Growth Accounting for the Soviet Manufacturing

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I. Introduction

For this paper we estimate the growth of total factor productivity of the Soviet manufacturing industry for 1958–1971. Since we compile the data for eight branches of the industry, we present the estimations for each of them as well as for the aggregate industry. The major purpose of this paper is to see how the estimates for branch industries are spread and how they have changed over time.

In the following Section II, we examine the data on output, capital stocks and labor force. In Section III, the estimated results are presented. Section IV summarizes our findings.

II. Data of Soviet Manufacturing

For estimation, we compile the annual time series from 1958 to 1971. Since we fail to cover only the fuel, non-ferrous metallurgy, and glass and ceramic industries, we are able to encompass most of the manufacturing industries. They consist of six producer goods industries and two consumer goods industries. Unfortunately, it is not possible to break down the official time-series data into more detailed industry classification.

(1) The data on capital

The "basic fund" and the "material circulation fund" in the official data correspond to the fixed capital and the material working capital, respectively. Both are limited to the capital stocks that are available at individual enterprises. By adding these two figures together, we construct the data on net capital stock in average of each year. The starting point of our construction is the government evaluation of the existing building, equipment and other fixed capitals as of the beginning of 1960. This figure may be interpreted as the value of net fixed capital. The prices prevalent in 1955 are used for the evaluation. For 1961–1972, we construct the net fixed capital stock at the beginning of each year by adding the annual net investment figures in constant (1955) prices to the 1960 capital stock. For 1958–60, we reverse the calculation and subtract the annual net investment from the 1960 stock. Having constructed the time series this way, we then calculate an average between the figures at the beginning and at the end of each year to obtain the annual average stock.

The return to capital in our estimation consists of enterprise profits and turnover taxes. Our profit figures include the amounts the enterprises have paid to the Treasury, but exclude the capital depreciation. We thus rely on the Soviet enterprise accounting data and take the profits before tax and after depreciation.

One may conceive of alternative ways to estimate the return to capital. One method would be simply to take an arbitrary rate of, say, 10% or 15%, and to assume that this rate is uniform across industries and remains constant throughout the period. This method was actually adopted by Moorsteen and Powell(1966), as the data on the enterprise profits were not made public at the time of their research. Although the assumed rate may, perhaps, be taken from a prevailing rate in a capitalist country in a similar stage of economic development, a problem of this method is that the evidence from the Soviet data is entirely lacking to support this rate. Furthermore, the type of a technical improvement presumed is of the Harrod neutral type that makes it possible to sustain the rate of returns to capital and the capital–output ratio at constant levels while increasing the wage rate. This type of technical change may indeed fit in the "stylized facts" of the U. K. and the U. S., but there is no guarantee to assume that it is also adequate to explain the pattern of other countries.

Even more basically, one must question the validity of adjusting the factor prices without simultaneously adjusting the product prices (except the direct adjustment of factor cost). The enterprise accounting in the Soviet official data indeed gives a very high figure for the rate of return to capital. But this may be a mere reflection of the Soviet commodity price structure which is characterized by the low prices for producer goods and the high prices for consumer goods. In other words, one observes the high rate of return because the capital stock is assessed low and the output, particularly that of consumer goods industries, is evaluated at a high price. If this is the case, the rate of return assumed arbitrarily at 10–15% may unduly diminish the profit share in the value–added.

Another approach may be to estimate a production function econometrically and to impute the marginal productivity of capital from the parameter estimates (Weitzman 1970). Although an interesting exercise theoretically, these estimations are not very recommendable from empirical point of view. Regression estimations of neoclassical production functions fitted in the Soviet data usually yield a very low estimate for the elasticity of substitution between capital and labor. Coupled with an increasing capital-labor ratio, the low elasticity of substitution generates a sharp fall of the profit share in the value-added. In light of the empirical estimations so far made available, the imputed profit share declines so sharply that it just defies one's sense of reality.

All the available methods have their own problems. Our method in this article is not immune of fault either. With the lack of market mechanism to allocate the capital for competing firms, the rate of return to capital calculated from the enterprise accounting does not function as a yardstick for this allocation. The profit share for the macro economy, or at least for the whole manufacturing, may still make some sense. But arbitrariness increases as one deals with individual industries, because the allocation of capital between industries is very far from being geared with the interindustrial differential in the return to capital. Deletion of the turnover tax reduces the rate of return and makes it closer to the level prevailing in capitalist economies. But this also has a danger of misjudging the decrease in turnover tax and the concomitant increase in profit as a sign of the improvement of productivity.

