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SOVIET IMPLEMENTATION OF DOMESTIC INVENTIONS: FIRST RESULTS

(By John A. Martens and John P. Young*)

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I. Introduction

Because the Soviet Union must rely increasingly on "intensive" sources of economic growth—principally technological advance—to halt or reverse the secularly declining economic growth rates of the 1960's and 1970's, the performance of the Soviet economy in generating, assimilating, and diffusing new technology is attracting increasing attention by both Western and Eastern economists. With the increased importance of science and technology has come an awareness in the Soviet leadership that advances must be channeled to economically effective ends, and that implementation of developed technology, in the words of General Secretary Brezhnev, is the "weak link" in the chain of development from research to production.

Recent studies by Western researchers describe well many of the institutional and managerial impediments to technical innovation within the Soviet economy.[1] For the most part, however, data limitations have forced researchers to rely on case studies, anecdotal material, and enunciated Soviet policy to identify these impediments to

*This is a staff research note. It is an analytic document and should not be construed as a statement of Commerce Department policy. The authors wish to thank Ron Oechsler and Bob Teal for their computational assistance.

[1] Joseph S. Berliner, The Innovation Decision in Soviet Industry (Cambridge: The MIT Press, 1976); Ronald Amann, Julian Cooper and R. W. Davies (ed.), The Technological Level of Soviet Industry, (New Haven: Yale University Press, 1977).

innovation and evaluate their relative importance. While an accurate overall general picture has thus emerged, the absence of rigorous empirical tests has limited our ability to compare Soviet and Western performance, to evaluate trends in Soviet performance, and to identify performance variations within Soviet industry.

This study considers an important aspect of technical innovation, the implementation of inventions in Soviet industry. Our analysis is based on a random sample of data from a Soviet journal—*Vnedrennye izobreteniya* (*Introduced Inventions*). Later in the paper we describe the sample more fully. First, inventions are grouped by technical area. Second, the flows of inventions among originating and implementing industrial sectors and the flows of inventions among originating and implementing facility types are described. These groupings allow us to analyze more carefully bureaucratic and organizational influences on the innovation process. Third, the flows of inventions among originating and implementing regions are described and permit us to analyze the influence of location on technical innovation. We then calculate statistically the impact of certain technical and organizational factors on a critical indicator of implementation performance—lead time, a period beginning with the filing of an application for a Soviet inventor's certificate and ending with the certification by the implementing facility that the invention has been implemented. Finally, we contrast Soviet lead times with those in the United States and the Federal Republic of Germany, based on the results of similar studies undertaken for those countries. Here we attempt to establish quantitatively whether the Soviet Union is, in fact, a slower implementer of inventions than are selected Western countries.

Before presenting the results, we briefly describe the concept of invention in the Soviet Union, the administrative network established to foster and regulate inventing activity, and the role of implemented inventions in Soviet technical progress. This discussion, apart from defining technology, will serve to clarify the kind of technical advances represented by the object of our analysis—the implemented invention.

II. The Invention in the Soviet Union

A. Standards for Inventions

In the abstract, inventing activity, or the act of conceiving a new product or process and solving the technical problems associated with its application, is not inherent to a particular nation or culture National differences do arise, however, when the invention becomes a "patented" invention, since somewhat different criteria are applied by most countries in determining which inventions will be accorded patent rights. Because it is the formally certified Soviet invention (*izobreteniye*) that is the basis for our sample, we describe the legal criteria that a proposed invention must satisfy to be awarded a Soviet inventor's certificate.[2]

[2] In the Soviet Union inventions can be protected in two ways—a patent or an inventor's certificate. A patent confers on the patentee the exclusive rights to the invention. An inventor's certificate transfers the exclusive rights to the invention to the state.

Both foreigners and Soviet citizens have the right to choose either form of protection. However, Soviet legislators clearly expect foreigners to choose patents, while Soviets are to choose inventor's certificates. In the last forty years only about forty patent grants were made to Soviet citizens. For a more detailed description of this dual system of protection see John A. Martens, "Patents and Soviet Socialism: the Formative Years, 1919–1931," Osteuropa Recht, 1977, No. 4, 251–280.

Historically, the term invention has always had a distinct and consistent legal meaning in the Soviet Union, and almost always connotes patentability (*patentnosposobnost'*). The chief legal characteristics of inventions are defined by the Statute on Discoveries, Inventions and Rationalization Proposals of 1973 [3] and include: novelty, usefulness, being technological in nature, and being sufficiently disclosed.

Novelty.—According to Soviet law: "A solution shall be recognized as new if, * * * the essence of that solution or an identical solution has not been disclosed in the USSR or abroad to an indefinite circle of persons in such a way as to enable the solution to be realized." In other words, the newness of an invention is not relative only to technical developments existing in the Soviet Union, but to worldwide technical developments.

Establishing the degree of novelty is by no means a simple matter and is conducted by a large staff of highly trained technical experts at the State Committee for Inventions and Discoveries. These experts, or patent examiners, compare the specifications of each filed invention to similar patent grants published in the patent journals of major industrialized countries and to other relevant technical information. If an application is rejected for lacking sufficient novelty, the examiner must supply the applicant with specific references to the materials supporting the rejection.

The novelty examination provides the basis to the contention of many Soviet economic policy makers that an increased emphasis on the use of inventions will bring the technical level of Soviet industry closer to world levels.

Usefulness.—Usefulness, (*polozhitelnyi effekt*), while not clearly defined by law, requires that an invention represent a practical advance over existing technology. A useful invention must on balance have positive characteristics which outweigh any negative features—e.g., raise quality sufficiently to outweight any cost increases or, conversely lower costs with, at worst, only marginal reductions in quality.

Actual practice indicates that very few applications are rejected on the grounds of not being useful. This undoubtedly reflects the difficulties inherently involved in evaluating usefulness, in part because such evaluations would often require considerable assistance from out-of-house experts who work at actual production facilities.

Technical solution.—Soviet law does not explicitly define what is meant by the term "technical solution," but the law does list specific subjects that are not considered technical solutions. For example, economic management and educational methods and systems, construction projects and schemes, industrial design proposals, codes, information systems, and calculation methods are not patentable. (Article 21 of the 1973 Law on Inventions.) Excluding these subjects is not an uncommon practice in many of the world's patent systems.

Sufficient Disclosure.—In addition to satisfying the above standards, an invention "* * * must be disclosed in the description and illustrative drawings, schemes and other graphic materials with such completeness and clarity * * * to make it possible to utilize the invention." (Article 44 of the 1973 Law on Inventions.) This requirement in effect ensures, among other things, that the concept behind the in-

[3] For the official English translation see, Industrial Property, July 1974, pp. 298–319.

vention is workable, i.e., it could be replicated by others and further developed.

Inventions, then, are clearly held to be technical applications of the product of scientific research. This implies that implemented inventions will constitute a technical innovation, but will not encompass other productive innovations in such areas as the management and organization of economic activity. While demonstration of a sufficient degree of novelty is undoubtedly the most stringent test that an invention must meet, it is also the most difficult to apply. Consequently, many inventions declared new—both in the West and in the Soviet Union—are marginal achievements and fall quite short of what the standard suggests. On the whole, however, this standard of world "best practice" can be expected to have an economic impact. For example, the implementation of new investions in those Soviet economic sectors which generally lag behind the West might require proportionately larger technical advances, with associated problems and delays, than implementation in Western industry.

We also note that the Soviet Union certifies a second kind of technical development—the "rationalization" (*ratsionalizatorskiye predlozheniye*, or "*ratspred*"). Formally, the chief distinction between a rationalization proposal and an invention centers on novelty. Whereas an invention is new to the world, a ratspred need only be new to the enterprise. In practice, however, the distinction seems to be greater. Many Soviet references to ratspred indicate that enterprise management, in fact, applies standards very loosely.[4] Thus, while ratspred may envisage massive changes, the vast majority are minor proposals yielding marginal or even insignificant improvements.[5]

Although individually yielding small economies (between 1964–1973 average economies for ratspred were 1,400 rubles and for invention, 30,000 rubles),[6] collectively ratspred are a major force in economic growth.

By Soviet estimates, rationalization proposals accounted in 1973 for 89 percent of total economies yielded by inventions and rationalization proposals.[7] Rationalizations are not considered in this study because of the looser standards applied, the probable inclusion of non-technical subjects, and the constraints imposed by our data base, but they must be acknowledged in any general investigation of Soviet technological advance.

B. The Organization Network Supporting Invention

As an important contributor to technological advance, Soviet inventing is ultimately the responsibility of the State Committee for

[4] About 35 percent of the invention applications filed are granted and only 25 percent of these are implemented, while almost 89 percent of submitted rationalization proposals are accepted and 85 percent of these are used. Authors' calculations from Ye. I. Artemyev and L. G. Kravets, Izobreteniya-Uroven' tekhniki-Upravleniye, (Moscow: "Ekonomika," 1977), pp. 47–50 and Narodnoe Khozyaistvo SSSR v 1974 g., p. 149.

[5] The significant difference in the technical level of inventions and rationalization proproposals is often mentioned by Soviets. One Soviet official wrote:

"(T)he heads of many ministries and important enterprises . . . introduce thousands of petty rationalization proposals whose development and implementation require almost no care from the manager, and no preparatory labor and material expenses from the enterprise."

F. T. Ananev, "Ulushchit' razrabotku: vnedreniye izobretenii," Izobretatel'stvo v SSSR, 1956, No. 2, August, 6.

[6] Artemyev and Kravets, op. cit., pp. 49–50.

[7] Ibid., p. 50.

Science and Technology (GKNT), the organization which oversees the development and implementation of Soviet science and technology policy. Inasmuch as inventions are nominally required to be economically useful, the State Planning Committee (*Gosplan*) is involved particularly in planning and administering the introduction of inventions in the national economy.

Operationally, however, Soviet inventing activity is directly overseen by the State Committee for Inventions and Discoveries (*Goskomizobreteniy*). Similar centralized invention agencies have managed inventing in the Soviet Union since the early 1920s. While all of these State Committees (of the Council of Ministers) are nominally equivalent in rank, the GKNT and Gosplan together exercise general supervision over all research, development, and innovation activity. However, the budget and scope of activities of the present State Committee for Inventions and Discoveries—dwarfing those of its predecessors—and its elevation in status from Committee to State Committee in 1973, underscores the importance now accorded to technical innovation by Soviet policy makers.

The State Committee for Inventions and Discoveries maintains the Soviet patent office, and it develops and applies standards for certifying inventions and rationalization proposals. The Committee provides a myriad of support services to ministries, institutes, and enterprises, and exercises some actual authority (by way of plan formulation and monitoring) over industrial invention and innovation. In particular, the Committee, with the Committee on Wages, manages the system established to award bonuses to innovators on the basis of the economic effectiveness of their developments.

