A PRELIMINARY ANALYSIS OF
THE SUPPLY OF INNOVATION:
THE RELEVANCE OF INTERVIEW
EVIDENCE TO PERESTROIKA

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Abstract

Interview evidence defines some of the important ways in which Soviet institutions distort the use of R & D resources and impede the flow of technological improvements into production. The main themes that emerge from our interviews are these: 1) Lack of support afforded the development of new technology; 2) lack of appropriate criteria for evaluating innovation and other shortcomings of the R & D process itself; 3) rigidity and compartmentalization of the institutional environment and isolation from world developments; 4) heavy costs imposed by an excess demand environment; 5) lack of incentives for diffusion of innovation. A recognition of these institutional barriers underlies the agenda of perestroika. One criterion for the success of perestroika will be whether it succeeds in addressing this agenda.
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A PRELIMINARY ANALYSIS OF THE SUPPLY OF INNOVATION: 
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We would be dismayed if evidence from interviews contradicted what we have learned in decades of following Soviet published literature and visiting the Soviet Union first hand; it does not. Similarly, we would be discouraged if the effort to find Soviet emigrant scientists and engineers and to interview them about their work yielded nothing more than interesting anecdotes to elaborate our established picture of the Soviet economy; it yields more.

After a small number of interviews—we have completed 31 three-hour interviews—we give very different weights to factors impeding innovation than we did when our view was based on the published literature. We have learned about some subjects, such as industrial safety, that were missing from the published literature entirely until very recently. Most importantly, our interviews with Soviet scientists and design engineers spotlight the same major themes that are at the center of Gorbachev's agenda for perestroika. The insights of participants in the innovation process allow us to assess the prospects for success of current institutional initiatives.

Interview evidence supplements other sources of information. Even now, with the advent of Glasnost', what we can read in the Soviet press and discuss on visits to the Soviet Union provides a faint and incomplete picture of what participants in the system could tell us in a frank and far-reaching discussion. Interviews provide a context and richness of detail that puts press accounts into perspective.
Our interviews with participants in the innovation process spotlight the microeconomics of choice in Soviet organizations. Unless the Soviet leadership itself gains a better understanding of the microeconomics of its own institutions and adjusts its policies in the light of that understanding, the economic process of perestroika will miscarry. In the pages that follow, we draw on interview evidence to identify and explore some of the circumstances impeding the supply of innovation in the Soviet Union, and we ask to what extent the measures undertaken by the Soviet leadership as a part of perestroika may succeed in reducing these obstacles to innovation.

The themes we have chosen to present come both from what Soviet engineers said to us and what they did not say. There are insights to be gained from the experience of the design engineer who had to get a new assembly line installed and operating; there are also inferences to be drawn from the design engineer who made no mention of contacts with the ultimate users of equipment; who did not know how the equipment he designed would actually be used.

The interview cases show both consistency and diversity. It is a recurring theme that design assignments are handed down from above, that they imitate foreign developments, and that their evaluation is based on arbitrary criteria unrelated to cost, but there is great diversity among industries in the available resource base and in access to information.

The main themes that emerge from our interviews are these: 1) The lack of support afforded the development of new technology; 2) the lack of appropriate criteria for the evaluation of innovation, along with other shortcomings of the R & D process itself; 3) rigidity and compartmentalization of the institutional environment, and isolation from world developments; 4) the heavy costs imposed by an excess demand environment; 5) the
lack of incentives for diffusion of innovation. Some of the economic measures of perestroika are designed to correct these failings, but some of these problems are likely to persist into the 1990s.

**Design Engineers**

The majority of our respondents are design engineers trained in industrial engineering institutes in various fields of machine building, machine tools and instruments, energy, or (occasionally) other heavy industries and who were employed in scientific research organizations, design bureaus, and project-making bureaus in the Soviet Union. A few are scientific researchers and computer specialists who worked in scientific research organizations. They range in age from, roughly, 35 to 65. Most left the Soviet Union in the period 1979-1985. Their job titles in their last regular job in the Soviet Union range from junior scientific associate to director of a scientific research institute. Twenty-seven of the thirty-one respondents completing full interviews are male. All but four worked in organizations subordinate to an All-Union Ministry. All but two held supervisory positions, but the majority supervised fewer than 25 individuals. The informants worked in organizations ranging in size from 250 to over 3,000 employees.

