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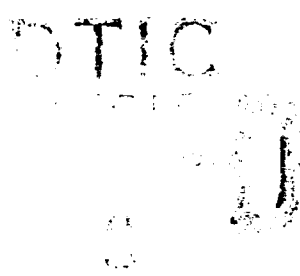
A RAND NOTE

The Changing Soviet Priority Economy:
Modeling the Conflict Between Gold and the Sword

Gregory G. Hildebrandt, Peter B. Staugaard

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RAND

PREFACE

This Note is part of a larger study whose purpose is the development of new methods and models for analyzing the Soviet economy that are linked more closely than are existing models to certain key characteristics of the Soviet system. The analysis investigates Soviet decisionmaking during plan implementation using a prototype input-output model. It characterizes the conflict between the exogenous priority system that is specified by the leadership and the endogenous priority system that emerges from the structure of an interdependent economy. The analysis continues to be relevant as civilian activities are moved inside the Soviet defense industry, which is currently managed using a priority system.

SUMMARY

The Soviet economy operates under a system of conflicting priorities. On the one hand, the leadership goals, which are embodied in the economic institutions and formulated plans, as well as in the rules associated with plan implementation, direct the activities of the first (or command) economy. On the other hand, individual economic agents operating in the monetized environment of the second economy, where decisions are based on individual values and opportunities, pursue their own goals, which may not be consistent with those of the leadership.

Therein lies Pushkin's tension between "gold and the sword," emphasized by Gregory Grossman over twenty years ago and relevant today as the Soviets employ a system of "state orders" that is used in conjunction with decentralized decisionmaking. It is unclear whether *perestroika* will eliminate this type of duality in the Soviet economy. Indeed, the new institutions may formalize the historical characteristic. For example, civilian production activities have been moved inside the defense industry, and a new priority ordering has been implemented in which top priority is given to certain classes of consumer-related products.

In this study, we develop a model of the Soviet conflicting priority system. One type of priority system is specified by the leadership and is exogenous to individual decisionmakers; this is the domain of exogenous priorities. The second type, based on the conditions of production of an interdependent economy, is endogenous to the economic system; this is the domain of endogenous priorities.

Before introducing our formal model, however, we first address in Sec. II some features of disequilibrium and priority in the Soviet economy. We believe that the link between priority, both exogenous and endogenous, and disequilibrium is implicit in the analysis of Rush Greenslade, who emphasized multiple opportunity costs as being a central feature of the Soviet economy. His result can be explained by both

changing leadership priorities and the clash between the two priority systems.

Our prototype priority model provides an empirical starting point for understanding and predicting the Soviet economy. In Sec. III, we develop this model by contrasting a situation in which defense, heavy industry, and consumption targets are achieved seriatim during plan implementation. The high status given defense is consistent with our understanding of historical Soviet military-economic doctrine and the supporting institutions; the low status given to the consumer is consistent with Mikhail Gorbachev's discussion of the "residual principal" being a major dimension of recent Soviet history.

We first contrast an (exogenous) priority model with both a GNP maximizing marginalist model and a proportionalist model. An illustrative shock to the infrastructure sector of these models leads to a more than proportional decrease in consumption and GNP in the priority model as the low priority sector provides the buffer to ensure that high priority output is achieved. As expected, the proportionalist model reduces all outputs and final outputs proportionally. Under the marginalist model, there is a less than proportional reduction in consumption and GNP. Appendix A summarizes our analysis of a number of alternative cases, and additional information associated with the models is contained in Apps. B and C.

In general, we find that a shock in any sector causes unemployed resources in the nonpriority sector of the priority model. Also, final output in this model is always less than or equal to that obtained in the marginalist model.

Recognizing that the marginalist model reflects a situation in which the *tolkachi*[1] (facilitator) of the state enterprises bid for bottleneck resources in the second economy based on the endogenous priorities, we describe a situation of conflicting priorities. If the system exhibits a mixed response that enforces both exogenous and

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[1]The tolkach has no close counterpart in a market economy. His task is to facilitate plan fulfillment by obtaining inputs in short supply often through semi-legal or illegal means.

endogenous priorities, there may be shortages and surpluses of inputs simultaneously, and the priority objectives of the leadership may not be met.

Such an outcome will motivate the leadership to design institutions that support its priority interests. Within the Soviet defense macninery industrics, prcduction has been "vertically integrated from basic industry to end product," and we can see in this phenomenon the leadership's response to the conflicting priority systems.

Insulating the defense sector from the economy in this fashion may have supported the defense interests in the short run, but it is also likely to have adversely affected the economic-technological base from which a modern military establishment must draw. The rigid priority system may, therefore, have been ultimately self-defeating.

Soviet economic priorities have clearly changed under Gorbachev. These changes have been marked by a significant erosion of the status of the military-economic institutions that have traditionally supported defense priority. These developments, however, need not greatly diminish the priority model's relevance.

To this point the history of Gorbachev's reforms can be captured largely as shifts in Soviet economic priorities away from defense, first toward investment and more recently toward consumption. The priority system, however, has remained very much in place, albeit in a somewhat diluted and altered state. The persistence of traditional methods of central planning, the transfer of high-priority civil production to the defense industry, and the continued use of state orders all suggest that the priority system has been revised rather than replaced. These revisions can perhaps best be captured through priority models of the type developed here.

Should the Soviet leaders follow through on their plans to make the transition to a market economy, priority models may prove useful in several ways. During the transition phase a model of conflicting priorities may help shed light on the difficulties likely to be encountered. And following a successful conversion to a market economy, the priority model developed in this study will remain useful both for

the light it sheds on historical Soviet military economics and as a
benchmark for assessing future changes.

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I. INTRODUCTION

> Q. "A bit of good planning and a bit of good market--won't
> that result in an awful chaos?"
>
> A. "There's no proving that and no refuting it. Let's be
> frank: As yet, we honestly and truly don't know what will
> come of it."[1]

According to Western economic theory, a market economy achieves equilibrium and determines the optimal allocation of resources based on the marginal analysis of individual costs and benefits. While this idealized picture serves as a useful representation of the essential features of Western economies, it stands in striking contrast to what we know about Soviet-type economies. For in the Soviet Union, disequilibrium effects are readily apparent and resource allocation often bears little relation to marginal costs and benefits.

In the state sector of the Soviet economy, resources have been and continue to be allocated by a directed-demand planning and administrative process in which tautly determined plans are developed "from the achieved level." The tautness of the plans ensures that the planned growth increment is difficult to achieve under normal circumstances. Although the relative importance of the leadership's objectives dictates how this demanding growth increment is to be allocated among the various sectors the taut nature of the formulated plan almost guarantees that bottlenecks and shortages will emerge. These shortages are then allocated based on administrative priorities rather than demand price during plan implementation.

Because these administrative allocation rules are exogenous to the scarcity relationships that are embodied in the conditions of production, we refer to them as *exogenous priorities*. They direct Soviet resource allocation in the so-called *first economy*.[2]

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[1]S. S. Shatalin, economist and corresponding member of the USSR Academy of Sciences responding to a journalist's question, *Argumenty i fakty*, June 6, 1987.

[2]A conceptual analysis of the operation of the Soviet priority

The practical operation of the Soviet economy differs in a significant fashion from this idealized picture. Increasingly the economy also contains non-administratively directed demands that are based in large part on the potential for individual economic gain that is endogenous to the system of individual values and opportunities. This endogenous priority system, operating in the *second economy*, directs resources on the basis of marginal analysis of the monetary benefits and costs by individual economic agents.[3]

Furthermore, while it is difficult to predict the form that the Soviet economy is likely to take as a result of *perestroika*--the Soviet Union may eventually move to a "full-blooded market"--the current system continues to contain a first economy based on priority and a second economy based on money. In fact, given the concurrent emphasis being placed on both market reforms and a system of "state orders," potential areas of price vs. priority conflict are emerging within the first economy.[4] The potential for conflict between plan and market elements has been widely recognized by Soviet economists, including Gorbachev's top advisers. As N. Ya. Petrakov, states,[5]

> Quite a few of the excesses that are stirring up the public are arising as a result of the clash between market and nonmarket, administrative-type management methods. For instance, sales are beginning to be organized in accordance with the law of the market, while supply is operating on the basis of administrative-command principles.

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system is contained in Richard E. Ericson, *Priority, Duality, and Penetration in the Soviet Command Economy,*, The RAND Corporation, N-2643-NA, December 1988. The Ericson study was also conducted under this project.

[3]When we use the term "second economy," we are addressing the sphere of activity in which economic methods are used to achieve objectives within the context of the official economy. In broad terms, however, our use of the term also applies to the the unofficial black market economy and other similar activities.

[4]As reported in *The Los Angeles Times* on May 6, 1990, p. 6, General Secretary Gorbachev has discussed the transition to a "full-blooded market."

[5]*Pravda,* November 15, 1989. Petrakov, Deputy Director of the USSR's Academy of Sciences' Central Mathematical Economics Institute, was recently named as one of General Secretary Gorbachev's top economic advisers.

And as Soviet workers have been quick to let Mr. Gorbachev know, often "what is profitable for the state is unprofitable for the collective."[6] As these examples suggest, there is a large potential for price vs. priority conflict even within the first economy.

At the center of the conflict between plan and market is the system of state orders or *goszakazy,* which represent the state's means of achieving its priority tasks. As Leonid Abalkin says,[7]

> I understand the state order as a system for the unconditional satisfaction of top-priority socially significant requirements. . . such orders entail, for instance, smaller deductions from profits into the budget. Also state orders could mean the priority supplying of scarce resources.

According to Soviet reform plans, the percentage of output accounted for by state orders has been scheduled to be reduced drastically in favor of wholesale trade between enterprises. In practice, the intended transition from priority to market-oriented allocation of resources has not gone well. To this point Alec Nove has said:[8]

> One consequence has been noted, which can adversely affect transition to reform: priority for state orders (*goszakazy*) is to be compulsory, at least in the first years, to insure that top-priority needs are met; while the rest of a given enterprise's productive capacity is to be available for free negotiation with customers. Many managers reluctant to launch themselves on the unknown sea of freely negotiated contracts, are seeking as many of the state orders as possible, in the hope of insuring priority supplies. The effect could well be the preservation of much of the existing system, not because (or not only because) planners and ministries seek to retain their powers, but through pressure from "below."

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[6]M. S. Gorbachev's Meeting with the Employees of State Bearing Plant No. 1, *Pravda,* March 8, 1988.

[7]*Pravda*, June 13, 1987.

[8]"Introduction" to Abel Aganbegyan, *The Economic Challenge of Perestroika*, Indiana University Press, Bloomington, Indiana, 1988, p. xxi.

Whether or not market reforms ever take hold in the first economy, in its current state it is clear that the first economy can conflict with the second economy. For traditionally, the first economy has operated by directive and used money merely as a unit of account. But in the second economy, money already serves as a bearer of options or, as Gregory Grossman puts it, "Money rules."

Consequently, the socialist first and second economies must be modeled differently. Moreover, they will compete for resources and clash in many instances over their allocation. Thus, one of the important tasks of a complete model of a socialist economy should be to capture the effects of clashes between the first and second economies.

Metaphorically, this conflict can be thought of as a clash between two economic spheres, one ruled by the sword, the other by gold. Referring to the first economy, Gregory Grossman has stated[9]

> Here, though the command principle prevails, it co-exists--
> deliberately so--with the use of money as the unit of account,
> medium of exchange, and to a very limited degree even as a
> bearer of options. The last, of course, is the crux, in that
> options exercised by the holder of money will often clash with
> options exercised by administrative decision and directive.
> Here--to employ a phrase borrowed from Pushkin on an earlier
> occasion--gold confronts the sword and, as in Pushkin, the
> sword wins.

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[9]Gregory Grossman, "A Note on Reform, Money and Administrative Supremacy," in *Stagnation or Change in Communist Economies?*, Center for Research into Communist Economies, p. 50. In the quotation, the "earlier occasion" Dr. Grossman is referring to is his paper, "Gold and the Sword: Money in the Soviet Command Economy," in Henry Rosovsky (ed.) *Industrialization in Two Systems* (Wiley, New York, 1966). On p. 216 of the earlier paper, Grossman also uses the distinction between "passive money" and "active money" to describe respectively the role of money as both as a unit of account and bearer of options. This idea, in turn, was developed by Peter Wiles in his "Rationality, the Market, Decentralization, and the Territorial Principle," in Gregory Grossman (ed.), *Value and Plan*, Harvard University Press, Cambridge, Mass., 1962, p. 188.

As Pushkin's 1826 quatrain indicates, the sword had traditionally prevailed over gold in Russia: "All is mine," said Gold; "All is mine," said the Sword; "I shall buy all," said Gold; "I shall seize all," said the Sword.

Historically, in the Soviet Union institutional and organizational forms have been created to protect the priority interests of the Soviet leadership, and in this sense "the sword has won." An example is the traditional role of the Military Industrial Commission (VPK). During plan implementation, this commission ensured that the defense sector met its targets by using the civilian sector as a buffer. When a bottleneck emerged, the defense sector was moved to the head of the queue; the costs of the shortage, therefore, were borne by the civilian sectors of the economy.

In addition, to protect itself against the vagaries of the Soviet supply system, much military production was vertically integrated. Consequently, a large amount of military production did not depend on inputs from the civilian sphere. Rather, the defense sector produced significant amounts of its own investment goods and military inputs.

Ironically, the defense sector's historical high priority may have contributed to more long-term defense problems arising from Soviet technical-economic weaknesses. For as defense goods became more complex, the technical-economic base of the Soviet Union necessarily became more important in weapons development. As the Soviets discovered, the defense sector became more closely linked to the civilian economy than was originally the case.[10]

Moreover, the Soviets' long neglect of other economic sectors has brought on a general economic crisis that poses a far more serious threat to the USSR's survival than do the military forces of the West. This crisis has forced sharp cuts in the USSR's military-economic commitments, exacerbated domestic conflicts, and prompted a sharp downgrading of defense priority. Indeed, as will be discussed at greater length below, civilian production activities have been increasingly incorporated into the Soviet defense sector. For these activities, a new priority ordering has been established to effectuate the process of civilian production.

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[10]David Holloway discusses this issue in "Defense Policy and the Soviet Economy," unpublished draft, January 1988.

In order to deal with the USSR's deepening political and economic crisis, President Gorbachev was recently granted extensive emergency powers. The effect of these new powers will be, as one Soviet writer puts it, "the clear-cut subordination, martial-style, to the president of all vertical structures of executive power."[11]

This suggests that the leadership is moving down a reform path that will renew the conflict between money and administrative directive. Attempting to create an economic model which captures this conflict, along with priority and disequilibria, is no simple task. By itself, the exogenous priority system of the first economy, operating in an environment with taut planning, has generated what are in a sense "planned" disequilibria in which shortages are pervasive. When one adds to this the fact that the interests of the second economy do not, in general, coincide with the interests of the first, shortages and surpluses of the same material input can exist simultaneously.

Such an outcome does not typically occur in Western models of market economies, and the use of such constructs to understand the Soviet economy must therefore be reconsidered. It may be the case that the two fundamental analytical techniques of Western economic analysis, finding an optimum and finding an equilibrium, may not be as relevant to the Soviet economy as they are to market economies.[12]

In response to these concerns, a review of existing models of the Soviet economy and an initial step in conceptualizing an alternative approach was taken at the 1984 RAND Conference on Models of the Soviet Economy, at which the strengths and weaknesses of existing models were discussed. Among the most important suggested improvements made by conference participant were: (1) to structure the model to capture the essential features of the Soviet centralized planning process; (2) to model priority and nonpriority sectors; (3) to incorporate multiple

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[11]S. Sokolov, "I Know of No Other Country Like This One--States of Emergency Have Been Introduced in 12 Regions of the USSR," in *FBIS Soviet Union Daily Report*, 26 November 1990, pp. 35-36.

