definitions used in the US and compares US and Soviet statistics. Section II describes the methods used to extrapolate and interpolate Soviet data. Section III lists the sources keyed to reference numbers in the text.

I. Concepts, Definitions, and Data

A. US Concepts and Definitions

In the US, the National Science Foundation (NSF) is the major source for basic definitions of R&D and for quantitative data which describe its funding and performance. As NSF notes:

> The term "research" is often used with considerable looseness--in some instances as synonymous with basic research, and in others as an abbreviation for research and development. Lack of precision in the use of these terms often results in apparent inconsistencies in the funds that are attributed to "research" performance by different writers. 15/

The problems are practical as well as semantic. For example, there is no clear line of demarcation between research and development and the preparatory stages of series production, nor between innovative design that results in the development of new products or processes and production design directed at providing modified products or processes.

In this report R&D covers the whole range of activity that begins with basic scientific investigation and extends to, but does not include,

commercial or operational production. This usage derives from the following definitions by the National Science Foundation:

> Research as an essential scientific activity is generally regarded as a seeking for knowledge and understanding for the direct or indirect benefit of all. ...Basic research is ... research in which the primary aim of the investigator is fuller knowledge or understanding of the subject under study rather than, as in the case with applied research, a practical application thereof.
>
> Development builds on the findings of research and leads to specific achievements in diverse areas such as industrial production, medical care, military defense, and air safety. Sometimes requiring exotic and expensive hardware, development accounts for a much larger portion of the total R&D funds expended in the nation than does research. 16/

Efforts of this scope have been labeled "research, development, test, and evaluation" activities (RDT&E) by the Department of Defense. The intelligence community has broadened this concept to research, development, test, evaluation, and space activities (RDTE&S), because of the difficulty of sequestering funding for space activities and distinguishing civil and military space activities in any meaningfully precise way.

B. US Data

The US has been attempting to make comprehensive, consistent, and reasonably sophisticated measurements of its national R&D effort for only a relatively short period of time. The results are a historical series for R&D funds for 1953-67 presented in two ways--by performer, and by source

(see Table 2). Industry is the dominant performer of R&D, regularly accounting for 70 percent or more of all R&D. The US Government on the other hand is the major source of funds. Moreover, it has provided an increasing share of the funds over the years, about 55 percent in 1953 to about 65 percent in 1965-66.

Military RDTE&S cannot be clearly delineated from other R&D as these are not necessarily mutually exclusive categories. For the US, military RDTE&S activities are defined to be the equivalent of those activities covered by the R&D budgets of the Department of Defense (DoD) and the Atomic Energy Commission (AEC), and the entire budget of the National Aeronautics and Space Administration (NASA). This definition is workable, but somewhat deficient in conceptual terms. It omits privately financed R&D which may have implications for military and space capabilities, and it includes some basic research undertaken by these agencies of the kind often performed under the auspices of a university or foundation. The amounts involved are relatively small and offsetting, however, and would be impossible to categorize fully.

To determine US costs of military RDTE&S it is necessary to know the funding supplied by DoD, AEC, and NASA. However, the NSF series Funds for R&D provides only the total funds received from the government sector (see Table 2). Detailed information on budgetary expenditures for R&D by federal agencies is available from another series, Federal Expenditures for Research and Development, which we abbreviate as Federal Expenditures. From these data it is possible to compute the total expenditures for military RDTE&S as defined above. Federal expenditures for military RDTE&S regularly account for about 90 percent of all federal expenditures for R&D (see Table 3).

The Federal Expenditures series, however, is not directly comparable with the Funds for R&D series. The Funds for R&D data are reported on a calendar year basis and are obtained from performers of R&D. Furthermore, Federal Expenditures data include capital expenditures rather than depreciation,