The characteristics of the older and younger respondents are somewhat different. The typical respondent in his late forties had worked as chief engineer of a ministerial design engineering bureau (*konstruktorskoe buro*). He worked in Moscow, Leningrad or a large city in the Ukraine, earned about 240-250 rubles per month, and received more than one "innovators certificate" or patent during his professional career in the Soviet Union. The typical respondent in his thirties, on the other hand, was a senior or junior scientific associate in a laboratory in a scientific research
institute. He had received his engineering degree within the last 6 to 10 years and earned less than 200 rubles per month, sometimes as little as 150 rubles per month. (These salaries compared to the average gross monthly salary of engineering technical personnel in the GI sample (Soviet Interview Project) of 178.5 rubles per month, or slightly lower than the average of 183 rubles per month for the entire sample.) What our respondents have in common is having held a job in an organization that bridged the gap between basic research and the final process of investment in new technology. Many of the respondents hold jobs in the U. S. similar to their jobs in the Soviet Union and are able, therefore, to compare levels of training, organization of work, availability of information and equipment and other aspects of engineering in the two countries.

Availability of Resources

The lack of official support afforded R & D is a recurrent theme in the interviews with Soviet designers. Many of the engineers in design bureaus laughed when we began asking a set of questions on the quality of equipment available to them. "What equipment?" was a common question, "I used pencil and paper." One respondent who answered in this way then went on to explain that the combination of low quality paper and frequent changes in design accounted for the low productivity of his organization. Every change in the design of a project required corresponding changes in the engineering drawings of a project, and the available paper was of such low quality that erasure or re-drafting resulted in torn paper and, hence, the task of re-drawing the whole design.

Almost a third of those who were asked about the availability of computers said their organizations had no computers or dismissed the subject with an answer such as: "That was another part of the organization. I didn't have any contact with that."
Many of those who answered that their organizations did have access to computers added that they were mainly for routine calculations such as payrolls and wages and not for engineering. The situation of scientists and engineers working in scientific research institutes (NII) was somewhat different. These individuals did use computers to analyze statistical data and to do formal modeling. However, even in these cases, the research institute did not always have its own computer. Sometimes quantitative work was carried out in the computer center of a neighboring institute.

There is considerable evidence that it was hard for R & D organizations to acquire the equipment and components that they needed from outside suppliers because the supplying organizations had gross output targets to meet that would be disrupted by the production of a few custom items for R & D.

Most of our design engineers said that their prototype production capacity was adequate. By this they meant that they had a small machine shop where small custom components could be fabricated. Many of those involved in prototype or experimental production describe construction of their own components in-house. When components could not be self-supplied, they usually turned to informal channels. The chief designer of one research institute recounted attempts to acquire a diesel engine for a prototype unit by offering the appropriate official of the supplying firm a trip to the Carpathian Mountains.

When we asked engineers who held similar jobs in the Soviet Union and the U.S. to compare their work in the two countries, a surprising number commented first on the difference in their physical surroundings in the two.

We found a substantial difference between the resources and information available to firms that supplied strategically important industry. Respondents in non-strategic industries reported that they used little foreign equipment—perhaps some tools from
Hungary or Czechoslovakia. Some designers in low priority sectors responded that it was illegal for them to specify foreign goods in their designs. Strategically important facilities, however, appeared to be in vastly different circumstances. For example, an engineer in an experimental factory in Leningrad who designed specialized electronic components reported that he was supplied with a variety of foreign equipment and had access to a whole array of foreign inputs, "including Swiss ball bearings." We infer that such factories are supplying customers in the military sector when the subordination of the factory is so designated by the respondent or by Western sources. In some cases, our respondents mention working with representatives of the user or comment that such equipment was shipped "to a post office box."