[12]Jack Hirshleifer in *Price Theory and Applications,* Fourth Edition, Prentice Hall, 1987, identifies optimization and equilibrium as the two basic techniques of microeconomic analysis.

goals into the objective function; (4) to develop an alternative to optimization models to better capture disequilibrium effects; (5) to further explore the impact of supply constraints and bottleneck effects on economic performance; and (6) to better capture the various dimensions of the defense sector's traditional priority position.[13]

In this Note, we will describe how disequilibrium effects, priority, and bottlenecks can be incorporated into a model of traditional Soviet plan implementation. We first compare the exogenous priority situation with an allocation system based on the marginal analysis of final demands using plan prices, and then with one based on the principle of proportional growth or cutbacks. Recognizing that the marginal allocation solution can be interpreted as the outcome of an endogenous priority system, we extend the exogenous priority model to illustrate the conflict between exogenous and endogenous priority interests. Interestingly, both shortages and surpluses of inputs (or capacities) can exist simultaneously, and the model, therefore, may capture one of the key stylized facts of the Soviet economy.

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[13]Gregory G. Hildebrandt (ed.), *RAND Conference on Models of the Soviet Economy, October 11-12, 1984,* The RAND Corporation, R-3322, October 1985.

II. DISEQUILIBRIUM AND PRIORITY IN THE SOVIET ECONOMY

GREENSLADE DISEQUILIBRIUM

While aware of the many disequilibrium effects pervading the Soviet economy, few Western economists have addressed the issue of disequilibrium directly in attempting to model or measure the Soviet economy. Those who have discussed disequilibrium in centrally planned economies, including Kornai, have tended to ignore the role of the priority allocation system in generating disequilibria. They have also failed to incorporate into their formal models the conflict between the first and second economies.

We believe, however, that this link between priority and disequilibrium is implicit in the analysis of Rush Greenslade, who addressed the problems of measuring the Soviet defense burden in a disequilibrium economy. Greenslade argues that even if the resource costs of defense in the USSR could be properly measured, these would still not provide a true measure of the opportunity costs of defense. In fact, because the Soviet economy operates in a chronic state of disequilibrium, the opportunity cost of an economic activity may be extremely difficult to define.[1]

If an economy is in equilibrium, the opportunity cost of any activity will have a unique value, due to the equalization of factor costs and prices throughout the economy. Also, if the government produces goods using resources from an economy that is in equilibrium, the burden of the government activity would equal the opportunity cost of the resources consumed. Thus, the opportunity cost of a $10 million military aircraft would also be $10 million--the value of the resources used to produce the aircraft could have been used to produce civilian goods that are valued at $10 million by the demanding consumers.

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[1] Rush Greenslade, "The Many Burdens of Defense in the USSR," mimeo, 1971, p. 2.

In practice, of course, no real economy functions in a state of perfect equilibrium. However, the assumption of equilibrium provides a useful benchmark, and a unique measure of opportunity cost can be determined so long as resources are allowed to move freely in response to economic demands.

In the Soviet economy, by contrast, most material resources continue to fail to move freely between economic sectors in response to scarcity signals. As we have indicated, the transfer takes place in response to the directions of the plan or bureaucracy. The result of this allocation process has been wide disparities in labor efficiency in agriculture and manufacturing, the surplus of some consumer goods coincident with the chronic shortage of others, and the waste of resources in unfinished construction and uninstalled equipment.[2] As a result, the Soviet economy can be said to operate in a pervasive state of disequilibrium.

Greenslade also argues that because of this chronic state of disequilibrium[3]

> The impact of a change in defense in the USSR, like the burden
> of defense as a whole, should be considered to be multi-
> valued. The value of a shift to investment, as measured by
> the effect on growth, may be much less than for a shift to
> consumption, or at least for some kinds of consumption.

Thus, while opportunity costs have a single value in equilibrium economies, in disequilibrium economies they may will take on multiple values, which bear no clear relation to resource costs.[4]

These multiple opportunity costs can be derived directly from the nature of the (exogenous) priority system. Each specified priority ordering induces its own opportunity cost when resources are reallocated. Furthermore, these multiple costs can also result from a

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[2]Greenslade adds a number of other features to this list in his paper. *Ibid.*, p. 9.

[3]*Ibid.*, p. 5.

[4]Or as Tolstoy might put it, "All balanced economies are similar to one another, but each unbalanced economy is unbalanced in its own way."

developing conflict between the exogenous and endogenous priority system that clouds the manner in which resources aie reallocated.

ADMINISTRATIVE PRIORITIES

The ability to concentrate resources on the achievement of priority aims has long been viewed as one of the key strengths of a Centrally Planned Economy (CPE). Historically, the principle of priority has been of fundamental importance in Soviet economic planning. In prewar and early postwar years, central planners designated key economic sectors as "leading links" which were granted priority in the allocation of resources in order to accomplish national economic goals. As a recent Soviet planning article recounts:[5]

> Those branches and types of production that to a considerable degree have predetermined the development of the entire national economy ... were classified as priority or leading links. Their priority status presupposed the top-priority allocation of the necessary production resources, the scale of which were negligible at the time. The remaining part of the resources was distributed among the remaining branches.

Similarly, the national economic plan was conceived as[6]

> a combination of the program for the development of branches of the leading link and a program for the potential development of all remaining branches based on the priority distribution in favor of the leading link.

[5]V. Novichkov and G. Abdykulova, "Some Problems in Determining the National Economy's Priorities," *Problems of Economics,* September 1985, pp. 21, 22.

[6]*Ibid.* The Soviet plan was similarly represented by Holland Hunter as the maximization of "the output of a limited range of high-priority products under centralized direction by known methods." Holland Hunter, "Soviet Economic Problems and Alternative Policy Responses," in U.S. Congress Joint Economic Committee, *Soviet Economy in a Time of Change,* two volumes, U.S. Government Printing Office, Washington, D.C., 1979, Vol. 1, pp. 23-27.

The concept of "target programs" (*tselevye programmy*) has now supplanted that of leading links as a means of achieving high-priority economic aims.[7] Often contemporary target programs, such as the Baikal-Amur railway, are presented as modern-day descendants of Lenin's accelerated GOELRO plan[8] for electrification of the entire country, deserving similar priority. Due to their high-priority status and extended duration, target programs have been influential in shaping the investment pattern of the Soviet five-year and annual plans.

For this reason, Soviet investment resources have tended to be concentrated (though not highly) in target programs aimed at accomplishing high-priority economic tasks rather than spread out evenly.[9] This pattern of concentrating investment in priority areas, with attention initially being given to machine building, has continued under Gorbachev. As the General Secretary stated at the 1985 Central Committee Plenum:[10]

> Of course a certain order of priority (*ocherednost*) is inevitable in the implementation of various measures.... The dispersal of capital investment on the principle of a chicken in every pot cannot be permitted.

Additionally, high-priority sectors enjoy a number of other advantages aside from receiving larger than average shares of capital investment. These include favored treatment in the allocation of material inputs and the supply of skilled labor. As Gorbachev

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[7] For a discussion of the target program method of long-range planning, see B. Raizberg, "Long-Range Planning and the Elaboration of Goal Programs," *Problems of Economics*, February 1980, p. 61.

[8] V. I. Lenin, "Communism = Soviet Power + Rural Electrification," from his *Report to the Eighth Congress of Soviets*, December 22, 1920.

[9] According to one recent Soviet estimate, target programs may consume up to 25 percent of the resources allocated for the development of the economy. B. Raizberg, "Long-Range Planning..., pp 59-74. As Raizberg recognizes, to assign high priority to a larger proportion would defeat the objectives of goal programs: "to be the means of priority solution of only individual, very urgent national economic problems."

[10] M. S. Gorbachev, "Speech to Central Committee Plenum," as translated in *FBIS*, June 11, 1985, p. 8.

instructed Party cadres at the January 1987 Central Committee Plenum:[11]

> Special attention should be paid to keeping priority sectors
> of the national economy and newly-completed production units
> supplied with personnel first, as well as to training
> specialists and workers to build and operate the new
> equipment.

Also, priority sectors are typically awarded more favorable salary and bonus structures, more generous levels of R&D funding, and higher output prices.[12]

At the same time, the priority system is integrally related to many of the Soviet economy's key weaknesses, particularly during plan implementation. Some type of priority system is necessary when material resources are allocated to the producing sectors because of the center's inability to deal with detail, overly taut planning, supply uncertainty, and the divergence of established prices from scarcity values. When prices are not permitted to adjust, and the objective function of the leadership is not known by those involved in the day-to-day allocation process, it is necessary to rely on simple allocation rules to guide the system to the exogenous goals.

When a priority economy experiences a substantial increase in economic performance, all claimants can share in the growth increment. When growth slows down, however, the priority system can have a harsh effect on the low priority sectors. The output targets of high-priority sectors of the economy, such as heavy industry and defense, are generally fulfilled. However, these targets are effectively achieved at the expense of less important plan targets, including the output targets of low-priority sectors such as light industry, agriculture, and social services. Moreover, the measures used to enforce the system of priorities may lead to further distortions. On this issue, General Secretary Gorbachev has stated[13]

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[11]*Pravda*, January 29, 1987, p. 1.

[12]For a discussion see Jan Prybyla, *Market and Plan Under Socialism,* Hoover Institution Press, Stanford, 1987, p. 163; also, Joseph Berliner, *The Innovation Decision in Soviet Industry,* MIT Press, Cambridge, 1976, p. 509.

[13]Mikhail Gorbachev, *Perestroika: New Thinking for Our Country and the World,* Harper and Row, Publishers, New York, pp. 19-20.

The gross output drive, particularly in heavy industry, turned out to be a "top priority task, just an end in itself. The same thing happened in capital construction, where a sizable portion of the national wealth became idle capital."

and

Declining rates of growth and economic stagnation were bound to affect other aspects of life in the Soviet society. Negative trends seriously affected the social sphere. This led to the appearance of the so-called "residual principle" in accordance with which social and cultural programs received what remained in the budget after allocations to production.

In this manner, the system of priorities has controlled the distribution of production resources to the various economic sectors and consequently has determined the sequence in which Soviet economic goals will be fulfilled.[14]

Historically, there have been three levels in the Soviet economy in which one can identify elements of priority: the design of the economic institutions, the formulation of economic plans, and the implementation of these plans.

Priority in Economic Institutions

It is apparent that the economic institutions of the state would necessarily support priority interests. Market institutions give priority to the individual consumers; Soviet economic institutions have given priority to state goals at the expense of the interests of individual consumers.

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[14]This is true in an *ex post* sense. *Ex ante* it is the national economic goals which determine priorities. As Novichkov and Abdykulova write, "The establishment of the sequence in which the goals of society's development are to be attained in accordance with their national economic significance and the corresponding distribution of production resources determine the essence of the priorities." V. Novichkov and G. Abdykulova, "Some Problems...," p. 21.

When Oskar Lange described the Soviet economy as *a war economy sui generis*, he was not describing (the) Soviet militarism, but rather an economy that resembled Western economies during wartime, when central planning procedures were implemented to mobilize resources toward non-consumer goals. The Soviet economic institutions were designed, therefore, to mobilize resources in support of the priority interests of the leadership.

For example, the evidence above suggests that until recently the Soviets attempted to vertically integrate the high priority defense industries to insulate them from shortages of required inputs and spare parts. This means of ensuring the production of priority goods was then used during the first years of Gorbachev's tenure. General Secretary Gorbachev, in calling for priority to be attached to machine building, argued:

> Clearly it is essential, following the example of the defense
> industries, for the output of special equipment for their own
> needs to be developed on a wide scale within each machine-
> building ministry.

Priority in Plan Formulation

These leadership interests would also be reflected during the formulation of economic plans. This type of priority might be reflected in the weights given to different factors in the planners' objective function and the constraints imposed, and this is the approach taken by the optimization models of the Soviet economy.

There are important features of the plan formulation process, however, that optimization models do not capture. Specifically, they fail to provide a realistic picture of how planners accomplish the complex task of plan formulation. In these models, the plan formulation process is implicitly assumed to be costless, instantaneous, and perfectly efficient. Each successive plan is assumed to be feasible and consistent, i.e., each firm's planned output can be produced using its planned allotment of inputs; total allotments of inputs do not exceed their planned production; and total allotments of primary inputs do not

exceed the economy's supplies. Moreover, the planned equilibrium is assumed to be perfectly efficient in that there are no idle or undervalued resources. Thus, assuming it is exactly fulfilled by each enterprise and industry, the plan as formulated fully determines the economic outcome.[15]

In reality, Soviet planners' behavior differs sharply from that of the efficient optimizers assumed in the optimal control models. Rather than costlessly, instantaneously, and efficiently calculating optimal plans for the economy, in practice Soviet planners have largely relied on the so-called "ratchet method"[16] and have formulated plan targets by adding an increment to last year's achieved level. This method of "planning from the achieved level," has been perhaps best described by Igor Birman, who states:[17]

> The well known words "from the achieved level" denote that the
> plan indicators are derived by means of adding to the relevant
> ex post figures a certain percentage of growth. That is the
> foundation of all the technique, all the methodology of Soviet
> planning. The rest is secondary.

Also, rather than formulating feasible and consistent plans, Soviet planners have tended to construct "taut" (*naprazhenniy*) and inconsistent plans. Plans have been kept taut due to political pressures to achieve a high rate of economic growth and to ferret out the "hidden reserves" of the firms. They have been necessarily inconsistent due to the

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[15]These conditions are described in Raymond Powell, "Plan Execution and the Workability of Soviet Planning," *Journal of Comparative Economics,* No. 1, 1977, p. 55. For a mathematical treatment see Joseph Brada, "Plan Execution and the Workability of Soviet Planning," *Journal of Comparative Economics,* No. 2, 1978, p. 68.

[16]This view of Soviet planning has recently been challenged by Granick (1980). Michael Keren, however, has argued that this generally accepted view of Soviet planning is well founded, and has shown that Soviet data, presumed by Granick to prove the absence of a ratchet, in fact proves its existence. Michael Keren, "The Ministry, Plan Changes, and the Ratchet in Planning," *Journal of Comparative Economics,* No. 6, 1982, pp. 327-342.

[17]Igor Birman, "From the Achieved Level," *Soviet Studies*, Vol. 30, No. 2, April 1978, p. 161.

planners' limited ability to obtain and process information and due to the inordinate difficulty of calculating a "system of material balances" for the entire economy.

Thus, the plan formulated by the central planners, because it is infeasible, does not generate an equilibrium outcome for the economy. Rather, under conditions of taut planning, the economy functions in a resource-constrained disequilibrium state, described by Kornai, which is marked simultaneously by shortages of some products and surpluses of others.

Priority in Plan Implementation

Because Soviet planners are not able to plan perfectly, they have intervened frequently during plan implementation to ensure that their priority goals are met. Due to the tautness of the original plan, the characteristic implementation problem faced by Soviet planners is that of dealing with shortages of particular inputs. Thus, as one Soviet writer puts it, "Gosplan is forced through the whole year to distribute resources; from some it takes, to others it gives."[18]

Planners also rely on satisficing rather than optimizing behavior during plan implementation. That is, rather than recalculating a new optimal plan following an economic shock, the planners have provided producers with a considerably simpler set of implementation rules or instructions.

One implementation rule followed by Soviet planners has been to allocate scarce resources according to a priority ranking. Historically, this ranking has favored defense and heavy industry over light industry and agriculture. As Jan Prybyla notes,[19]

> When steel is in short supply the production of tanks and trucks will not suffer. The input of steel in the refrigerator industries will be reduced and fewer refrigerators will be available for private consumption.

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[18]Quoted in Raymond Powell, "Plan Execution...," p. 54.
[19]Jan Prybyla, Market and Plan..., p. 147.

Under this absolute priority rule, the output of the high-priority sector is maintained no matter what the cost to the low-priority sectors of the economy. Historically, defense and heavy industry got everything they needed; agriculture and light industry received what was left or nothing.

