PLANNING WITH MATERIAL BALANCES IN SOVIET-TYPE ECONOMIES

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The material balance is at the core of Soviet planning; it is the most operational (or bureaucratic) of all balances in the sense that all its elements—output orders, import and export quotas, inventory changes and allotments of materials to various consuming groups—hang on administrative decisions.

Until recently so little was known about the practice of central planning in the Soviet Union and in Eastern Europe that material balances and other "balanced estimates" meshing the supply and demand for commodities and for factors of production were rarely discussed in Western economic literature.[1] But of late Soviet and Czech publications have become more candid about planning methods actually in use; while of course the Poles and the Hungarians, ever since 1955, have been less reticent than any other members of the Soviet bloc to expose their economic system to public scrutiny.

The structure of planning and of administrative organs differs in these various countries, and it has undergone a substantial reform since 1957 in the Soviet Union itself. Yet the task of elaborating a set of consistent balances presents the same basic problems in every centralized economy despite these differences: regional or industrial organs of the bureaucratic apparatus, whether higher or lower, are called upon to make economic decisions, the coordination of which, in the absence of markets and of a flexible price system,[2] must be effected by matching the total demand for every major resource against its available supply

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[1] A notable exception is a recently published book by Hans Hirsch [20]. Useful information on the subject is also to be found in Granick [15] and Grossman [16]. H. S. Levine's highly competent paper [42] was published while this article was in the press.

[2] Soviet economists are eager to mend their price system to improve economic accounting, but they have no intention at the present time of allowing prices to play a major role in allocating resources. After three years of lively debate, the Poles now seem to have reconciled themselves to the primacy of physical planning.

at the highest level of planning. This is the role of the U.S.S.R. *Gosplan* and of the Planning Commissions of the other Soviet bloc countries.[3]

The first section of this paper briefly describes the administrative framework of central planning in Soviet-type economies. In the second, I consider various procedures open to the central planners for approximating perfect consistency in building up a large set of interlocking balances. These theoretical alternatives are then compared with the information available about actual planning methods in the Soviet Union and in the other countries of the Soviet bloc. In the last two sections, the practical limitations of planning by the method of balances are brought out in detail on the basis of recent evidence taken from these economies.

I. *The Administrative Framework*

Material balances may be drawn up for short-run planning purposes (for a quarter or for a year) or as the foundation for the long-run plans (five years and upwards). The latter, called "perspective balances," are not so operational as the short-term balances, since the long-term-plan output figures are subject to change and the requirements for materials (the outlay side of the balance) are only round estimates. The long-term plans, however, do mark out the course along which the socialized sector of the economy will travel, and they tend to hold good, barring major changes in policy, as long as no really troublesome obstacles supervene. However, "shortfalls" due to forecasting errors on the credit or on the debit side of perspective balances may have repercussions on the yearly balances, which can only be "closed" by cutting the output of certain branches of the economy short of their productive capacity.

The following procedure illustrates how the yearly plans for critical ("funded") products[4] were elaborated in the Soviet Union and in Poland, Czechoslovakia and Hungary before various—and divergent—reforms were put into effect in 1957 and 1958.

Some six to eight months before the beginning of the plan-year, the Planning Commission prepared preliminary balances of essential materials, taking into account the latest production figures as well as forecasts of productive capacity and labor force. Tentative targets ("con-

[3] As of 1958, *Gosplan* prepared balances for ferrous and nonferrous metals, fuels, oil products, electric energy, chemicals, lumber and building materials, the main types of machinery and equipment, agricultural raw materials and the chief products of the light and food-processing industries [22, p. 14].

[4] "Funded" products were essential materials (from planned or from above-plan production of socialized enterprises), which could be distributed solely by the Council of Ministers of the U.S.S.R. The most widely used raw materials and semifabricates were still funded in 1958.

trol figures") based on these balances were handed down to the various industrial ministries, which subdivided them among their Chief Industrial Administrations (*glavki*). Each *glavk* in turn set specific targets for its subordinate enterprises, which were then expected to calculate the material inputs they would require to hit these production targets. The enterprise's material requirements, written up in formal applications (*zaiavki*), were transmitted to its *glavk* and eventually to the procurement organization of its ministry. At every echelon, all applications were checked and their approved version consolidated with other applications. Each authority made sure that the material requirements corresponded both with the latest available output figures and with the established "technical-progressive norms" regulating the maximum permissible expenditure of materials per unit of output.[5]

The ministry finally turned over its procurement plan (covering the material requirements of all its enterprises) to the Council of Ministers and to *Gosplan*. Simultaneously with this process, ministries, with the help of their marketing organizations and of their *glavki,* drafted more detailed production plans, modifying and complementing the control figures they had previously received. These plans were also submitted to *Gosplan,* whose specialized industrial departments were now charged with preparing material balances for funded commodities on the basis of these latest production and procurement data. The process of concurrent adjustment of the supply and demand for each balanced commodity ended with the "closing" of the material balance—when the sum total of allocations earmarked for the various consuming groups matched the total supply from all sources planned for the year. Before all balances could simultaneously be closed, it was often necessary to go through most of this administrative procedure a number of times, on each occasion the relevant department of *Gosplan* or the ministry being expected to figure out the input requirements of subordinate enterprises from the output targets in the latest "version" of the yearly plan.[6]

Once all the material balances had been closed and had received approval by the Council of Ministers, each ministry subdivided its global allotment of material inputs among subordinate enterprises [11, p. 8]. The latter, within their appointed portions, communicated their exact requirements by size, type or make of the material to procurement agencies at various administrative levels. The detailed require-

[5] These norms or coefficients of output are fixed by special commissions for each enterprise. They must, in principle, be rigorous enough to guarantee that the enterprise will only maintain itself within their limits by dint of the most stringent economy. See below, pp. 977-79.