Table 2

US: Funds for Research and Development a/
1953-67

Billion US $

	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965 b/	1966 b/	1967 c/
Total R&D	5.31	5.73	6.27	8.47	9.90	10.85	12.52	13.71	14.50	15.61	17.35	19.18	20.47	22.22	23.80
By Performer:															
Federal government	1.01	1.02	0.90	1.04	1.22	1.37	1.64	1.73	1.87	2.10	2.28	2.84	3.09	3.26	3.36
Industry	3.63	4.07	4.64	6.61	7.73	8.39	9.62	10.51	10.91	11.46	12.63	13.51	14.20	15.40	16.61
Colleges and universities	0.48	0.52	0.59	0.67	0.77	0.89	1.02	1.19	1.38	1.61	1.89	2.22	2.51	2.83	3.04
Other nonprofit institutions	0.11	0.12	0.14	0.15	0.18	0.20	0.24	0.28	0.34	0.44	0.55	0.61	0.67	0.73	0.79
By Source:															
Federal government	2.75	3.12	3.49	4.84	6.10	6.76	8.04	8.72	9.22	9.88	11.22	12.53	13.07	14.07	14.93
Industry	2.24	2.36	2.51	3.34	3.46	3.70	4.06	4.51	4.75	5.12	5.44	5.88	6.53	7.21	7.87
Colleges and universities	0.15	0.17	0.19	0.20	0.23	0.26	0.29	0.33	0.37	0.42	0.49	0.56	0.64	0.70	0.75
Other nonprofit institutions	0.07	0.07	0.08	0.09	0.11	0.12	0.14	0.15	0.16	0.19	0.20	0.21	0.23	0.24	0.25

a. Source reference for these data.17/ Data cover total costs including depreciation and overhead and excluding capital expenditures. Because of rounding, components may not add to the totals shown.
b. Preliminary.
c. Estimated.

Table 3

US: Federal Expenditures for Research and Development a/
Fiscal Years 1953-67

	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966 b/	1967 b/
	Billion US $														
Total federal expenditures for R&D	3.10	3.15	3.31	3.45	4.46	4.99	5.80	7.74	9.28	10.37	11.99	14.69	14.87	15.96	16.15
Of which:															
Expenditures for military RDTE&S c/	2.91	2.96	3.09	3.18	4.10	4.55	5.21	7.04	8.47	9.34	10.72	13.20	13.34	13.97	13.70
Department of Defense	2.45	2.49	2.63	2.64	3.37	3.66	4.18	5.65	6.62	6.81	6.85	7.52	6.73	6.85	6.89
NASA	0.08	0.09	0.07	0.07	0.08	0.09	0.15	0.40	0.74	1.25	2.54	4.17	5.09	5.60	5.30
AEC	0.38	0.38	0.39	0.47	0.66	0.80	0.88	0.99	1.11	1.28	1.34	1.51	1.52	1.52	1.51
	Percent														
Military RDTE&S as a percent of total federal expenditures for R&D	94	94	93	92	92	91	90	91	91	90	89	90	90	88	85

a. Source reference for these data.18/ Data cover all expenditures including capital expenditures; pay allowances of military R&D personnel; and support from procurement appropriations for development, test, and evaluation activities.
b. Estimated.
c. Because of rounding, components may not add to the totals shown.

Table 4

US: Comparison of the Two NSF Series on Federally Sponsored Research and Development
1953-66

Billion US $

	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Total for 1953-66
Data from Federal Expenditures series a/	3.12	3.23	3.38	3.95	4.73	5.40	6.77	8.51	9.83	11.18	13.34	14.78	15.42	15.06	119.71
Data from Funds for R&D series b/	2.75	3.12	3.49	4.84	6.10	6.76	8.04	8.72	9.22	9.88	11.22	12.53	13.07	14.07	113.81

a. From Table 3. Data are adjusted to calendar basis by averaging adjacent years.
b. From Table 2.

while Funds for R&D data exclude capital expenditures and include depreciation. Nevertheless, over the long run we should expect these two series to equate reasonably well. They are presented in Table 4. There are sizable differences between the two series in certain years, and for the 1953-66 period as a whole, federal agencies have reported R&D expenditures 5 percent greater than the total reported by the performers. Consequently, comparison of US military RDTE&S with total R&D on an annual basis cannot be considered precise.

C. Soviet Data Compared with US Data

The Soviet series labeled "expenditures for science (nauka)" is an older series than its US counterpart. Two basic figures are usually published annually. One figure is reported as a component of expenditures for the Social-Cultural category, one of the major expenditure categories of the consolidated State Budget. The second, and larger, figure includes this budgetary account and is described as expenditures for science from the "budget and other sources." "Other sources" include funds of industrial enterprises and organizations, and the items from the Financing the National Economy (FNE) category of the State Budget. 2/ The published Soviet data are shown in Table 5.