Of course, when there is an extreme shock to the economy, the leadership may employ a relative priority rule that allows for limited cutbacks in high-priority sectors to avoid extremely high costs to the low-priority sectors. Although defense and heavy industry got everything they needed under normal shortage conditions, in the face of severe shortage conditions they suffered limited cutbacks in order to prevent severe economic or political disruption.

It is useful to compare these priority allocation systems with several alternatives. One alternative might be to use a rule of proportional growth and, when required, proportional cutbacks. Under this type of plan implementation procedure, the planners may instruct producers to allocate their supplies so that final output is maintained in proportion to the original output plan. As Western and Soviet authors alike have maintained, the requirement for balanced growth of the economy and hence for planning proportional development of its sectors is an integral part of Soviet economic doctrine.[20] This type of plan implementation procedure effectively places equal priority on achieving plan targets in all sectors of the economy.

Another procedure that can be compared with absolute and relative priority is one in which the planners may give no instructions to producers or may enforce their instructions ineffectively. In this case, the response of producers and consumers to black market prices and other scarcity signals will determine the actual economic outcome. In priority terms, the rule of "letting the managers work out their own supply problems" amounts to setting no exogenous priorities.[21] As we

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[20] Albina Tretyakova and Igor Birman, "Input-Output Analysis in the USSR," *Soviet Studies*, Vol. 28, No. 2, April 1976, p. 157. See also A. Gorodetskii and D. Gorodetskii, "Planned Proportionality and the Mechanism of Supply and Demand," *Problems of Economics*, May 1984, p. 80.

[21] Of course, the planners can still enforce their priorities indirectly by appointing superior managers, offering higher wages and

shall see, however, one can interpret this as a type of plan
implementation resulting from the endogenous priority system.

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bonuses, assigning less taut plans, and offering more legal leeway to
high-priority industries. In such a case, the relative priority rule,
rather than the marginalist rule, would in fact be operative.

III. THE PROTOTYPE PRIORITY MODEL

The prototype priority model (PPM) developed in this project uses goal programming to capture two essential features of the Soviet planning system: the disequilibrium effects such as supply bottlenecks that are generated by the system of priorities and the sequential or lexicographic decisionmaking implicit in the Soviet priority system.

Goal programming is applicable for the PPM because it permits us to model the sequential fulfillment of output targets according to their priority ranking. Moreover, because goal programming is able to generate disequilibrium solutions, we are able to capture the supply bottlenecks generated by the diversion of resources to priority sectors.

At its current state of development, the model focuses on the implementation phase of Soviet planning. The leadership's objectives during plan implementation will be represented by a simple rule to reflect the satisficing nature of planners' behavior. These priorities are exogenous to the objectives of the individual economic producers; they reflect the priorities in the output of final goods that are imposed and subject to change by the planners.

As we indicated in Sec. I, these exogenous priorities are distinguished from the endogenous priorities of the production relationships. As Michael Manove (1973) has shown, an implicit priority ranking for fulfilling output targets can be derived from the relative consequences that a shortage in each type of output would have on the achievement of the overall goal of the economy.[1] In this approach, the inputs used extensively in primary stages of production are of high endogenous priority, whereas final goods that are expensive to hold in inventory are of low priority. In effect, this priority ranking is determined by the structure of the input-output model, and so we define these priorities as endogenous.

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[1]See John P. Bonin, "The Visible Hand: Quantity Targets as Coaxing Tools," *Journal of Comparative Economics*, No. 1, 1977, p. 293.

As will be shown below, in this type of model the economic outcome will depend critically on the priority rule in effect, as well as on the input-output coefficients, capacity constraints, and the type of shock generating the bottleneck. Because intersectoral trade flows are significant, high-priority sectors may divert resources from low-priority sectors, thereby idling complementary resources and causing production shortfalls in these sectors. Thus, most of the social costs of meeting the output target of the high-priority sector are borne by the low-priority sectors of the economy.

To incorporate the various plan implementation rules discussed in Sec. III into our prototype priority model we will summarize the form of four simple rules that parallel our discussion in Sec. II.

1. *Absolute priority rule* -- Output is reduced in the lowest priority sector first. Assuming defense is the highest priority sector, it will suffer no reduction in output and therefore is said to have absolute priority.

2. *Relative priority rule* -- Output is reduced in all sectors, including defense. However, defense is reduced proportionally less than are investment and consumption and therefore is said to have relative priority.

3. *Equal priority or "proportionalist" rule* -- Output is reduced in all sectors in proportion to the planned output mix. Under this rule all sectors are effectively assigned "equal" priority by the planners.

4. *No priority or "marginalist" rule* -- Output is determined by the response of individual economic agents to price and other scarcity signals in the second economy. The shortfall in defense output may be proportionally greater or less than that in investment or consumption.

By summarizing the plan implementation strategies in the form of simple rules we are able to incorporate them into the prototype input-output models. For example, the absolute priority rule can be modeled by using a slightly modified linear programming method--goal programming--that causes goals to be fulfilled in lexicographic order.

Relative priority is more difficult to model with a simple satisficing rule. One would need to both specify and employ an approximation of the planners' objective function during plan implementation. This would take the form of a function in which penalties are increased the farther one moves from the priority goods target. Because we are attempting to portray plan implementation when the planners' objective function is not known by the decisionmaker, we introduce relative priority for the sake of comparison with the other decision rules, but do not employ it explicitly in the model.

The proportionalist rule can be implemented by adding a set of constraints to the above problem to ensure that the final output vector retains its planned proportions. This causes all gross outputs and inputs to be scaled back proportionally following a shock.

Finally, the marginalist rule is easily modeled as an ordinary linear programming problem in which, say, GNP is maximized using the plan prices. As we have indicated, this rule can be interpreted as being applicable to an endogenous priority system.

To understand how this endogenous priority system works in the marginalist model, we will employ, in a somewhat idealized fashion, the *tolkach* (facilitator) of the state enterprise whose task is to facilitate plan fulfillment by obtaining shortage inputs. Given a shortage of a particular input, the tolkach who can generate the largest ruble value of output by providing that input to his firm will be able to offer the highest price and therefore will be first to acquire the input. After the first tolkach has met his requirements, the other tolkachi will again bid until the input is entirely consumed, with the low bidder unable to satisfy his plan requirements. By this process, the shortage input would be allocated first to industries in which the input-output ratio for the input is smallest and its marginal value product highest. Thus GNP at plan prices would be maximized.[2]

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[2] See App. C for a discussion of the relationship between tolkachi decisionmaking and the marginalist model.

To illustrate these models, we employ a prototype four-sector input-output table that is assumed to be based on the economic plan. The model's sectors are defense, heavy industry, light industry, and infrastructure. Table 1 contains the input-output table that we use in our calculations.

We view the defense sector fairly broadly, reflecting not only the production and operation of weapons plus RDT&E, but also the penetration by this sector into civil activities. Thus, our measure of defense includes the services obtained from expenditures on the design, construction, and location of industrial plant and infrastructure, and from various types of mobilization preparations.

Many of the material inputs of the economy are produced within heavy industry. The economy's investment goods are a final output of this sector. Light industry includes some intermediate inputs supporting other sectors, but primarily produces the consumer goods of the economy, including the agricultural commodities and consumer services that are provided to final output.

Infrastructure is a broad sector that includes not only such conventional categories as transportation and communications, but also production of those inputs that support much of the "civil" costs of military preparations. The planning infrastructure that controls the priority allocation system is also included in infrastructure. The infrastructure sector is a pure intermediate input sector and there are no deliveries to final output.[3]

There is the important question of the rank ordering of the priorities. Although the Soviet priorities have recently been changing, we will fashion the model to reflect the historical situation. The general features of the model apply to any absolute priority system that is in effect during plan implementation.

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[3]At the conceptual level, one could also interpret "infrastructure" as any potential bottleneck sector that does not directly produce some component of final output.

Table 1

INPUT-OUTPUT TABLE FOR PROTOTYPE MODEL

(Planned input-output values)

	To Sector			
From Sector	Light Industry	Infrastructure	Heavy Industry	Defense
Light industry	0.00	0.00	10.00	0.00
Infrastructure	5.00	0.00	5.00	5.00
Heavy industry	15.00	0.00	0.00	5.00
Defense	0.00	0.00	0.00	0.00
Labor	30.00	5.00	20.00	5.00
Capital	10.00	10.00	15.00	5.00
Gross output	60.00	15.00	50.00	20.00

	Consumption	Investment	Defense	Final Demand
Light industry	50.00	0.00	0.00	50.00
Infrastructure	0.00	0.00	0.00	0.00
Heavy industry	0.00	30.00	0.00	30.00
Defense	0.00	0.00	20.00	20.00
Labor				60.00
Capital				40.00

Total final demand	100
Total gross output	145

In 1967, there was a clear summary of Soviet supply priorities, provided only a few years after the start of the Brezhnev defense build up. Table 2 shows this historical priority ranking.

Given the sectors of the input-output values in Table 1, we select defense as the first priority, heavy industry as the second priority, and consumption as the lowest priority. This then becomes the hierarchy of goals applicable to the priority model. The problems that we solve in the alternative models are represented in Fig. 1.

Although there are many cases that can be evaluated, we focus here on the effect of a shock to the infrastructure sector. In our analysis, we represent the effect of a decline in the productivity of capital in this sector. To be concrete, one might think of this shock as representing a bottleneck in the transportation sector.

Figure 2 illustrates the effect of this shock on the production possibility curve describing alternative combinations of guns (defense) and (butter) consumption when the different allocation rules are in effect. Because of the structure of the input-output table, the production possibility frontier both shifts inward and rotates counterclockwise to reflect the relatively heavier dependence of guns production on infrastructure inputs. Also, there are capacity constraints that are not shown on the diagram but which prevent guns or butter from rising above the planned levels that are indicated by the circle on the outer dashed production possibility curve.

Table 2

SOVIET SUPPLY PRIORITIES, 1967

1. Military production and activities
2. Current industrial production
3. Consumption
4. Material stocks and working capital
5. Investment in repair activities, repair equipment, and technological change
6. Capital construction

SOURCE: *Materials Equipment Supply* (Journal of Gossnab), November 1967.

Under absolute priority the plan for guns production is maintained at the expense of butter. Although we do not actually apply the model for the relative defense priority situation, we illustrate what might happen if there is a significant shock to the economy; the allocation rules favor defense, but some of the requirements set in the plan are reduced to prevent a significant decline in butter.

Under the proportionalist model, one maintains the same proportions of guns and butter that apply in the plan. In the marginalist solution, on the other hand, the butter plan is maintained at the expense of guns. The latter solution occurs because each unit shortage of infrastructure inputs would idle more resources in light industry than in defense. Light industry will receive the scarce inputs because the manager in this sector will be able to offer a higher price per unit of infrastructure than will the defense manager. Therefore, the plan target for butter production will be met, whereas the target for guns will be underfulfilled.

Clearly, if the production possibility curve had shifted inward, but also rotated counterclockwise, the marginalist solution would have been identical to the priority solution. In App. A, we summarize several of these other possibilities. Note, however, that because the marginalist allocation rule maximizes GNP, aggregate output will always

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Alternative Models

| Marginalist/Proportionalist Model	Priority Model
Maximize:	Minimize:
Defense and consumption and investment	1. Deviation of defense from target
	2. Deviation of heavy industry from target
	3. Deviation of light industry from target
Subject to:	
Input-output relationships	
Relevant labor and capital contraints	Subject to:
Relevant final demand constraints	Input-output relationships
	Relevant labor and capital constraints

Fig. 1—Prototype input-output problems
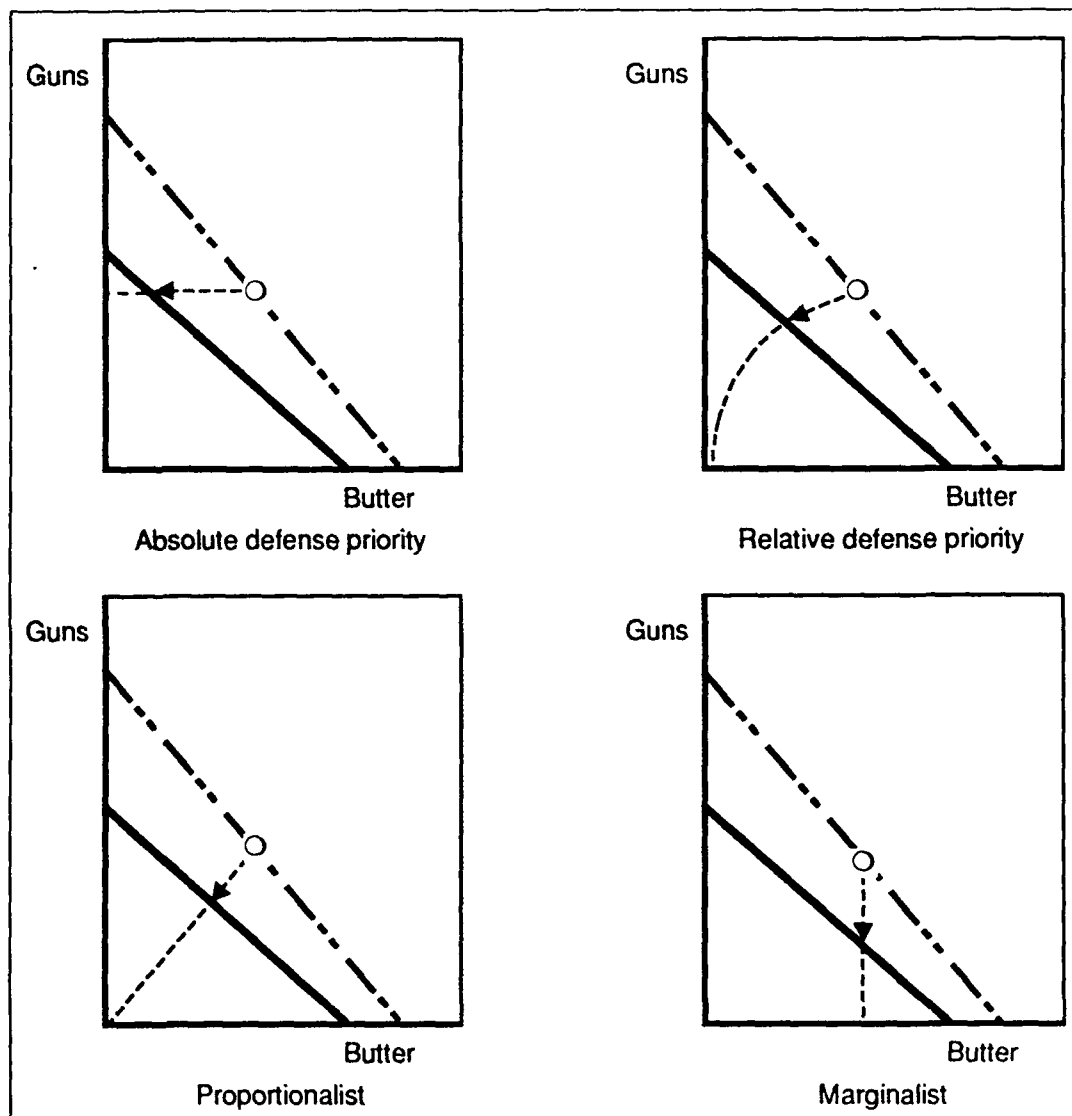
Fig. 2—Alternative resource allocation rules and shock in infrastructure

be at least as large in the marginalist case as in the absolute priority situation.

To develop this analysis further, now consider a situation in which the productivity of capital allocated to the sector declines in efficiency from 0 to 15 percent. As shown in Fig. 3, as the shock increases in size, defense output is maintained at plan (or target) values under the priority model.

One can also see, however, the reduction associated with the proportionalist model and the significant reduction in defense that occurs in the marginalist model.

In Fig. 4, we describe the impact of the capacity constraint on consumer goods. Target levels are met in the marginalist model, proportional reductions occur in the proportionalist model, and significant reductions occur in the priority model. We find that a reduction in infrastructure capacity leads to a more than proportional reduction in consumer goods. Because of the supply-side consumption multiplier in operation in the priority model, the consumer absorbs most of the shock associated with the infrastructure capacity shortage.