The Draft Guidelines for Economic and Social Development of the Twelfth Five-Year Plan (FYP) promised a massive infusion of modern instruments, equipment, means of automation, and materials to improve the material and technical base of science, but the implementation of these plans is going slowly.\(^1\) Although the output of

\(^1\)Pravda, November 9, 1985, 1-6.
computer equipment and scientific instruments is scheduled for priority growth, both are starting from seriously inadequate levels. The Soviet Union lags the West to an extraordinary extent in its ability to supply its economy with computer services. The Soviet Statistical Abstract reports that the Soviet economy received 16,200 computer systems (measured in "units of standard quality") as well as 16,600 personal computers in 1986. By comparison, in 1984, U.S. industry purchased 2,182,005 computers—10,700 mainframes, 72,130 minis, and 2,100,000 micros.\(^2\) During 1987, plans for computer production were met, but plans for production of instruments were not fulfilled. Since, in addition, there was a large drop in imports of Western machinery and equipment, it looks as though the process of building up the R & D resource base is still proceeding slowly. A recent communication of the Central Committee CPSS on July 10, 1988, indicates that R & D will gain priority access to computers. This report says that a large share of computer output will go to 44 priority programs. This share will constitute roughly one-half of the scientific-technical output of research institutes and construction bureaus (NII i KB) in machine building and metal working; it will account for two-thirds of the investment in the scientific research and development base; and it will account for three-fourths of the computer resources allocated to the whole machine building sector.\(^3\)

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\(^3\)"Soveshchanie v TsK KPSS," Pravda, July 10, 1988, 2.
Organization of R & D: Shortcomings of the R & D Process

Only in the scientific research institutes did the design engineers seem to enjoy a certain amount of influence in drawing up their scientific plans and setting research agendas. Most other engineers describe their research goals as coming from higher up the ministerial hierarchy. Goals seemed to be set arbitrarily by the central ministry. There were many cases in which design organizations were supposed to generate "new discoveries" according to plan. One engineer reported that his organization had to fulfill a plan to earn a set number of author's certificates for new designs each year. A design engineer who wrote the specifications for a new plant or assembly line would actually see his project under construction and participate in installation and start up of operations, but a designer who designed a new prototype piece of equipment usually did not participate in the process of determining whether his model would be adopted for serial production by the ministry.

The plans for innovation handed down by the Main Technical Directorate of a Ministry were generally imitative of developments in the West. An example is an engineer in one of the transportation ministries. His department would be assigned the task of designing an alternative component to achieve the same technical result in a different way without infringing on the foreign patent.

We asked each respondent to select a particularly significant project and posed a series of questions about that project, including how the project had been initiated. The experience of a designer of medical equipment is typical. She said that her most significant design had been a prototype piece of equipment for radiological diagnosis. The project originated when a scientist at the scientific research institute saw such equipment in a Western technical journal and prepared a report for the ministry. Her
ministry's Chief Administration subsequently assigned to her organization the task of replicating the Western model.

It seems that Soviet design engineers reflect a different outlook in talking about technical problems than their American counterparts. There are frequent references in our interviews to designing the best, or most advanced model, one that is "up to world standards." In talking about similar products, the U.S. engineer goes almost immediately to the question of choosing between technological tradeoffs, that is, trading off flexibility, for example, against fuel efficiency, weight against durability. The difference in emphasis may reflect the fact that the Soviet engineer confronts a smaller range of choices and is more constrained to specify his project "according to the spravochnik."

The chief performance criterion for design organizations is the timely completion of projects. There were almost no reports of projects terminated unsuccessfully. "When completion was in question, quality was reduced," was one answer. Design engineers describe without embarrassment the need to convince customers to sign-off on unfinished blueprints and specifications or to accept a deficient prototype.

The enormous pressure to achieve planned goals seems to account for the frequent references to violations of safety practices and accidents that informants brought up. One source who designed safety equipment for mines listed accidents and casualties by place and time in considerable detail. Another, in the power industry, described steps that he took to put a large turbine on line by December 31. Since the appropriate boiler was not yet in working order, he bribed the chief engineer of the turbine factory to approve connecting the turbine to an existing boiler that produced steam at a lower pressure and temperature. He said the procedure was "strashno opasno" (extremely dangerous), but the cost of failing to meet the plan was so high that he
chose to take the risk. (An American engineer to whom I described the procedure said that it was risky indeed.) Another respondent described a co-worker who unplugged a frozen gas pipeline by piling truck tires under the plug and setting them on fire.