[6] In the later stages of planning, the input requirements of new output targets were usually calculated within the Planning Commission itself. (For certain limitations and exceptions to this basic scheme, see below, pp. 977-79.)

ments were eventually transmitted to the marketing organization of the supplying ministry, which supervised the transfer of goods from selling to purchasing enterprises.

In 1957, as part of the reorganization of Soviet planning on territorial principles, most industrial ministries were liquidated and a hundred-odd regional Economic Councils (*Sovnarkhozy*) were charged with the concrete supervision of 18,000 enterprises, accounting for the bulk of industrial output [25, p. 56]. Production and procurement plans instead of shuttling back and forth between *Gosplan* of the U.S.S.R. and the enterprise along functional-ministerial lines were now made to travel along territorial lines—through the *Gosplan* of each constituent Republic down to the regional Economic Council. Transmission channels are now different but the procedure for building up and controlling procurement plans is still essentially the same as it was prior to the reform [23, p. 325].

Some Soviet economists argue that the reorganization will make it easier to coordinate plans from the center: *Gosplan* of the U.S.S.R. will work on fewer balances (800 to 1000 in all). This reduction will be effected by grouping together many commodities formerly balanced separately. These more aggregated balances are supposed to account for a more complete coverage of industrial production than in the past, when nonfunded commodities were planned by ministries and their output was imperfectly coordinated with the rest [25, pp. 59-60]. In any case, it should now be possible to manipulate a smaller number of balances more flexibly and a more systematic effort can be made to reach over-all consistency.

II. *Theoretical Models of Administrative Planning*

Let us first consider theoretically how all the balances can simultaneously be "closed" with the labor force and resources available, leaving aside for the moment the problem of limited plant capacity.

We assume that the material balances form an interlocking set which can be arranged as an input-output table.[7] Coefficients are now calculated relating the amount of each material input needed for producing a unit of each of the different outputs and ordered as a square matrix,

[7] In input-output terminology, our simplified balances look as follows:

Resources		*Disposals*
x_i	$=$	$\sum_{j=1}^{n} a_{ij}x_j + y_i$

where x_i is the gross output of the ith commodity, a_{ij} is the technological coefficient showing the amount of x_i required to produce every one of n commodities, and y_i is the final demand for the ith commodity. There are n balances, one for each commodity.

A mathematical appendix to this section of the paper is obtainable from the author.

with as many rows and columns as there are balances. Since the balances are all expressed in physical units (e.g., tons of steel, thousands of tractors), the coefficients are "technological" (e.g., tons of coke per ton of pig iron), unlike the coefficients in a Leontief matrix which express the costs of input necessary to produce a dollar's worth of output.

Let us suppose that certain final demands are communicated by the authorities to the planners for investment goods and construction, defense, consumer goods, exports and reserves. The gross output target for each good necessary to fulfill its quota of final demand plus any amounts required by other industries as inputs can theoretically be calculated by input-output methods.[8] In recent years, the Russians and their more advanced partners (the Poles, the Czechs, the Hungarians and the East Germans) have studied the use of systematic methods of input-output programming, but their attempts to apply these techniques have hitherto been confined to small-scale (highly aggregated) pilot schemes.[9] Up to now, no system of interlocking balances for the national economic plan has been "harmonized," or made to "close" by these methods.

Soviet planners, who apparently believe that an internally consistent plan can be framed by traditional bureaucratic methods, given any feasible initial conditions of final demand or of minimum gross outputs, envisage the use of input-output methods mainly to work out the ultimate effects of different "variants" in these initial conditions. At present, the method of balances with its successive approximations to reach consistency, involves so cumbersome and time-consuming a procedure that an insufficient number of variants can be investigated, particularly in drafting long-range plans.[10]

But can the method of balances even lead to one consistent plan? The shuttling back and forth of targets, the groping toward a simul-

[8] In general, for this to be possible, the matrix formed by subtracting the technology matrix from the identity matrix must have an inverse. It is not certain that such an inverse will always exist, since the technological coefficients are supposed to be drawn, not from the actual performance of the economy, but from engineering data; and it may turn out, by a freak of chance, that the total inputs required to produce a given set of gross outputs with the prescribed technical processes exceed these outputs. The system would then "eat itself up"; no positive final bill of goods could be produced. It is only when the coefficients are calculated *after* the plan has been fulfilled, that we can be sure that the iteration process will be convergent. We may note in passing that if the technology matrix can be transformed into a Leontief matrix by a suitable change in units, and if every column of these new coefficients adds up to less than one, inversion will be possible. In this case, every product could be produced at zero or positive profit.

[9] Articles which describe some of the basic research being conducted in the Soviet-bloc countries are: for the Soviet Union, V. Belkin [3]; for Poland, K. Porwit [33] and E. Krzekowska and others [28]; for Czechoslovakia, A. Červený and J. Vácha [6]; for East Germany, H. Schöhen [38]; and for Hungary, A. Bródy [4].

[10] Interview material.

taneous "closing" of the balances, suggests various iterative techniques, which, systematically carried out, would, in effect, invert a matrix made up of the technological coefficients and approximate full consistency in the output plan. Our task now consists in finding the iterative technique which most closely resembles the administrative procedures actually followed in Soviet-type economies.