Finally, what for our purposes is one of its most important functions, the Committee manages the collection, publication, and dissemination of information on inventions, both when first certified and when implemented. In 1962, the Central Scientific Research Institute of Patent-Technical Information (TsNIIPI) was established subordinate to the Committee. One of TsNIIPI's most important duties was the processing and distribution of Soviet and foreign patent information. This information has become a vital tool for the management of innovation policies by other state agencies. For example, the State Committee for Science and Technology makes extensive use of TsNIIPI data in technological forecasting and in the process of central R&D planning. Gosplan and the individual industrial ministries also draw heavily on TsNIIPI data for their R&D planning and estimations of technical levels. The Soviet Bureau of Standards (Gosstandardt) makes use of patent information in establishing many nationwide technical standards. Thus, TsNIIPI's patent information provides a convenient technical yardstick against which domestic developments can be measured and an important platform from which new foreign technical trends can be spotted.

Two of its publications are of particular interest—the Soviet patent journal (*Ofitsial'nyi Byulleten': Otkrytiya, Izobreteniya, Promyshlennye obratsy i Tovarnye znaki*) and the Soviet journal Introduced Inventions (*Vnedrennye izobreteniye*). Abstracts of all inventions when certified are to be published in the patent journal. Typically, publication takes place approximately 2 years following the filing of an application. If the invention is subsequently implemented, notification of such implementation is published in the second journal (see Section III.B).

Finally, at the policy level, the State Committee interacts with the central patent departments of industrial ministries, the Ministry of Higher and Specialized Secondary Education, and the academies of sciences; and, at the operational level, with patent organizations in their subordinate research and production establishments. In most industrial ministries, invention and accompanying patent services are managed in the technical main administrations (*glavnye tekhnicheskiye upravleniye*). Most research institutes, design bureaus, production associations, and enterprises maintain a Bureau of Rationalizations and Inventions, known by the acronym BRIZ.

C. Process for Granting an Inventor's Certificate

When an employee creates a new invention,[8] the invention bureau (BRIZ) of the empoyee's place of work is notified. The BRIZ patent specialists make a preliminary search of the available patent and technical literature to ascertain whether the proposed invention is in fact new. If the BRIZ search uncovers no materials vitiating the proposed invention's novelty and if the proposed invention does not contradict other rules of patentability, the BRIZ specialists draft the specifications for the inventor's certificate. The drafted application is then filed at the State Committee's examination institute (VNIIGPE).

As soon as an application is received in the State Committee, it is dated and checked for compliance with the Committee's formal requirements—proper number of forms, necessary signatures, an object not obviously unpatentable, etc. If the application is in the correct form, one copy is sent to the appropriate patent examiner and another copy is sent to a relevant industrial organization. During the examination of the application, there may be considerable correspondence between the examiner and the inventor(s) on the exact nature of the claims being made. If the examiner finally considers the invention to be patentable and if the industrial organization has not successfully challenged the usefulness or novelty of the invention, the inventors are granted an inventor's certificate. Once granted, the invention is assigned a number from the state register for inventions and published in the official bulletin of the State Committee.

D. Comparability With Western Concepts and Procedures

The present Soviet Statute on Inventions has deep roots in German[9] and early Russian law.[10] Consequently, most Soviet legal concepts and procedures are quite similar to those found in Western patent laws.

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[8] Approximately 93 percent of Soviet inventors' certificates are granted to individuals connected with state organizations, rather than to independent inventors. Ye. I. Artemyev and L. G. Kravets, p. 47. Thus, the process described refers exclusively to inventions created within state organizations.

[9] John A. Martens, "The Development of the Soviet Law on Inventions, 1919–1959," unpublished Ph. D. dissertation, University of Notre Dame, August 1977, p. 71.

[10] Hiance, Martine and Plasseraud, Yves, "La Protection des Invention en Union soviétique et dans les républiques Populaires d'Europe," (Paris: Libraires Techniques, 1969), p. 50.

On the basic issue—standards for patentability—Soviet criteria are common to Western laws. While the actual application of the legal criteria—for example, how strictly do Soviet examiners interpret novelty—is difficult to assess, many Western patent attorneys consider Soviet standards to be rigorous.[11]

Especially important for our purposes is the fact that Soviet law requires that applications for inventors' certificates disclose an invention to such a degree as to demonstrate its workability. Of further importance is the Soviet practice of giving the rights of inventorship to the person(s) who first file for protection and not necessarily to those who first invent. Patent lawyers refer to this regulation as a first to file system, and it is identical to the system of West Germany and most other countries. Both of these practices imply that our data and lead times (see Section V) are likely to approximate well the period of development and engineering associated with implementation, and they facilitate comparisons between Soviet and certain Western performance (see Section V.B(2)).

E. Invention and Technological Progress in the Soviet Economy

The implementation of individual certified inventions—or innovation—is clearly but one of many contributors to technological progress in the Soviet Union. Significant innovation also occurs in large projects which involve combinations of patented inventions and other technical and managerial developments not officially recognized. The implementation of rationalization proposals makes, as noted, an important contribution, and there clearly are a host of engineering developments, often associated with major construction or reconstruction of industrial plant, that are either not patentable or not patented. Finally, as has often been noted, subsequent diffusion of technical advances throughout Soviet industry will have a substantially greater quantitative impact than implementation at the first facility.

Having acknowledged these alternative sources of technological advances, we believe, first that implementation of inventions is likely to account for an important and growing share of overall Soviet technical advance; and second, that the object of our analysis—Soviet performance in implementing inventions at the first facility (innovation)—can serve as a good proxy for performance in diffusing inventions throughout industry.

In early years of Soviet industrialization, much technology with great impact on industrial productivity was imported. Further, with the preeminence of ambitious production targets, filing for inventor's certificates on relatively minor developments might have been considered by certain planners and managers as a bureaucratic "afterthought", and in failing to file, they incurred no economic penalties.[12]

Continued dependence on imported technology institutionalizes a technological lag. Soviet progress in reducing technological lags in

[11] For some comments of Western attorneys on Soviet practice see, John A. Martens, "Patenting in Communist Countries: The Experience of Some U.S. Companies," Journal of the Patent Office Society, 1978, April, pp. 248–260.

[12] See Martens, op. cit. (dissertation), pp. 273–301.

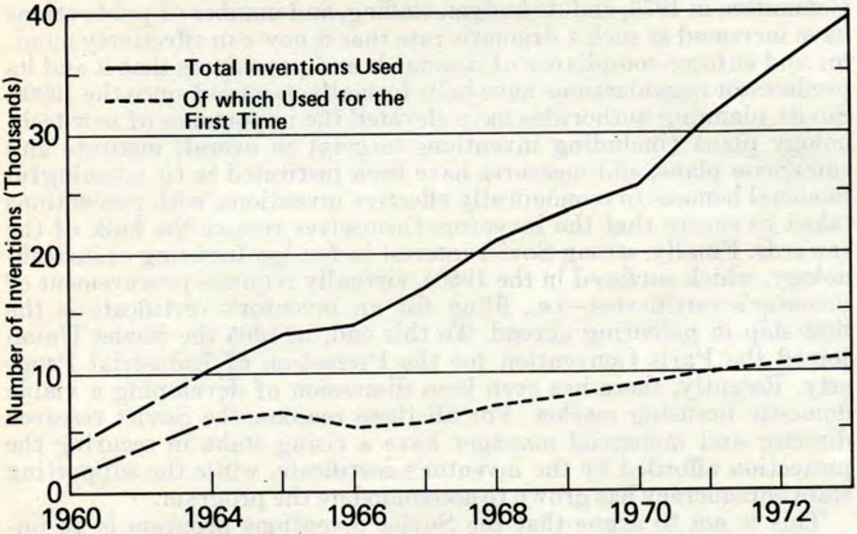
certain areas [12a] and Soviet desire to equal or exceed Western capabilities argue that the Soviet leadership would have a greater stake in a viable inventions program. Soviet actions bear this out. The Committee for Inventions and Discoveries was elevated in status to a State Committee in 1973, and its budget, staffing, and number of publications have increased at such a dramatic rate that it now can effectively monitor and enforce compliance of standards and procedures that it and its predecessor organizations have been formally accorded since the 1920s. Soviet planning authorities have elevated the importance of new technology plans (including inventions targets) in overall institute and enterprise plans, and measures have been instituted to tie meaningful financial bonuses to economically effective inventions, with precautions taken to ensure that the inventors themselves receive the bulk of the rewards. Finally, strong Soviet interest in foreign licensing of its technology, which surfaced in the 1960s, virtually requires procurement of inventor's certificates—i.e., filing for an inventor's certificate is the first step in patenting abroad. To this end, in 1965 the Soviet Union joined the Paris Convention for the Protection of Industrial Property. Recently, there has even been discussion of developing a viable domestic licensing market. For all these reasons, the Soviet research director and industrial manager have a rising stake in securing the protection afforded by the inventor's certificate, while the supporting state bureaucracy has grown to accommodate the program.

This is not to argue that the Soviet inventions program is an unqualified success. Yet, Soviet data reveal that the number of inventor's certificates granted has been increasing at a high rate—higher than the rates of increase in spending on R. & D. (In 1965 slightly over 10,000 inventor's certificates were granted; in 1974, well over 40,000.) Moreover, while inventions make up less than 1 percent of total introduced innovations, they account for a significantly greater share (11 percent) of the economic savings attributable to inventions and rationalizations.[13] The increased "inventions consciousness" of managers also seems to be reflected in the strong growth in the subsequent diffusion of inventions. (See figure 1.) Finally, the Soviet invention system has received increasing recognition from foreign firms. Foreign patent applications, mostly from the West, have risen from 1,250 in 1965 to 5,858 in 1974.

[12a] For an excellent discussion of this topic, see R. Amann, J. M. Cooper and R. W. Davies, The Technological Level of Soviet Industry, New Haven: Yale University Press, 1977.
[13] Artemyev and Kravets, op. cit., p. 49.

Figure 1

Inventions Used in the U.S.S.R.
(Total and used for the first time)



Sources: 1960 in Maksaryev, Yu. E., "Po leninskomu puty," *Voprosy izobretatel'stva*, 1969, No. 6, 20 and 1964-1973 in Artemyev, Ye. I. and Kravets, L. G., *Izobreteniya—Uroven' tekhniki—Upravleniye*, Second revised edition, (Moscow: "Ekonomika," 1977), p. 49.