The USSR does not provide any direct or specific information regarding the concepts involved and the methodology employed in the collection and presentation of these statistics. Although there are important institutional and procedural differences, the evidence indicates that the USSR does subscribe to a concept which is compatible with that used in the US. The Soviets seem to perceive science as embracing a range of activities beginning with basic investigation of the environment and culminating just prior to the initiation of commercial or operational production.

Table 5

USSR: Announced Expenditures for Science a/
1950-67

Billion Rubles

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Total expenditures for science b/	0.88	NA	NA	1.11	NA	NA	1.71	NA	2.40	2.80	3.27	3.78	4.28	4.91	5.38	5.88	6.77	7.30
Expenditures for science from Social-Cultural category of the State Budget c/	0.52	0.52	0.55	0.61	0.67	0.81	1.01	1.34	1.68	1.98	2.31	2.65	2.98	3.44	3.95	4.27	NA	NA
All-union budget c/	0.40	0.41	0.44	0.49	0.54	0.67	0.84	1.09	1.33	1.55	1.87	2.18	2.48	2.97	3.46	3.75	NA	NA
Budgets of the union republics c/	0.12	0.11	0.11	0.12	0.13	0.14	0.17	0.25	0.35	0.43	0.45	0.48	0.50	0.48	0.49	0.52	NA	NA
Other expenditures for science d/	0.36	NA	NA	0.51	NA	NA	0.70	NA	0.72	0.82	0.95	1.12	1.30	1.47	1.43	1.61	NA	NA

a. All series have been adjusted for the transfer in 1964 of expenditures for museums and exhibits from the science account to the account for cultural-educational work. 27/ Because of rounding, components may not add to the totals shown.
b. Source references: 1950, -53, -56, -58, and -59. 7/ 1960. 28/ 1961-62. 29/ 1963. 30/ 1964. 31/ 1965. 32/ 1966. 33/ 1967. 3/
c. Source references: 1950-57. 34/ 1958-59. 35/ 1960-65. 27/
d. Residual.

The Soviet term "nauka," however, is almost synonymous in meaning with knowledge and pertains to much more than just the physical and natural sciences. It covers such additional disciplines as law, economics, history, linguistics, and the like. Fortunately, for comparative purposes, the NSF concept covers more territory than is often realized. To the extent that social science research is financed and performed in the government, universities, or other nonprofit institutions, the costs are included in US figures. 19/ Social science research in US industry is not included because it has not been adequately defined to permit its measurement in an accounting sense. Nevertheless, such research certainly would not significantly affect the aggregate industrial expenditures for R&D. Because nontechnical R&D does not require the expensive equipment and hardware of technical R&D, any differences that may exist in the coverage of nontechnical R&D probably do not seriously affect the comparability of US and Soviet data.

While US data are collected by surveys and are based on prescribed definitions, Soviet data primarily represent the funding of a variety of institutions and facilities. When talking about science, Soviet writers refer to "scientific research institutes, design bureaus, scientific research institutions for construction, and project and design institutes or bureaus." The research institutes engage in basic and applied research and development, hence are clearly covered by the definition of R&D used here. Some of these institutes have associated design bureaus probably involved in the design, building, and testing of prototypes--again activity within the definition. The situation with regard to other project and design institutes--those apparently involved in routine drafting and design work for production and construction--is unclear.

Science expenditures cannot be related to the various institutes and activities with precision. Budgetary expenditures for science apparently support primarily the scientific research institutes and their subordinate institutes and bureaus. The

remaining science funds (those of enterprises and organizations) are not sufficient to support all the various project and design bureaus. It seems reasonable, therefore, to conclude that science expenditures do not finance a large amount of routine design work. 20/

The reporting of the performance of research financed by nonbudgetary funds depends in large part upon the reporting procedures of the Central Statistical Administration. The Soviets have indicated that some of this activity may not be reported properly and, therefore, is not reflected in the expenditure data for science. 21/ It appears that the cost of much of the traditional university research, which is performed in school laboratories by personnel whose primary function is teaching, is reported as part of the general operating cost of the university and not as part of expenditures for science. Also, the cost of R&D performed in plant laboratories is not always reported as science expenditure. In the case of these possible omissions, however, it seems reasonable to assume that the volume of activity is not great enough to have a significant effect on the aggregate data.