We start again with our somewhat unrealistic assumption, namely, that the first set of output targets circulated to all industries consists of final demands only. On the basis of these targets, all industries producing end-products calculate their input requirements, which are then summed for the whole economy, and added to the original targets of final demand to yield first estimates of gross output. These estimates make up a second set of targets which again are sent around to the various industries. Input requirements are now revised upward in line with the higher targets. The old summation procedure is then repeated to yield second estimates of gross outputs. It can be shown that every new set of gross-output targets obtained in this manner would come closer to the perfectly consistent set of targets that could be calculated by direct matrix inversion.[11]

An immediate improvement in this method suggests itself. Final demands are usually not a good starting point for the first iteration, especially if they represent only a small proportion of total production; therefore, gross-output targets adapted from the five-year plan or adjusted upward from last year's targets may be used, instead, to compute requirements of intermediate products in the first round. If these preliminary targets (the "control figures" of Soviet practice) are not too far out of line with each other, the first iteration will yield larger, more accurate estimates of the "correct" (consistent) output targets than by starting with final demand. The successive approximations starting from this arbitrary point should converge toward the same consistent set of gross outputs as before [13, p. 69].

[11] Letting $x_i^{(1)}$ stand for the first estimate of any gross output, we may use the terminology of note 7 to represent the initial phase:

$$x_i^{(1)} = \sum_{j=1}^{n} a_{ij}y_j + y_i \tag{1}$$

The second set of targets follows by repeating this procedure. Thus for the ith sector:

$$x_i^{(2)} = \sum_{j=1}^{n} a_{ij}x_j^{(1)} + y_i \tag{2}$$

This expression can be expanded by substituting (1) into (2). Each subsequent set of targets can be derived from the preceding set and expanded in the above manner. The iterative technique described here is equivalent to the inversion of a Leontief-type matrix (formed by subtracting the technological coefficients from an identity matrix) by a power series. It is assumed of course that this matrix has an inverse, otherwise iteration will fail to converge toward *any* set of targets [13, p. 63].

Are there any other shortcuts which would pare down the time required to reach an acceptable approximation? At least three come to mind: (1) aggregation of coefficients, (2) extrapolation toward more exact estimates, and (3) more "efficient" routing of the control figures throughout the administrative system.

1. The principal advantage of aggregation lies in the possibility of restricting the iteration process to a smaller number of planning organs and of speeding up the entire procedure. In Poland, for example, it is known that the last stages of planning a yearly program are all carried out within the Planning Commission itself, with the various departments of material balances (e.g., for metallurgy or for light industries) grinding out input requirements on the basis of aggregated coefficients [33, p. 338]. In this way the material requirements needed to produce the various estimates of the gross output targets can be worked out much more rapidly—though less exactly—than if these estimates had to filter all the way down to the producing plants.

Aggregation entails a loss in accuracy, unless the input-output coefficients of every product in each consolidated group happen to be the same or unless the relative outputs of the individual commodities to be aggregated are expected to remain in exactly the same proportions for all variations in the final program [29, pp. 195-200]. American experience with inverting large matrices indicates that the loss of accuracy due to this cause is not so damaging as might at first blush be supposed [30]. In practice, as we shall see in the next section, the worst losses due to aggregation probably stem from errors and omissions in the aggregation process itself.

2. Extrapolation: if the iteration process converges, then the differences between successive estimates of the gross outputs will tend to fall according to a constant ratio.

Let this ratio be called K. Then the planners could reach forward from, say, the third iteration to an ultimate approximation of the correct values of the gross outputs by computing the increase in the gross output of any good generated by the third iteration (compared to the second), multiplying this increase by the ratio of K to $1 - K$, and adding the result to the output of the third iteration for this good [13, p. 74].[12] No such formal methods are used in Soviet planning, although the planners do seem to anticipate feedbacks by using their past experience and their planning "instinct" to extrapolate the estimates of material requirements on the outlay side of their balances.[13]

[12] Experience with the inversion of U.S. input-output matrices has shown that four to five iterations *cum* extrapolation were sufficient to encompass at least 96 per cent of the true value of the gross outputs.

[13] Interview material.

3. In this theoretical model of administrative planning, inefficient use has been made of the data generated at each step in the process. All the agencies and firms have computed their material needs from estimates of gross outputs corresponding to the *same* stage in the iteration process. It will usually be more advantageous to start the iteration process with industries producing mainly finished products and work back toward raw materials, making use at each stage of the gross outputs already generated. The advantages of this method are illustrated by the following example.

Let all industries be classified into three groups: (1) manufactures, (2) semifabricates, and (3) raw materials. Suppose that the last two groups drew no inputs from any manufacturing industry, while raw material industries consumed neither manufactured nor semifabricated products. The matrix of input-output coefficients for these three groups would then be free of all "circular relations" between groups.[14] The Planning Commission might be instructed first to calculate all the internal needs of the manufacturing group, add these needs to the final demand for manufactures and fix gross output targets for this group;[15] then use this target (together with the final demand for the second group) to work out the total needs for semifabricates. And, in the third stage, use both the gross-output targets for groups 1 and 2 to derive the target for group 3. These three steps would be sufficient to provide the planners with a consistent plan for all three sectors. No further interations would be necessary. The above procedure, which corresponds formally to the Gauss-Seidel method for finding the inverse of a matrix by iteration, would obviously save much time, provided that the technology matrix lent itself to its employment.

In practice, according to a Soviet economist interviewed, work on the balances starts simultaneously from "both ends": balances are first prepared for industries turning out mainly finished products and for industries producing mainly raw materials. Inconsistencies come to light somewhere "in the middle" as balances of intermediate products are reconciled with both raw-material availabilities and final demand re-

[14] Letting a_{ij} $(i, j = 1 \text{ to } 3)$ stand for an aggregated coefficient relating any two groups, the matrix of these three industries could be arranged as follows:

$$\begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

A positive value for any coefficient above the diagonal of the matrix means that two or more groups are purchasing inputs from each other ("circular relation").