In sum, we believe that a strong case can be made that the inventor's certificate today is less likely to be viewed as an afterthought. Further, because the past decade's increase in the proportion of inventor's certificates coming from State organizations [14] indicates the development of a "patent consciousness" within the Soviet R. & D. establishment and because the opportunities for wholesale Soviet borrowing are becoming increasingly limited, we believe that first implementation and subsequent diffusion of Soviet inventions are likely to account for a growing share of technological progress.[15]

While our sample of implemented inventions covers only implementation at the first facility, there is reason to believe that the revealed patterns of implementation, including lead time, can provide useful insights into implementation of all new technology. The supporting organizational infrastructure and most policies that move new technology are not unique to first implemented inventions. If anything, we may be focusing on a subject of Soviet innovation where performance is relatively good. Innovative activities not recognized and rewarded by formal programs, such as certain process engineering developments, may be given particularly inadequate attention by Soviet managers. Management of complex programs not accorded high priority also is alleged to be another Soviet weakness.

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[14] In 1965, 29 percent of inventor's certificates granted came from state organizations; in 1974, 93 percent. Ibid., p. 47.

[15] For a very important Soviet decree on the importance now accorded the management inventory see "O dal'neishem razvitii izobretatel'skogo dela v strane, uluchshenii ispol'zolaniya v narodnom khozaistve otkrytii, izobretenii ratsionalizatorskikh predizohenii i povyshenii ikh roli v uskorenii auchno-teknichesrogo progressa." Postanovieniye Tsentral'nogo Komiteta KPSS i Sovyeta Ministrov SSSR No. 575 of Aug. 20, 1973.

Overall, however, we believe our findings on the impact of technical, organizational, and administrative factors on lead time will be relevant to general analyses of Soviet implementation of technology.

III. Soviet Data on Inventions

A. The Use of Invention Data

Researchers have long sought to use patent statistics as measures of technical change and inventive activity, or to correlate patent statistics with such general economic phenomena as productivity and growth.[16] These past studies are careful to point out, however, that there are many pitfalls and limitations associated with patent data.

One of the most obvious weaknesses of patent statistics is their inability to reflect the wide variation in the level of sophistication among patented inventions. Other difficulties come from sources as disparate as technological breakthroughs (causing grants to mushroom disproportionately to R. & D. investments), interindustry differences in the propensity to patent, and changes in judicial philosophies (a reluctance of the courts to uphold patent rights would tend to discourage filing).

While some of the above problems certainly apply to the Soviet data used in the present study—especially the effects of technological revolutions and changes in the propensity to file—an important difference should be noted. The patent statistics customarily used by social scientists are gathered from a population of all granted patents. No distinction is usually made between grants which were actually implemented and those never used. The Soviet data in our study, however, represent a subset of all granted "patents", viz. inventions which were actually put to use in the Soviet economy. This subset is probably less influenced by some of the above mentioned quirks of patent law and clearly permits us to focus on the economic factors in the innovation process itself. For example, it is reasonable to assume that many of the basically insignificant or parallel inventions commonly found in the population of all grants in any country are excluded from this study's data base, for usage implies a favorable on-site economic or technical evaluation that goes beyond formal legal criteria. Further, the problem of the disproportionate number of grants surrounding single technological breakthroughs creates less of a distortion when looking at inventions used, for only those grants which reflected truly economical potential—not those filed primarily to stake out technical areas—would appear in the subset.

Consequently, the data used in our study provide an unusually favorable framework for addressing a multitude of technical and economic questions on innovation in the Soviet economy.

B. Sources of Soviet Data on Inventions

There are two main sources of data on Soviet inventions. The first is the official journal (*Ofitsial'ny Byulleten'*), which announces all

[16] See, for example, Richard R. Nelson, "The Economics of Invention: A Survey of the Literature." The Journal of Business Volume XXXII (1959), No. 2, pp. 101–127 and The Rate and Direction of Inventive Activity: Economic and Social Factors, A Report of the National Bureau of Economic Research, New York, (Princeton: Princeton University Press), 1962.

newly granted inventor's certificates, and patents. The official journal has been published—under various titles—since 1924 and corresponds to the official publications of Western patent offices. The second source *Vnedrennye izobreteniya* (*Introduced Inventions*) has no counterpart in the West and fulfills a need peculiar to a socialist economic system.

Although this second journal was first published in 1968, the fundamental ideas behind its publication were formulated early in Soviet history. During the NEP period of the 1920s, the Soviet state established formal procedures for the dissemination of important technical developments among industrial branches. Later, under the first five year plan, these procedures became centralized through a central card file for socialist exchange (*Kartoteka "SO"*). Upon implementing a suggestion of significant economic or technical importance, factories were to make the suggestions readily available to other factories by describing it on a centrally stored file card.[17] The journal *Vnedrennye izobreteniya*, a modern equivalent of the Kartoteka "SO", lists information on Soviet inventions which are implemented or introduced into the economy for the first time.

IV. Patterns of Soviet Inventing and Implementation

As the basis for our analysis, we have taken a random sample of 1619 implemented inventions from four issues (published between 1974 and 1977) of the journal *Vnedrennye izobreteniya* (*Introduced Inventions*). We estimate that our sample includes approximately 3–5 percent of the total number of inventions implemented for the first time during the period covered by our data (1967–1975). In addition to listing the title and authors of each implemented invention, data is provided relating to its chronology, technology, and supporting organizational network. Specifically, the information permits us to construct a measure of lead time, to classify inventions by technical area, and in most cases to classify inventions by the industrial sector, facility type, and geographic location of the originating and implementing facility. In this section, we define our measure of lead time and describe our sample along the above dimensions.

A. The Measure of Lead Time

While the information listed in the journal varies in its completeness, the two data elements of central importance to our study—the filing date for an inventor's certificate and the use date for an invention—were almost always provided. We define lead time as the elapsed time from the filing date to the use date.

The filing date is considered the day on which the State Committee for Invention receives the proper forms disclosing the invention. Since this date protects the inventor from any subsequent filings of identical inventions in the U.S.S.R. by others and establishes a one-year period of similar protection in foreign countries that belong to the Paris Convention, inventors and their institutes are under considerable pressure to file for an inventor's certificate at the earliest date

[17] A. Smirnov and A. Zapol'skii, Izobretatel'stvo v SSSR i za granitsei, (Moscow: ONTI izdatel'stvo NKTP, 1934), p. 31. See also Martens, op. cit. (dissertation), pp. 260–268.

possible. For these reasons, the filing data probably closely approximates the moment when researchers are reasonably sure of the technical orginality and potential usefulness of their research. In addition, the disclosure requirement mentioned above ensures that the filing date corresponds to a time when the invention is actually developed enough to be workable.

Soviet legislators have carefully established legal criteria to define the concept of introduction or implementation, since fixing the date of introduction or use directly affects inventors' rewards and partially affects the evaluation of enterprise innovation performance.

An invention is considered used: (1) "if a method, when it began to be used in the production process"; (2) "if a device or substance, when it began to be applied in the manufacture of products or in the use of existing products including experimental models brought into operation"; (3) when it is recognized as fit for industrial manufacture prior to the conclusion of experimentation and is transferred into manufacture; (4) when previously prepared and tested and then included in an experimental model (batch, series) or method (technology); (5) when previously prepared and tested and then used in testing another proposal; or (6) when applied to improving the production and testing of experimental models. An invention is not considered used: (1) during its trials; (2) during the manufacture or testing of an experimental model; (3) during the preparation of production; or (4) if only included in the standards, standard designs and other documentation.[18]

This legal definition of use corresponds most closely to Soviet use of the term *vnedreniye* (introduction) in common parlance.[19] Use or introduction, however, is not synonymous with assimilation (osvoyeniye), and the commonly cited assimilation period does not correspond with our measure of lead time. A new product or process is not considered fully assimilated until rated design and engineering parameters (unit cost, quality criteria, etc.) have been attained in the manufacturing facility, a stage that is typically not reached until several years *after* introduction.

In addition to providing well-defined legal criteria on introduction, the Soviets have also established an elaborate computerized system for monitoring the use of inventions in the economy. This system was developed in the early 1960's and includes a series of standardized forms issued by the Central Statistical Administration for data collection.[20] Consequently, the Soviet data on introduced inventions undoubtedly possess a remarkable degree of homogeneity.

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[18] See article 91 of the 1973 Statute on Inventions and points 4 and 5 of "Instruktsiya o poryadke vyplaty voznagrazhdeniya za otkrytiya, izobreteniya i ratsionalizatorskiiye predlozheniye of Jan. 15, 1974" in Voprosy izobretatel'stva, 1974, No. 6, 52–58.

[19] An equivalent term is "use" (ispol'zovaniye). See I. E. Mamiofa, Osnovy izobretatel'skogo prava (Leningrad :Lenizdat, 1976) p. 58. On some of the conceptual difficulties surrounding the term vnedreniye, see John A. Martens, "Disputes Over Inventors' Rewards in Soviet Law—An Analogy to Infringement," International Review of Industrial Property and Copyright Law, vol. 8 (1977), No. 4, pp. 314–320.

[20] For the questionnaires used by the Soviets see "Instruktsiya o poryadke sostavleniya otcheta o postuplenii i vnedryenii izobretenii i ratsionalizatorskikh predlozhenii po forme No. 4–NT: Utverzhdena TsSU SSSR on 11 July 1975," in Normativnye akty: Prinyate v period s 1 Yanvarya po 31 Dekabrya 1975g., (Moscow: TsNIIPI, 1978), pp. 67–86. See also "Razyasneniye o poryadke sostavleniya perechnya ispol'zovannykh v proizvodstve izobretenii po forme No. 4–NT (perechen') ot Oct. 30, 1975 g. No. 3," in ibid., pp. 273–286.

B. Technologies

Every invention is classified by the Soviets according to the second edition of the International Patent Classification. On this basis, we were able to assign technical areas to each invention in our sample. Furthermore, many of the sampled inventions contained information of sufficient detail on the using facility to allow their assignment to a specific Soviet industrial sector. These two sets of information were combined in table 1.

TABLE 1.—INDUSTRIAL IMPLEMENTATION OF SAMPLED SOVIET INVENTIONS

[By technical area]

Sector where used	Technical area: Instrumentation (materials testing; measurement and control)	Computers and related equipment	Radio-electronics	Electrical engineering and machinery	Scientific instruments (physical and chemical property evaluation)	Metalworking	Nonferrous metallurgy	Ferrous metallurgy	Chemistry	Transportation equipment
Educational and scientific [1]	16	11	7	4	11	3	3	2	8	0
Civilian machine building	49	31	14	53	2	98	11	18	8	30
Defense industrial	37	28	59	28	13	57	7	3	8	6
Other civilian heavy	13	5	8	21	6	17	7	20	47	17
Light industry	1	1	2	7	2	7	1	0	11	4
Transportation	10	11	1	22	2	27	5	1	6	50
Power generation and transmission	6	6	6	18	1	4	0	0	0	1
Construction	3	0	2	3	0	6	0	0	0	10
Other	19	8	6	11	18	17	2	2	12	7
Unknown	7	4	4	7	0	9	2	2	2	2
Total	161	105	109	174	55	245	38	48	102	127
Percent	9.9	6.5	6.7	10.7	3.4	15.1	2.3	3.0	6.3	7.8

See footnote at end of table.