US and Soviet data treat capital investment in facilities and equipment differently. The NSF asks respondents to include operating expenses incurred in the conduct of research and development such as wages, salaries, materials, and supplies consumed, property and other taxes, maintenance and repairs, overhead, and depreciation. 22/ The inclusion of depreciation, which is not an expenditure, and the exclusion of capital investment, which is an expenditure, tend to understate actual expenditures during periods of expanding investment in R&D and to overstate actual expenditures when such activity levels off or declines.

Soviet data do not include charges for depreciation. On the question of capital investment expenditures Soviet sources are ambiguous, contradictory, and inconsistent. Expenditures for science from the budget and other sources have been assumed to include virtually all capital investment. A recent Unesco publication on Soviet R&D, however, gives separate figures for capital

investment for the years 1959-67 which are added to expenditures from the budget and other sources to arrive at a new total figure for science. 23/ This process also appears to clear up the confusion surrounding the larger figures for science expenditures which appeared in a recent Soviet statistical publication. 24/

The trouble with accepting the new data at face value is that it contradicts other official Soviet sources. The Unesco report clearly indicates that no capital investment funds are included in the data for science expenditures from the budget and other sources. Specific figures for capital investment financed by the science budgets of the union republics are available, however, for each year from 1950 through 1965. Similar data are available from the all-union budget from 1950 through 1957, when the Soviet Union stopped providing such detail, apparently for security reasons. In addition, the official statistical handbook indicates that capital investment expenditures for science are provided by the FNE budget category and are included in the "budget and other sources" expenditure figure (see the discussion of military RDTE&S expenditures in Section II, B, of this Appendix). Until these contradictions are clarified, a strong possibility of double counting must be associated with the new data.

Use of these new data would not have much effect on the rate of growth of science expenditures, but it would serve to increase their magnitude by about one-sixth in each year.

Despite the data problems on both sides of the Iron Curtain, we believe the Soviet concept, "science," and the US concept, "R&D," as expenditure categories are comparable at least in a very general aggregative sense. There is evidence to indicate that this is the view of the Soviets also. They have shown themselves to be familiar with the NSF figures on US R&D and have discussed their own science expenditures in the same context without expressing significant reservations about the total range of the US R&D activity or the relevance of aggregate data on US R&D expenditures. 25/

II. Interpolation and Extrapolation of Soviet Data

In order to develop complete annual series for Soviet expenditures for all R&D and for the military and space components, it is necessary to fill a number of gaps in the Soviet data. Many of these gaps are indicated in Table 5.

A. Total Expenditures for R&D

Table 6 is a detailed breakdown of estimated Soviet expenditures for all R&D for the years 1950-67. The series shown are based on Soviet data with the exception of the cost of military manpower supporting R&D. As explained in the body of the report, this series is computed independently on the basis of estimated military manpower assigned to R&D.

The Soviets have not announced figures for total expenditures for science for the years 1951, 1952, 1954, 1955, and 1957. For the first four years estimates were made by applying the average annual rate of growth for the period 1950-53 to 1951 and 1952 and for the period 1953-56 to 1954 and 1955. The science allocation for 1957 in the Social-Cultural category of the consolidated State Budget represented a sizable increase relative to 1956. This increase was too large to be covered by application of an average rate of growth. Failure to cover the increase in the budgetary account would imply that R&D financed from other sources declined in 1957.

It could be argued that the increase in this 1957 budgetary figure resulted from transferring to this account activities which previously had been funded from other sources. Since 1957, however, funds from other sources have continued to grow and are always greater than the 1957 figure. It does not seem likely, therefore, that the aggregate of funds from other sources declined in 1957. Total expenditures for science were increased by the amount of the documented increase in the Social-Cultural science account of the consolidated State Budget in 1957.

Table 6

USSR: Total Expenditures for Research and Development, by Source of Funds a/
1950-67