Our interview data contain many examples in which modernizing enterprises were expected to retool an existing production line and continue previous levels of production simultaneously—normal inconsistent activities. A number of cases are also detailed in which new products or processes were deficient in important ways. An extreme example is the case reported by a designer in the motor vehicle industry in which a new model could not be mass produced with the required tolerances that had been achieved by hand-crafting when the prototype was built. In another case, a newly-installed unified assembly line was, indeed, more productive than the several separate machines that it replaced when the assembly line was running, but, each time a part needed replacement or a component needed adjustment, the whole assembly line had to be shut down. Before modernization, production had continued on the remaining machines when any one machine was stopped for repair or adjustment.

Two surprising findings that emerge from the interview study of Soviet design engineers are the engineer's disinterest in and disregard of costs in the design process and the small share of new technological developments that actually found their way into use in production. Many of the engineers interviewed treat as naïve our questions about whether their new prototypes cost less to produce than old models or whether the newly-developed equipment will lower the costs to users. A frequent answer was: "Cost estimates were made in a different division," although one engineer did answer, "Oh, yes, I know what you mean; I did my engineering diploma paper on the cost-saving afforded by one of our designs."
One engineer responded that he did not design with any concern for accounting costs, but did design with concern for scarcity. In laying out utility conduits, for example, there were certain small "connectors" that cost just a few kopeks but were extremely scarce, so his engineers would design everything else in a project around the need to minimize the number of connectors used. Instead of delivering power to each apartment building through its own conduit (which would require as many connectors as apartments), he brought power into the center of a complex and branched all the individual delivery systems off of a single connector.

The separation of technical from economic considerations may be one factor in explaining the small share of new prototype technologies that is actually put into serial production. An engineer who worked in a design bureau for motor transport for almost 20 years reported that the plan of his division required the production of a new prototype vehicle each year. In answer to the question,

4I am avoiding reference to specific industries and products in order to protect the anonymity of respondents.
"How many of these vehicles found their way into serial production," he responded, "One and one-half." An engineer whose institute was affiliated with the famous Paton Institute of Welding Technology, and who had received several foreign patents for his equipment designs, reported that only two of his designs were put into general production in the Soviet Union.

Another engineer who directed the lead design institute in an energy producing ministry, whose organization designed several new models of equipment each year, and who, individually, had received "dozens" of inventor's certificates, reported that only one major piece of equipment developed by his organization was ever put into production. He reported that this equipment was put into production for a couple of years and was then discontinued because it was too expensive to maintain.

Our impression is that the technical level of organizations designated as "scientific research and production organizations" is very uneven. Some respondents reported that they began working for design bureaus which were subsequently designated "scientific research and production organizations." The change, we are told, increased the status of the organization and gained it more resources. But we speculate that the resulting proliferation reduced the average resource base of each research and design unit in the ministry and added to the fragmentation of research activities.

So far, the practice of perestroika is ambiguous as to whether it will end the arbitrary, centralized setting of research agendas or put decentralized producers in a position to focus innovation more directly on processes and products that lower economic and social costs. In the Twelfth FYP, the State Committee for Science and Technology was assigned the primary role of overseeing ministerial programs for implementation of science and technology. The result of this centralized process is the identification of "44 priority projects" (the ultimate socialist oxymoron) whose
implementation is to be assured. This approach, as well as the creation of Interbranch Scientific Technical Complexes in priority areas indicates that the selection of directions of technological priority will remain centralized.\(^5\)

The new rules for foreign trade that give individual ministries and large firms direct access to the foreign market are a more promising development, as are laws allowing joint ventures between Soviet and foreign entities. These rules, if they are fully implemented, could give Soviet producers greater opportunity to acquire desired technology and to benefit from the resulting improvement in efficiency. Similarly, a full implementation of the Law on State Enterprise would create a demand for cost-reducing innovation. (This point is discussed under incentives, below.)

Finally, the more open discussion in the press of industrial safety and health conditions for workers has encouraged research and development into safety systems and the design of safer equipment. Developments in the nuclear power industry in the wake of the Chernobyl plant accident are one example. The notes of Valeriy Alekseyevich Legasov, Deputy Director of the Kurchatov

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\(^5\)There seems to be little evidence that interbranch complexes are succeeding in breaking down departmental barriers and obstructions, but that is the subject of another paper.
Institute for Atomic Energy, were published in Pravda after Legasov took his life on the anniversary of the Chernobyl plant accident. In his notes, Legasov describes the shortcomings of research and development in the nuclear power industry with the same candor that we encountered in our interviews about other industries. Research on the safety of coal mines is another example. A recent issue of Ekonomicheskaia gazeta presents two full pages about the development and installation of mine safety equipment designed at the Donetsk Coal Scientific Research Institute. The article refers to a number of major methane explosions and fires, and ask why the coal ministry has been so slow to install safety systems designed by scientists at the Donetsk Institute.