TABLE 1.—INDUSTRIAL IMPLEMENTATION OF SAMPLED SOVIET INVENTIONS—Continued

[By technical area]

	Technical area									
	Power generation	Construction	Mining and drilling	Glass and ceramics; paper and pulp; timber and woodworking	Domestic goods; textiles and publishing	Food processing and handling	Medical equipment and preparations	Agriculture	Total	Percent
Educational and scientific[1]	1	1	1	4	1	3	0	1	77	4.8
Civilian machine building	31	14	3	15	16	13	0	8	414	25.6
Defense industrial	8	1	0	7	4	1	5	0	272	16.8
Other civilian heavy	4	12	17	26	1	3	0	0	224	13.8
Light industry	4	2	1	6	27	42	4	3	125	7.7
Transportation	2	14	1	11	5	2	1	3	174	10.7
Power generation and transmission	8	2	0	3	1	0	0	0	56	3.5
Construction	0	26	0	7	1	0	0	1	59	3.6
Other	0	11	3	4	9	3	20	20	172	10.6
Unknown	1	0	0	4	0	2	0	0	46	2.8
Total	59	83	26	87	65	69	30	36	1,619	
Percent	3.6	5.1	1.6	5.4	4.0	4.3	1.9	2.2		100.0

[1] Academy of Sciences and MinVUZy.

Source: Authors' sample from the journal Vnedrennye izobreteniya.

On the whole, technologies line up with expected users. For example, the use of chemical inventions is concentrated in the Other Heavy sector, which includes the Soviet chemical industry; use of metalworking inventions is concentrated in the "civilian machine building" and "defense industrial" sectors; and domestic goods and food processing inventions are used in "light industry".

Several other important relationships also emerge from table 1. First, the technical areas of the inventions used by the Educational and Scientific Sector closely parallel the technical areas of the inventions used in the three heavy industry sectors. This pattern lends credence to the view that the Educational and Scientific sector is much more oriented toward the producer goods industries (sector A) than toward the light industries (sector B). Second, both the defense industrial and construction sectors show a greater degree of technical specialization than do the other sectors. Six technical areas account for slightly more than 58 percent of all inventions used by the defense industrial sector and the three construction related technical areas account for almost 75 percent of inventions used in the construction sectors. In comparison to the defense industrial sector, the other two heavy industrial sectors (Machine Building and Other Heavy) are much more broadly based.

C. Sectors

Since in many cases both an originator and a user of an invention are identified, we were able to assign facilities to economic sectors. Table 2 summarizes the intersectoral movement of Soviet inventions. (Information on originating sectors was, unfortunately, often missing. Of the 1619 sampled inventions, 790 had no information on the originating sector. Information on using sectors was far more complete, with only 46 sampled inventions without using sector information.)

The number of inventions remaining within a sector—almost 75 percent of the sampled inventions for which originators and users were identified—emerges as the most striking feature of this table. In addition, several sectors stand out as being predominately net suppliers of inventions to other sectors (Educational and Scientific) or net users of inventions from other sectors (Transportation).

D. Facilities

Information on the type of facility which created an invention was available for slightly over half of the inventions sampled. Information on the type of facility implementing an invention was more complete, available for somewhat over two-thirds of the inventions sampled. The data on interfacility movement is presented in table 3.

TABLE 2.—INTERSECTORAL MOVEMENT OF SOVIET INVENTIONS

Originator	User											
	Educational and scientific	Civilian machine building	Defense industrial	Other civilian heavy	Light industry	Transportation	Power generation and transmission	Construction	Other	Unknown	Total	Percent
Educational and scientific	57	14	5	11	5	10	4	2	7	15	130	8.0
Civilian machine building	0	189	4	19	7	15	3	2	13	11	263	16.2
Defense industrial	0	0	1	0	0	0	0	0	0	1	2	.1
Other civilian heavy	1	8	1	81	2	10	2	0	5	4	114	7.0
Light industry	0	2	0	0	41	3	1	1	6	0	54	3.3
Transportation	0	1	0	1	0	47	0	4	3	0	56	3.5
Power generation and transmission	0	3	0	0	2	2	27	1	0	0	35	2.2
Construction	0	3	0	4	0	9	2	27	8	1	54	3.3
Other	0	9	0	10	16	16	5	7	46	12	121	7.5
Unknown	19	85	261	98	52	62	12	15	84	2	790	48.8
Total	77	414	272	224	125	174	56	59	172	46	1,619	
Percent	4.8	25.6	16.8	13.8	7.7	10.7	3.5	3.6	10.6	2.8		99.9

Source: Authors' sample from the journal Vnedrennye izobreteniya.

TABLE 3.—INTERFACILITY MOVEMENT OF SOVIET INVENTIONS

Originator	User: Scientific research facilities: Total	Of which— Scientific research institute	Of which— Project design and technological institute	Project and design bureaus	Production facilities	Educational facilities: Total	Of which— University	Of which— Polytechnical institute and higher technical school	Other (main administration)	Unknown	Total	Percent
Scientific research facilities	110	104	6	5	209	1	1	0	59	99	483	29.8
Of which—												
Scientific research institute	103	103	0	4	177	1	1	0	46	93	424	26.2
Project design and technological institute	7	1	6	1	32	0	0	0	13	6	59	3.6
Project and design bureaus	1	1	0	12	79	0	0	0	11	28	131	8.1
Production facilities	1	1	0	1	139	1	1	0	8	23	173	10.7
Educational facilities	0	0	0	0	10	9	3	6	0	7	26	1.6
Of which—												
University	0	0	0	0	1	3	3	0	0	2	6	0.4
Polytechnical institute and higher technical school	0	0	0	0	9	6	0	6	0	5	20	1.2
Other (main administration)	0	0	0	0	2	0	0	0	9	11	22	1.4
Unknown	46	42	4	8	301	9	1	8	55	365	784	48.4
Total	158	148	10	26	740	20	6	14	142	533	1,619	
Percent	9.8	9.1	0.6	1.6	45.7	1.2	0.4	0.9	8.8	32.9		99.9

Source: Authors' sample from the journal Vnedrennye izobreteniya.

While the table indicates that the solid majority (approximately 75 percent) of implemented inventions for which data on both facilities exists comes from R&D establishments, the almost 25 percent share provided by production facilities is, perhaps, surprising.[21] The relatively minor participation of education facilities (providing about 3 percent of the implemented inventions) and their relative isolation from production facilities (providing only about 2 percent of inventions implemented by production facilities) is striking. This isolation has often been criticized in the Soviet press and is further underscored by the fact that educational facilities are reported to provide more than 10 percent of all Soviet inventions.[22] Also striking is the minor participation of independent design bureaus of various types, which, since they are charged with elaborating and incorporating applied research findings, were expected to figure most significantly in our sample.

E. Locations

While information on facility locations is the most incomplete (only 40 percent of sampled inventions for originators and 65 percent for users), a number of patterns do appear.

Foremost, table 4 on interregional movement depicits a strong tendency for inventions to be created and used in the same republic—over 78 percent of sampled inventions for which location data exist. Although the unusually large concentration of industry in the RSFSR alone might seem to preordain such an outcome, this tendency remains even at the oblast' levels. Secondly, table 4 illustrates the relatively larger contributions made by the major industrial R&D centers—Moscow, Leningrad, and Kiev—in the creation of useful inventions. Interestingly, the Ukraine's proportion of inventions used (19.1) is much larger than its proportion of inventions created (10.7). This might, however, be to some degree a result of having more complete data on the users of inventions.

F. Representatives of the Sample

When organized according to the broadest technical categories of the International Patent Classification, our samples of introduced inventions are representative of the total population of recently granted Soviet inventor's certificates.[23] (See figure 2.)

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[21] E. Zaleski; J. A. Kozlowski; A. Wienert; R. W. Davies; M. J. Berry; and R. Amman, Science Policy in the USSR (Paris: OECD, 1969), pp. 410–413. The inventions originated by production facilities do not appear to be economically insignificant. The average annual economies for these inventions (51,370 rubles) exceed the average economies for the whole sample (34,652 rubles).

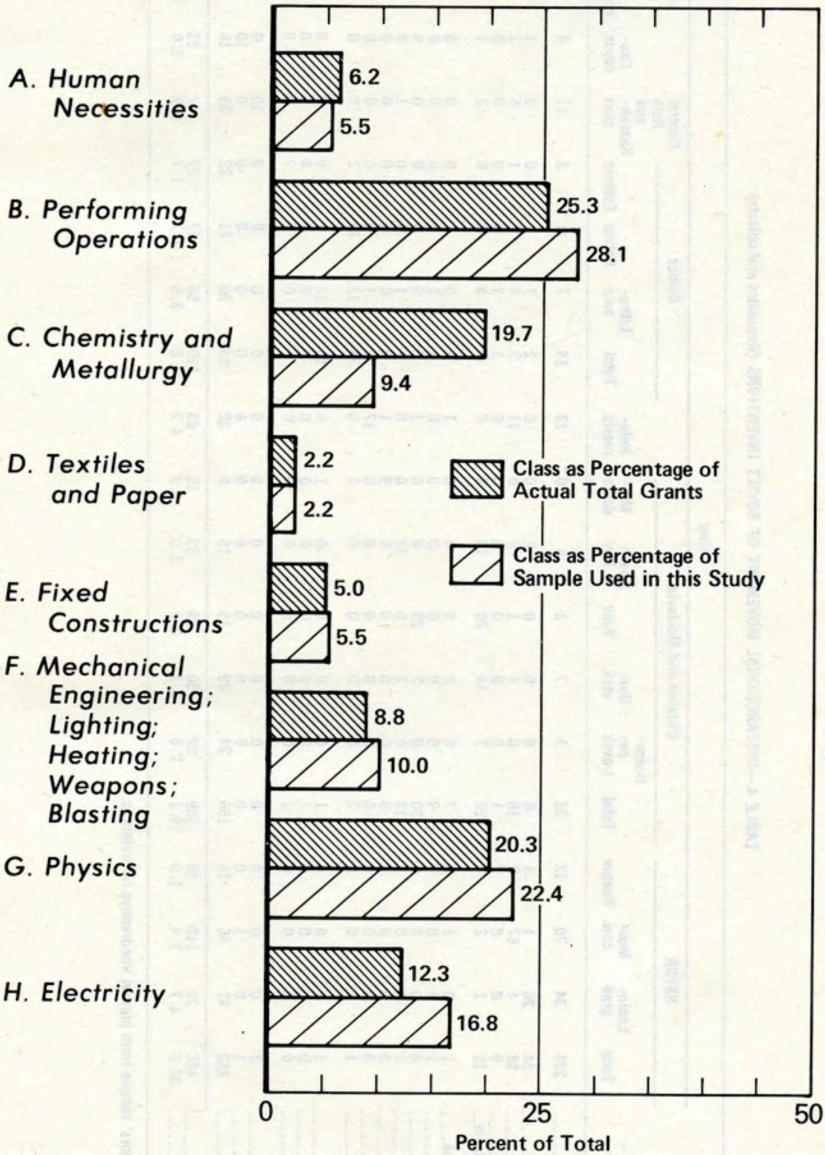
[22] See "Tvorcheskoi deyatel'nosti izobretatelei i ratsionalizatory—vse mernuyu poderzhku," Voprosy izobretatel'stova, 1979. No. 1, p. 6.

