A RAND NOTE

Models of the Military Sector in the Soviet Economy

Gregory G. Hildebrandt
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THE TRADITIONAL VIEW of the relationship between Soviet defense spending and the Soviet economy is that military activity is the priority good, and that the resource-allocation system is geared toward maintaining both high rates of military production and wartime mobilization potential. Historically, this relationship has repressed consumption and economic growth. It is important to remember that the basis for Soviet military activity is the Soviet economy itself, and that if it is unable to generate the technologies needed to produce the latest weapons, the country’s superpower status may conceivably be placed at risk.¹

However, many observers of the Gorbachev modernization program are now questioning whether defense activity continues to be the Soviet economy’s priority good. It remains unclear to what extent perestroika is mainly concerned with long-run defense capability rather than general economic performance; indeed, this may never be fully understood. Just as it is unclear whether Stalin’s “forced-draft” industrialization was motivated principally by a desire to support the Red Army or to build Soviet socialism, so too may the full rationale for the current modernization program remain a mystery.

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To better understand the precise interaction between the defense sector and the Soviet economy, it is useful to employ both case studies and economy-wide models that contain defense activity as a key element. Detailed case studies provide both the institutional structure and qualitative dimensions of the defense-economic interaction. Economy-wide models, on the other hand, impose checks for consistency on the specified economic relations and associated data. Since these models are necessarily aggregate pictures of the Soviet economy, they may describe how members of the Soviet ruling elite view the tradeoffs between defense and economic performance.

Several large-scale, economy-wide models of the Soviet Union have been developed in the West. The first, SOVMOD, has been operated by SRI International and Wharton Econometric Forecasting Associates (WEFA); an outgrowth of this model, SOVECON, is now being used by PlanEcon. A third model, SOVSIM, was constructed by the U.S. Central Intelligence Agency (CIA). These three econometric-trend models of the Soviet economy can be viewed as sophisticated extrapolations from historical experience. Two large-scale, optimal-control models have also been developed, by the RAND Corporation and Decision-Science Applications (DSA); these models allocate resources to achieve a specified objective.²

Before discussing these large-scale, economy-wide models, it is helpful to begin with a simplified aggregate model. Besides its practical uses, this model highlights several general modeling uses—for example, to forecast Soviet economic performance through the year 2010 and to estimate the tradeoffs between the growth of defense spending and per capita consumption. I then discuss the econometric-trend models employed by WEFA, PlanEcon, and the CIA. These models maintain general consistency between production and final demand, but do not contain a detailed structure of the economy’s input-output relationships. Particular attention is paid to the machinery sector because of its central role in producing military equipment, machinery investment, and consumer durables.

Because the econometric-trend models do not maintain consistency between the production of specific gross outputs and the fulfillment of a final demand vector, they are not effective in assessing the effect of bottlenecks. This is an important drawback, since the taut Soviet planning system is a planned disequilibrium system that generates pervasive bottleneck constraints. It is one of the considerations that led to the development of optimal-control models by DSA and RAND. Although
these models meet the necessary consistency condition and have certain advantages over the econometric-trend models, as dynamic models that employ marginalist optimization methods they also minimize the impact of bottlenecks, and may not accurately portray the waste induced by taut central planning.

Instead of working around bottlenecks using optimization methods, the Soviets deal with these constraints using a priority allocation system. Work is underway at RAND to capture the nature of the Soviet priority system and shed light on the interplay between priority and bottlenecks. I provide some preliminary results of this analysis below. I also discuss the Soviet economy as a system in which the planners' priorities conflict with those of the managers within various sectors, which can generate a surplus of one or more material inputs in a nonpriority sector at the same time as shortages exist elsewhere. As a result, the defense sector may be motivated to support its priority status by vertically integrating the production processes that affect its output.

Aggregate Economic Model

The simplest model that can shed light on the broad nature of the interaction between defense and the Soviet economy consists of a single technological relationship in which GNP is produced with inputs of labor and capital combined at some level of total factor productivity. Final output is then distributed to consumption, defense, and investment, and the resulting investment is used to augment the remaining capital stock.

Figure 9.1 depicts such a model, and the next several figures portray some of the forecasts obtained using this model for the period 1990–2010. The two dashed lines in Figure 9.1 represent relationships not normally incorporated in economic models, but frequently mentioned in qualitative discussions. One of these lines represents a hypothesized relationship in which the Soviet defense sector's use of a significant proportion of high-technology resources impedes the growth and development of the more sophisticated manufacturing technologies that would otherwise increase total factor productivity. For example, each year's increment of high-quality research and development (R&D) engineers assigned to the defense sector might be more productively employed in the civilian sector. Not only might these engineers make the technologies of civilian enterprises more productive, but the increased openness of
the civilian sector could result in a greater diffusion of the improved technologies than would be the case for the more specialized defense technologies. The potential civilian activities of these key technologies would, in fact, represent a type of public good, conferring benefits to the economy as a whole that would exceed either their defense or civilian cost.