Interestingly, as depicted in Fig. 5, a shock to the infrastructure sector can increase investment in the priority model. We have a situation in which the heavy industry sector, after fulfilling its
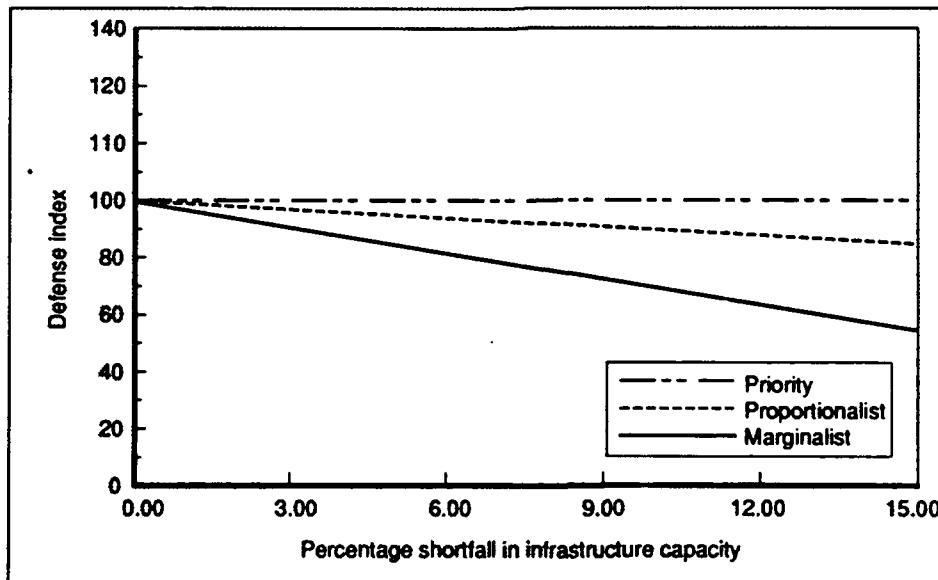

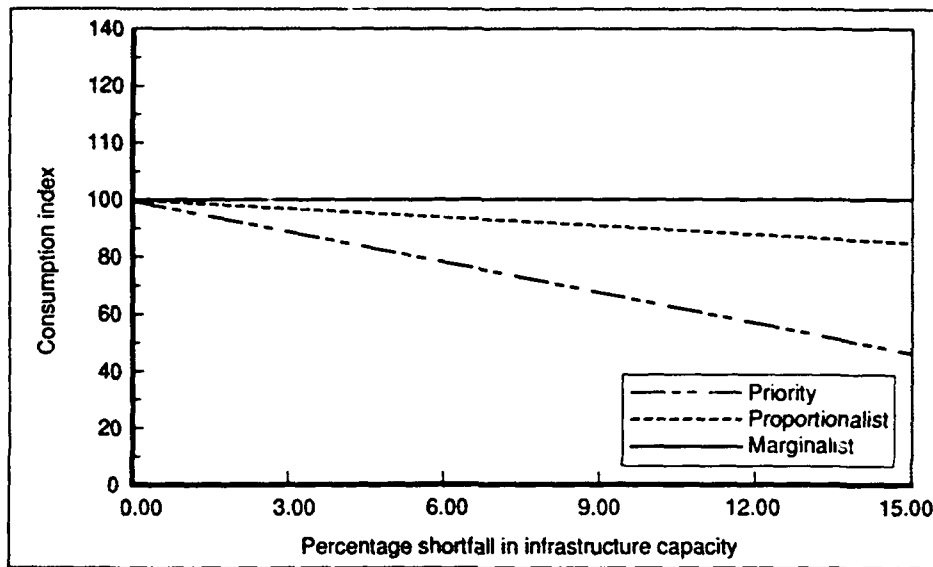Fig. 3—Effect of infrastructure capacity on defense

Fig. 4—Effect of infrastructure capacity on consumer goods

deliveries to defense and to the lower priority consumer goods sector, has capacity left over for investment. Under the marginalist solution, there is a slight increase in investment, and there is the expected proportional reduction in the proportionalist model.

In Fig. 6, we show that there is the greatest reduction of final output (GNP) in the priority model as a more than proportional reduction occurs. Of course, the marginalist model, which maximizes GNP, achieves the greatest GNP for size capacity, whereas the proportionalist model reduces it, as expected.

While we permit labor to flow across sectors in these models, the capacity constraints eliminate any advantages from such short-run labor mobility when there is a shock to the infrastructure capacity. As shown in Fig. 7, we end up with significant labor unemployment in the priority model. There are excess workers in both the infrastructure and consumer goods sector. The lowest level of unemployment is in the marginalist model, and the proportionalist model is an intermediate case. Presumably, the unemployment described would not be identified in the economic statistics. Rather, it should be viewed as an underemployment of labor.
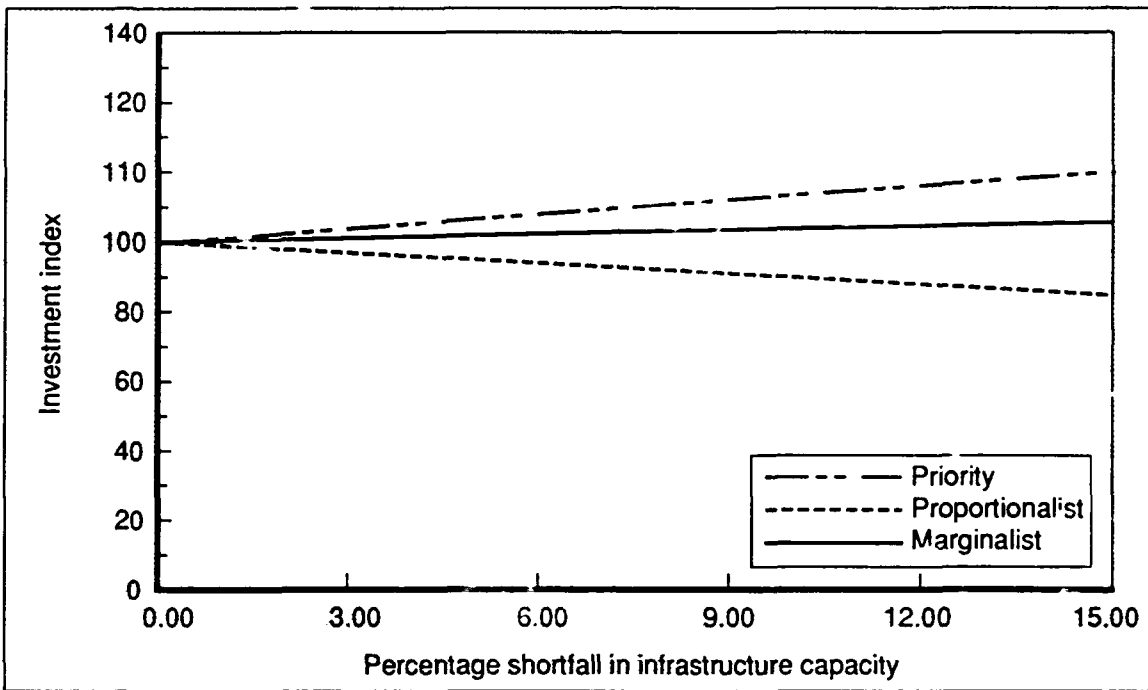
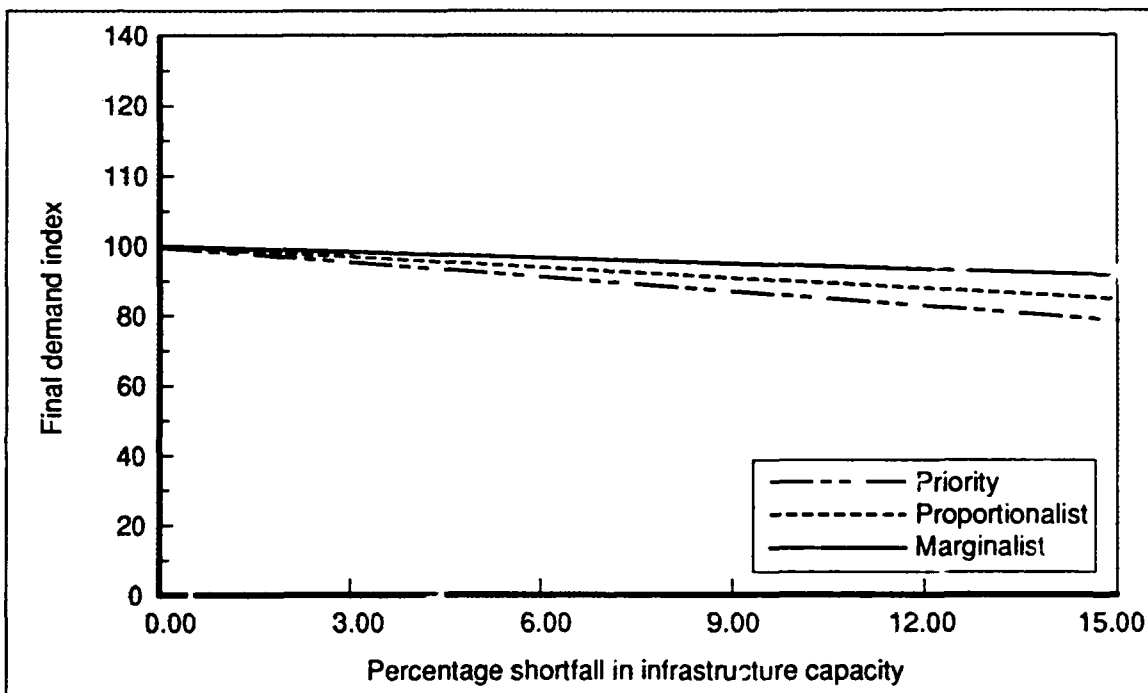Fig. 5—Effect of infrastructure capacity on investment goods

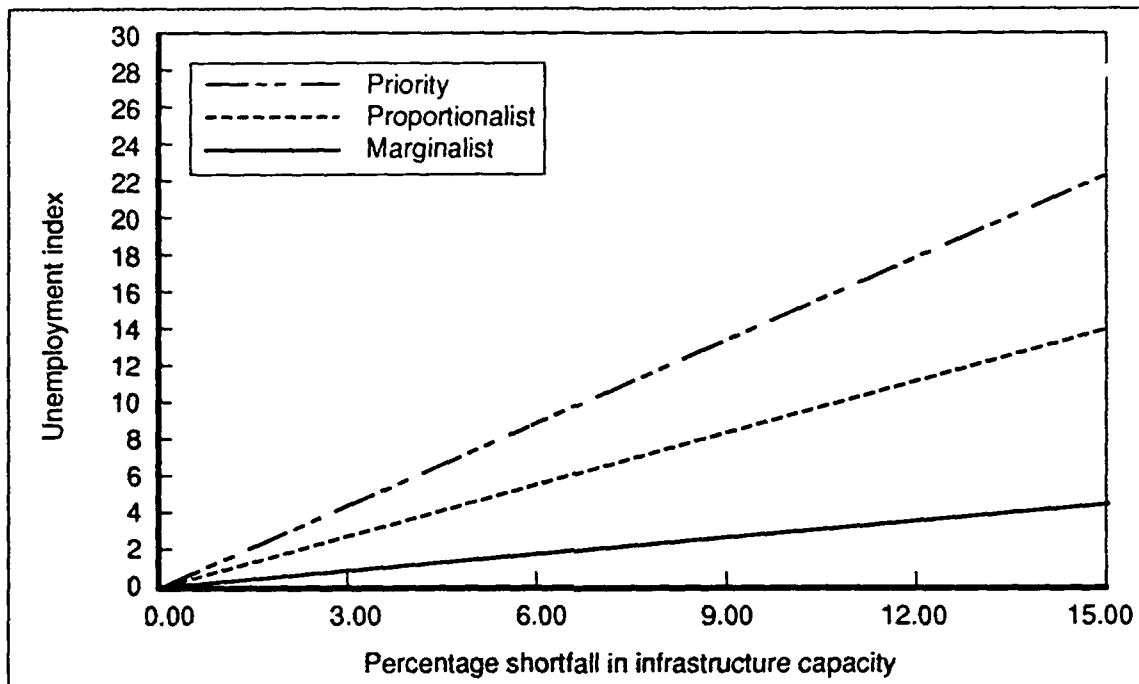Fig. 6—Effect of infrastructure capacity on final demand

Fig. 7—Effect of infrastructure capacity on unemployment

To summarize some of the results obtained, we see that in the priority model the defense target output level is achieved; an economic shock can have a multiplier effect on low-priority consumption; heavy industry priority can lift investment above target; there can be a multiplier reduction in GNP; and a significant underutilization of labor can occur.

Our discussion of the ideas of Rush Greenslade indicated that there can be multiple opportunity costs in the Soviet economy. One of the challenges to be undertaken by the priority model is to capture these multiple opportunity costs, as well as the other disequilibrium features of the Soviet economy. Let us compare, therefore, the differing costs of a shock to the infrastructure sector for the marginalist versus the priority situation. We will use as our measure the final output (or GNP) forgone as a result of shock. Figure 8 compares the marginal cost of the shocks in the two situations.[4]

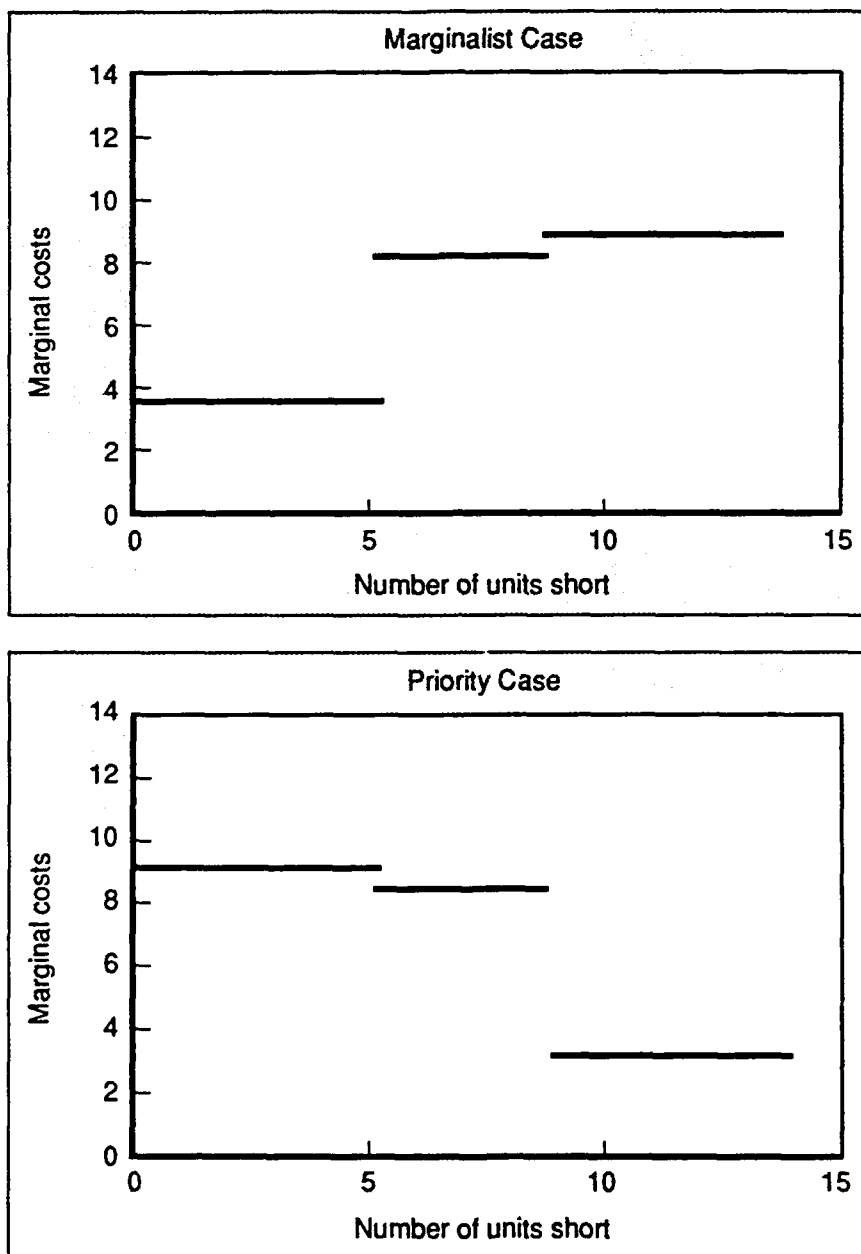[4]Appendix B discusses of the cost of various shocks under different allocation rules.