[23] Data on total population is from 1967 to 1974. See Artemyev and Kravets, op. cit., p. 48.

Figure 2

Distribution of Soviet Inventors' Certificates by Technical Area

(As specified by the international patent classification)



Source: Percentage of actual total grants from Ye. I. Artemyev and L. G. Kravets, *Izobreteniya—Uroven' tekhniki—Upravleniye,* Second revised edition, (Moscow: "Ekonomika," p. 47; Percentage of sample from authors' sample of inventions in Soviet journal *Vnedrennye izobreteniya.*

TABLE 4.—INTERREGIONAL MOVEMENT OF SOVIET INVENTIONS (Republics and oblasts)

	User																			
	RSFSR				Ukraine and Moldavia							Baltics								
Originator	Total	Leningrad	Moscow	Rostov	Total	Dnepr-pe-trovsk	Don-etsk	Kiev	Khar'-Kov	Mol-davia	Belo-russia	Total	Lithu-ania	Latvia	Estonia	Central Asia and Kazakh-stan	Cau-casus	Un-known	Total	Percent
RSFSR	224	34	70	12	33	1	7	1	5	0	13	14	7	4	3	11	4	83	382	23.6
of which—																				
Leningrad	34	26	1	1	6	0	0	0	2	0	0	2	1	1	0	2	1	13	58	3.6
Moscow	98	4	67	2	16	0	4	1	3	0	11	7	4	2	1	5	2	43	182	11.2
Rostov	9	0	0	7	1	0	0	0	0	0	0	1	1	0	0	0	0	0	11	.7
Ukraine and Moldavia	15	1	2	3	118	7	14	20	13	9	6	7	5	2	0	2	1	24	173	10.7
of which—																				
Dneprpetrovsk	1	0	1	0	7	6	0	0	0	0	1	1	0	1	0	0	0	1	11	.7
Donetsk	1	0	0	0	9	0	9	0	0	0	0	1	1	0	0	0	0	3	14	.9
Kiev	4	0	0	2	30	0	2	20	0	0	1	0	0	0	0	0	0	13	48	3.0
Khar'Kov	1	0	0	1	18	0	2	0	13	0	0	1	1	0	0	1	0	3	24	1.5
Moldavia	0	0	0	0	9	0	0	0	0	9	1	0	0	0	0	0	0	2	12	.7
Belorussia	0	0	0	0	0	0	0	0	0	0	17	1	1	0	0	0	0	3	21	1.3
Baltics	1	1	0	0	2	0	0	0	0	1	0	24	12	10	2	0	0	3	30	1.9
of which—																				
Lithuania	1	1	0	0	1	0	0	0	0	1	0	13	12	1	0	0	0	0	15	.9
Latvia	0	0	0	0	1	0	0	0	0	0	0	9	0	9	0	0	0	2	12	.7
Estonia	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	1	3	.2
Central Asia and Kazakhstan	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	1	13	.8
Caucacus	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2	13	.8
Unknown	253	41	46	15	156	24	29	15	15	5	32	63	30	11	22	23	18	440	985	60.8
Total	496	76	119	30	309	32	50	36	33	15	68	110	56	27	27	47	33	556	1,619	99.9
Percent	30.6	4.7	7.4	1.9	19.1	2.0	3.1	2.2	2.0	0.9	4.2	6.8	3.5	1.7	1.7	2.9	2.0	34.3	99.9	

Source: Authors' sample from journal Vnedrennye izobreteniya.

However, when compared to the total population of introduced inventions for 1966–1967 (see figure 3), our sample reflects one major bias, viz. an underrepresentation of inventions from the defense industrial sector.[23a] The noticeable difference is the sizes of "Unknown" and "Other" categories merely reflects the more detailed information on users provided in the journal *Introduced Inventions* than was provided in the 1967 Soviet study.[24]

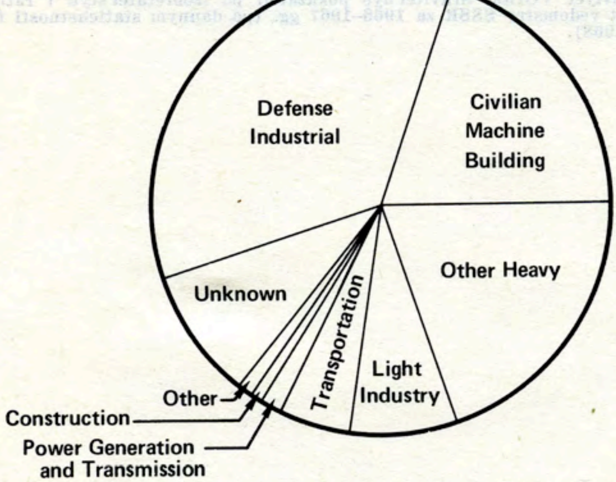
[23a] We believe that our sample of inventions implemented in the defense industrial sector are dual use in nature. We base this belief on the technical description of the invention and on the fact that the journal *Introduced Inventions* is published to disseminate information on potentially useful inventions throughout the Soviet economy.

[24] Tsentral'nyl Soviyet VOIRa, Sravitel'nye pokazateli po izobretatel'styu i rationalizatsii ministerstv i vedomstry SSSR za 1966–1967 gg. (po dannym statichetnosti forme 4–NT), (Moscow : 1968).

Figure 3

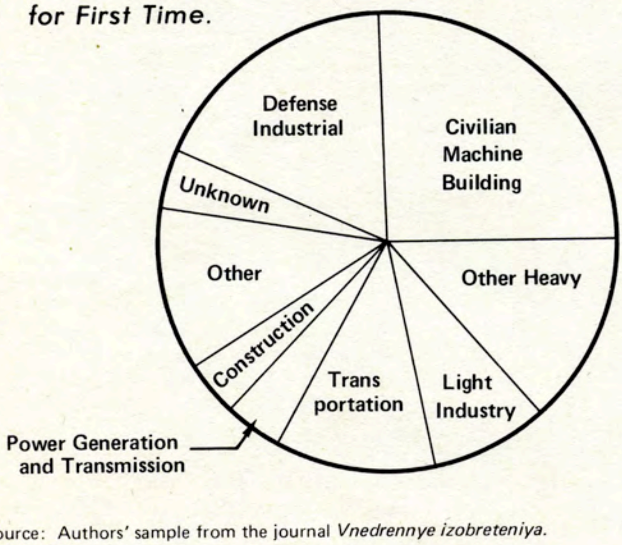
Soviet Inventions Used for the First Time According to Industrial Sector

A. All Inventions Implemented for First Time in 1966 and 1967.



Source: Tsentral'nyi: Sovyet VOIRa, *Sravnitel'nye pokazateli po izobretatel'stuv i ratsionalizatsii ministerstv i vedomstv SSSR za 1966-1967gg. (po dannym statotchetnosti po forme 4-NT).* Moscow: 1968, pp. 7-8.

B. Sample Used in this Study of Inventions Implemented for First Time.



Source: Authors' sample from the journal *Vnedrennye izobreteniya.*

V. Lead Time for the Implementation of Soviet Inventions

The time required to bring new technology on stream is acknowledged to be an important determinant of the rate of technological progress. In a static context, time saved in the implementation of technology permits benefits to be realized that much sooner. More important is the dynamic impact, since technological progress is usually an incremental, reinforcing process. The effect of more rapid implementation of technology is compounded through succeeding generations of technical advance.

We measure lead time as the period from the filing for an inventor's certificate to formal certification by a Soviet facility that the invention has been introduced. Ideally, this measure of lead time would correspond closely for every observation to the underlying period required for implementation of an invention. The period would begin at the point when economic feasibility is accorded a high probability, following the completion of applied research and sufficient developmental work to justify the application for an inventor's certificate,[24a] and the period would encompass the advanced developmental and engineering stages leading to successful introduction or realization.

We recognize that our definition of the lead time period—dictated by the data—is somewhat arbitrary. It is clearly implausible to certify that advanced developmental work begins or introduction takes place on a particular day. Furthermore, because certain individuals (at least the inventor himself) will appreciate the economic and technical significance of the invention at some point prior to filing and may then begin steps to implementation, our use of the filing data as the beginning point may tend to slightly understate actual lead time periods in Soviet industry. However, we believe this bias is minimized by the "first-to-file" pressures of the Soviet patent system, providing that the inventor risks losing his rights by delaying the filing. Furthermore, to the degree that any bias created by our measure is felt equally throughout industry, or to the degree that we are able to make adjustments for the bias when it is not, our estimates will provide reliable indicators of relative lead time performances among technological areas and Soviet industrial sectors.

In the next section we briefly outline theoretical considerations affecting lead time, followed by a series of estimates based on our sample of implemented inventions.

A. *Theoretical Considerations*

We hypothesize that lead time (LT) required to implement an invention will be a function of the capital, labor, and material inputs (I) applied to the developmental and engineering process. A higher rate of application of inputs may be expected to decrease requisite lead time.

[24a] Our interpretation of the filing date is not totally without precedent in the Soviet technical literature. One recently published work clearly places the application for an inventor's certificate at the end of the stage of applied scientific research work (prikladyne nauchno-issledovatel'skiye raboty), which directly precedes developmental work (opytno-konstrukforskiye raboty). See V. S. Sominskiy, V. I. Kublis and K.G. Fedorov Unravlenive naukoi v khimicheskoi promyshlennosti, Moscow: Izadatel'stov "Khimiya", 1978, p. 40.