The other dashed line in Figure 9.1 connects the defense sector to the Soviet population to suggest the interaction between the size of the military manpower pool and the civilian labor force, although this is not included in the present model. More difficult to assess quantitatively, but frequently mentioned, is the effect of military conscription on the socialization process and, in turn, on the effectiveness of the labor force.
Quantitative estimates of this relationship and their effect on the model would be worth further consideration.

We can now consider some of the empirical results obtained with this model, ignoring the effects that might ensue from the links between defense and both total factor productivity and labor effectiveness. To illustrate the results for the time period 1990–2010, investment growth is assumed to be 4 percent annually, which is consistent with the Twelfth Five-Year Plan and might be a reasonable investment rate to assume for the forecast period if the modernization program succeeds. An annual growth rate of 2 percent in defense spending is also assumed, which is roughly consistent with a stable military-force structure and routine force modernization.

In Figure 9.2, forecasts of GNP growth are provided for two alternative growth rates of total factor productivity. Recent historical experi-
ence suggests negligible or possibly even negative growth in total factor productivity in the Soviet economy. In other words, output has grown no faster than the combined growth of labor and capital, and thus the production process that combines these inputs has become no more efficient. The bottom curve in Figure 9.2 can be viewed as a simple extrapolation of historical experience on the premise of static efficiency conditions rather than declining ones. The upper curve assumes that the modernization program is reasonably successful and the growth of total factor productivity amounts to 0.5 percent per year. Such a rate would have approximately the same effect as a one-third increase in the marginal productivity of capital in the initial forecast year, and is slightly lower than the growth productivity experienced by the United Kingdom during the first half of the 1980s.
Note that the growth rate begins to decline in the twenty-first century as the Soviets encounter their third demographic shock since World War II. Such long-range forecasts should be treated with special caution, but it is important to be alert to impending demographic problems. The most important uncertainty, though, concerns the assumed growth of total factor productivity. Unfortunately, there is no systematic way of projecting the future value of this key variable, and each analyst must decide how much weight to give recent performance and other factors that may affect Soviet economic prospects.

Figure 9.3 contains forecasts of the growth in per capita consumption under the same two scenarios of factor productivity. Per capita consumption will remain flat and negligible if there is no growth in total factor productivity, but it can increase by 1 percent annually for the remainder of this century if total factor productivity increases by 0.5 percent annually. Again, Soviet economic performance is seen to decline during the twenty-first century as a result of the demographic shock.

This aggregate model can be used to illustrate the effect of any given growth rate of defense spending on the behavior of any other variable determined in the model. Figure 9.4 describes the tradeoff relationship between growth in defense spending and in per capita consumption. Based on the underlying assumption that investment continues to grow at 4 percent per year, GNP growth would remain constant under the two alternative assumptions about the growth of total factor productivity.

Figure 9.5 provides a hypothetical linear production-possibility curve (PPC) for consumption versus defense that applies to this model. Even if one is willing to assume that the prices used in the model reflect the initial rate of productive transformation, a more conventional view of the actual tradeoff relationship would be that depicted by the curved line tangent to the linear PPC at the current output level. This curve depicts an increasing marginal cost of defense in terms of consumption foregone as the defense sector is expanded. In many cases, however, one is not interested in analyzing major increases or decreases in the level of defense activity over a short period of time, but rather in assessing the effect of marginal changes in growth rates. Provided the underlying increments of labor and capital are reasonably transferable between defense and consumption, the linear PPC assumption of the aggregate model may not be very misleading.

On the other hand, it may not be realistic to expect the prices used to measure Soviet economic activity to reflect the true tradeoff relationship. Figure 9.5 also contains a tradeoff based on the assumption that
defense goods are underpriced. The effect of such underpricing would be to understate the burden of defense spending. Although there is a belief within the intelligence community that defense prices are a reasonable measure of opportunity cost in the base year, the tradeoff between defense and nondefense goods may change over time. In fact, the intelligence community has recently concluded that the Soviet defense burden is higher in 1982 rubles than when measured in 1970 rubles. So the two tradeoff curves in Figure 9.5 may depict the change in slope that occurred between 1970 and 1982.