[15] Note that the requirements of any group for its own products (a_{ii}) add a complication. The gross output target for the first group should theoretically equal the final demand for this group divided by $1 - a_{ii}$. But if the a_{ii} were small, the error involved in ignoring their higher powers would be negligible.

quirements. This procedure probably reaps only a fraction of the computational savings of the Gauss-Seidel method.

In order to test roughly the effect of calculating gross outputs from final demands in a few iterations, the Gauss-Seidel method was tried out on the RAND Corporation's twenty-sector input-output matrix of the Soviet economy for 1941 [21] (rearranged so as to minimize the total value of above-diagonal elements).[16] In one complete iteration, approximately 84 per cent of the known value of the total of gross outputs was derived from the final bill of goods. Another iteration left 9 per cent unaccounted for. However, certain sectors with a small percentage of final demand to gross outputs—such as coal, peat, ferrous and nonferrous metallurgy—were still underestimated by as much as 30 or 40 per cent. By adjusting for the heavy internal requirements of these sectors,[17] and by limiting the next Gauss-Seidel iteration to just those sectors (using values already obtained for the remaining sectors), all sectors can be brought up to a minimum 85-90 per cent of the correct outputs. In practice, if sufficient reserves and inventories were available, and if the final demand for exports and for low-priority sectors offered a modicum of flexibility, the results might already be held satisfactory for operational purposes.

There is a strong presumption that better estimates could be made after two iterations if control figures of gross output were used in the first iteration, since some of the final demands amounted to only a fraction of gross output (e.g., 6 per cent in the coal industry).

In the long run, however, the case for iterative planning is not so strong. As a country develops, its products normally become more fabricated. Fewer products go directly from the mine or from the field to the ultimate consumer. The proportion of final demand in total output may be expected to fall. Once the industrial structure has become more complex, it should take more iterations to reach acceptable estimates of gross output whether we start from final demand or from any arbitrary starting point [13, p. 83]. In addition, relations among industries consuming each other's products (directly or indirectly) are more likely to develop with time. Indeed, such industries as chemicals, paper products, ferrous and nonferrous metals, which account for a large share of the circular relations, tend to grow more rapidly than the rest and assume increasing importance in more developed countries [8, p. 497]. These circular relations will have the effect of slowing down the convergence process for any method of iteration. In so far as

[16] The above-diagonal elements were reduced in a few operations to 2.5 per cent of the sum of gross outputs. These elements could be brought down further by more trial- and-error reshuffling of rows and columns.

[17] See note 15 above.

the Russian economy conforms to these general trends in development, the Soviet planners are likely to get larger errors than in the past (for a given number of iterations). This in itself may help explain the recent flurry of Soviet interest in the application of formal input-output techniques to planning problems.

Up to this point we have assumed that gross output targets could be systematically derived from a neat bundle of final demands.[18] But it has been suggested by at least one observer of the Soviet economy that certain intermediate products might belong to a higher order of priorities than the end-uses they can generate.[19]

Take for example, the "leading links" of Soviet planning, sectors of the economy that were given top priority in order to widen bottlenecks in development. The yearly increases in the output or services planned for these sectors were not determined directly by their net contributions to the investment program, to defense or to private consumption; neither did they follow automatically from the nicely calculated requirements of other sectors for their products. The planning of these leading links had a profound impact on the entire program for the year—which may in certain cases have overridden planners' preferences for end-products.

Still this objection cannot be pushed too far: the ultimate decision-makers need not have a sharply etched preference map to tell whether they wish to see more tanks produced or more automobiles, whether they plan more investments in electric power or in dairy production; and the choice of gross-output targets does have a decisive effect on whether tanks or automobiles will be produced this year, and electric light or milk five years hence. The planners must eventually adjust gross-output targets to any strong preferences they may have for end-products. Moreover, as the quality of long-range planning improves and flagrant disproportions in the economy are gradually eliminated, hectic campaigns to build up top-priority sectors "at all costs" should eventually yield to a more comprehensive approach to planning problems.

Capacity limitations in certain key industries also contradict the basic assumption of one-factor scarcity implicit in our iterative solution of an input-output program. It may actually wreck all our theorizing, for, strictly speaking, no program saddled with both capacity

[18] The use of "control figures" as initial estimates of gross outputs, instead of final-demand requirements is only a convenient device to accelerate convergence. In the last analysis final demand still determines gross outputs and not the other way around.

[19] In the Soviet Union, according to Gregory Grossman "production targets for certain key intermediate goods are set by political decision. . . . These are . . . the goods which symbolize military-economic power and independence in the mind of the regime: e.g. coal, petroleum, electric power, steel, etc. . . ." [16, p. 102].

limitations and a limited supply of labor is susceptible of solution by input-output methods; and linear programming, which can handle this type of problems, has no counterpart in the planning of Soviet economies. Fortunately, only one not-too-far-fetched assumption needs to be made to bring us back into charted territory, namely, that the entire capacity of every capacity-limited industry should be used up. This implies that the planners will have to be content with just those quantities of net output in the capacity-limited industries that will be left over after satisfying the internal requirements of the system and the final demands prescribed for the remaining industries.[20]

Economists of the Polish Planning Commission have recently analyzed the problem of finding an input-output solution to such a program, in the belief that, for short-run planning, a "mixed model" (with capacity limitations) would better answer practical needs than one where output in every industry was determined solely by its supply of material inputs [34, pp. 11-30].