More specifically, the productiveness of inputs applied to implementation will be influenced by: (1) the technical features of the innovation; and (2) the effectiveness of the relevant organizations and administrative policies in managing the implementation process. In the former case differences in levels of inputs required to implement two inventions might be attributable to such factors as the technical areas, the proportionate advance in state-of-the-art, and the scale of industrial application. In the latter case, innovation takes place not in a vacuum but in a supporting infrastructure which moves the technology from research to production. In the Soviet Union there is variation in the organizational makeup, administrative policies, access to inputs of economic sectors and, more specifically to industrial ministries. This variation in what amounts to managerial effectiveness could produce different results for the same invention applied in different ministries. In functional notation, lead time for the ith invention (LT_i) will be a function of the rate at which inputs (I_{it}) are applied, the resources required by technical characteristics of the invention (f_i) and the set of (assumed to be applied on a sectoral (s)) conditions that determine the effectiveness of application (g_i^s):

$$LT_i = g_i^s(f_i(I_{it}))$$

where

$$\frac{dLT_i}{dI_{it}} < 0, \frac{d^2LT_i}{dI_{it}^2} > 0$$

Planners may be expected to allocate resources to invention implementation with the objective of maximizing the discounted sum of net economic benefits associated with each invention in the first and subsequent applications. Net economic benefits may be defined as the sum of annual economies and related benefits beginning in the first period following implementation less the costs incurred in effecting implementation. Clearly, the lead times themselves are a function of the pattern of input application. Thus, lead time is, within limits, a variable subject to planner manipulation with optimal lead time a function of the tradeoff between the benefits perceived by planners with successful implementation and of the opportunity cost of the required resource inputs.

For our purposes this simple formulation has two important implications. First, the real test of performance in the introducing facilities and sectors—the productiveness of resources applied to the implementation process—must take into account the "objective" technical features of the invention. Second, the appropriateness of the rate and size of input application can only be judged in relation to the pattern of costs and benefits associated with each invention. Thus, we can estimate relative lead times in technical areas or industrial sectors and we can find that lead time is relatively slow (or fast) by some objective measure or international standard. This could be accounted for by particularly bad (or good) Soviet management and utilization of resources in the implementation process, but we must allow for a alternative explanation—namely, that Soviets chose to devote a different quantity and time distribution of resources to the process. This decision in turn might reflect bad judgment or real differences in perceptions of costs and benefits. We could find, for example, that lead time in Soviet defense industrial sectors averaged 20 percent less than lead time for similar inventions implemented in civilian industry. We cannot conclude that defense industrial/management is superior, as the 20 percent time savings might have required a doubling in cost. And even if so, it might still have been a proper decision in light of Soviet objectives.

B. Estimates of Lead Time

In this section we first present measures of lead time corresponding to the technical, sectoral, facility type and geographic classifications of our sample. The hypotheses we test do not exhaust the possibilities afforded by the data, but rather are designed to illustrate important lead time differentials in the main dimensions of the sample and to illustrate useful areas of future research.

Our analysis of factors influencing lead time are constrained by two features of the data—one endemic and one which can be partly compensated for by enlarging the sample.

First, the data provide no information on the inputs applied to the implementation process—i.e. we cannot distinguish between "large" and "small" inventions. The implications of this omission for any evaluation of performance were discussed in the previous section. Second, as apparent from the tables in Section IV, not all observations have a complete set of data elements. In some cases this can be compensated for by enlarging the sample. However, in other cases the pattern of missing information is not random, but is correlated with features of our sample (e.g., the defense/civilian dichotomy).

Finally, we compare overall Soviet lead times with lead times measured in other studies for West Germany, the United States and a special U.S. national Aeronautics and Space Administration program.

1. LEAD TIME IN THE SOVIET UNION

a. Lead time by technical area

Table 5 presents average lead time by technical area in ascending order. An F-test on the sample means is significant at the 1 percent level.

Many different factors—for example, differences in the relative complexity of inventions, in the mastery of related skills, in the managerial efficiency of involved organizations or in state priorities can influence average lead times among technologies. The relative impact of these factors on each technical area is difficult to identify, thus making a rigorous interpretation of the rankings presented in table 5 difficult. For example, the relatively fast performance of radioelectronics (ranked third) and "computers" (ranked seventh) corresponds roughly with perceptions of rapidly advancing technologies by world standards. Yet, the relative slow performance of "electrical engineering and machinery," where related ministries have undergone considerable reform, seem only explainable by somewhat tenuous ad hoc forms of reasoning—such as having relatively more complex inventions or requiring greater inputs for implementations. Similarly, while the slower performances of "domestic goods" and "food processing" squares with commonly held views on Soviet industrial priorities, the top performance of "glass and ceramics; paper and pulp; timber and wood working" requires additional explanation—e.g., a high concentration of petty inventions or inventions which require few resources to implement.

TABLE 5.—ESTIMATES OF LEAD TIME BY TECHNICAL AREA

[In ascending order]

Rank and technical area	Mean lead time (years)	Within class standard deviation
1—Glass and ceramics; paper and pulp timber and woodworking	3.30	2.53
2—Scientific instruments (physical and chemical property evaluation)	3.55	3.07
3—Radioelectronics	3.66	3.12
4—Medical equipment and preparations	3.67	2.86
5—Transportation equipment	3.73	2.45
6—Construction	3.78	2.56
7—Computers and related equipment	3.79	2.40
8—Metalworking	3.90	2.70
9—Ferrous metallurgy	3.92	3.15
10—Power generation	4.01	2.45
11—Domestic goods; textiles and publishing	4.01	2.86
12—Food processing and handling	4.04	3.48
13—Instrumentation (material testing; measurement and control)	4.26	3.49
14—Agriculture	4.26	3.28
15—Mining and drilling	4.47	2.47
16—Electrical engineering and machinery	4.82	3.82
17—Nonferrous metallurgy	4.91	3.94
18—Chemistry	5.35	3.69
Sample average	4.01	

$F^{17}_{1,601} = 2.745$

The appearance of chemistry at the very bottom of our list, however, corresponds to frequently heard criticisms of the Soviet chemical industry—including harsh criticism by the Soviet leaders themselves.

b. Lead time by implementing sector

Table 6 presents average lead time by identified implementing sector. An F-test on the sampled means is significant at the 1 percent level.

There is rough correspondence between technical and sectoral rankings (tables 5 and 6 respectively) where sectors are predominant users of a given technology (e.g., transportation, construction, and power generation and transmission technical areas and sectors). There is a striking difference between mean lead times for the defense industrial and civilian machine building sectors. However, the approximately 11.5 percent lower mean lead time in the defense industries is the result of a technical profile more heavily weighted in favor of rapidly technical advancing areas than is the case for civilian machine building as a whole (see tables 1 and 5). After accountng for the technical area of the invention, the lead time difference between the defense industrial and civilian machine building sectors is *not* statistically significant.

TABLE 6.—LEAD TIME BY IMPLEMENTING SECTOR

Rank and sector	Number	Mean lead time (years)	Within class standard deviation
1—Transportation	173	3.27	1.94
2—Defense industrial	260	3.77	3.54
3—Construction	58	3.78	2.83
4—Education and scientific	75	4.02	3.26
5—Light industry	121	4.15	2.88
6—Civilian machine building	387	4.26	3.10
7—Other heavy civilian	216	4.70	3.44
8—Power generation and transmission	52	5.01	4.27
Total sample	1,342	4.09	

$$F^{7}_{1,334} = 4.584$$

c. The impact of facility type—the movement from research to production

A number of Western and Soviet scholars have pointed out difficulties associated with movement of new technology from research or educational to production facilities.[25] On the one hand, research facilities may be expected to have the physical plant, human resources and the time to prepare new technology for eventual introduction. On the other hand, research facilities have been criticized for failing to adapt new technology to the requirements of production facilities and for general lack of interest in the eventual use of their results.

Of all inventions implemented in production facilities, we know that 337 originated in research, design, and educational facilities, and 150 other production facilities (not in-house: associations (*obyedineniye*), enterprises (*predpriatiya*) and plants (*zavody*)).

Average lead times for the inventions implemented in identified production facilities are presented in table 7, with the production facility to production facility flow broken down to account for in-house or same facility implementation.

The means of the relevant sub-samples—research originators (3.92) and organizationally district production facilities—(3.86) are not significantly different. While the sub-samples are small, these results suggest that the type of originating facility does not have a significant impact on lead time.

TABLE 7.—LEAD TIME IN THE MOVEMENT OF INVENTIONS TO PRODUCTION FACILITIES

Originator	Number	Mean lead time	Within class standard deviation
Inventions orginating in research facilities and used in production facilities [1]	337	3.92	2.19
Inventions originating in production facilities and used in production facilities	150	2.97	2.16
Of which originated in-house	101	2.53	1.81
Of which from other production facilities	49	3.86	2.53
Total	487		

[1] Excludes in-house production.

[25] See Berliner, op. cit., pp. 104–108.

d. In-house implementation and adjustment of sectoral results

As implied by the last set of results, whether or not an invention is implemented and introduced in the same facility has a marked impact on lead time. This is plausible for several reasons: (1) Problems of imparting know-how and transferring documentation and materials are minimized; (2) actual recognition of the presence of a patentable invention might occur after implementation had begun; and (3) the incentives to file may be reduced when only in-house use can be envisioned. We have sufficient information to determine whether or not the invention was originated and used in the same facility for 754 of our observations.

Average lead times within this subset are as follows:

	Number	Mean lead time	Within class standard deviation
In-house implementation	240	2.85	1.89
Implementation of inventions originating out-of-house	514	3.82	2.28
Total	754	3.51	2.21

The difference in means is statisically significant at the 1 percent level.[25a] In-house implementation reduces average lead times by approximately one-third, but this subsample ($\overline{X}$ 3.51) is not representative of the full sample ($\overline{X}$=4.01)

A factor with such a large impact must be accounted for in measurements of lead time along other dimensions. Tests reveal that results for two sectors may be significantly affected after accounting for this factor.

First, virtually all inventions implemented in the scientific and educational sectors are in-house inventions. Therefore, the relevant comparison for lead time in this sector is with in-house implementation in other sectors, as presented in table 8. On this basis, Educational/Scientific lead times are particularly long.

Second, the defense industrial sector is the only sector of our sample for which virtually no information is provided on the originating facility. Thus, we have no indications of which defense industrial inventions were implemented in-house. However, while a particularly high proportion of in-house defense industrial implementation could help explain superior overall defense industrial lead times, we have no basis for assuming that the proportion is significantly different from that for other sectors.

[25a] The evidence of shorter lead-times in the case of in-house implementation suggests why the Soviets are creating scientific production associations (NPO's)—organizations usually incorporating a research institute, design bureau and production facilities—inteneded to reduce the time required for new technology assimilation.