The role of defense priority on the tradeoffs also has a bearing on the slope and position of the PPC. The priority system has smoothed the flow of resources to the defense sector. As all final demands that are produced cannot receive priority treatment, this special attention is itself
a scarce resource that would have an implicit shadow price that would not, however, be adequately reflected in the cost of defense goods. The result would be a further underpricing of defense activity.$^4$

Econometric-Trend Models

To understand the common structure of the econometric-trend models, it is helpful to abstract from the separate sectors, such as agriculture, energy, and trade. A stylized version of the econometric-trend models can be described using only two sectors, machinery and “other.” Machinery is emphasized because consumer durables, machinery investment, and most defense procurement are assumed to be produced in this sector. Figure 9.6 contains our simplified representation of the econometric-trend models. In this model, labor and investment are allocated
to the machinery and other sectors based on historical trends. Each sector's resulting capital stock and employment produces the added values that compose GNP. Given the investment determined by the model and defense spending, consumption is the residual.

Focusing on the left side of Figure 9.6, which depicts the machinery sector, the model links the value added produced in this sector to final demand using a historical factor. This final demand is divided among civilian machinery investment, consumer durables, and military machinery. Military machinery consists mainly of weapons and supporting military equipment, associated spare parts, and capital repair. This category is nearly identical to military procurement, except that it may include some R&D prototypes built within the machinery sector, and exclude military ordnance, which is part of procurement but would not be contained within the machinery sector. The econometric-trend models assume that the three types of final machinery demand can be exchanged for each other on a ruble-for-ruble basis. My earlier comments about the linear versus curved PPC apply to machinery final demand as well, as do those about the arguable accuracy of defense prices. If the prices employed are reasonably accurate and the analysis is conducted in terms of growth tradeoffs, the forecasts are not likely to be seriously in error.

For example, all of the final demand elements of the machinery sector are produced with the aid of machine tools that are also produced within this sector. In fact, additions to the machinery sector's capital stock consist, in significant part, of the output of the machine-tool branch. In growth-tradeoff analysis, the new machine tools produced must be transferable, and it is probably not unreasonable to assume that there is sufficient flexibility within the machine-tool branch to reorient new output during an extended planning period. To the extent that this is not possible, however, one might obtain somewhat distorted results. A detailed analysis of the Soviet machine-tool branch might shed some light on this important question.

In operating the econometric-trend models, one would initially specify the levels of output over time for consumer durables and military machinery; the remainder of machinery final demand would then equal machinery investment, which would augment the civilian capital stock and contribute to economic growth. By changing the military-machinery trend to a different growth path, one can calculate the effect of such a reallocation of resources on economic performance. In a given period, a one-ruble reduction in military machinery would increase machinery
H = Historical relationship; T = Technological relationship; A = Accounting relationship. SOURCE: Author; see also note 6 in text.
investment by one ruble. The increased civilian investment would, in turn, increase the civilian capital stock by one ruble. GNP would then rise by the marginal productivity of civilian capital. Alternatively, one could shift the defense ruble into consumer durables and obtain a ruble of extra consumption. In this case GNP would not change, because there has been no change in capital formation. All of this seems reasonably straightforward; the problem is that the Soviets do not publish data on military machinery. The CIA uses a building-block methodology to estimate this variable, and then incorporates the resulting series into the estimated final demand of the machinery sector. PlanEcon, on the other hand, employs a residual method that maintains consistency between final demand and its three components.6

It turns out there that there is sufficient uncertainty associated with the structure of machine-building final demand that there may be some interplay between the data available and the structure of the model selected. To illustrate this phenomenon, let us consider Figure 9.7, which was recently published by PlanEcon. The graph includes defense machinery, investment machinery, and consumer durables for the histori-
The period 1960–1985 and the forecast period 1986–1990. The defense machinery series in this graph is estimated as a residual, given estimates of the machinery sector’s final demand total and of consumer durables and machinery investment. The estimates are provided in 1984 rubles. It is important to note that the defense machinery series experienced sustained growth during the period 1974–1984, when the intelligence community was reporting that procurement expenditures were flat. It is therefore interesting to plot the PlanEcon defense machinery series on the same graph as the CIA’s military procurement estimates in both comparable and constant 1982 rubles (Figure 9.8). The comparable ruble measure is developed using the Soviet price deflator, whereas the constant 1982 series is developed using the CIA’s price deflator. The PlanEcon series and the CIA comparable ruble series are actually quite similar over the relevant time periods. As expected, the CIA series in 1982 constant-resource rubles is fairly flat from 1974 to 1982. Indeed, it is the agency’s view that the difference between the comparable and constant ruble series can be accounted for by the 5 percent inflation rate that has affected military procurement.
Although the issue seems at first to concern the difference between comparable and constant rubles, the CIA has recently argued that there is substantial uncertainty associated with the residual estimation technique. Figure 9.9 describes the range of uncertainty associated with the residual estimate as seen by the CIA. In comparable prices, the growth in military machinery can range from a negative figure to 9 percent. Presumably this increases confidence in the building-block estimates that the CIA develops relative to those obtained using a residual method.\(^7\)