An approximate solution to a mixed program can be found by iteration with even less effort than in the case where no capacity limitations have been allowed for. The planners may proceed as follows: they may calculate by iteration the gross-output requirements of the industries whose output is limited by their supply of material inputs (introducing the gross outputs of the capacity-limited industries only as a source of demand for inputs from the industries under consideration) and, once acceptable estimates of these gross outputs have been ground out, use them to calculate the residual net outputs of the capacity-limited industries. The iteration process can therefore be confined to sectors with a predetermined final demand, while data from the limited-capacity sectors need only be introduced into the balances after all the time-consuming calculations on the remaining sectors have been completed.[21]

[20] That this is an assumption and not a necessity can be shown by the following example. Suppose industries A and B were capacity-limited and bought inputs from each other. Then the *net* output of A could be increased slightly by operating B below capacity, thus releasing some of A's intermediate products for final demand, which would otherwise be brought by B from A. This possibility is ruled out in the model that follows.

[21] We again use the terminology of notes 7 and 11 for a three-sector model. It is assumed that the output of sector 1 (the capacity-limited industry) cannot exceed x_1. Final demand is known for the remaining sectors (y_2 and y_3). Our unknowns are y_1 (residual final demand in sector 1) and gross outputs x_2 and x_3. We call $x_2^{(1)}$ and $x_3^{(1)}$ our first estimates of x_2 and x_3, equal to $(y_2 + a_{21}\, x_1)$ and $(y_3 + a_{31}\, x_1)$ respectively. The second estimates of x_2 equals the first estimate plus indirect requirements amounting to $(a_{22}\, x_2^{(1)} + a_{23}\, x_3^{(1)})$. This sum expands to $(1 + a_{22})\ (y_2 + a_{21}\, x_1) + a_{23}\ (y_3 + a_{31}\, x_1)$. Further estimates can be obtained by repeating the same operations. Once acceptable estimates of the unknown outputs have been reached after k iterations, the residual final demand of the first industry can be obtained as follows:

$$y_1 = (1 - a_{11})\ \ x_1 - a_{12}\ \ x_2^{(k)} - a_{13}\ \ x_3^{(k)}$$

where $x_2^{(k)}$ and $x_3^{(k)}$ are the kth estimates of x_2 and x_3.

To conclude the foregoing analysis: the method of material balances is not inherently wasteful or theoretically unsound. It *may* lead to full consistency if the iteration process is carried on long enough and if the technical coefficients are accurate. Even if we knew that only one or two iterations were carried out, we still could not be sure that the method would lead to large errors; for the organization of planning and the nature of the technology matrix might be such that substantially correct estimates of gross outputs could be derived by its use.

Finally, attention should be drawn to the essential flexibility of iterative procedures. The technological coefficients need not all be transmitted to the Planning Commission. A "control figure," or preliminary output target, may be sent to a ministry, to a *glavk* or to a regional Economic Council, depending on how industry is organized and on where it may be convenient to calculate the inputs to hit this target. The working out of input needs at lower echelons saves on the time and expense and on the errors in aggregation involved in bringing all the coefficients together in one place. It is conceivable that these savings might more than offset the increased cost of transmitting input and output estimates back and forth between the center and the peripheries.

A Yugoslav economist and former central planner has pointed out that trial-and-error methods for reaching consistency permit more *ad hoc* adjustments in the coefficients than the mechanical inversion of a matrix [31, p. 215]. Suppose, for example, that an increased final demand for aluminum hollowware and agricultural machinery has given rise to larger electric-power requirements than were originally planned. The full extent of the discrepancy has perhaps come to the attention of the planners only in the third "version" of the program. The extra power must come from inefficient generating capacity with a high coal intake. The average coal-electricity coefficient can now be raised to take these new circumstances into account. And there is no need to start the whole programming over again—as long as coal output can be raised to the new required level.

Similarly, if the balances for certain key materials cannot be closed, substitution of other materials in more abundant supply may be enjoined on all producers by the Planning Commission, and corresponding adjustments in the technological matrix and in the production program may be made for further iterations.

III. *The Models Compared with Actual Planning Methods*

In the models of the preceding section, a set of interlocking balances has been posited for all commodities: if aggregation had to be resorted to, it was not supposed to affect the interdependences linking all the commodities in the system. This assumption will not bear scrutiny: in

all the economies under study, a good many of the less important commodities were planned, balanced and distributed at lower administrative levels—sometimes even by the producers themselves, more often by marketing organizations.[22] These plans were poorly integrated, if at all, with the more fundamental balances elaborated in the Planning Commission and approved by the Council of Ministers. Furthermore, at all administrative stages, material requirements were consolidated along "organizational" lines (by ministries or lower organizations named as "custodians" of allotted funds) rather than according to the type of output which they would help to produce. Thus, prior to the reorganization of Soviet industry, total coal disposals in *Gosplan* balances were broken down by ministry, not by detailed use. (Only the principal commodities for which coal served as input, such as coke and steel, were typed out under each ministry in the Polish balances.) According to a Soviet statistician, though detailed data are collected from each producing enterprise on its consumption of materials (corresponding to the widest industrial classification in use), "this extremely valuable material is neither summarized nor processed" [35, p. 368]. It is evident, however, that the central planners must have at their disposal aggregated input-output norms for all commodities for which they wish to draw up a consistent plan by successive approximations.

In the opinion of Soviet experts, the organizational makeup of the balances also limits their use as a source of data for input-output programming; considerable expense would have to be incurred to fill the gaps by working up raw data furnished by enterprises.[23]

Summarizing some of these difficulties, the *Gosplan* economist A. N. Efimov complains that "material balances . . . for individual products, not being integrated into a single system, solve only limited problems of intersectoral proportions" [10, p. 108].[24]

[22] In 1954, out of 62 machinery groups or subgroups balanced by the Polish planners, 18 were balanced in the Planning Commission, 14 by the Central Agency for Machine Economy (C.Z.G.M.); 3 by departments of ministries, 9 by central boards, 4 by procurement organizations, and 14 by marketing organizations [32, p. 650]. Some, but not all, of those balances were integrated into summary balances drafted in the Planning Commission.