TABLE 8.—TOTAL, SCIENTIFIC-EDUCATIONAL, AND CIVILIAN MACHINE BUILDING LEAD TIMES, TAKING INTO ACCOUNT IN-HOUSE IMPLEMENTATION

Sector	Number	Mean lead time	Within class standard deviation
Total implementations	754	3.51	2.21
1. Of which—			
Originated in-house	240	2.85	1.89
Originated out-of-house	514	3.82	2.28
2. Of which—Implemented in educational/scientific sector[1]	56	3.18	2.01
3. Of which—			
Implemented in civilian machine building sector	217	3.78	2.28
Originated in-house	81	3.18	2.02
Originated out-of-house	136	4.13	2.36

[1] Only 2 inventions originated out-of-house.

e. The impact of location

Several urban areas in the Soviet Union are known to have especially large concentrations of long-established research and developments facilities. Close proximity to R. & D. establishments may be expected to facilitate implementation for a number of reasons, including proximity to the inventions themselves, proximity to supporting technical assistance, and reliance on a large and well-developed infrastructure for supply of skilled labor and special-purpose materials.

To test this hypothesis, we measured average lead time by implementing location, with a subset of inventions defined for those implemented in Moscow, Leningrad, Kiyev and Kharkov oblasts, all oblasts with large R. & D. bases. Results are presented in table 9. The difference in mean lead times between this group of urban centers and other locations is statistically significant at the 1 percent level. While part of the difference is explained by a slightly higher concentration of in-house implementation in urban centers, the difference remains significant after taking this factor into account.

TABLE 9.—LEAD TIME BY IMPLEMENTING LOCATION

Location	Number	Mean lead time	Within class standard deviation
All locations	1,015	4.26	3.17
Of which—			
Moscow, Leningrad, Kiyev, and Kharkov Oblasts	244	3.40	2.52
All other locations	771	4.52	3.31

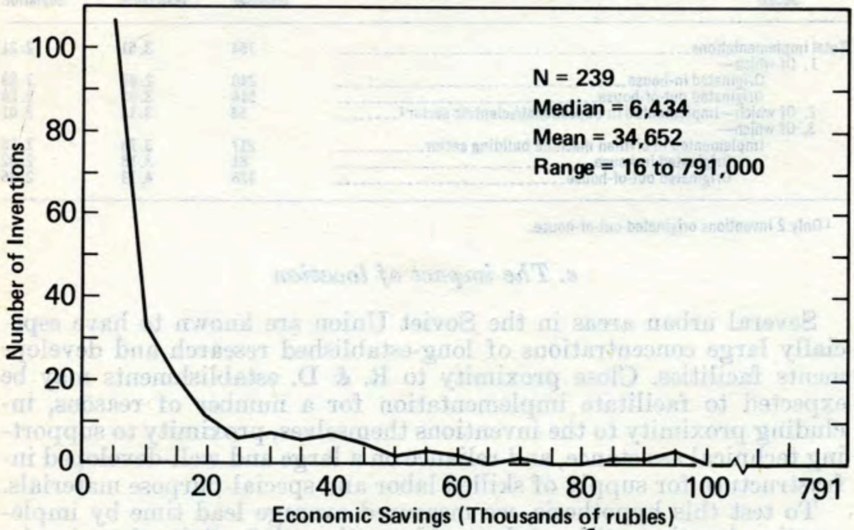
f. Economic effectiveness of the invention

Calculations of economic effectiveness are provided for 239 of our observations.[25b] The distribution of these observations is presented in figure 4.

[25b] Economic effectiveness is an expression representing the annual cost savings expected or realized from a new advance in relation to the process it is replacing. The net unit current and pro-rated capital cost savings are multiplied by annual output to arrive at the sum of annual economies.

Figure 4

The Distribution of Economic Savings for Inventions Sampled in this Study*



*23 inventions had economic savings greater than 100,000 rubles and are not represented on this graph.

Source: Authors' sample from *Vnedrennye izobreteniya.*

The number of observations is too few to be representative of the entire sample, especially since missing calculations are not randomly distributed. With this caveat, we have performed a simple linear regression of lead time (in days) on economic effectiveness (in rubles). The coefficient on effectiveness has a value of −.001, not significantly different from 0.

However, as indicated in the first part of this section, we cannot assess whether economic effectiveness should be correlated positively or negatively with lead time without information on the technical requirements and cost of implementation. To the extent that increase in economies is likely to be associated with increase in the "size" or cost of the invention, we might expect a positive correlation between lead time and effectiveness. This hypothesized relationship is not borne out, possibly because (apart from the expected weak correlation) the higher effectiveness of "larger" inventions can more than compensate for higher costs associated with rapid implementation, yielding roughly equivalent lead time as smaller inventions.

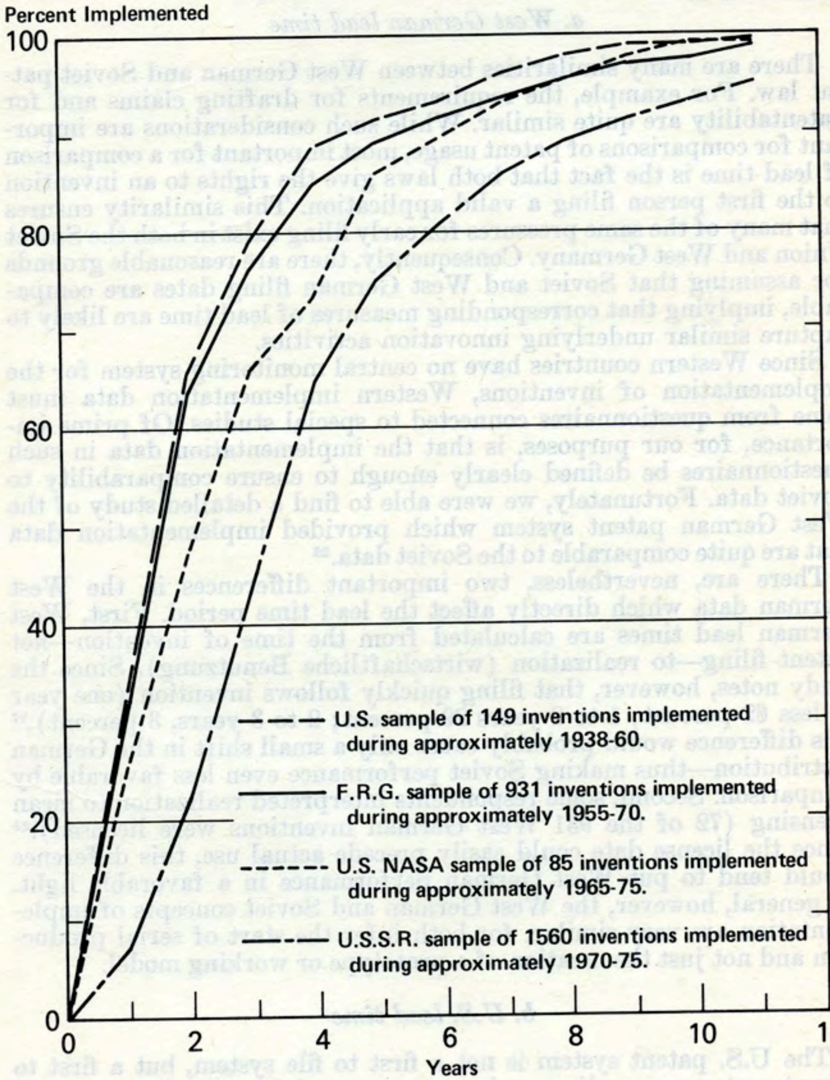
2. COMPARISON OF SOVIET AND WESTERN LEAD TIME

Our definition of lead time—which uses features of patent law common to many countries—provides an unusual opportunity to compare the technical innovation performance of several countries. In fact, some Western studies on the use of patented inventions permit, with varying degrees of qualification, just such comparisons.

Figure 5

Lead Time for the Implementation of Inventions—U.S., F.R.G., U.S. NASA, and U.S.S.R.

(Cumulative distribution)



Source: U.S. data from Barkev S. Sanders, "Speedy Entry of Patented Inventions into Commercial Use," *The Patent, Trademark and Copyright Journal of Research and Education,* Volume 6 (1962), No. 1, p. 95; FRG data from Klaus Grefermann, et. al. *Patentwesen und technischer Fortschritt, Teil I Die Wirkung des Patentwesens im Innovationsprozess,* (Goettingen: Verlag Otto Schwarz, 1974), Tabelle 62-65; NASA data collected by authors from NASA patent waiver records; and USSR data from authors' sample of inventions in journal *Vnedrennye izobreteniya.*

Figure 5 presents cumulative implementation of inventions for the Soviet Union (based on our sample), the Federal Republic of Germany, the U.S., and the U.S. National Aeronautics and Space Administration, (based on results of other studies). The curves indicate the percent of inventions implemented (y-axis) in any given number of years (x-axis). We now describe the basis and findings of each of the other studies.

a. West German lead time

There are many similarities between West German and Soviet patent law. For example, the requirements for drafting claims and for patentability are quite similar. While such considerations are important for comparisons of patent usage, most important for a comparison of lead time is the fact that both laws give the rights to an invention to the first person filing a valid application. This similarity ensures that many of the same pressures for early filing exist in both the Soviet Union and West Germany. Consequently, there are reasonable grounds for assuming that Soviet and West German filing dates are comparable, implying that corresponding measures of lead time are likely to capture similar underlying innovation activities.

Since Western countries have no central monitoring system for the implementation of inventions, Western implementation data must come from questionnaires connected to special studies. Of prime importance, for our purposes, is that the implementation data in such questionnaires be defined clearly enough to ensure comparability to Soviet data. Fortunately, we were able to find a detailed study of the West German patent system which provided implementation data that are quite comparable to the Soviet data.[26]

There are, nevertheless, two important differences in the West German data which directly affect the lead time period. First, West German lead times are calculated from the time of invention—not patent filing—to realization (wirtschaftliche Benutzung). Since the study notes, however, that filing quickly follows invention (one year or less 62 percent; 1 to 2 years 29 percent; 2 to 3 years, 3 percent),[27] this difference would probably cause only a small shift in the German distribution—thus making Soviet performance even less favorable by comparison. Second, some respondents interpreted realization to mean licensing (72 of the 931 West German inventions were licensed).[28] Since the license date could easily precede actual use, this difference would tend to put West German performance in a favorable light. In general, however, the West German and Soviet concepts of implementation are very similar, for both infer the start of serial production and not just the creation of a prototype or working model.

b. U.S. lead time

The U.S. patent system is not a first to file system, but a first to invent system—according an inventor some rights even before filing. Thus, it is questionable whether the U.S. filing date can be used as a

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[26] A. Grefermann, Karl Heinrich Oppenlaender, Elfried Peffgen, Karl Ch. Roethlingsholfer, and Lothar Scholz, Patentwesen and Technischer Fortschritt Teil I: Die Wirkung des Patentwesens in Innovations prozess, (Goettingen : Verlag Otto Schwarz and Co., 1974).