The other side of the coin, however, is that there is also uncertainty associated with the estimates of civilian machinery. Figure 9.10 displays CIA’s calculations of the uncertainty associated with both military and civilian machinery when these totals are estimated in current rubles. Careful analysis would be required to determine how much of the uncertainty about civilian machinery would remain if one accepted the CIA’s building-block estimate of procurement as a given. Some analysts, whose estimates of the military-machinery residual are significantly
lower than the comparable-ruble building-block estimate, argue that the model structure for the machinery sector depicted in Figure 9.6 is incorrect. They conclude that there is a defense final-assembly sector outside the identified productive sphere of the economy that has been ignored in much of the existing analysis. Interestingly, these analysts end up with a total military-machinery estimate that, with final assembly included, is roughly comparable to that obtained using the CIA building-block approach. None of these data uncertainties inspires confidence that the model structure shown in Figure 9.6 is necessarily valid, but resolution of the issue awaits further analysis.

Another issue associated with the econometric-trend models is that there is only a partial connection between the production of gross outputs and the achievement of final demands. Note in Figure 9.6 the factor linking value added in the machinery sector to final demand, based on historical data. Though frequently ignored in discussions of Soviet models, this factor is quite important, and represents the simplified method used in the econometric-trend models to maintain consistency between gross outputs and final demand. While this factor is
frequently assumed to be constant, one might expect it to depend on the final-demand structure of the economy. For example, if nondurable consumption were to be significantly increased, one would expect a larger share of the machinery sector's intermediate output to be delivered to other sectors. This would reduce the ratio of final demand to value added in the machinery sector. However, only a relatively small portion of the machinery sector's intermediate output is used elsewhere; hence the approach taken by the model is a reasonable approximation.

A similar question concerns the allocation of investment and labor to different sectors of the economy. As indicated in Figure 9.6, labor and investment are allocated to sectors of the economy based on historical trends. Forecasting based on historical trends may be reasonable if one assumes that the final shares of GNP allocated to consumption, investment, and defense will continue in line with historical trends. But if these end-use shares change, or if one wants to explore the feasibility and implications of such a change, the model's historical allocations of investment and labor may no longer be relevant.

**Optimal-Control Models**

These considerations led to the development of optimal-control models by RAND and DSA. If there were a significant increase in defense at the expense of consumption, one would be interested in reallocating investment and labor to those sectors that directly and indirectly support defense and away from those that support consumption. Historical allocations of labor and investment might not be relevant. Furthermore, if bottlenecks emerged during the reallocation, perhaps because it became more costly to produce one of the supporting material inputs, this constraint should be taken into account.

Figure 9.11 shows a stylized representation of the optimal-control models. These models operate with between twenty-one and thirty-five sectors, but for exposition purposes the model is formulated in terms of machinery and "other" output. Outputs of these two sectors are produced with the labor and capital assigned to them. The model also contains the input-output relationships that tie the production of gross outputs to achievement of consumption, investment, and defense final demands. Rather than allocating investment and labor based on historical trends, the model bases the allocation on a choice of how best to achieve some objective, such as maximizing the growth rate of consump-
C = Choice relationship; T = Technological relationship.
tion subject to a specified growth rate for defense production. As the defense growth rate is varied, allocations of investment and labor are changed, and a different growth rate of consumption results.\textsuperscript{9}

The optimal-control models have been used productively to evaluate alternatives facing the Soviet leadership. Figure 9.12 presents one of the RAND results.\textsuperscript{10} Shown is the effect of Western machinery on Soviet economic performance under alternative assumptions about the marginal efficiency of imported capital. The tradeoff curve between consumption and defense growth for the period 1980–1990 is depicted for two situations: one in which the imported machinery is no more efficient than that produced domestically, and another in which the imported machinery is assumed to be ten times as productive as that produced domestically. The PPC expands more toward defense growth as the marginal efficiency of imported capital increases, because when defense is emphasized, the mix
of imports favors machinery, which affects economic growth; when consumption is emphasized, the import mix favors agricultural goods, which do not influence economic growth in this model.

It is quite interesting that the curvature displayed in Figure 9.12 is similar to that presented in Figure 9.4, which we obtained using the aggregate model. For the marginal growth rates considered, there are no bottlenecks created that the optimal-control model cannot work around. The result is that total consumption and total defense can be exchanged on a ruble-for-ruble basis over the ten-year forecast period, as in the case of the aggregate model. This may happen because there is never a need to assign significant amounts of additional labor to fixed capital stocks and thereby induce significant diminishing marginal returns to labor and reductions in labor productivity. Rather, in this growth-tradeoff analysis, the underlying labor and capital increments can be allocated to different sectors over time. Although the capital/labor ratios in the two sectors would change as a result of the reallocations, the production functions that produce the defense and consumption final demands are sufficiently similar so that increasing costs do not ensue.