[23] The input-output team of the Polish Planning Commission has found an ingenious way of circumventing this difficulty by combining data based on "product-organizational" lines (e.g., tons of coal per million zlotys of output of the ministry of the chemical industry) with detailed physical output data supplied by the different ministries and their subordinate agencies [34, pp. 31-42]. The Czechs propose to develop a new industrial classification to make up their input-output tables and to collect the requisite data directly from plants for this purpose [6, pp. 339-41].

[24] Similar, but more detailed, criticism of the balances is to be found in the work of various Hungarian economists (for example [1, p. 568]). In a 1957 article, another Hungarian economist, A. Bródy, complained that statistical data available at present are not sufficient to prepare a detailed input-output table for industry as a whole. Differences in nomenclature among the various administrative organs are mostly to blame. No informa-

This failure is particularly evident when changes must be made in the last stages of drawing up the year's program. Efimov remarks that, in view of the great expenditure of computational labor needed to rework the material balances, as well as the lack of time for carrying out this work, "recalculations may be limited in practice to the balances directly affected by the changes." These he calls "first-order linkages" (e.g., the adjustment of the steel balance to an increase in the demand for trucks). "Balances related to the original change by second-order and especially by third- and fourth-order linkages are altered only where the changes are significant" [10, p. 107].[25]

Nevertheless, if I may judge from the Polish example, a determined effort *is* made to achieve consistency at least for priority sectors, even if the balances have to be closed by cutting down allotments to lower-priority sectors. Two plausible courses of action for resolving basic inconsistencies in the master-plan can be looked into. First, the planners may meet deficits in the balances by calling for a reduction in the input-output coefficients of heavy users of materials in short supply; second, the allocation of materials to consumer-goods industries may function as a buffer which softens the impact of shortages on the other key sectors. Both hypotheses are partially valid but neither holds up under all circumstances.

1. The input-output coefficients the planners work with are already strained. Only a hortatory purpose can be served by decreeing their further reduction:[26] firms will have to make shift with the materials actually dealt out to them; if they exert enough effort toward reducing unit costs, they may still hit their output targets with lower coefficients. But they may just as easily exceed their allowances—especially if the quality of materials rationed out is below standards. This approach will not go far toward eliminating the trouble.

2. The quotas of materials earmarked for household consumption are sometimes cut; but these quotas already tend to be niggardly, since the original bill of consumer goods—low in the planners' priority scale—

tion can be had on "products that are not easily measurable" (steel castings and forgings, some types of machines etc. . . .). Consequently, "one is unable to find out what happens to over half of the output of heavy industry" [4, pp. 138-39]. These, and all the other Hungarian references in this paper, were kindly made available to me by Bela Balassa from his forthcoming study on the economy of communist Hungary.

[25] For further comments of the same nature, see Belkin [3, p. 140] and Ausch's remarks on Hungarian planning [1, p. 568].

[26] In the stormy industrialization period of the early 1930's, systematic overcommitment of resources may well have helped to "mobilize the masses" toward more strenuous efforts to fulfill impossible plans. (*Cf.* the chapter "Problem Solving, the Overcommitment of Resources and 'Storming'," in [2].) In the 1950's, the Soviet economic system seems to have moved away from these *Sturm und Drang* methods toward a tighter budgeting of resources. This trend is important in assessing the present Soviet search for more rational planning procedures.

was already pared down to bare essentials. There is not much more "play" here than in the producer-goods sector.

It is interesting to note, in the case of Poland, that, from about the middle of 1954 on, the consumer-goods sector (of key industry) became the least resilient of all—after acting as one of the most elastic buffers in former years: an effort was being made at that time to regain the losses in real wages suffered in the first stages of the six-year plan, and if any element of demand had to "give" when shortages arose, it was industrial construction and other investment activities rather than any consumer-goods industry.[27]

A minor component of demand to feel the pinch in certain cases is the "pool" of materials going to producers' cooperatives and to private handicrafts. The beneficiaries of this pool—whether they produce consumer or producer goods—receive harsher treatment at the hands of the planning board than large-scale textile or food-processing plants by reason of their inferior social status and of the marginal nature of their deliveries in the total supply of most goods. It is apparently believed that ups and downs in the output of these dwarf producers (caused by their procurement difficulties) are less damaging than occasional cuts in the production of consumer staples by plants employing thousands of workers.

If exports are an essential ingredient needed for industrial growth—through the imports of raw materials that they make possible—then exports will be the last "end-use" to be cut. This was apparently the case in Hungary. However, in Poland, exports of raw materials and semifabricates (including coal and rolled zinc) were frequently trimmed when the requirements of domestic industry and transportation could not otherwise be satisfied.[28]

There is no set of rules binding for every time and place to deal with shortages in the balances as they arise: consumer goods, investment projects, exports, or even the defense program may bear the brunt of adjustments, depending on the priorities of the moment.

IV. *Obstacles to Accurate Planning by the Method of Balances*

The routine obstacles that stand in the way of accurate planning by the method of balances may be divided into two groups: (1) failures

[27] This does not imply that the investment budget was greatly reduced—it was actually held at approximately the same absolute level as in former years—but it was thought expedient to maintain a certain level of output of consumer goods as an irreducible minimum, irrespective of the vagaries of planning.

[28] In the routine planning of material balances in Poland, the officials of the Planning Commission earmarked for export those quantities of goods that could be drawn off from the pool of domestic allotments "without prejudice to procurement needs at home." The quantities exported of many goods ended up as a resultant item, "left over after other needs had been met" [36, p. 25].

in the transmission to higher authorities of information about the production functions of individual producers, and (2) errors that come to light in the process of fulfilling the plan.