Fig. 8—Marginal costs of infrastructure shortage

In the marginalist case, one obtains increasing marginal cost as the size of the shock increases. This makes sense because in this case one is reallocating inputs, following the shock, to minimize the effect on GNP. In contrast, in the priority solution the marginal cost declines as the shock increases: the defense priority is first met at the expense of a significant amount of GNP; then, in contrast to the marginalist case, the GNP forgone decreases.

As the three models discussed in this section stand, they represent what are ideal types. The priority model portrays a basic tendency of the Soviet economy to fulfill the objectives of the planners; this is the exogenous priority system. A countervailing tendency is for individual managers, through the use of tolkachi, to fulfill their specified targets and maximize their own economic welfare; this is the endogenous priority system.

With both systems in operation in the Soviet economy, there is clearly room for substantial conflict. One force moves the system in the direction of the leadership objectives; a second force moves the system toward the largest GNP. It is not surprising that this inconsistency can result in economic waste.

To explore this issue further, we consider a mixed shock to the economic system in which the capacity levels of both heavy industry and infrastructure are lower than the planned values. We then pass this shock through a pure (exogenous) priority model, a marginalist (endogenous) priority model, and a conflicting (mixed) priority model. In the conflicting priority model, we assume that the tolkachi of the light industry sector are able to obtain the amount of infrastructure needed to fulfill their sector's plan; all other material inputs are allocated based on the exogenous priorities.[5]

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[5]To illustrate the case of conflicting priorities in our model, shortages in two sectors and therefore two constraints are required. This allows deficit goods to be allocated by market forces in one sector and by administrative commands in the other. Another case of conflicting priorities might be modeled using a single deficit good, a proportion of which is allocated administratively and the rest by the black market.

Figure 9 shows the final output obtained as the size of the shock is increased. As expected, total final output, or GNP, is highest in the endogenous priority model and lowest in the exogenous priority model. The conflicting priority model results in a level of GNP somewhere between the other two models.

Interestingly, the conflicting priority model captures one of the important stylized facts of the Soviet economy--the existence of surplus material inputs in some sectors under conditions of a general shortage. Figure 10 portrays the value of unused infrastructure that results from shocks of increasing size to the economy.

In Western optimization models of the Soviet economy, all intermediate materials delivered to a sector are employed in the production of the gross outputs. We obtain the same result in the (exogenous) priority, marginalist (endogenous priority), or proportionalist models. While the latter models do yield excess capacities and underemployed labor, each sector uses all of the delivered material inputs.

As shown in Fig. 11, the defense sector's target output level is not achieved in either the conflicting priority model or the endogenous priority model. As before, the defense target is achieved in the exogenous priority solution. One should note that the conflicting
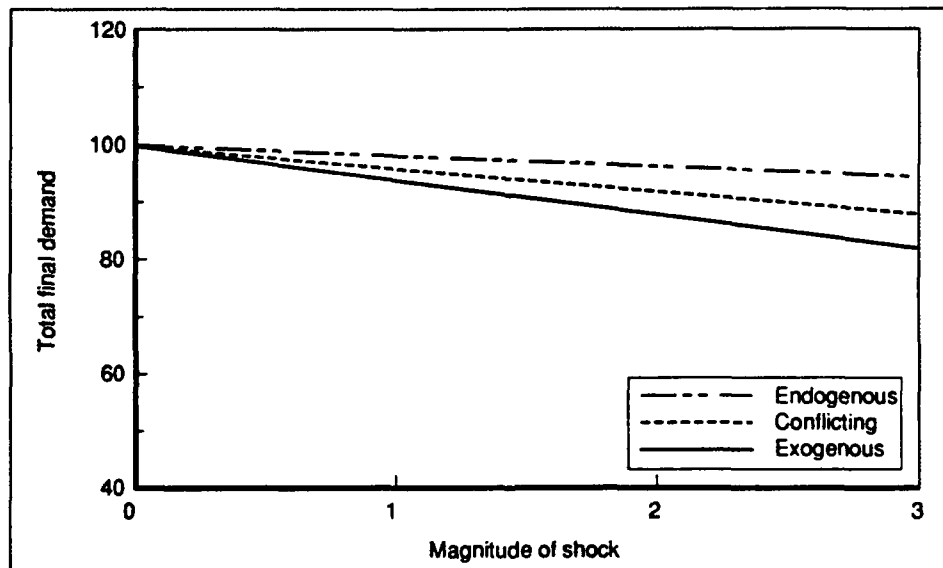

Fig. 9—Effect of a mixed shock on final demand

A magnitude 1 shock corresponds to a 1.0 percent reduction in heavy industry and a 3.33 percent reduction in infrastructure. Higher magnitude shocks are proportionally greater.
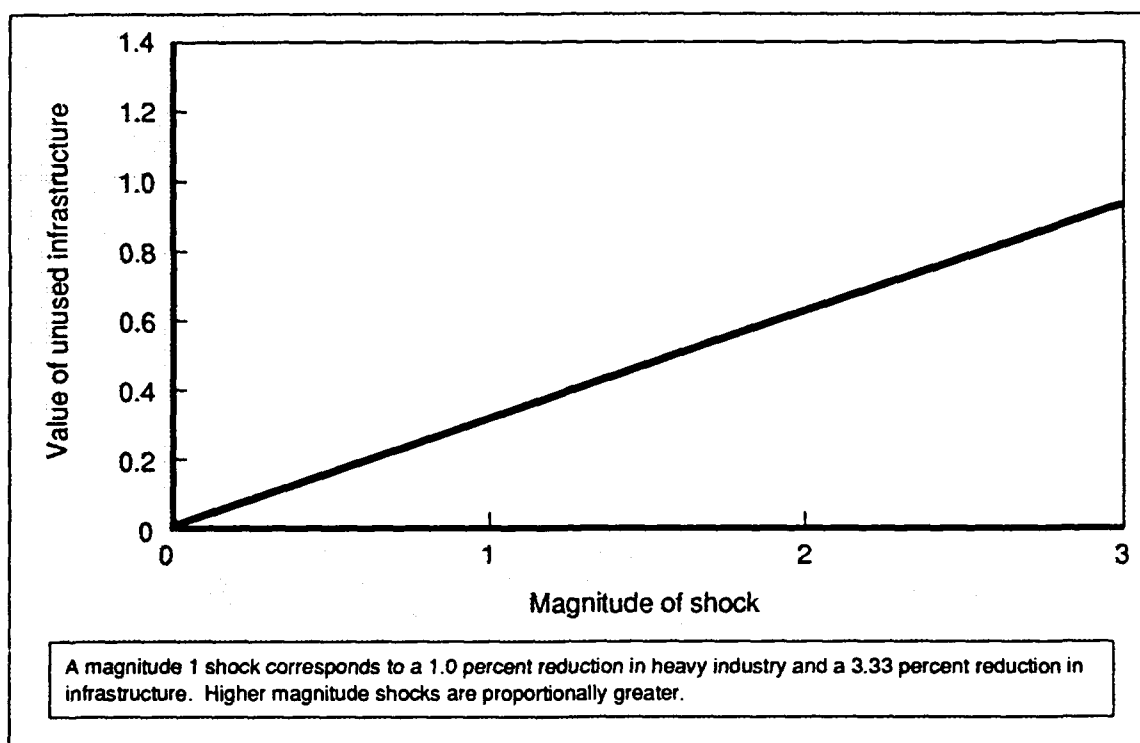
Fig. 10—Value of unused infrastructure inputs under conflicting priorities

priority model results in the same defense output level as the endogenous priority model. Although the Soviets obtain additional total final output in the conflicting priority model, relative to that obtained in the exogenous priority model, the cost of this increase is a reduction in defense output.

We conclude that the conflict from the two priority systems may hinder the leadership from achieving its defense goals. Clearly, this inconsistency between leadership objectives and economic outcome can be expected to have an effect on the organization of production in the Soviet economy.

As David Holloway has argued, in the Soviet Union "demand and supply emanate from the same source." Not only does demand call forth a supply of goods as is the case in a market economy, but in the Soviet situation, the leadership also affects the nature of the supply institutions.[6]

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[6]See David Holloway, "Economics and the Soviet Weapons Acquisition Process," in *Soviet Military Economic Relations, Proceedings of a*
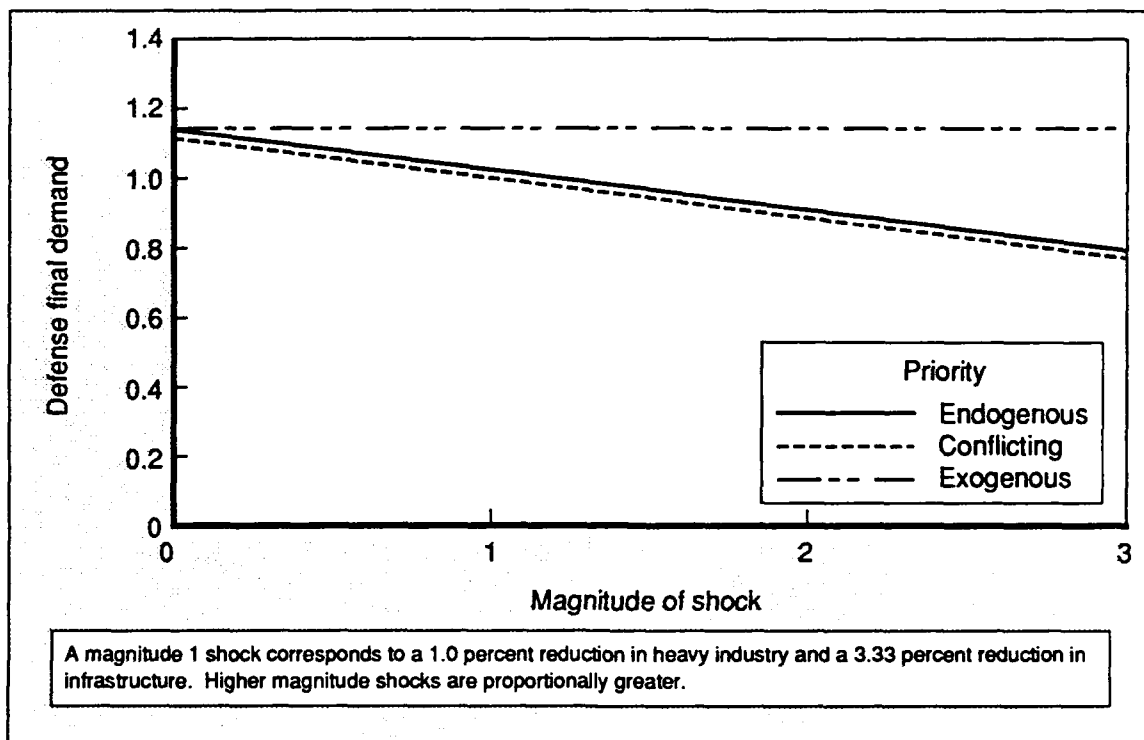
Fig. 11—Effect of a mixed shock on defense

One would, therefore, predict the priority sector to have a vertically integrated production process to better ensure that the leadership objectives are achieved. As we have indicted, this is precisely what occurred in the defense machinery ministries, where production has historically been "vertically integrated from basic industry to end product." We see, therefore, that the limitations on the leadership's ability to achieve their priority objectives during plan implementation has influenced the nature of the institutions within which resource allocation takes place.[7]

Workshop, July 7 and 8, 1982, sponsored jointly by the Subcommittee on International Trading, Finance, and Security Economics of the Joint Economic Committee and the Congressional Research Service, Library of Congress, U.S. Government Printing Office, Washington, D.C., 1983, p. 47.

[7]USSR: Military Economic Trends and Resource Allocations--1983, Defense Intelligence Agency, August 1983, p. 1.

Furthermore, imbedded in this vertical integration is a significant amount of civilian production. The historical role of this civilian production capacity has been to act as a buffer should the defense sector need to surge production. There have, however, been recent attempts by the leadership to employ defense capabilities in production of civilian goods. At first, the leadership tried to get the defense sector to assist the modernization program. Then the defense sector was asked to produce consumer-related goods.[8]

Despite the many recent reforms, nearly all of the civilian output of Soviet defense plants has been produced through the traditional central planning system. State orders have accounted for almost the entire output of defense enterprises, including their output of food and light industry equipment, consumer goods, and other civilian goods.[9] Thus, while Soviet economic priorities have shifted under Gorbachev, the priority system has remained largely in place.

The nature and timing of the various changes in Soviet economic priorities under Mr. Gorbachev have been widely discussed by both Soviet and Western analysts. Abraham Becker summarized the intitial change in the priority order that was applicable to Gorbachev's first two years,[10]

> In the tens of thousands of words that issued from his mouth during the first two years, and in the actions of the regime accompanying them, it was apparent that his top priority was economic growth, followed by consumer welfare; the defense budget appeared to be a distant third.

As chairman of the Council of Ministers, N. I. Ryzhkov stated, the most substantial structural changes in the economy were "related to stepping up the priority growth of machine building."[11]

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[8]For a discussion of the military's support of civilian activities, see Julian Cooper, "Technology Transfer Between Military and Civilian Ministries," *Gorbachev's Economic Plans*. This paper appeared in Joint Economic Committee, *Gorbachev's Economic Plans* (USGPO, Washington, November 23, 1987), pp. 388-404.

[9]Julian Cooper, "The Contradictions of Soviet Defence Industry Civilianisation", unpublished manuscript, March 1990, p. 19.

[10]*Ogarkov's Complaint and Gorbachev's Dilemma: The Soviet Defense Budget and Party-Military Conflict,* The RAND Corporation, R-3541-AF, December 1987, p. 30.

[11]Report by N. I. Ryzhkov to the 27th Congress of the Communist

Other observers, such as Jim Noren, have viewed the Soviet shift away from defense priority as coming somewhat later and in stages[12]

> In the initial stage, Soviet defense programs and policies were relatively untouched. . . . The stage in which the USSR finds itself now took shape in 1988 as economic restructuring fizzled and the leadership decided to abandon its original strategy for the 1986-90 Plan.

Thus, while analysts generally agree on the nature of the shift in Soviet economic priorities, the timing of this shift remains a matter of debate.

As the economic crisis in the USSR has deepened during 1989-90, there appears to have been a further shift in priorities in favor of consumer goods at the expense of defense and to a lesser extent investment. For example, Soviet leaders set 1989 Plan targets that called for 130 percent higher growth in Group B (consumer goods) as opposed to Group A (producer goods).[13] Soviet hard-currency also reflected the greater emphasis on the Soviet consumer, with imports of capital goods suffering cutbacks in order to pay for increased supplies of food and consumer goods.[14]

Some of the detailed features of the new priority system have been discussed by Julian Cooper:[15]

> From the outset, the Party and government authorities, probably reflecting Gorbachev's personal view, have consistently granted first priority to consumer-related

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Party of the Soviet Union: On the Basic Guidelines for the Economic and Social Development of the USSR in 1986-1990 and in the Period Up to the Year 2000, *Pravda*, March 4, 1986.