Thus the PPC for the ten-year period is close to linear, and if any bottleneck constraints are associated with the reallocation of resources, this model does not reflect them. Because the effect of such constraints on production is an important issue in the Soviet economy, it is necessary to know whether large changes in defense activity over several years can result in a measurable reduction in GNP. That effect would indicate a significant curvature in the PPC, as would be expected from bottleneck constraints.

DSA constructed an experiment using a thirty-five-sector optimal-control model in which there was a significant increase in defense activity over a five-year period. Table 9.1 presents a synopsis of the economic situation after three years relative to historical-trend levels. Besides modest reductions in public and private consumption, significant reductions in investment occur. With labor/leisure choice incorporated in the DSA model, a 4 percent increase in the work week results. I calculated the change in GNP for this example and obtained a reduction of 4.4 percent from the historical-trend pattern. Whether this is a significant bottleneck effect can be inferred by comparing this result with that which would be obtained using an aggregate model, like that described in Figure 9.1, when investment is reduced and labor hours per week are increased: the trend pattern of GNP remains nearly unchanged. I therefore conclude that the effect of rising resource costs reduces GNP by less than 5 percent in this defense-surge situation. While the effect may be
TABLE 9.1  Percentage Change in Activity after Three Years of a Five-Year Surge in Soviet Defense Spending

<table>
<thead>
<tr>
<th>Percentage change</th>
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<tbody>
<tr>
<td>Government defense spending</td>
</tr>
<tr>
<td>Government education and health spending</td>
</tr>
<tr>
<td>Private consumption</td>
</tr>
<tr>
<td>Capital investment</td>
</tr>
<tr>
<td>New housing</td>
</tr>
<tr>
<td>Labor hours per week</td>
</tr>
</tbody>
</table>


slightly greater than that obtained from a marginal-growth-tradeoff analysis, it seems quite small considering the political environment that would induce such a defense-spending surge. We would expect the contraction in GNP to increase somewhat as the number of sectors in the model increased, but it is never quite clear how many sectors should be incorporated in a model in this type of analysis. Aggregate models may ignore the rising cost constraints, while very detailed models may fail to take account of the ability to make substitutions among material inputs and to shift capital capacities in the short run.

Priority Models

The reason the change in GNP obtained was so small is that optimal-control models minimize the effect of bottleneck constraints. If there is a shock to one of the economic sectors, optimal-control models assume that it is possible to increase output in any sector with appropriate additional amounts of labor and intermediate inputs. Labor and material inputs are reallocated to the appropriate sectors to minimize the cost of the shock.

In practice, the Soviets have historically reacted to shortages with a priority allocation system rather than with a system-wide optimization strategy. And when the Soviets specify an economic plan, the targets are set on the basis of "taut planning," so it seems reasonable to view them as reflecting capacity limits and assume that, during normal short-run operations of the economy, it is not possible to increase output signifi-
cantly beyond the capacity level by simply using more labor and material inputs than specified in the plan.

As a result of these considerations and criticisms of existing models made at the RAND Conference on Models of the Soviet Economy, RAND has been developing alternative models. Conference participants stated that existing models were based too extensively on Western economic concepts and constructs, and that it might be inappropriate to view Soviet decision-making as being based on marginalist principles when in fact there was a priority system in operation. This issue is dealt with by assuming that during the implementation phase of planning, the allocation of resources following a shock occurs sequentially according to priorities. First the number-one priority plan is fulfilled, and when its "needs" have been met, the second-priority plan is fulfilled, and so forth. This is a type of exogenous priority system in which the allocation of shortages is determined outside each sector's decision-making activities.

This formulation of the Soviet economy can be contrasted with several alternatives. In the marginalist model, resource allocation following a shock is based on plan prices. This is equivalent to maximizing GNP—or total final demand—following the shock, where GNP is valued using the prices contained in the economic plan. This criterion may not seem a realistic one to ascribe to the Soviet leadership; after all, part of the reason there is a priority system in the first place is that prices do not adjust following a shock, as would occur in a market economy, and the plan prices may no longer be useful guides to fulfilling the leaderships' objectives. Nevertheless, there is a type of endogenous priority system that operates in the Soviet economy that may tend to maximize GNP at plan prices. To understand how this system works in the marginalist model, recall that each enterprise employs tolkachi, whose task is to expedite the production process by obtaining shortage inputs. A tolkach can garner the most surplus during his transactions by first acquiring the material input of which a ruble results in the greatest increase in gross output; that is, by acquiring the input with the smallest input/output ratio. After having obtained this input, the attention of the tolkach would shift to the input with the second-lowest input/output coefficient. If each tolkach were successful in his endeavors, GNP at plan prices would be maximized.