1. The knowledge which planners in *Gosplan* or the equivalent organization have of the relevant input-coefficients may be inaccurate for a number of reasons:

(a) Technical norms are often unrealistic to start with, since they usually assume a quality of material inputs and conditions of repair and maintenance of equipment which are not normally met in practice. They may also hinge on an above-average performance of the workers operating the materials-consuming equipment.

(b) Many norms at the plant level are ignored because the complexities of the production processes and the frequently changing specification of the products render them useless for planning purposes.[29]

(c) Due to rapid technical progress, it is not possible to keep all the norms up to date.

(d) The norms are often poorly aggregated even at the level of the enterprise—there are as many norms of coal utilization as there are furnaces and boilers in a plant (and there may be several plants in the enterprise)—but particularly, prior to the reorganization of Soviet industry, at the level of *glavk*. Only a few of the aggregated norms are systematically built up from their output-weighted components; in a majority of cases the planners make use of "statistical coefficients" relating inputs to outputs for a group of enterprises in the most recent planning period.[30]

(e) The relation between the output of a product and the consumption of materials for repairs and maintenance associated with its production cannot be predicted with accuracy. The quotas of materials earmarked for these uses are liable to a wide margin of error [37, pp. 61, 62].

(f) The output-mix of an industry is frequently so complex that materials needs can only be gauged in proportion to the gross value of output of the industry or of a group of products rather than for each of the products separately. In the Soviet Union, the material inputs of the construction industry are estimated as so many tons of bricks, cement or lumber per million rubles of construction. This is a highly unreliable method since the material-intensity of different stages of construction

[29] The complex factors bearing on fuel norms and the difficulty of working out usable technical-progressive norms are described in a Czech article [40, pp. 549-52].

[30] The technical difficulties of conveying usable information about production functions to the ministries and to the Planning Commission must be formidable when we consider that a single machine-building factory in the Urals turned over to its superiors 17,000 sheets of "documentation" relating to its norms and to its actual consumption of materials [14, p. 46].

varies appreciably [22, p. 11]. In Polish industry, only about 60-70 per cent of total output could be planned with physical coefficients; for the rest, materials needs were geared to gross output forecasts and were to some extent distorted by the irrational elements in the prices that served as output weights for the individual commodities aggregated.

Breakdowns in the transmission of operational information cause still another source of errors in the balancing process. The correct material quota on the expenditure side of a balance depends not only on the output of its consumers and on their coefficients but also on the inventories of materials and goods in process these consumers may have on hand. Unfortunately, accurate data on these inventories are hard to get, not only for technical reasons—constant fluctuations, poor accounting methods, and the like—but because firms find an advantage in concealing their materials hoards to be able to claim higher rations.[31]

The shortcomings of the norms might be alleviated if producing firms had a real voice in planning their inputs. But because firms tend to "plan upwards" (inflating their requirements in expectation of cuts) and because it takes too much time and trouble to bring every firm into the laborious planning process, the contribution of producers to the drafting of material balances is often perfunctory. This has evidently been the case in Poland since 1954 when "planning from above," as this short-cut method was termed, began to prevail.[32] In Russia, also, ministries did not always consult their subordinate enterprises in drafting their plans, particularly in industries with a highly diversified output.[33]

2. So many unforeseen contingencies may cause production and consumption plans to go awry in the course of their fulfillment that we can only list the major sources of disturbance.

(a) Changes in the demand for finished products ordered by the authorities during the year: political events—such as war scares—may precipitate short-run revisions in the investment program affecting the

[31] E. Devons [9] reports on the British experience with physical planning of aircraft production during the second world war, offering a vivid sketch of similar statistical deficiencies and of the mistakes they sometimes occasion. Indeed, a good part of the book might apply to planning in Soviet-type economies.

[32] [39, p. 379]. Before firms were cut off from detailed planning, they had to rework their industrial-financial technical plans as many as ten times a years in response to changes suggested by higher authorities. To reduce excessive "versionism," the instructions for the 1954 plan called for a maximum of independent planning by the Planning Commission and by the ministries—the first on the basis of the previous year's results, the second on the basis of technical data—with a final reconciliation of all projects in the last stage of planning [41, p. 6]. This arrangement seems to have been patterned after Soviet practice of the late 1930's [15, pp. 64-68].

[33] Eidel'man writes that "when ministries prepare their applications for materials without the participation of producing firms, they are subsequently compelled to introduce significant corrections in their applications" [11, p. 32]. For further details on Russia see [14, p. 48-49], and on Czechoslovakia [18, p. 59].

make-up of most material balances. If time is too short to elaborate a new consistent set of interlocking balances, then quotas earmarked for one purpose may be preempted for another without adjustment for the consequent indirect effects. This will upset the fulfillment of enterprise plans.[34]

(b) The time-lag between the drafting of the plans and operational decisions is such that, for the first quarter of the year, most firms operate without any approved plan at all.[35] In the Soviet Union, special "advances" of funded materials equivalent to the previous year's rate of consumption must be extended to consumers of materials pending receipt of final plans [22, p. 11].[36] During this hiatus, there is a minimum of coordination, since with a high, uneven rate of growth in the different sectors of the economy, the structure of the economy's output is constantly undergoing changes which will disturb the balances of last year's plans. Even if the previous year's plans were all perfectly balanced, a projection of these plans into the next year, disregarding the increased capacity and the new needs for end-uses that have come up in the meantime, could hardly be consistent.

(c) Producers frequently fail to notify consumers of production breakdowns and, when their deliveries must be postponed, they present their clients with a *fait accompli,* leaving them no chance to find alternative sources of supply.