[12]Jim Noren, *The Effects of Perestroyka on the Defense Sector and Resource Allocation in the USSR*, unpublished manuscript, February 1990, pp. 1-2.

[13]Report by Yu. D. Maslyukov on the State Plan for the Economic and Social Development of the USSR in 1989 and Progress in the Fulfillment of the Plan for 1988, *Pravda,* October 28, 1988.

[14]*PlanEcon Report,* Vol. 5, No. 1, January 6, 1989.

[15]Julian Cooper, "The Contradictions of Soviet Defence Industry Civilianisation," pp. 12-13. See also *Pravda*, August 28, 1989.

products, above all equipment for the food and light
industries, consumer goods and medical equipment. Lower in
the priority ranking have been the electronics, computing, and
civil aircraft and shipbuilding.

According to Cooper, this defense conversion plan was developed by
Gosplan in consulation with the Military Industrial Commission (VPK).
However, there is mounting evidence that the VPK's traditional role in
enforcing military priorities has been significantly altered and
weakened. The VPK, which apparently lacks formal representation on the
new Presidential Council, may soon be forced to yield its managerial
role either to Gosplan or, perhaps, to radical market reforms. The role
of the VPK in implementing the new civilian priority system within the
defense industry is, therefore, uncertain.[16]

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[16]The change in VPK's organizational status has been discussed in
SOVSET. For example, see Grey Burkhart's reply to to Brenda Horrigan's
message number 2837, April 12, 1990.

IV. APPLICATIONS AND EXTENSIONS OF THE MODEL

APPLICATIONS OF PRIORITY-DRIVEN MODELS

As we discussed in the introduction, our primary aim in developing the PPM was to better capture the characteristic features of the traditional Soviet-type economy. Those characteristic features--taut planning, disequilibrium effects, priority, supply bottlenecks--have been well described by Western analysts. The goal of the present project is to incorporate the findings of this rich descriptive literature into the framework of a more formal model.

When fully developed, a priority model of the Soviet economy will serve many of the same purposes as traditional models. For example, the model might be used to evaluate the feasibility of the Soviet annual plans and to determine the likely effect of supply bottlenecks on plan fulfillment. A dynamic model would be able to serve the same purpose with respect to five-year and longer-term plans, and also to examine the effect of shifting priorities on Soviet economic growth and military spending.

Although Gorbachev's economic reforms have shifted priority from defense to investment and consumer goods, models incorporating military priority will remain useful as a historical reference. Models with a revised priority structure could also be useful in examining shifts in Soviet economic priorities in a number of areas, including resource allocation among: (1) consumption vs. investment vs. defense; (2) domestic use vs. export to allies vs. export for hard currency; (3) important geographical areas; (4) the 15 Soviet republics; and (5) major branches of industry.

Priority-driven models might also be useful in measuring a reform's impact on the Soviet economy. Due to their explicit treatment of priority, the models are particularly well-suited to test the extent to which Soviet economic priorities have undergone major changes. And by comparing their explanatory power to that of price-driven models, priority-driven models might also be useful in gauging the extent to

which the traditional priority system and the system of state orders is being replaced by market mechanisms.

Finally, priority models might be applied to the study of Western hierarchical institutions such as corporations, the military, government bureaucracies, etc. In fact, many of the ideas incorporated in the PPM have their origins in the extensive Western organizational literature. Thus, there is a potential for developing a strong linkage to the works of Herbert Simon on satisficing, Jan Tinbergen on target planning, and Oliver Williamson on markets and hierarchies.

EXTENDING THE SCOPE OF THE PROTOTYPE PRIORITY MODEL

In its current form, the empirical use of the PPM is limited by its static, single-period nature. Therefore, perhaps the single most important extension is to make the model dynamic. This might be accomplished by incorporating the assumption that each year's plan targets are derived largely by adding regular increments to the previous year's actual output. In the sectors for which it is available, Soviet annual plan data may be used.[1]

Several other extensions would also make the model more realistic. Among these are: (1) incorporating the accumulation and decumulation of inventories as a response to shortage; (2) adding a foreign trade sector that allows for the importation of some inputs which are in short supply, but which also may generate domestic shortages due to priority being attached to meeting hard-currency obligations; (3) modeling in greater detail economic sectors such as energy, transportation, and steel, which are the source of potential supply bottlenecks; (4) developing a model of relative priority through the use of a piecewise-linear objective function in order to avoid extreme predictions of the impact of shocks on low-priority sectors; (5) capturing the economic and

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[1]The use of Soviet plan data presents many difficult problems. For example, as a CIA paper argues one must be wary of attempts to compare Soviet planned and actual output data. For a discussion, see *Comparing Planned and Actual Growth in Industrial Output in Centrally Planned Economies*, Central Intelligence Agency, ER80-10461, August 1980, Washington, D.C.

political importance of consumption by constraining consumption to grow at a certain minimum rate or by linking labor productivity to growth in the output of food, housing, and light industry; and (6) incorporating technological change and allowing for production using different technologies.

Following its extension along these lines, the PPM should prove capable of addressing many of the policy questions asked of the existing models. By doing so it will offer the policymaker an alternative view of the Soviet economy that has been specifically formulated to highlight its most distinctive features.

DEVELOPING MICROFOUNDATIONS

The development of a solid set of microfoundations provides another broad avenue along which our work on the PPM can be extended. Already, much important research in describing the microeconomic effects of taut planning and supply uncertainty has been carried out by Berliner, Levine, Kornai, Bergson, and other researchers. As discussed above, Manove has shown that firms can be assigned priority based on how a shortage of the firm's output would affect the achievement of the central planner's overall goal.[2] Bonin has extended this work by deriving incentive structures aimed at minimizing deviations from planned output levels for a three-tier priority ranking of firms.[3] Keren has derived output and substitution effects for Soviet firms responding to plan targets and planners' priorities.[4] More recently,

[2]Michael Manove, "Non-Price Rationing of Intermediate Goods in Centrally-Planned Economies," *Econometrica*, Vol. 41, No. 5, September 1973, pp. 829-852.

[3]Bonin finds that "For firms producing output in the intermediate tier of the priority ranking, an incentive structure can be designed to make large deviations from the output target unlikely...Such firms should be given strongly concave output incentive and strictly convex penalty functions. On the other hand, firms whose output is top priority are in the highest tier and should have piecewise linear penalty functions for both inputs." John P. Bonin, "The Visible Hands: Quantity Targets as Coaxing Tools," *Journal of Comparative Economics,* Vol. 1, No. 3, 1977, p. 295.

[4]Keren demonstrates that increased tautness in the firm's plan induces both an expansion effect, which usually increases output in the desired direction, and a substitution effect, which deflects output away from the desired mix. See M. Keren, 1979.

Linz and Martin have demonstrated that under conditions of taut planning
and supply uncertainty all firm managers will overorder inputs, thereby
giving rise to further shortages.[5]

Based on this preliminary research, we are able to offer some
general suggestions on the further development of solid microfoundations
for the PPM. First, as Weintraub argues, the microfoundations should be
capable of modeling both equilibrium and disequilibrium conditions, that
is, of generating both coordination successes and failures.[6] Second, as
Brown and Neuberger (1969) suggest, microfoundations of the Soviet
economy may be better captured by models of bargaining behavior than by
traditional models of rational resource allocation.[7] We therefore
conclude that in further developing the microfoundations of the PPM (and
for other macromodels of the Soviet economy), an Edgeworthian or game-
theoretic approach may be more appropriate than a Walrasian or general
equilibrium approach.

Specifically, as much recent research on the management of the
Soviet firm suggests, the relationship between planner and manager can
be usefully modeled as a principal-agent problem.[8] Other important
relationships throughout the Soviet economy, such as that between the
political leader and economic planner and between the manager and
worker, can be modeled in a similar fashion. In fact, due to its
hierarchical structure, a realistic model of the Soviet economy might
involve a chain of such relationships extending from the level of the
General Secretary all the way down to the individual worker or peasant.

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[5]Susan J. Linz and Robert F. Martin, "Soviet Enterprise Behavior
Under Uncertainty," *Journal of Comparative Economics*, Vol. 6, No. 1,
1982, pp. 24-36.

[6]E. Roy Weintraub, *Microfoundations*, Cambridge University Press,
Cambridge, 1979.

[7]Alan A. Brown and Egon Neuberger, "Basic Features of Centrally
Planned Economy," in Morris Bornstein (ed.), *Comparative Economic
Systems*, Richard D. Irwin, Inc., Homewood, Illinois, 1969, pp. 99-109.

[8]For example, see M. Weitzmann, "The New Soviet Incentive Model,"
Bell Journal of Economics, 1976, pp. 251-257 and "The Ratchet Principle
and Performance Incentives," *Bell Journal of Economics*, 1980, pp.
302-308. Also, B. Holmstrom, "Design of Incentive Schemes and the New
Soviet Incentive Model, *European Economic Review*, 1982, pp. 127-148.

V. CONCLUSIONS

The four-sector priority model has proven to be a useful tool for developing some basic intuitions about how a priority economy might operate. Our findings can be summarized as follows:

1. *The variance of output plan fulfillment is greater in nonpriority than in priority sectors.* This is a direct result of imposing a hierarchical (lexicographic) ordering of preferences. When the economy is faced with a shortage or bottleneck in production, the leadership orders that the output of priority industries be maintained, and that of nonpriority industries be reduced.

2. *A shock in any sector causes unemployed resources in nonpriority sectors.* When there is a shortage of any input, the nonpriority sectors suffer the shortfall. Because production is assumed to be linear, a shortage of one input causes the complementary inputs in the nonpriority sector to lay idle.[1]

3. *Final output in the priority model following an adverse shock is always less than or equal to that in the marginalist model.* This will always be true because the marginalist model's objective function is to maximize final output. In contrast, the priority model's objective function is to minimize the deviation of each industry from its output target according to a priority ranking. Thus, in general the priority model will not maximize final output.

4. *Final output in the priority model may be either less than, equal to, or greater than that in the proportionalist model.* The proportionalist model maximizes final output subject to the constraint

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[1] In *Priority, Duality, and Penetration* Richard Ericson developed a model in which the priority sector typically has idle inputs. The apparent contrast in the predictions of Ericson's model with that presented here is one of emphasis rather than fundamental disagreement. In his model, Ericson emphasizes the idle capacity built into the high-priority sector as a means of reducing the impact of shocks on that sector's output. By contrast, our model emphasizes the resources that are left idle in nonpriority sectors when scarce inputs are diverted to high-priority sectors.

that its components be in proportion to the planned final output vector. The severity of this constraint depends on the input-output coefficients of the model and the type of shock.

5. *It is useful to distinguish between endogenous and exogenous priorities.* Exogenous priorities are determined by the Party leadership with the aim of promoting the development of certain sectors of the economy at the expense of others. In contrast, endogenous priorities are determined by the structure of the economy as reflected in the input-output coefficients and are those required to maximize net output.

6. *Imposing exogenous priorities generally raises the marginal costs of input shortages in terms of both gross output and final output.* When an input shortage occurs, the most economical response is to reduce the use of the input in the sector where its marginal value product is lowest. By imposing exogenous priorities, the planners may in fact cause the input shortage to be felt in the sector where its marginal value is highest.

7. *If exogenous priorities, either by chance or by design, coincide with endogenous priorities, then imposing the priority causes no social cost.* For any exogenous priority ranking of economic sectors, there may be economic shocks for which that priority ranking is optimal for maximizing net output. In such a case the exogenous and endogenous priorities would coincide and there would be no social cost to imposing the priority.

8. *The exogenous priority system is likely to impose social costs in the form of reduced final output in the Soviet Union.* To eliminate the social costs of imposing exogenous priorities, the planners would have to shift the priority ranking of industries according to the type of shortage. Historically, the Soviet leadership's priorities have remained constant over fairly long periods of time regardless of the shock suffered. Under such conditions social costs are incurred.

9. *A mixed response (enforcing both endogenous and exogenous priorities) to a mixed shock (affecting two or more economic sectors) may produce both shortages and surpluses of inputs simultaneously.* If one assumes that endogenous and exogenous priorities are in conflict and

that the Party's ability to impose its priorities is imperfect, it is possible that some resource may be allocated according to exogenous priorities, whereas others are allocated endogenously. Thus it is possible for an industry to receive one input allocated by administrative priority and be short another input allocated through the system of tolkachi. At the same time, another industry may suffer the reverse situation, causing simultaneous shortages and surpluses of the inputs.

Appendix A
EFFECTS OF SHOCKS IN OTHER SECTORS

In addition to the infrastructure shock discussed in the text, other types of shocks are of potential interest. For example, Fig. A.1 illustrates the effects of an economy-wide shock on production of defense (guns) and consumption (butter) for each of the four rules. Because the shock is the same economy-wide, the production possibilities' frontier shifts inward but does not change in slope.

Under absolute defense priority, guns production remains at its planned level. Output is constrained at that level by the defense capacity constraint and by the central planners' demand. Butter production, on the other hand, suffers the full shock of the decline in light industry's productivity as well as that of the other sectors.

Under relative defense priority, the planners distribute some of the shock to all areas of the economy to avoid economic disruption and perhaps political unrest due to butter shortages. Defense industry sustains only a small shock and so guns production falls only slightly below its planned level. Light industry bears the major burden of the shock and butter production drops sharply, but not so sharply as under absolute defense priority.

Under equal priority or proportional cutbacks, the planners distribute the shock equally among defense, light industry, and other economic sectors. Guns and butter production therefore fall proportionately by an amount determined by the size of the shock and the original plan proportions.

Under no priority or marginalist decisionmaking, the outcome is determined by the response of producers, consumers and *tolkachi* to price and nonprice scarcity signals. These in turn depend on the shock's effect on the relative productive efficiencies of the different economic sectors. This itself depends on the nature of the shock. For instance, if the shock is in labor productivity, labor intensive industries will be hurt the most. If the shock is in the transportation of intermediate products, those industries most dependent on inputs from other
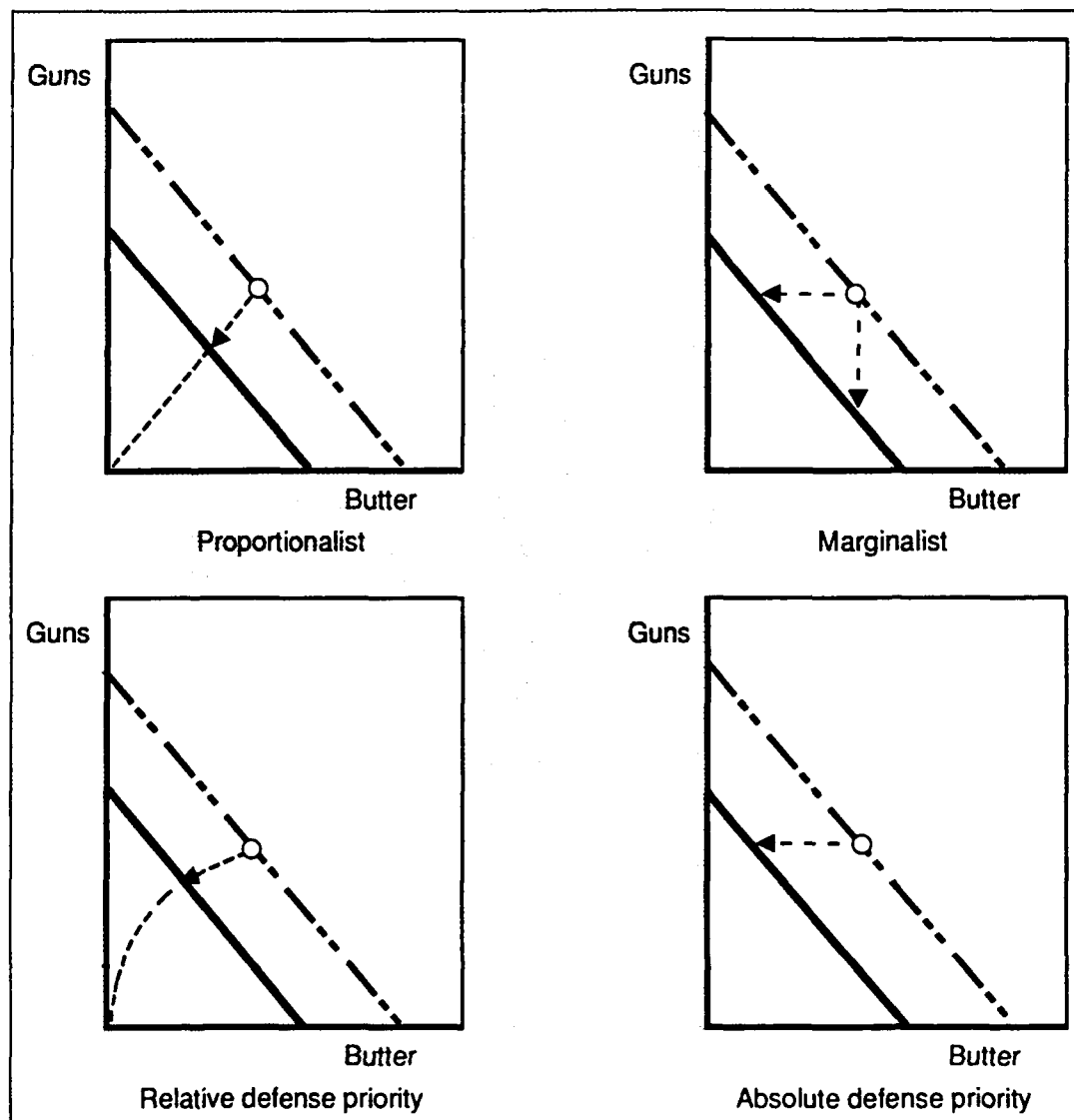
Fig. A.1—Alternative resource allocation rules under overtaut planning

industries will suffer. Therefore, the specific location of the
production outcome along the PPF will depend on the input-output
coefficients of the industries.