Another alternative is a proportional-reduction model, in which the plan proportions are maintained during adjustment to the bottleneck. Although the Soviets apparently consider the principle of proportional growth in setting plans, adjustment to a shortage may not occur on this
<table>
<thead>
<tr>
<th>From</th>
<th>Light industry</th>
<th>Infrastructure</th>
<th>Heavy industry</th>
<th>Defense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light industry</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Infrastructure</td>
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<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Heavy industry</td>
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<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Defense</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Labor</td>
<td>30</td>
<td>5</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Capital</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Gross output</td>
<td>60</td>
<td>15</td>
<td>50</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>From</th>
<th>Consumer</th>
<th>Investment</th>
<th>Defense</th>
<th>Final demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light industry</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Heavy industry</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Defense</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

**Total final demand** 100

**Labor** 60

**Capital** 40

**Source:** Author.

basis. It is nevertheless interesting to compare results obtained using the proportional-reduction model with the others, because they serve as a useful benchmark. This type of model can be illustrated using a prototype four-sector input-output table that is assumed to be based on the economic plan. The model's sectors are light industry, infrastructure, heavy industry, and defense. Table 9.2 contains the input-output table used in the calculations. In this model, the defense sector is construed broadly to reflect not only the production and operation of weapons plus research, development, testing, and evaluation, but also the penetration of this sector into civil activities. Defense thus includes the design, construction, and location of industrial plant and infrastructure as well as expenditures on various types of mobilization preparation. Heavy industry produces many of the economy's material inputs, and the
economy's investment goods are a final output of this sector. Light industry includes some intermediate inputs supporting other sectors, but this sector primarily produces the economy's consumer goods, including the agricultural commodities and consumer services produced for final demand. Infrastructure is a broad sector that includes not only such conventional categories as transportation and communications, but also those inputs that support much of the "civil" costs of military preparations. It also includes planning infrastructure that controls the priority allocation system. Infrastructure is a pure intermediate-input sector in which there are no deliveries to final demand.\footnote{13}

How should the sectoral priorities be ranked? Although the Soviets have not been explicit about this issue recently, a clear summary of Soviet supply priorities was made in 1967, only a few years after the start of the Brezhnev defense buildup:

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\footnote{14}

The priority ranking used in this analysis is roughly consistent with the historical situation. Defense is assured first priority, heavy industry second, and consumption the lowest priority. The problems solved in the alternative models are represented in Table 9.3.

While many cases can be evaluated, we focus on the effect of a shock to the infrastructure sector in which the productivity of capital allocated to the sector declines by as much as 15 percent. For example, the shock might result from a transportation bottleneck. Figure 9.13 shows that, as the shock increases in size, defense output is maintained at plan (or target) values under the priority model. But reductions in defense do occur in the proportional-reduction model, and even more substantial reductions occur in the marginalist model. Figure 9.14 shows the impact
<table>
<thead>
<tr>
<th>Marginalist and proportional-growth models</th>
<th>Priority model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximize</strong></td>
<td><strong>Minimize</strong></td>
</tr>
<tr>
<td>defense + consumption + investment</td>
<td>deviation of defense from target</td>
</tr>
<tr>
<td></td>
<td>deviation of heavy industry from target</td>
</tr>
<tr>
<td></td>
<td>deviation of light industry from target</td>
</tr>
<tr>
<td><strong>Subject to</strong></td>
<td><strong>Subject to</strong></td>
</tr>
<tr>
<td>input-output relationships</td>
<td>input-output relationships</td>
</tr>
<tr>
<td>relevant labor and capital constraints</td>
<td>relevant labor and capital constraints</td>
</tr>
<tr>
<td>relevant final demand constraints</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author.

...of the capacity constraint on consumer-goods output. Target levels are met in the marginalist model; proportional cuts occur in the proportional-reduction model; and significant reductions occur in the priority model. A reduction in infrastructure capacity leads to more-than-proportional reduction in consumer goods. There is a supply-side consumption multiplier in operation in the priority model, and the consumer absorbs most of the shock associated with the infrastructure capacity shortage.

Figure 9.15 shows that a shock to the infrastructure sector can increase investment in the priority model: in this case, after fulfilling its deliveries to defense and to the lower-priority consumer-goods sector, the heavy-industry sector has capacity left over for investment. There is a slight increase in investment under the marginalist model, and the expected proportional reduction in the proportional-reduction model. Figure 9.16 shows that the greatest reduction of final demand (GNP) occurs in the priority model. Of course, the marginalist model, which maximizes GNP, achieves the greatest level of GNP for any level of capacity shortage, while the proportional-reduction model results in an expected reduction of GNP.
These models allow labor to flow across the sectors, but the capacity constraints eliminate any advantages from short-run labor mobility that result from a shock to infrastructure capacity. Figure 9.17 shows that significant unemployment ensues in the priority model, in both the infrastructure and consumer-goods sectors. The lowest level of unemployment occurs in the marginalist model, with the proportional-growth model an intermediate case.