(2) **The data on labor**

The labor represents the total working hours of the industrial production personnel. The industrial production personnel is the general term for all wage workers, engineering-technical personnel, salaried employees, and others employed in the industries. The wages in the official data include the money wages as well as the income-in-kind and the bonuses.

They do not represent, however, the wages for a unit of labor service of the same skill, intensity and duration. Substantial differences in wage earning across industries are at least in part due to the inter-industrial differences in working conditions, geographic amenities and skill of an average worker. We correct these shortcomings of data and present the labor expressed in "efficiency units."

To illustrate our process of converting the labor into the one in efficiency units, we start with the difference in productivity due to skill. It is a common practice in the Soviet industry that a worker is ranked by his skill and is placed in either one of six grades. The higher skill group a worker is placed in, the higher wage he earns. And each industry establishes the wage scale with the wage rate in the lowest skill group as unity. In Column 1 of Table 1, we show the average skill level for each industry with number of workers in skill groups as weights. We make use of this wage scale and assume that this reflects the difference in quality of a worker. More specifically, our underlying assumption is that if an industry establishes the wage scale according to which the wage rate for a certain skill group is twice as high as the wage rate for another skill group, for example, then a worker in the former group will be twice as efficient as that of the latter. The wage rate per efficiency unit will thus be the same between these two groups[1].

Even after the employment figures are adjusted by the differences in skill, there still remain substantial differences in basic wage rate between individual industries. The main reason is the differences in disutility of a work involved. As we adjusted the quantity of labor service by skills, we also adjust it by the disutility. For this purpose, we utilize the wage scale proposed by Soviet economists Batkaev and Markov as shown in Column 2 of Table 1. This scale is formulated in order that the wage differentials between industries reflect the differences in working conditions. The scale grades a worker in the first skill group of each industry as against a worker in the same skill group of the local dairy industry. The flow of labor service of the latter is assumed to be unity.

After these adjustments have been made, the labor inputs are now measured in a fairly

Table 1 The Scale of Average Wages

Industry	Due to the Difference in Skill Distribution*	Due to the Difference in Working Conditions** (for the lowest skill group in each industry)	Due to the Combined Effect
Electric Power	1.38	1.170	1.615
Steel	1.96	1.369	2.683
Chemistry	1.57	1.170	1.837
Machinery	1.27	1.170	1.486
Timber, Pulp and Paper	1.33	1.170	1.556
Construction Materials	1.41	1.170	1.650
Light Industry	1.34	1.149	1.540
Food Processing	1.28	1.125	1.440

*The wage rate of the lowest skill group as unity.
**The wage rate of the lowest skill group of the local dairy industry as unity.
Sources: Batkaev and Markov (1964), *Vestnik Statistiki*, 1966, No. 3.

1) Denison (1962, p. 69) assumes that the three-fifths of the income differential arising between people with different education are due to the difference in quality of their work. In our data, however, we do not make a similar assumption that only three-fifths of the wage differential really reflect the difference in quality of work.

homogeneous unit. We multiply the scale in the first column by the one in the second column and obtain the figures in the third column. Using this scale, we convert the annual employment figures into the man-years in efficiency unit. After this conversion has been made, the unit of measurement is not the number of persons, but the labor service of a worker in the lowest skill group of the local dairy industry.

(3) Data on output

We rely on the "sample indexes" which were constructed by Greenslade (1972) on the basis of physical quantities of some 350 products. The Soviet official figure is represented by the gross output index in constant prices. This official index, though more widely used than the sample index, implies an overestimation. The reason is that the enterprise managers are tempted to exaggerate improvement (or to conceal deterioration) in quality of the products and that this practice leads to a downward bias in the product price index and an upward bias in the output index (Becker 1973, 1974). We thus decide to reject the gross output index and use the sample index, although the latter is also beset with some problems. (For example, the products covered by the sample index may be too few. Since the index takes into consideration only the annual changes in "physical" quantities, it may fail to capture the quality improvements.)

The Greenslade indexes are used for the period 1950-68 when they are available. For the remaining 1968–71 period, we estimate the sample indexes by ourselves for the chemical industry and the machinery industry, and link the estimated indexes with the available indexes. The chemistry and the machinery are the industries which exhibit wide disparities between the official gross output series and the sample indexes. For the other industries where the gap is not very wide, we simply take the official series for 1968–71 and link them with the Greenslade series.