Organization of R & D: Organizational Barriers to Innovation

The most important organizational barrier that differentiates Soviet designers from U.S. designers is lack of physical mobility. It was only after many interviews that it struck us just how many of our respondents spent their whole careers in a single city and in a single organization. When we brought up questions of changing jobs or moving georgraphically, respondents were quick to remind us of the propiska. Both of the engineers whose careers were in the forest products industry—one very senior, the other very junior—said they had chosen the forest products fields because they wanted to remain in Leningrad and knew that design organizations for the forest products industry were clustered there.

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6Legasov's notes were published in Pravda, May 20, 1988, pp# 3,8.
Respondents from major cities, such as Moscow, Leningrad, or Kiev often worked at scientific research institutes or design bureaus that were far removed from the major production installations of their ministries where their designs would be used. Design engineers in the Ukraine only were likely to report proximity to/and interaction with their user clients.

Among our respondents there were no examples of close technological or institutional cooperation on projects that cut across ministries. One design engineer who worked for the Experimental Scientific Research Institute of Metal Cutting Machines (ENIMS) reported that he was assigned the task of designing computer-aided metal-cutting machines but was denied the right to design and produce the associated computer controls. Computer controls were the responsibility of the Ministry of Instrument Making, Automation Equipment, and Control Systems, a ministry, incidentally, that gave low priority to ENIMS projects. The result was inevitable delay in civilian machinery projects that could neither produce their own nor extract components from other more powerful partners.

On the other hand, there were examples of loose coordination of a large group of subcontractors on investment projects. Sometimes design engineers actually played the role of general contractor on such projects. There were also examples of scientific collaboration among groups of related scientific research organizations. One scientist reported that the most important project on which he worked was a large study for which his research institute was the lead institute. In this role, he coordinated the contributions of dozens of other research laboratories at other institutes. Finally, there were frequent examples of informal exchange of deficit inputs between units subordinate to different ministries. One example was the main computer center of a republican ministry. A former engineer in the center described a regular multi-sided
exchange of components and peripheral materials, such as computer paper, with the
computer centers of other ministries in the city.

A strong theme emerging from our interviews is the bureaucratic environment in
which scientists and design engineers function. In their descriptions, initiation of a
new project is preceded by a prolonged perepiska, or correspondence, between the
ministry and subordinate units over the terms of implementation. This accounts for
much of the delay in completing Soviet construction projects, they say. Each stage of
a design project is supported by a large amount of paperwork and is reviewed at several
levels of the ministerial hierarchy.

Engineers and developers seemed to have little sense of control of their work
environment. For engineers in experimental factories, requested equipment arrived six
months to three years after it was requested. Scientific research institutes and
experimental construction facilities in high priority machinery sectors reported
receiving necessary equipment and components within six months. Two to three years was
the median reported waiting time in other sectors.

Organization of R & D: Access to Information

Although there are sometimes barriers to the horizontal flow of information
between units in different ministries, many of the scientists and engineers interviewed
in our project said that their access to some kinds of information in the Soviet Union
was superior to their access to information in an engineering office in the U.S.
American suppliers, they say, provide brochures, detailed manuals, and frequent visits
by salesmen to inform designers about products and components that are available. In
the Soviet Union, a Soviet designer could get similar data only by making visits to
supplying plants. On the other hand, Soviet design bureaus are obliged to provide
valuable technical information, blueprints, and designs to other organizations without compensation when instructed to do so by their ministries, so Soviet design engineers frequently commented that they were dismayed to have to pay for information in America that was available without charge in the Soviet Union.