To summarize: in the priority model, under a shock to infrastructure capacity, the defense target output level is achieved; such a 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 significant underutilization of labor can occur.

The priority model portrays a basic tendency of the Soviet economy to fulfill planners' objectives in what is called the exogenous priority system. A countervailing tendency is for each sector, as a result of the motivations of its managers as expressed through the behavior of the
to fulfill its specified targets, which forms the endogenous priority system. With both systems in operation in the Soviet economy, there is clearly room for conflict. One force moves the system in the direction of leadership objectives; the other moves it toward the largest GNP. It is not surprising that this inconsistency can result in economic waste.

To explore the 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 third, conflicting priority model. In this last model, we assume that the tolkachi of the light-industry sector are able to obtain the infrastructure services needed to fulfill their sector's plan; all other material inputs are allocated on the basis of exogenous priorities.
Figure 9.15 shows the final demand obtained as the size of the shock is increased. As expected, total final demand, or GNP, is highest in the endogenous priority model and lowest in the exogenous priority model. The conflicting priority model predicts a level of GNP somewhere between the two, and thus captures one of the important stylized facts of the Soviet economy: the existence of surplus material inputs in a sector while a general shortage exists. Figure 9.19 portrays the value of unused infrastructure that results from shocks of increasing size to the economy.

In the optimal-control models developed by RAND and DSA, 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 proportional-reduction models. While these last three models do yield excess capacities and underemployed labor, each sector uses all of the delivered material inputs.
As shown in Figure 9.20, the defense sector's target output level is not achieved in either the conflicting priority model or the endogenous priority model. As in Figure 9.13, the defense target is achieved in the exogenous priority model. One should note that both the conflicting priority and endogenous priority models result in the same defense output level. Although the Soviets obtain additional total final demand in the conflicting priority model, the cost of this increase relative to that obtained in the exogenous priority model amounts to a reduction in defense output.

In conclusion, the conflict that exists from the two operating priority systems may hinder the Soviet 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 in a
market economy, but the leadership also affects the nature of the supply institutions.\textsuperscript{15}

One would therefore predict that the high-priority sector would have a vertically integrated production process in order to ensure that leadership objectives were achieved. This is precisely what has happened in the defense-machinery ministries, where production is "vertically integrated from basic industry to end product." This picture of the Soviet Union as a dual economy was also identified at the RAND conference as being inadequately captured by existing models.\textsuperscript{16}

Embedded 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 a surge in production. However, the leadership has made recent attempts to employ defense capabilities in the production of civilian goods in a clear effort to get the defense sector to provide assistance to the modernization program.\textsuperscript{17} Indeed, several careful observers of the Gorbachev modern-
FIGURE 9.18 Impact of a Mixed Shock on Soviet Final Demand

![Graph showing impact of a mixed shock on Soviet final demand](image)

**NOTE:** Capacity of heavy industry and infrastructure are lower than planned values. A magnitude 1 shock corresponds to a 1% reduction in heavy industry and a 3.33% reduction in infrastructure. Higher magnitude shocks are correspondingly greater.

**SOURCE:** Author.

...ization program have argued that Soviet priorities have changed under Gorbachev. As Abraham Becker says of the General Secretary, "In the tens of thousands of words 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." To support a new priority system, Gorbachev must contend with the priority institutions that have already been established to effectuate production in the defense sector. For example, he would certainly have to deal with the status of the Military Industrial Commission (VPK), which has effectively operated the military priority system.

To monitor developments in this area, it might be advisable to follow the activities of the Bureau of Machine Building to determine whether it becomes a competitor to the Military Industrial Commission. One
Conclusion

In this examination of econometric-trend and optimal-control models against the background of an aggregate model and the foreground of priority models, I have attempted to clarify the role of these models in analysis of the defense sector and the Soviet economy. As one moves from the aggregate model to the econometric-trend models, the structure of the machinery sector is elaborated. This forces the analyst to be sensitive to potentially direct competition between machinery investment and military machinery. In light of the Gorbachev modernization...
program, it is helpful to keep these two types of machinery closely linked. The machinery sector also involves dual-use technologies that support both the defense and civilian sectors, as an outgrowth of the modernization program. The simple structure of the machinery balance has also stimulated much of the recent data analysis, which may ultimately call for a redefinition of this sector.

Analysis of the econometric-trend models also helps in understanding the link between gross outputs and final demand. The models' simple method of dealing with this link may be satisfactory if economic changes are not so pronounced as to induce dramatic shifts in the ratio of value added to final demand. A related question is how relevant historical allocations of labor and investment are to the different sectors when either forecasting or scenario analyses are conducted. While we would expect bottlenecks to result from dramatic shifts in labor and
investment allocations, the optimal-control models, which pay close attention to the links between final demand and gross output, do not seem adept at capturing these effects. By minimizing the effect of bottlenecks on the economy, these models yield tradeoff relationships that are similar to those obtained with either the aggregate or econometric-trend models.