Billion Rubles

Source	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Social-Cultural category of the State Budget b/	0.57	0.52	0.55	0.61	0.67	0.81	1.01	1.34	1.68	1.98	2.31	2.65	2.98	3.44	3.95	4.07	4.94 c/	[illegible] c/
All-union budget	0.40	0.41	0.44	0.49	0.54	0.67	0.84	1.09	1.33	1.55	1.87	2.18	2.48	2.97	3.46	3.75	4.39 c/	[illegible] c/
Budgets of the union republics	0.16	0.11	0.11	0.12	0.13	0.14	0.17	0.25	0.35	0.43	0.45	0.48	0.50	0.48	0.49	0.52	0.55 c/	0.55 c/
Financing the National Economy category of the State Budget c/	0.11	0.16	0.18	0.21	0.31	0.35	0.40	0.42	0.40	0.40	0.48	0.56	0.65	0.73	0.71	0.80	0.91	[illegible]
Enterprise funds d/	0.21	0.27 e/	0.30 e/	0.30 e/	0.30 e/	0.33	0.30	0.28	0.32 e/	0.42 e/	0.47 c/	0.56 c/	0.65 c/	0.74 c/	0.72 c/	0.81 c/	0.96 c/	0.97 c/
Total expenditures for science from the State Budget and other sources b/	0.88	0.95 c/	1.03 c/	1.11	1.28 c/	1.48 c/	1.71	2.04 c/	2.40	2.80	3.27	3.78	4.28	4.91	5.28	5.88	6.77	[illegible]
Cost of military manpower for R&D f/	0.11	0.11	0.11	0.12	0.12	0.12	0.13	0.14	0.15	0.16	0.17	0.19	0.20	0.20	0.20	0.21	0.22	[illegible]
Estimated total expenditures for R&D	0.99	1.06	1.14	1.23	1.40	1.60	1.84	2.18	2.55	2.96	3.44	3.97	4.48	5.11	5.58	6.09	6.99	[illegible]

a. Actual expenditures including capital expenditures. Because of rounding, components may not add to the totals shown.
b. From Table 5, unless otherwise indicated.
c. Estimated.
d. Large enterprises for 1950-59. e/
e. Estimate of the above source.

Table 7

USSR: Expenditures for Military RDTE&S, by Source of Funds a/
1950-67

Source	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
	Billion Rubles																	
All-union budget residual b/	0.23	0.25	0.25	0.31	0.34	0.45	0.60	0.82	1.05 c/	1.26 c/	1.56 c/	1.85 c/	2.13 c/	2.61 c/	3.07 c/	3.34 c/	3.94 c/	4.16 c/
All-union itemized budget funds c/	0.06	0.05	0.06	0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.13	0.14	0.15	0.15
Financing the National Economy category of the State Budget c/	0.08	0.12	0.14	0.16	0.23	0.26	0.30	0.32	0.30	0.30	0.36	0.42	0.49	0.55	0.53	0.61	0.68	0.73
Enterprise funds c/	0.06	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.10	0.12	0.14	0.16	0.18	0.18	0.20	0.23	0.24
Cost of military manpower for R&D c/ d/	0.11	0.11	0.11	0.12	0.12	0.12	0.13	0.14	0.15	0.16	0.17	0.19	0.20	0.20	0.20	0.20	0.22	0.23
Total	0.54	0.60	0.64	0.73	0.84	0.98	1.19	1.44	1.67	1.92	2.31	2.71	3.09	3.66	4.11	4.49	5.22	5.51
	Percent																	
Total military RDTE&S as a percent of total expenditures for R&D c/	55	57	56	59	60	61	65	66	65	65	67	68	69	72	74	74	75	74

a. Actual expenditures including capital expenditures.
b. Source reference for 1950-57. 24/
c. Estimated.
d. From Table 6.
e. See Table 6 for total Soviet expenditures for R&D.

The difference between total expenditures for science and expenditures from the science allocation of the consolidated State Budget is believed to represent funds from two sources. As noted in the body of this report, one source is locally generated funds labeled "enterprise funds" and the other is unidentified funds included in the FNE category of the State Budget. For the period 1950-59 Soviet figures are available for enterprise funds, although in seven of these ten years, estimates have been made because only plan figures were announced. 26/ No stable relationship can be identified, and the figures after 1959 have been determined by assuming that one-half are enterprise funds and the other half FNE budget funds. This is admittedly a rough approximation, but it is consistent with the figures for 1959, the last year for which Soviet data were available.

B. Expenditures for Military RDTE&S

Table 7 presents the components of the estimated expenditures for Soviet military RDTE&S.

1. The All-Union Residual

In 1958 the USSR published a small social-cultural, statistical handbook which itemized expenditures for science in the consolidated State Budget for the period 1950-57. This handbook provided detail for this account as a whole and also for the union republics. Thus, it has been possible to derive the same detail for the all-union account (the central government account) by subtracting the republic data from the State Budget totals.