Even in research facilities and experimental factories that appeared to be poorly supplied with equipment and support in most respects, engineers reported that they were able to draw on an extensive research information infrastructure. Most of the respondents in the interview sample had access to technical libraries containing Soviet abstract journals, Western technical journals, and a large body of technical publications and handbooks produced by the ministry. Many reported that a special technical information office in their organization provided them with translations of scientific material of particular relevance to their work. Many report receiving Russian translations of relevant foreign patents systematically. Access to published material provides a passive form of technology transfer. There was much less evidence of active forms of technology transfer.

Although our respondents made heavy use of published materials, including ministry handbooks of specifications and domestic and foreign technical materials, they reported surprisingly little "technical networking" — personal interaction with researchers in other organizations working on related topics or through attendance at meetings or conferences. They did report frequent visits to supply organizations to become familiar with equipment (and, sometimes, to facilitate the supply of such equipment to their projects) and to client enterprises during construction and installation to debug assembly lines and equipment.

Some of our respondents also commented that they thought Soviet engineers had
greater "hands-on" familiarity with equipment than American engineers, particularly as young beginning engineers. Soviet engineering students are often trained in branch institutes, which gives them a detailed knowledge of industry production processes, and most completed a fifth year practicum in a factory. A few of our respondents also received their engineering training while they were working as machinists or factory workers.

The Environment for Innovation

One of the long-term goals of perestroika is the dismantling of departmental barriers, but there is little evidence yet of real change in the institutional structures of industry. It is possible that the legalization of cooperatives and the passage of a new law on intellectual property rights may foster the growth of Hungarian-style professional cooperatives. In the past, khozraschetnyi research organizations and experimental shops for constructing prototypes have operated on a contract basis to serve clients from a variety of ministries. Such short-term quasi-market arrangements should be easier to form in the future.

The greater openness of Soviet society and the expansion of direct contracts and joint ventures with foreign firms, particularly with firms in CMEA, may well give Soviet engineers opportunities for much greater first-hand exposure to developments outside the Soviet Union. Such contacts would allow more active technology transfer and could lessen Soviet technological lags.

The Excess Demand Environment and Competition

Operating in an excess-demand environment both increases the difficulties faced by R & D organizations in the innovation process and weakens the pressure on them to perform. An excess demand environment means that technical personnel will devote
considerable time to efforts to get access to components. Our respondents report that they often found it less costly to self-supply needed components on a small scale than go through existing formal bureaucratic channels. When they could not self-supply, they often turned to informal channels. One designer in the electric power industry, for example, reported that his production association employed one individual whose sole function was to seek out inputs through informal channels.

An offsetting beneficial aspect of an excess-demand environment is the sense of monopoly control that a supplier of services enjoys. Although research organizations may not enjoy monetary benefits from their control of supply, they clearly felt that the absence of competitive pressure was an important source of security. In comparing their experiences in work environments in the Soviet Union and the U.S., many of our respondents reported that they gave heavy positive weight to the job security that they had enjoyed in the Soviet Union and that they felt some insecurity operating in the highly competitive environment of the U.S.

One of the long-run goals of perestroika is the introduction of competitive processes into the Soviet work environment. The Soviet military has long had mechanisms for setting up competitions in performance between two or more research organizations. Now, Yuri Marchuk, President of the USSR Academy of Sciences, writes that the Academy of Sciences will use a competitive mechanism in assigning projects to alternative groups of scientists.

"Each bidder will substantiate ways of solving this or that problem. A competent commission will decide by secret ballot which of the projects is to be preferred. Only then will the scientists involved receive funds. In this way all scientific activity is put on a competitive basis."
"If before funds were made available to the director of an institute, today it is heads of laboratories who win competitions who receive funds. A special fund will be set up to finance projects, where results are hard to forecast. It is also based on competition."\textsuperscript{8}

Mechanisms for competition could make researchers and designers more accountable, but unless the underlying extent of excess demand is reduced, the R & D sector will still be designing for a cost-pass-through environment and will have little interest in cost-reducing innovations. At the moment, the extent of repressed inflation must be a source of alarm to the economic planners. They are no doubt aware that in such an environment, even well-designed rules will operate perversely.