The search continues, then, for methods of addressing bottlenecks, and particularly for the Soviet priority planning response to this common feature of taut central planning. As the discussion of the prototype priority models suggested, a priority planning system can exercise leverage on the output of a low-priority sector; reductions in capacity that generate a bottleneck can result in more-than-proportional reductions in both consumption and GNP. The next step is to build a dynamic version of a priority model.

Our priority model, based on a historical set of priorities, can also serve as a benchmark should the priority system change. We will attempt to use the dynamic model under development to test whether such a change has occurred. We need to recognize, however, that a change in priorities will not be easy for the Soviets. The conflict between the exogenous and endogenous priority systems has led the Soviets to put in place organizational forms that help achieve the leadership's objectives. Although the waste in the system indicates that they have not been completely successful, but due to the existing organizational forms, significant costs would probably be associated with any change in priority.
Notes


2. For a discussion of these models, see Gregory G. Hildebrandt, ed., *RAND Conference on Models of the Soviet Economy, October 11-12, 1984*, R-3322 (Santa Monica, Calif.: RAND, October 1985).


4. If resources, but not priority, are transferred to consumption, a measured ruble's worth of defense may generate less than a ruble's worth of consumption. On the other hand, transfer of a ruble of defense to consumption, with the transfer of priority at the margin, might yield more than a ruble of consumption. If the defense sector were to lose its priority status, the point depicted as the current output level might no longer be feasible, and the entire production-possibility curve would shift.

5. Figure 9.6 most closely approximates the CIA model, SOVSIM. For a discussion of a recent application of this model, see Robert L. Kellogg, "Modeling Soviet Modernization: An Economy in Transition," *Soviet Economy* (January–March 1988): 36–57. A description of the current version of SOVECON is contained in Ed. A. Hewett et al., "On the

In its current version, SOVECON does not contain labor-force inputs to the model’s production functions as described by Figure 9.6. Rather, output in each sector depends only on the sector’s capital stock and is determined by specifying a value for capital productivity in each sector. Furthermore, total gross investment is determined in SOVECON by dividing the calculated level of machinery and equipment investment by this investment category’s exogenously specified share of total gross investment.


9. RAND solves this type of problem, while DSA maximizes a utility function that contains defense and consumption as arguments. Because these models do not run over an infinitely long planning horizon, it is necessary to impose a restriction on the terminal values of the capital stocks. This insures that the model continues to take a long-sighted view as the end of the planning horizon is approached. The cost of this restriction, however, is that the models must be used carefully if one is interested in assessing the effects of various modernization programs on GNP. With terminal capital specified, and the size of the labor force exogenously specified, the value of GNP at the end of the planning horizon is essentially determined in the model. To assess GNP development issues in the near term, it may be necessary to operate the model.
for extended periods of time. But it is still difficult to specify long-run
terminal capital values (or shadow prices) that reflect the preferences of
Soviet leadership.
63–64.
11. Ibid., pp. 95–98.
12. The research summarized here is being conducted with Peter
Staugaard and is sponsored by OSD/Net Assessment. It will be pub-
lished as The Soviet Priority Economy: Modeling the Conflict between Gold
and the Sword (Santa Monica, Calif.: RAND, forthcoming). Other work
on this project includes Lee D. Badgett, Defeated by a Maze: Historical and
Structural Aspects of Modeling the Soviet Economy and Its Defense-Industrial
Sector, N-2644-NA (Santa Monica, Calif.: RAND, October 1988); Richard
E. Ericson, Priority, Duality, and Penetration in the Soviet Command Econ-
omy, N-2643 (Santa Monica, Calif.: RAND, December 1988); and Alvin
H. Bernstein, Soviet Defense Spending: The Spartan Analogy (Santa Monica,
Calif.: RAND, forthcoming).
13. One could also interpret “infrastructure” as any potential bot-
nleneck sector that does not directly produce some component of final
demand.
15. See David Holloway, “Economics and the Soviet Weapons Ac-
quision Process,” in Soviet Military Economic Relations, proceedings of
a workshop sponsored jointly by the Joint Economic Committee, Sub-
committee on International Trading, Finance, and Security Economics
and the Library of Congress Congressional Research Service (Wash-
17. For a discussion of the military’s support of civilian activities, see
Julian Cooper, “Technology Transfer between Military and Civilian
18. Abraham Becker, Ogarkov’s Complaint and Gorbachev’s Dilemma:
The Soviet Defense Budget and Party-Military Conflict, R-3541-AF (Santa
Monica, Calif.: RAND, December 1987).