[27] See ibid., table 32.

[28] Ibid., tables 60–65.

starting point for lead times or is conceptually similar enough to be compared to the filing dates of first to file countries. In other words, lead times calculated on the basis of U.S. filing dates would be inherently shorter than the lead times of first to file countries. Nevertheless, for the sake of completeness, we have included on figure 5 the results of a study on U.S. patent usage.[29]

c. U.S. NASA lead time

Although comparisons of U.S. and Soviet lead times are severely hampered by the differences in legal systems mentioned above, a NASA program on patent waivers offers an unusual opportunity to calculate some more comparable U.S. lead times. Specifically, private contractors working on NASA funded research projects may apply for the patent rights to inventions considered to have potential commercial value.[30]

The granted petition for the patent rights is termed a patent waiver. This waiver is offered by NASA as a means of encouraging commercial spin-offs and is to be applied for when contractors first become aware of the technical originality and commercial potential of their research. In our sample, the date of a petition for a patent waiver preceeded the actual filing for a patent in one-third of the cases. Consequently, the date of a petition for a patent waiver can reasonably be assumed to correspond more closely to the Soviet and West German filing dates than do U.S. filing dates.

To administer the patent waiver program, NASA established an Inventions and Contributions Board. One of this Board's functions has been the monitoring of the commercial development of waived patents. In carrying out this function, the Board has followed up the granted patent waivers by means of a questionnaire. The date of first commercial use is one of the items of this questionnaire. Consequently, we are able to establish a lead time for NASA patent waivers by calculating the time between the waiver petition and first commercial use.

d. Comparing lead times

In addition to the problem created by differences in U.S. and FRG/U.S.S.R. filing criteria, the comparison of lead times needs additional qualification. As indicated in figure 5, the time periods covered by the inventions sampled differed among studies. With differing time periods, the technologies and technical generations covered by the sample clearly differ. If newer or older technologies differ inherently in their required lead times or if R&D management practices have changed significantly over time, the comparisons are, to that extent, misleading.

However, the differences between U.S.-West German performance and Soviet performance are striking. (The U.S. and West Germany implemented over 50% of their inventions in little more than one year,

[29] Barkev S. Sanders, "Speedy Entry of Patented Inventions into Commercial Use," The Patent, Trademark, and Copyright Journal of Research and Education, 1962, Volume 6, No. 1, pp. 87–116. Since many inventions were actually used before patent applications were filed, the U.S. distribution would include a large number of negative lead times. These cases were discarded, thus making U.S. performance somewhat less favorable.

[30] "Patent Waiver Regulations," Federal Register, Volume 42, No. 212 (Nov. 3, 1977), pp. 57449–57454.

whereas the Soviets needed slightly more than three years to achieve this percentage of implementation). In fact, while the U.S., West German and NASA distributions are not significantly different statistically from each other, all are significantly different from the Soviet distribution at the 1 percent level.

VI. Summary and Implications

A. Summary

In this paper we have exploited a newly available data source—*Introduced Inventions*—to investigate Soviet performance in the implementation of inventions. We first outlined the Soviet concept of an invention and described the process by which inventions become formally certified. In particular, we argued that inventions implemented for the first time make an important contribution to overall technological progress, and due to a number of factors inventions as a whole may indeed be growing proportionately as a source of technological proggress. In any case, because Soviet inventions are implemented in the same organizational networks and subjected to the same types of policies as other technical innovations, our findings may be expected to apply—with appropriate qualification—to Soviet innovation in general.

Secondly, we defined the critical performance measure—lead time—and described our sample of implemented inventions on the basis of technical concentration, sector of origin and use, types of originating and using facilities, and location of origin and use. The technical and sectoral breakdown of our sample closely paralleled the corresponding breakdowns in the population of total Soviet inventions, testifying to the representativeness of our sample. Patterns of intersectoral, interfacility and interregional flows are consistent, for the most part, with prior expectations, particularly concerning: (1) the high proportions supplied internally within broader sectors (regions, etc.); (2) the tendencies for certain sectors to be net originators (e.g., scientific and educational) and certain sectors to be net users (e.g., transportation); (3) the tendencies for certain facility types to be net originators (e.g., research institutes) and certain types to be net users; and (4) the expected geographic concentrations of sources of inventions in acknowledged "science centers"—namely Moscow, Leningrad, and to a lesser extent Kiyev and Khar' kov. The only unexpected result in this outline of the sample is the surprisingly small role played by independent design bureaus of various types in the invention process.

Following a theoretical discussion of the factors influencing leadtime and the limited way our data encompasses these factors, we presented measures of lead time for several dimensions of our sample. Among the major findings:

There is significant difference between average lead times by technical areas, with 2.05 years separating the fastest and slowest of the 18 areas;

There is significant difference between average lead times by implementing sector, with 1.74 years separating the fastest and slowest of the 8 sectors;

Lead time is found to differ significantly when the invention was originated and implemented in the same facility, reducing lead time by an average of 25 percent over the implementation of inventions from different facilities;

Lead time for implementing inventions in production facilities is found to be unrelated to whether the invention originates in a research/educational facility or a second production facility;

Lead times for inventions implemented in R&D intensive urban centers (Moscow, Leningrad, Kiyev and Khar'kov oblasts) are found to be approximately 24 percent less than lead times for inventions implemented in other locations;

Lead time is found to be uncorrelated with the economic effectiveness of the invention, although we are unable to account for the cost of the invention; and

Average lead time for inventions implemented in the defense industrial sector is found to be 11.5 percent less than average lead time for inventions implemented in the civilian machine building sector. However, the lead time difference between the two sectors can be accounted for by the defense industrial sector's proportionately greater number of inventions from rapidly advancing technical areas, i.e., after accounting for the technical area of the invention, the difference is not statistically significant.

We note that severe missing data problems make it inadvisable to test other important hypotheses until the sample is expanded, which is now underway.

Finally, we presented comparisons of overall lead time performance between the U.S.S.R. (based on our sample), the U.S., the Federal Republic of Germany (based on earlier studies) and the U.S. National Aeronautics and Space Administration (based on a special NASA program). Differences in national patent policies and study data collection standards make it impossible to draw exact comparisons, but even allowing for a significant margin of error, it is evident that U.S.S.R. lead time is by far the longest of the four. At the end of two years, 66 percent of U.S. inventions were implemented, 64 percent of FRG inventions, 47 percent of NASA inventions, and 23 percent of Soviet inventions. A F-test on the means of the three Western samples failed to show a significant difference at the 5 percent level, while a F-test on all four means was significant at the 1 percent level.

B. Implications

To the best of our knowledge, we have provided the first comprehensive measure of Soviet lead time and measure of certain technical, organizational, and administrative factors affecting Soviet lead time. These findings demonstrate the value of studying Soviet inventions in general and of using the journal *Introduced Inventions* in particular. Further, it is interesting to note that data on implemented inventions comparable to Soviet data are not collected in Western countries. Thus, for once, more accurate international comparisons await expansion and improved standardization in Western data sources, not Soviet.

The results of this paper bear out most of the hypotheses developed earlier by Western scholars on the basis of case studies, Soviet policy pronouncements and anecdotal material. As previously noted, the breakdown of our sample by technology, sector, facility type and location reveals almost without exception the expected concentrations and flows of inventions. "In-house" implementation drastically reduces lead time, and Soviet lead time is considerably slower than Western lead times. These and other expected results are testimony to the value of traditional research approaches and particularly to Western abilities to deduct performance on the mass of complex economic policy pronouncements that issue from all levels of the Soviet state and party apparatus. However, our finding of similar lead times in the defense industrial and civilian machine building sectors—after accounting for technology—questions the generally accepted view of markedly superior defense industrial performance.

The implications of our finding of relatively slow Soviet lead time—and hence poor innovative performance—for future Soviet technological advance have been well developed in numerous other sources and are not repeated here.[31]

The damaging effect from the compounding of each successive technical generation's long lead times is, however, worthy of reiteration. In general, our findings help explain the secular decline in Soviet factor productivity demonstrated in macroeconometric studies of the Soviet economy.[32]

The findings of differentials in sectoral performance also have important implications for Soviet economic prospects. Our results suggest that lead times in civilian machine building are slightly longer than lead times in other civilan industries. (This result may stem from our inability to take into account all relevant factors—e.g., possibly larger and more complex inventions within civilian machine building sector.) The civilian machine building sector includes ministries that specialize in computers, instruments and sophisticated electrical machinery, and it has been a principal recipient of Western technology (automobiles, chemical machinery). Generally, machine building has been acknowledged by Soviet specialists to be the principal foundation for technical progress. Comparatively poor performance in this key sector can only hinder performance in other sectors that rely on machine building for plant and equipment. As sectors become increasingly interdependent, both technically and economically, poor civilian machine building performance may even affect the defense industries.

Finally, we reiterate the crucial point made earlier that our study of lead time lacks essential data—e.g. resources applied to innovation and Soviet priorities—necessary for a fuller evaluation of sectoral managerial performance and economic organization. Thus superior sectoral or ministerial lead times may be "bought" at such a cost in resources so as to more than overcome what may in fact be comparatively poor management and organization. Nevertheless, our study strongly implies that overall Soviet management and economic orga-

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[31] See, for example, Berliner, op. cit.; Philip Hansen, "International Technology Transfer from the West to the U.S.S.R.," in Soviet Economy in a New Perspective (Washington: Joint Economic Committee, 1976), pp. 786–812; David Granick, Soviet Introduction of New Technology: A Depiction of the Process, SSC–TN–2625–7, SRI/Strategic Studies Center, 1975; and John P. Young, Alvin M. White, Hugh L. Shaffer and L. N. Freudenreich (Batellie Memorial Institute), A Description and Comparison of the Planning and Management of Research and Development in the U.S.A. and the U.S.S.R., Report prepared for the National Science Foundation, June 17, 1977.

[32] See, for example, Rush V. Greenslade, "The Real Gross National Product of the U.S.S.R., 1950–1975," in Soviet Economy in a New Perspective (Washington: Joint Economic Committee, 1976), pp. 269–300 and Donald W. Green, Gene D. Guill, Herbert S. Levine and Peter Miovic, "An Evaluation of the 10th Five-Year Plan Using the SRI–WEFA, Econometric Model of the Soviet Union," in ibid., pp. 301–376.

nization for technical innovation are comparatively poor by Western standards.

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