Figure A.2 illustrates the effect of a shock in light industry,
which is depicted as a shift of the PPF inward along the butter axis.
Under absolute defense priority, the defense industry is fully insulated
from the effects of the shock and guns production remains at the planned
level. Under relative defense priority, defense industry suffers a
small cutback in its inputs from other sectors and guns production falls
slightly below plan. Under equal priority, the planners cut back light
industry's supply of inputs to other sectors to the point where the
percentage shortfall from the plan targets is the same in all sectors.
Under no priority, light industry will not cut back its inputs to other
sectors (inputs commanding higher shadow prices than final outputs) and
butter production will suffer the full effect of the shock.

Figure A.3 illustrates the effect of a shock in the defense sector.
Here the PPF rotates counterclockwise and inward along the guns axis to
reflect the lower efficiency of defense production. Due to its high-
priority status, however, defense is assumed to have sufficient excess
capacity to avoid a capacity bottleneck. Therefore, under absolute
defense priority, other industries are forced to divert extra inputs to
defense in order that the guns production target may be fulfilled.
Consequently, butter production falls. Under relative defense priority
and equal priority, somewhat smaller diversions of inputs will take
place. Only under no priority will the impact of the shock in the
defense industry be isolated to guns production.

Lastly, Fig. A.4 illustrates the effect of a shock in heavy
industry. Here the movement of the PPF is complicated by the fact that
investment, the primary output of heavy industry, is the second-priority
good. Hence, under the absolute, relative, and equal priority rules,
extra inputs will be diverted from light industry, and in the latter two
cases from defense, to ensure that investment fulfills its target.
Under no priority, the full effect of the shock will be allowed to fall
on the output of investment and so no inputs will be diverted from other
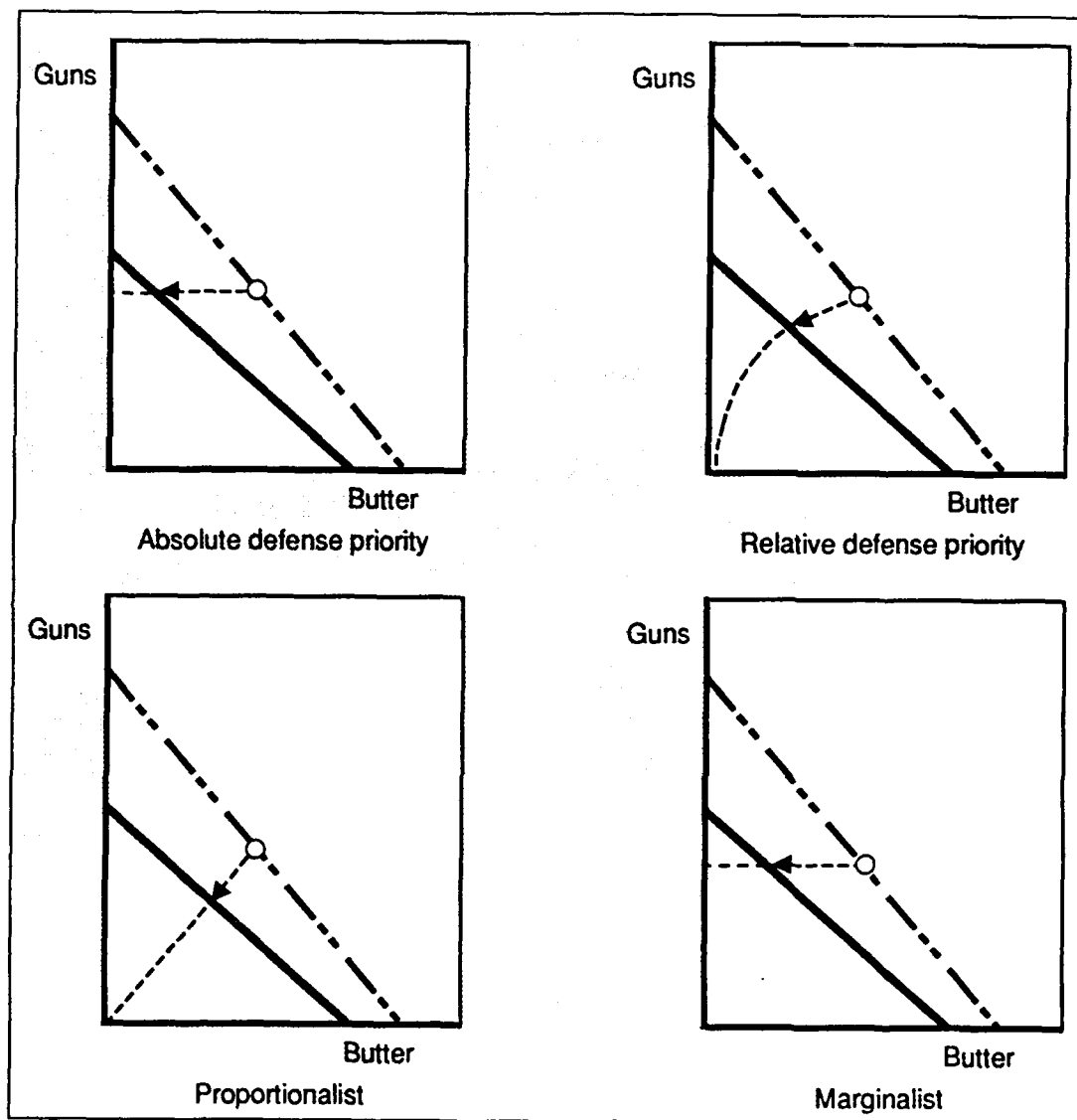
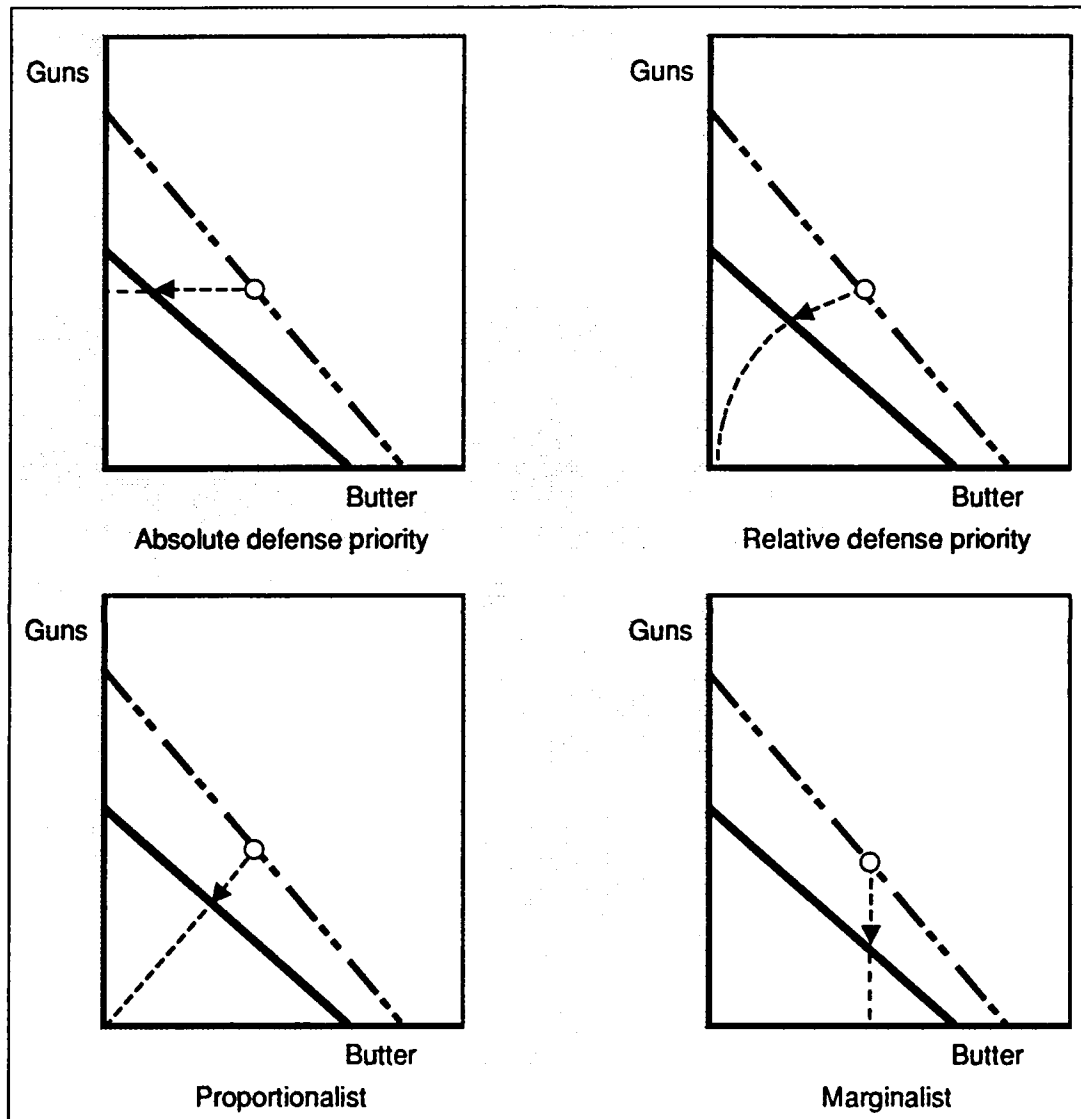Fig. A.2—Alternative allocation rules and shock in light industry

Fig. A.3—Alternative allocation rules and shock in defense

sectors. Consequently, the location of the PPF will be different under each priority rule.

As the preceding discussion should make clear, the outcome in each case is determined not only by which priority rule is in effect, but also by the input-output coefficients. To reveal their importance, we have constructed a set of simple input-output tables demonstrating the effects of a shock in infrastructure capacity under the absolute defense, equal, and no-priority rules.

Table 1 of the text contains the input-output table as conceived *ex ante* by the central planners. The final outputs for consumption, investment, and defense represent the plan's primary targets. Given the input-output coefficients shown in the table, the plan is both feasible and consistent.

In Table A.1 we can see the effects of a one unit decrease in infrastructure capacity on the final output vector under the absolute defense priority rule. Comparing this *ex post* input-output (IO) table with Table 1, we see that the shock is reflected by the drop in the values of the IO elements and the fall in the gross output (from 15 to 14) of infrastructure. Compared to the original plan there is now a shortage of infrastructure inputs.

Defense will be guaranteed its planned allotment of inputs under this rule. The same will be true of heavy industry due to the second-priority status accorded to investment under this rule. Consequently, the full effect of the infrastructure bottleneck will fall upon light industry.

Looking now at the final outputs, we see that the target for consumption has been underfulfilled, that for investment has been overfulfilled, and that for defense met exactly. The consumption plan has been underfulfilled because of a shortage of infrastructure inputs. Because of this shortage, other light industry inputs were idled including those supplied by heavy industry. Assuming these inputs were not demanded, the investment target could be overfulfilled, as indicated. The defense target, which was accorded first priority, was exactly met.
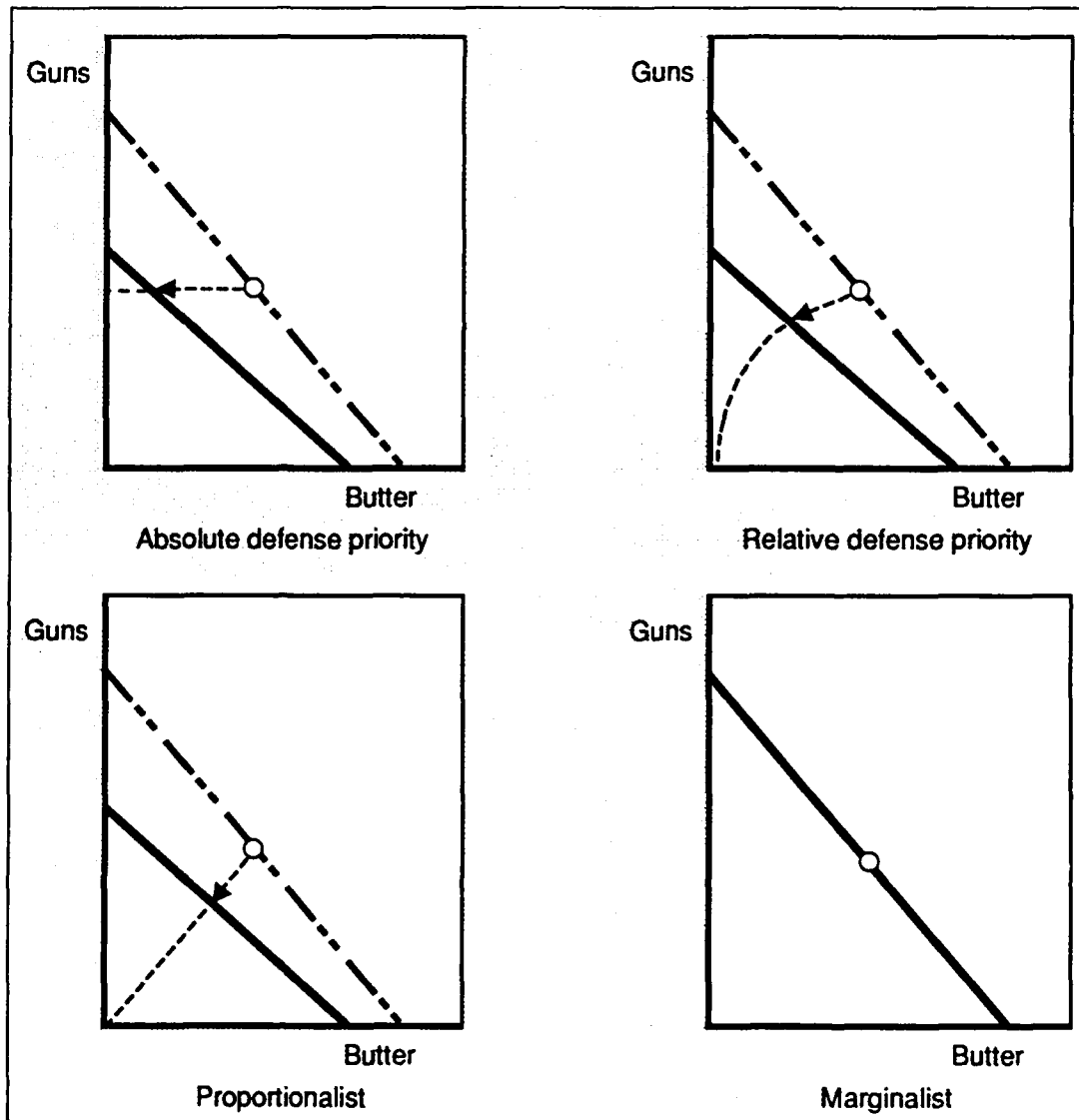
Fig. A.4—Alternative allocation rules and shock in heavy industry

Table A.1

EFFECT OF INFRASTRUCTURE BOTTLENECK WITH
ABSOLUTE DEFENSE PRIORITY

	To Sector			
From Sector	Light Industry	Infrastructure	Heavy Industry	Defense
Light industry	0.00	0.00	10.00	0.00
Infrastructure	4.00	0.00	5.00	5.00
Heavy industry	12.00	0.00	0.00	5.00
Defense	0.00	0.00	0.00	0.00
Labor	24.00	4.67	20.00	5.00
Capital	8.00	9.33	15.00	5.00
Gross output	48.00	14.00	50.00	20.00

	Consumption	Investment	Defense	Final Demand
Light industry	38.00	0.00	0.00	38.00
Infrastructure	0.00	0.00	0.00	0.00
Heavy industry	0.00	33.00	0.00	33.00
Defense	0.00	0.00	20.00	20.00
Labor				53.67
Capital				37.33

Total final demand   91

Total gross output   132

Table A.2 depicts the outcome of an identical shock under the equal priority or proportionalist rule. As before, the shock creates a shortage of infrastructure inputs. This time, however, the planners decide to allocate them such that all final outputs are scaled back in proportion to the original plan targets. Consequently, each of the sectors receives less of the input than planned, with the amount of the cutback dependent on the values of the IO coefficients of all the sectors.