\textsuperscript{8}Marchuk is quoted in TASS, September 15, 1988; translation appears in FBIS-SOV-88-181m September 19, 1988, 85.
Incentives

The engineers in our sample were relatively poorly paid as professionals. Salaries in the sample ranged from 150 rubles per month (including bonuses) to 400-500 rubles. In general, respondents who were earning more than 260 rubles a month were involved in work that appeared to have strategic significance, including work on computers, or they were performing management functions above the level of the director of a design bureau. The bonuses received by members of our sample were smaller and were paid less regularly than the production bonuses received by industrial workers. For basic engineers, the average annual bonus (usually for timely completion of projects) averaged less than 10 percent of base wages. Basic design engineers reported few or no in-kind perquisites, such as access to housing or low-cost vacations. Engineers at management levels enjoyed substantially more perquisites—usually housing and the right to buy a car. Even directors of larger organizations in the sample, however, report few substantial incentives payments. Such incentive payments resulted from completion of a major investment project. In one case, the bonus was estimated to be about 40 percent of base wages.

With the exception of the directors of scientific research institutes, design personnel appear to have little control over the direction of their work. Most of their activities are specified in work orders drawn up by a superior organization—usually a ministry. These activities are initiated by the signing of a contract called a technical assignment (tekhnicheskoe zadanie), describing a "scientific research project" (nauchno-issledovatel'skaia rabota), or the subsequent "experimental design project" (opytno-konstruktorskaia rabota). The terms of these technical assignments specify the expected results, the time schedule of work, the planned level and
structure of staffing and other terms of compensation well as incremental benefits for early completion or above-plan performance and penalties for late or deficient performance. The larger the size of the project, the more levels in the ministerial hierarchy must review and approve the program. Most of our respondents reported that the budget for a project was determined by the number of personnel and the allocation of time to a project. They also reported informal shifting of personnel and resources from one project to another when a project could not be completed with the planned resources.

In most cases, our respondents did not know whether their designs received more than one use. A substantial number of them took out inventor's certificates (usually jointly with superiors in their organization). They described the process of applying for an inventor's certificate as lengthy and time-consuming. Usually a research and development organization has specialized staff whose only function is the overseeing of applications. Engineers who received certificates, however, reported that they received a trivial payment for their efforts. When asked whether their designs had gone into general use, they usually answered "no", or said they did not know.

A Western economist interviewing Soviet design engineers is struck again and again by the incentive consequences of the absence of Western-style protection of intellectual property rights. The lack of effective legal arrangements by which a research institute can license its new technology to a variety of users impairs the incentive to disseminate information about new possibilities and distorts the nature of innovations themselves. A developer of new software applications, for example, could not find a sponsor to underwrite the development of a general software environment that could be applied by many users to solve a wide variety of programs. Instead, he entered into individual, informal arrangements to solve specialized software problems.
for individual clients. Soviet scientific research institutes frequently report that it is easier for them to maintain a laboratory of custom programmers for their own use than to acquire and assimilate universally available packages.

Three measures undertaken in the past two years could eventually have strong effects on the operation of the R & D sector. They are transferring of research organizations to khozraschet and the emergence of producer cooperatives.

The attempt to transfer R & D to khozraschet was initiated by a resolution passed in October, 1987. The resolution provided that R & D organizations attached to production associations should enter into direct contracts specifying a set of development tasks, a budget, and a date of completion and could set down incentive arrangements relating to the quality and timeliness of their work. At the same time, the measures also provided that R & D organizations subordinate to the Main Technical Directorate of a ministry could receive state orders, goszakazy, from their ministry and could operate much as they had in the past. Indeed, without goszakazy for crucial inputs, R & D organizations would be hard put to carry out their commitments.

The Hungarian model of professional and scientific cooperatives must be an attractive example to some Soviet scientists. A recent issue of Ekonomicheskaia gazeta describes a venture cooperative (Vizir) organized to introduce innovations. Its 200 innovator members hold over 1500 author's certificates and patents. Its products include the Vektor computer, developed by the radio electronics cooperative, Servis, as well as industrial robots that are said to be marketed in West Germany, Japan, and the U.S.. Moreover, the joint venture mechanism could allow the Soviet developers of new technology to license their processes abroad or find the resources to manufacture and market their products on the world market. Two of our respondent were successful
innovators on the U.S. market. One had taken out Western patents on several promising processes for the production of energy. Another had established a software firm that was selling a successful three-dimensional modeling environment for engineering applications. Their success suggests that some Soviet R & D organizations may well have technological developments that would interest a Western firm.