The summation of the itemized science expenditures in the budgets of the union republics about equals the total given for these expenditures. The detail for the all-union budget, however, leaves unexplained a substantial and rapidly increasing residual. The failure to reveal the detail plus the size and rate of growth of this residual suggest it is probably an important source of military RDTE&S funds. The Soviet government, itself, has identified the all-union science allocation as the

source of funds for "works of national importance," and Soviet literature has associated science expenditures with ballistic-missile development and the space program. 4/

The next budget handbooks published in 1962 and 1966 were limited to detail for the republic budgets for science. No detail for the total State Budget for science, hence no means of deriving detail for the all-union account, was included.*

The rate of growth of the residual is significant. In 1950 the unexplained residual was 0.23 billion rubles, or 57 percent of the all-union science budget. In 1957 it was 0.82 billion rubles--three and one-half times the 1950 level, and 75 percent of the all-union science budget. During 1953 through 1957 the annual increase in the residual as a percent of the annual increase in the all-union budget grew from 60 percent to 88 percent. In projecting the all-union residual beyond 1957 this trend has been continued so that the share of the annual increase in the all-union budget which is part of the residual grows to 94 percent before stabilizing.

2. Other Sources

The derivation of the series that represents unidentified funds for R&D in the State Budget is as follows:

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* *It might be noted, too, that there are other examples of Soviet data containing unexplained residuals, which suggest coverage of activities affected by the Soviet State Secrets Act.* 36/

	Billion Rubles							
	1950	1951	1952	1953	1954	1955	1956	1957
Total science expenditures*	0.88	0.95	1.03	1.11	1.28	1.48	1.71	2.04
Less Social-Cultural budget expenditures *	0.52	0.52	0.55	0.61	0.67	0.81	1.01	1.34
Equal funds from other sources	0.36	0.43	0.48	0.51	0.61	0.68	0.70	0.70
Less enterprise funds*	0.25	0.27	0.30	0.30	0.30	0.33	0.30	0.28
Equal net addition to science expenditures	0.11	0.16	0.18	0.21	0.31	0.35	0.40	0.42

The total expenditures series, adjusted for the Soviet redefinition in 1959, less budgetary expenditures for science (the same before and after the 1959 revision) gives a series that the Soviets call "other sources." Before 1959 the Soviets announced a series labeled "enterprise funds for science" and this series, subtracted from the revisions announced in 1959, brings out a new series that represents the net addition to total science expenditures resulting from the 1959 adjustment in reporting procedures.

In 1958, Minister of Finance A. G. Zverev wrote that published science expenditure figures did not include "large allocations for capital investment and equipment being allotted to scientific research establishments at the expense of the national economic plan." 6/ After the 1959 revisions, the 1960 edition of the Statistical Handbook and succeeding editions describe Social-Cultural expenditures as including

* *From Table 6.*

capital investment in construction provided by the sources for financing the national economy. 2/ Science is specifically included as a component of the Social-Cultural category, and it is quite probable that the 1959 revisions picked up the FNE funds which Zverev had noted as formerly excluded from science expenditure data. The new series grows rapidly, and it is estimated that about three-quarters of these funds are allocated to capital investment in support of military RDTE&S.

The announced Soviet data for total science expenditures were fragmentary during the 1950's, both before and after the 1959 adjustments. Often a planned figure was announced, but actual expenditures were only occasionally provided. Either by coincidence or design, the revised Soviet figures for annual science expenditures, with the exception of 1950, were not published for the same years for which the Soviets had announced actual expenditures under pre-1959 definitions. Therefore, a direct calculation of the addition to science expenditures resulting from the 1959 revision cannot be made, as is shown by the following tabulation (in billion rubles):

Announced Actual Expenditures for Science

Year	Old Series 26/	1959 Revision
1950	0.79	0.88
1951	NA	NA
1952	NA	NA
1953	NA	1.11
1954	NA	NA
1955	1.15	NA
1956	NA	1.71
1957	1.64	NA
1958	NA	2.40

The financial plan for enterprises controlled by the ministries of the defense industries includes a planned profit from which deductions are made for the enterprise fund as is the case with civilian industry. 8/ An indication

of the magnitude of the defense industry profits was provided by a recent journal article 37/ that reported the profits of the various ministries for the first five months of 1967. No data was provided for the ministries of the defense industries and, significantly, the itemized profits accounted for only about 75 percent of reported total profits. We believe that the defense industries account for most of the remaining 25 percent of profits, and on this basis judge that they probably provide a similar portion of the enterprise funds for science.

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