(d) Above-plan output, rewarded by bonuses to management, usually necessitates extra consignments of material inputs, which must either be deflected from other consumers (by administrative fiat) or made good by unplanned output somewhere else. Unforeseen increases in materials requirements by priority consumers, from this and from other causes too numerous to mention, call for a myriad of lower-level decisions which may or may not be in harmony with the central plan or, for that matter, with each other.

(e) Certain industrial consumers are allotted supplies from "new production" of factories scheduled to be launched during the year. But it is difficult to fix an exact date for the start of full-scale operations in

[34] A Slovak economist, writing in the official organ of the Czechoslovak Planning Board, remarks that "the effects of foreign trade, changes in the demand of private consumers, technical progress, natural events, and defects in the elaboration of the plan militate against the absolute inflexibility of yearly plans . . ." [27, p. 34].

[35] In Poland, the ministries and the Planning Commission started work on the coordination of the plans as early as May and June of the year preceding the plan year. Most of the work of formulating an internally consistent plan was supposed to be over by mid-September [41, p. 9]. Yet producers only received concrete directives by the end of the first quarter of the plan year or, in 1953 for instance, as late as May [17, p. 30].

[36] Polish enterprises operated during the first quarter on the basis of tentative plans submitted to the Central Boards of Industry in the fall of the preceding year—which usually differed substantially from later versions [17, p. 30].

new projects. Consumers are therefore at the mercy of "bugs" in the production processes of their suppliers. Shortfalls in deliveries will of course upset their own output plans with repercussions in the rest of the economy. This element takes on special significance in the first periods of rapid industrialization when each new plant put into operation may contribute a large proportion of the nation's output of a particular commodity.

What do all these discrepancies amount to? According to *Pravda* (August 10, 1955), 31 to 40 per cent of all industrial plants in the Soviet Union failed to fulfill their annual plans between 1951 and 1954.[37] Even if a large number of plants produced over and above their plan, the chances are that differences in the location of the surplus-output plans and in the specifications of their products would make the latter somewhat less than perfectly substitutable for the products in deficient supply.

Disproportions in short-run planning are made good, in so far as possible, by the manipulation of reserves held by the planning board and by other agencies, or by fluctuations in the inventories maintained by producers and consumers. Inventories in the Soviet Union apparently have to be built up to higher levels than in capitalist economies such as the United States [7, pp. 561-65]. But they still are not sufficient to cushion all disturbances in procurement; and production breakdowns due to material shortages remain a perennial source of complaints in all the centralized economies.[38]

V. *Concluding Remarks*

This paper confines itself to the purely technical aspects of drawing up a consistent set of interlocking balances of material resources. We have not related these balance sheets to the composite ("synthetic") balance sheets of money flows which are used, among other purposes, to equilibrate the aggregate supply and demand for consumer goods. Neither have we related the short-term balances to investment planning or to plant capacity. We have thus by-passed one essential function of the material balances: the detection of bottlenecks and their eventual elimination by suitable investments (in plant capacity, in equipment, or in the expansion of extractive industries, including geological prospecting).

[37] In Czechoslovakia, according to a detailed breakdown for 1957 published in 1958, only 15 per cent of 1,429 enterprises covered in a survey failed to fulfill their production plan [5, p. 51].

[38] These snags in procurement are chiefly responsible for the uneven rate of production in many plants (*nieritmitchnost*), which must slow down during certain periods while they wait for essential parts or materials and then must "storm" the plan in the last ten days of the month.

This technical survey also fails to explore the relation between our limited "ideal" of Soviet planning (the working out of a perfectly consistent program) and the static model for the efficient allocation of resources. In view of the fact that factor-mixes are endowed with *some* flexibility in many, if not in most, production processes, we might ask how the method of balances and administrative rationing are expected to reach an efficient allocation (where the ratios of marginal physical products of any two factors will be equated in every use). How can the most economical production processes be selected without any more refined knowledge of relative scarcities than the occurence of surpluses or deficits in trial-balances? Can an effective price system be grafted on physical planning and help to resolve these dilemmas?

It will appear to some readers that these questions need only to be raised in order to be answered.[39] But before we become complacently critical, let us bear in mind that static efficiency is not the be-all and end-all of the art of planning. The Soviet system with all its compulsion and waste is a vehicle for high rates of growth. To some extent, a higher rate of growth than might otherwise be feasible makes up for short-run inefficiencies. These speculative remarks aside, my conclusions are leveled at a lower plane.

Whether or not the method of balances is, at best, inherently wasteful, there is vast room for improvement before this "best" can be attained in the economies of the Soviet bloc. It is clear that achievement of the things the planners strive for, such as better technological norms, standardization, faster and more exact materials-accounting procedures at the plant level, and more efficient processing of data at intermediate levels, must help to overcome some of the present weaknesses of the planning process.

For the purpose of improving the coordination of the plans, the Soviets may have much to gain from the studies of input-output programming being conducted at present by their own theoreticians. Even if they do not find it practicable to invert a matrix of coefficients with electronic machines within *Gosplan*—possibly because not all the coefficients can be brought together in one place—they may learn from studying their *tableaux économiques* how to devise a scheme of administrative iteration which will invert the matrix without shedding along the way any of the significant interdependences that link together the different sectors of the economy. If, moreover, the Communist planners, by resort to some form of linear programming, can contrive to

[39] Walter Eucken, in his illuminating analysis of German wartime planning [12], supplied an unequivocal answer to our questions—"it cannot be done." Another West German economist, K. P. Hensel, argues that surpluses and deficits in the balances do give a sufficiently exact measure of relative scarcities [19, p. 134]. Hensel's contentions on this point are refuted by Hirsch [20, pp. 25-26].

find more economical input-mixes to achieve their goals, they will be tapping a new potential for increased power and growth.

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