The outcome of an identical shock under the no-priority or marginalist rule is depicted in Table A.3. Again there is a shortage of infrastructure inputs, which this time the planners allow the tolkachi to reallocate. This they will do according to scarcity signals that take the form of shadow prices in a linear programming model. While the shadow prices are not shown in the table, one can determine their relative values by determining the fraction that infrastructure inputs make up in the output of each industry. The smaller that fraction, the more the tolkachi for that unit will be willing to pay for a unit of infrastructure input, as a very small shortage will cause a large shortfall in output. Calculating these ratios, for light industry we get 1/12 (5/60), for heavy industry 1/10 (5/50), and for defense 1/4 (4/16). Therefore, the tolkachi for light industry will be willing to offer the highest price per unit, those for heavy industry the next highest, and those for defense the lowest. Consequently, the defense target is underfulfilled, the consumption target exactly met, and the investment target overfulfilled due to decreased demand for heavy industry's inputs in defense.

Table A.2

EFFECT OF INFRASTRUCTURE BOTTLENECK WITH
PROPORTIONALIST IMPLEMENTATION

To Sector

From Sector	Light Industry	Infrastructure	Heavy Industry	Defense
Light industry	0.00	0.00	9.33	0.00
Infrastructure	4.67	0.00	4.67	4.67
Heavy industry	14.00	0.00	0.00	4.67
Defense	0.00	0.00	0.00	0.00
Labor	28.00	4.67	18.67	4.67
Capital	9.33	9.33	14.00	4.67
Gross output	56.00	14.00	46.67	18.67

	Consumption	Investment	Defense	Final Demand
Light industry	46.67	0.00	0.00	46.67
Infrastructure	0.00	0.00	0.00	0.00
Heavy industry	0.00	28.00	0.00	28.00
Defense	0.00	0.00	18.67	18.67
Labor				60.00
Capital				40.00

Total final demand   93.33

Total gross output   135.33

Table A.3

EFFECT OF INFRASTRUCTURE BOTTLENECK WITH MARGINALIST IMPLEMENTATION

	To Sector			
From Sector	Light Industry	Infrastructure	Heavy Industry	Defense
Light industry	0.00	0.00	10.00	0.00
Infrastructure	5.00	0.00	5.00	4.00
Heavy industry	15.00	0.00	0.00	4.00
Defense	0.00	0.00	0.00	0.00
Labor	30.00	4.67	20.00	4.00
Capital	10.00	9.33	15.00	4.00
Gross output	60.00	14.00	50.00	16.00

	Consumption	Investment	Defense	Final Demand
Light industry	50.00	0.00	0.00	50.00
Infrastructure	0.00	0.00	0.00	0.00
Heavy industry	0.00	31.00	0.00	31.00
Defense	0.00	0.00	16.00	16.00
Labor				58.67
Capital				38.33

Total final demand   97

Total gross output   140

Appendix B
RUBLE COSTS OF INPUT SHORTAGES

As argued in the text, the opportunity cost of diverting scarce resources to defense or other high-priority sectors does not have a unique value. Rather its value depends upon (1) the type of input diverted, (2) the amount of the input diverted, (3) the sector the input is diverted from, and (4) the sector the input is diverted to. Specifically, the opportunity cost of diverting a scarce input is equal to the ruble cost of the input shortage imposed on the low-priority sector less the ruble cost of the input shortage the high-priority sector would suffer without the diversion.

To estimate the ruble costs of various input shortages, we begin by calculating the amount of each scarce input required to meet the final output target in each sector. From these values we can then obtain the average values per unit of each scarce input for each final output sector. These represent the average costs of various input shortages in the various sectors which, due to the linear production functions of the model, are equal to the marginal costs.

When the supply of an input to a sector is cut, one might expect the immediate drop in that sector's production to be proportional to the cut in the input. However, this is true only if other sectors continue to produce their full quota of inputs for the low-priority sector. In fact, a smart planner would instruct the suppliers to the low-priority sector to cut back production as well. Then, the suppliers to these branches would be able to cut production, saving additional inputs and so on.

Thus, calculating the amount of an input required to reach each final output target is complicated by the interdependent production functions of the input-output model. As a first approximation we might assume that the industry suffering the shortage would continue to receive all its other inputs. Other industries would continue to produce at full capacity despite the fact that some of the inputs they supplied were remaining idle. We could then simply use the proportions

used to produce gross output to estimate the inputs required to produce final output.

To obtain a better approximation it is necessary to go through the second and later round adjustments in the production of the various sectors. In doing so we assume that the other industries would cut back their production of inputs for the low-priority industry. Consequently, some inputs required by these industries might be freed up for use by the low-priority industry. Also the low-priority industry could reduce its producti of inputs and add to its production of final output goods. As a result the cost of the input shortage would be less than if only the first round effects were considered.

Fortunately, there is a simple economic interpretation for both the first round and the cumulative effects. The first round effect provides an estimate of the cost of an input shortage in gross output terms; the cumulative effect of the first and later round adjustments provides an estimate of the cost in final output terms.

INFRASTRUCTURE
Cost of an Infrastructure Shortage in Light Industry

To calculate the marginal cost of cutting infrastructure supply to consumer goods industries we first calculate the average cost of all consumer goods production in terms of infrastructure. By referring to the planned input-output coefficients we see that it requires 5 units of infrastructure (IN), 15 units of heavy industry (HI), 30 units of labor (L), and 10 units of capital services (K) to produce 60 units of light industry (LI) as gross output. Some of this LI is used to produce HI and indirectly DE. For our calculation, however, we are interested only in what is required to produce the 50 units of LI for final output.

Also, because we are interested in the cost of each final output sector in terms of infrastructure, we need not be concerned with labor and capital, which require no infrastructure to produce. Nor do we need to be concerned with defense, which is not required in the production of light industry. We do, however, need to be concerned with heavy industry, which requires infrastructure inputs and is used to produce

light industry. Thus our calculations for the cost of 50 units of consumption in terms of infrastructure are derived from the planned input-output coefficients as follows:

50/12 IN 50/4 HI --> 50/40 IN 50/20 LI --> 50/240 IN 50/80 HI --> 50/800 IN 50/400 LI -->50/4800 IN 50/1600 HI...

The sum of this infinite series converges to 5.70 IN. That is, it requires 5.7 units of IN to produce the 50 units of LI in final output. Assuming that all other inputs are freely available each unit of IN supplies 50/5.7 = 8.77 rubles of final output for consumer goods. Thus, the cost of a shortage of infrastructure in LI is 8.77 rubles per unit IN.

Cost of an Infrastructure Shortage in Heavy Industry

30/10 IN 30/5 LI --> 6/12 IN 6/4 HI --> 6/40 IN 6/20 LI --> 6/240 IN 6/80 HI --> 6/800 IN 6/400 LI -->...

The sum of this infinite series converges to 3.68 IN. Thus the cost of an infrastructure shortage in heavy industry is 30/3.68 = 8.15 rubles per unit IN.

Cost of an Infrastructure Shortage in Defense

20/4 IN 20/4 HI --> 5/10 IN 5/5 LI --> 1/12 IN 1/4 HI --> 1/40 IN 1/20 LI -->1/240 IN 1/80 HI -->...

The sum of this infinite series converges to 5.61 IN. Thus the cost of an infrastructure shortage in the defense industry is 20/5.61 = 3.55 rubles per unit IN.

LABOR

Cost of a Labor Shortage in Light Industry

50/2 L 50/12 IN --> 50/36 L 50/4 HI --> 50/10 L 50/40 IN --> 50/120 L 50/20 LI --> 50/40 L 50/240 IN --> 50/720 L 50/80 HI --> 50/200 L 50/800 IN --> 50/2400 L 50/400 LI --> 50/800 L 50/4800 IN 50/1600 HI

The sum of this infinite series converges to 33.48 L. Thus the cost of a labor shortage in light industry is 50/33.48 = 1.49 rubles per unit L.

Cost of a Labor Shortage in Heavy Industry

30/2.5 L 30/10 IN --> 1   L 30/5   LI --> 6/2 L 6/12 IN --> 1/6   L
6/4   HI --> 12/20 L 6/40   IN --> 1/20 L 6/20 LI --> 3/20 L 6/240 IN
--> 1/120 L 6/80   HI --> 6/200 L 6/800 IN --> 6/400 LI -->

The sum of this infinite series converges to 17.02. Thus the cost of a
labor shortage in heavy industry is 30/17.02 = 1.76 rubles per unit L.

Cost of a Labor Shortage in Defense

20/4 L 20/4 IN --> 5/3 L 20/4 HI --> 10/5 L 5/10 IN --> 1/6   L 5/5   LI
--> 1/2 L 1/12 IN --> 1/35 L 1/4 HI --> 2/20 L 1/40 IN --> 1/120 L
1/20 LI --> 1/40 L 1/240 IN --> ... 1/80 HI --> ...

The sum of this infinite series converges to 9.5 L. Thus the cost of a
labor shortage in the defense industry is 20/9.5 = 2.11 rubles per unit
L.

CAPITAL

Cost of a Capital Shortage in Light Industry

50/6   K 50/12 IN --> 100/36 K 50/4 HI --> 15/4   K 50/40 IN --> 5/6 K
50/20 LI --> 5/12 K 5/24 IN --> 5/36 K 5/8 HI --> 3/16 K 5/80 IN -->
1/24 K 1/80 LI --> 1/48 K 1/96 IN -->... 1/32 HI -->...

The sum of this infinite series converges to 16.52 K. Thus the cost of
a capital shortage in light industry is 50/16.52 = 3.03 rubles per unit
K.

Cost of a Capital Shortage in Heavy Industry

The sum of this infinite series converges to 12.98 K. Thus the cost
of a capital shortage in heavy industry is 30/12.98 = 2.31 rubles per unit K.

Cost of a Capital Shortage in Defense

20/4 K 20/4 IN --> 10/3 K 20/4 HI --> 15/10 K 5/10 IN --> 1/3 K 5/5
LI --> 1/6 K 1/12 IN --> 1/18 K 1/4 HI --> 3/40 K 1/40 IN --> 1/60
K 2/40 LI --> 1/120 K 1/240 IN -->... 1/80 HI -->...

The sum of this infinite series converges to 10.5 K. Thus the cost of a
capital shortage in the defense industry is 20/10.5 = 1.90 rubles per
unit K.

Finally, it should be noted that the above examples can be
explained more compactly using a conventional input-output and linear
programming framework. In this framework the impact multipliers and
infinite series described above can be exposited in terms of direct and

indirect requirements. These simpler mathematics, however, tend to conceal the complex problem faced by planners in calculating and compensating for the impact of shortages. For this reason the infinite series approach to determining the impact of shortages, while more unwieldy, perhaps better reflects the real problems faced by Soviet planners.[1]

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[1]Both the infinite series and simultaneous equations solutions to an input-output system are described in R. Dorfman, P. Samuelson, and R. Solow, *Linear Programming and London Economic Analysis*, McGraw-Hill International Book Company, London, 1964, pp. 215-219.

Appendix C
THE TOLKACH INTERPRETATION OF THE MARGINALIST MODEL

Assume each industry has a single tolkach, who knows the IO coefficients and the degree of shortage or surplus of all inputs for his industry. Also assume that the final values of output calculated using official prices are the most important targets for the industries.

CASE 1: A SHORTAGE OF INFRASTRUCTURE

Each tolkach calculates how much he is able to bid for the scarce input on the basis of its productivity in producing final output. The productivity of the scarce input in each industry is calculated as the reciprocal of its input-output coefficient. Thus the productivity of infrastructure in light industry is 12R/unit (60/5); in heavy industry is 10R/unit (50/5); and in defense is 4R/unit (20/5). Therefore the tolkach for light industry can afford to pay up to 12R/unit, that for heavy industry 10R/unit, and that for defense only 4R/unit.

Consequently, the infrastructure needs of light industry and heavy industry are met while defense suffers a shortage; consumption and investment achieve their planned levels while the defense target is underfulfilled.

CASE 2: SHORTAGE OF LABOR

The tolkach for light industry can bid 2R/unit (60/30); the tolkach for heavy industry can bid 2.5R/unit (50/20); the tolkach for defense can bid 4R/unit (20/5); and the tolkach for infrastructure can bid 12R/unit.

The calculation of the productivity of labor infrastructure is slightly more complicated because it is delivered only as an input, not as a final good. Therefore its value is calculated as the product of labor's productivity in producing infrastructure and infrastructure's lowest productivity in the final goods sectors. The productivity of infrastructure in its least productive final goods industry is used under the assumption that the labor shortage is small, and that infrastructure will be in short supply in only a single sector.

Therefore the total productivity of labor in infrastructure (12 = 3 x 4) is equal to the simple productivity of labor in infrastructure (15/5 = 3) times the productivity of infrastructure in defense (20/5 = 4).

Therefore the tolkach for infrastructure will be the highest bidder; the next high bidders will be that for defense and then heavy industry; the tolkach for light industry will be the low bidder and therefore consumption will suffer the shortage.

CASE 3: SHOCK IN ALL INPUT-OUTPUT COEFFICIENTS

A simultaneous increase in all A_{ij}'s produces a shortage of output from light industry, heavy industry, and infrastructure. Because demanders of final goods are willing to pay only one ruble per unit, the shortages of heavy industry and light industry inputs are met by reducing final output. (Because input-output coefficients are always < 1, their reciprocals are > 1; therefore, inputs always have productivities > 1.)

Because infrastructure is not a final output, its use as an input must be reduced in one sector (assuming the shock is small). Also as its productivity is lowest in defense, the infrastructure shortage is suffered by that sector.

Note, however, that because the A_{ij}'s have increased in value, the productivity values for infrastructure are lower than in Case 1. The new productivity values are:

For light industry: (60/5.5) = 10.91. For heavy industry: (50/5.5) = 9.09. For defense: (20/5.5) = 3.64.

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