The ability of Soviet innovators to enter into joint efforts with foreign firms and their ability to profit from their developments domestically depend on the codification of property rights arrangements allowing licensing and royalties for new technologies. At present, the Soviet leadership is discussing the draft of a new law that would provide some of the incentives now absent in the Soviet Union to design innovative computer software and hardware products and to license them to domestic and foreign users.

The process of certification of inventor's certificates is complex and bureaucratic. It is initiated by application to the All-Union Scientific

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Research Institute of State Patent Examination (Vsesoiuzni nauchnoissledovatel'skii institut gosudarstvennoi patentnoi ekspertiza), which receives over 100,000 applications annually. A proposed patent is subjected to examination and, if it is certified, is then published in the Bulletin for Inventions and Trademarks.

Subsequently, an enterprise that makes use of an inventor's certificate in serial production for the first time must file a form listing the dates of use and estimated economic savings from the innovation. Once an innovation is put into first use, the development group receives a small award based on the "effect" of the new technology.

In the West, there are substantial economies of scale to research and development, for once a promising new technology is developed, then the average cost of applying the new technology is lower the larger the number of units that embody it. In the West, too, research results developed in one industry tend to have spill-over effects onto costs of production and quality of products in related industries and no industry generates greater spill-overs than computers. The Soviet leadership appears to have concluded that greater protection of property rights in innovation will be required to acquire Western patents, licenses, and technological know-how, to create incentives for the broad diffusion of domestic results of research and development, and to license Soviet innovations on the world market.

One of the working groups drafting documents for perestroika has the responsibility for drafting new laws on the protection of intellectual property rights. A recent issue of Pravda summarized a discussion held at the Presidium of the Council of Ministers on the possible content of a new law protecting intellectual property rights. There appeared to be general agreement on the need to give innovators "exclusive rights to innovation," but the discussants diverged on whether rights to
innovation should be vested in the individuals responsible for an innovation or in the organization funding the research. In their discussion, members of the commission referred to "an enterprise or association" as the relevant managing organization, but in an environment in which many research and development units are directly subordinate to the Chief Technical Directorates of branch ministries and others have dual subordination to branch ministries and to institutes of the Academy of Sciences, there is likely to be more than one organization in the ministerial system contending for a share in the returns to innovation.

Vice-president of the Academy of Sciences E. P. Velikhov seemed to reflect the consensus of the commission when he reported that a proposed draft would assign exclusive rights to an innovation to its author, which might be either a person or a juridical unit. A patent could identify two patent owners—the author and the enterprise where the innovation was developed. In this case, the two authors would enjoy equal legal protection and would enter into a joint agreement that would provide a basis for putting the innovation into use.

The establishment of cooperatives and joint ventures and the prospect of broadened property rights for innovation seem to be creating an expectation of

positive change on the part of scientists and engineers. Satisfaction of these expectations will involve the Soviet leadership in institutional changes that lie outside previous acceptable boundaries, but to disappoint these expectations would be costly for the system too.

Conclusions

What light does the interview evidence shed on the process of perestroika? The interview evidence reveals some of the important ways in which Soviet institutions impede innovation. A recognition of these institutional barriers underlies the agenda of perestroika. One criterion for the success of perestroika will be whether it succeeds in addressing these barriers.

In our view, the attempt to open the economy to direct foreign ties offers the greatest potential for short-term infusion of new technology. The large-scale introduction of new processes from abroad would require four developments, all of which have been unattainable in the past: 1) The establishment of direct links with Western producers offering them direct access to the domestic Soviet market; 2) a major increase in international borrowing; 3) an opening up of society to allow freer exchange in education, technology, and economics; and possibly, 4) a lessening of tensions with the West so as to reduce the restrictions imposed from outside. The Asian countries that have enjoyed rapid economic growth in recent years have profited from most, if not all, of these links with the world market. The Soviet leadership is seeking membership in Western economic organizations — GATT, the World Bank, and the IMF — but it still manages its economy in isolation from the world market. Few of our design engineers had ever traveled abroad in his work. In answer to the question "Have you ever traveled abroad?" The joking response was, "Ras na vsegda," or "once for all"
time." If Soviet technological performance is to improve, from global economic currents isolation will have to cease.