As information on the use of intermediate materials is very limited, we are unable to construct the net output series. Since we take the gross figures in the output side, and consider only the primary factors in the input side, we are thus implicitly assuming that the input-output ratios remain constant in so far as the intermediate material inputs are concerned.

As a makeshift device, one could use the value-added figure, deflate it by the product price index (with the gross output as weights) and assume the resultant number as the net output index in constant prices. However, we do not follow this method. In order that this method generate the net output index, it is necessary to meet a restrictive assumption that the price index of intermediate inputs for an industry coincides with the price index of finished products of that industry (Hansen 1974).

III. Estimations of the Growth of Total Factor Productivity

Estimation of the growth of total factor productivity is now a well established procedure for capturing the rate of technical change. With a neoclassical production function and a competitive equilibrium as the underlying assumptions, this procedure calculates the rate of technical change from the previous (T–1$^{\text{th}}$) year to the current (T^{th}) year as a discrete approximation to the Divisia index (Richter 1966; Theil 1967; Jorgenson-Griliches 1967), which is shown by the formula:

$$\rho_T \simeq \ln Q_T - \ln Q_{T-1} - \theta_{KT}(\ln K_T - \ln K_{T-1}) - \theta_{LT}(\ln L_T - \ln L_{T-1})$$

In this formula, ρ, Q, K and L represent the annual rate of technical change, the level of

Table 2 Index of Total Factor Productivity in 1971 (with the 1958 levels as 100)

Industries	Output	Capital	Labor	Combined Factor	Total Factor Productivity
Electric Power	343.01	339.33	194.61	289.51	118.48
Steel	243.41	251.67	136.69	185.87	130.96
Chemistry	319.47	434.93	222.59	323.91	98.63
Machinery	268.00	268.95	173.80	206.23	129.95
Timber, Pulp and Paper	150.66	159.79	99.35	114.22	131.90
Construction Materials	307.79	284.56	144.48	169.16	181.95
Light Industry	197.31	227.03	125.74	202.69	97.34
Food Processing	207.39	214.34	126.41	201.67	102.83

outputs per year, the capital stocks, and the man-hours, respectively. The shares of profits and wages in the value-added, which add up to one, are denoted as θ_K and θ_L. They usually take the arithmetic average of the shares in the previous year and the current year. As the annual technical change is recorded by ρ's, the index of total factor productivity measures their cumulative total from the initial year to the current year, that is

$$I_T = \exp(\textstyle\sum_1{}^T \rho_t)^{2)}.$$

For eight industries of the Soviet manufacturing, we calculate ρ's in the first formula, and then obtain their cumulative total from the initial year 1958 through the terminal year 1971 according to the second formula. The indexes of total factor productivity thus estimated are shown in Table 2. The first three columns give the output index and the two input indexes. In the fourth column, we calculate the cumulation of weighted geometric average of two factor inputs with the weights varying each year. The last column shows the index of total factor productivity.

Comparing the indexes in the fourth column, one is struck with a wide variance of their estimates between industries. In 13 years, four industries (steel, machinery, timber, and construction materials) increase their productivities by 30% or more, whereas a virtual standstill or even a slight retrogression of productivity is observed for three industries (chemistry, light industry, and food processing). In general, the productivity is growing for producer goods industries (the first six industries), while it is stagnant for consumer goods industries (the last two industries). The contrast between producer goods industries and consumer goods industries is noteworthy, particularly because we are using the sample index as our output index. The sample index presents much lower figures than does the official output index for producer goods industries (notably the machinery and the chemistry), but the disparity between the two indexes is not significant for consumer goods industries. This implies that if we had used the official output index instead of the sample index, the difference in the index of total factor productivity between producer goods industries and consumer goods industries would have been even wider.

An interesting question that may deserve attention is whether the high rate of growth of total factor productivity goes together with the high rate of increase in output. One might argue that the economy of scale may well make the two positively correlated, but it is equally conceivable to observe a contrary case where the rising cost caused by a higher rate of output growth leads to a lower rate of productivity improvement.

In Table 2, however, one fails to detect any definitive correlation. In the last three industries (construction materials, light industry, and food processing), the increases in gross output

2) The index in the initial year I_0 is of course treated as unity.

and productivity seem to proceed together, as the growth rate of the construction materials industry is located in a higher range, and the growth rates of the light industry and the food processing are in a lower range both in terms of gross output and factor productivity. However, the chemical industry and the timber industry pose counter examples, as the chemical industry presents a rapid rate of output growth and a slow rate of productivity growth, and the timber industry shows an opposite case.

So far we have seen the growth of factor productivity for the whole period. Let us turn now to the annual growth as shown in Table 3. In order to focus our attention on the time profile, Table 3 presents the figures for more aggregated sectors than for individual industries.

For both producer goods industries and consumer goods industries, the productivities were still increasing at substantial rates in the beginning of 1960's. However, the growth rates started to slow down in 1961–62 and, although a slight recovery was observed in 1964–65, it was not until 1969–70 that the growth process, similar to the one at the beginning of 1960's, resumed.

Before conclusion, we should mention a difficulty which is intrinsic in estimating the index of total factor productivity in the Soviet economy. By now the reader is aware that the estimations in Table 2 and Table 3 are much influenced by the factor shares taken as weights in combining the capital input and the labor input. The underlying assumption to justify this weighting method is the presence of competitive equilibrium and marginal productivity pricing. It goes without saying, however, that the Soviet economy lacks the institution that guarantees the equilibrium. An econometric study by the present author (Toda 1976) indicates that the observed ratio of the capital rental to the wage rate is much too high to reflect the ratio of the marginal productivity of capital to the marginal productivity of labor for the two consumer goods industries and possibly for the chemical industry. This means that the profit share should be reduced and the wage share should be raised to represent more accurately the contribution of the two factors. Once this adjustment is made, the index

Table 3 Aggregate Indexes (with the 1958 level as 100)

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Producer Goods Industries													
(1) Output	109.79	119.99	130.72	142.65	151.48	161.82	173.43	185.32	196.68	207.17	218.18	238.64	257.52
(2) Capital	107.95	117.45	128.36	140.61	154.01	168.26	181.39	193.49	207.29	222.46	238.98	258.14	277.63
(3) Labor	103.78	105.21	109.87	114.86	120.01	124.17	129.60	135.51	140.13	145.08	149.10	151.46	154.94
(4) Combined Inputs	105.15	109.27	115.95	123.28	131.11	138.57	146.52	154.47	162.26	170.89	179.47	187.96	130.65
(5) Total Factor Productivity	104.41	109.81	112.74	115.72	115.54	116.78	118.36	119.97	121.20	121.22	121.56	126.96	130.65
Consumer Goods Industries													
(6) Output	107.95	112.34	118.91	124.73	126.29	132.11	144.75	151.36	161.59	169.78	178.80	191.56	203.23
(7) Capital	107.11	112.87	118.60	125.21	134.62	144.98	157.31	169.53	179.64	188.99	196.05	206.89	219.53
(8) Labor	102.84	100.41	98.18	100.45	100.91	104.55	109.29	113.43	117.73	122.06	124.26	124.62	125.99
(9) Combined Inputs	106.54	111.15	115.61	121.48	129.32	138.48	149.41	160.06	169.03	177.34	183.37	191.77	201.81
(10) Total Factor Productivity	101.33	101.07	102.86	102.68	99.65	95.40	96.88	94.56	95.60	95.71	97.50	99.88	100.70
Total Manufacturing													
(11) Output	108.72	115.61	123.97	132.41	137.13	144.92	157.07	166.02	176.69	185.89	195.77	212.11	227.15
(12) Capital	107.73	116.27	125.85	136.64	149.01	162.27	175.19	187.32	200.17	213.84	227.92	244.94	262.67
(13) Labor	103.50	103.75	106.32	110.48	114.20	118.20	123.43	128.79	133.32	138.08	141.55	143.30	146.13
(14) Combined Inputs	106.31	111.99	118.95	127.17	136.10	145.58	155.33	164.65	173.97	183.83	193.25	203.39	214.33
(15) Total Factor Productivity	102.27	103.23	104.22	104.12	100.75	99.55	101.12	100.83	101.56	101.11	101.30	104.28	105.98

of total factor productivity for consumer goods industries may come closer, though not exactly equal, to the index for producer goods industries.

IV. Summary

The time profile of our data reveals that the growth of total factor productivity of the Soviet industry was retarded since the early 1960's. More recently, however, the industry has somewhat regained the previous growth rate.

The data also exhibit the interindustrial pattern that the total factor productivity grows at a much slower rate for the consumer goods industries than for the producer goods industries. One must be reminded, however, that this pattern greatly depends on the estimation of the factor shares which are used as weights to combine the factor inputs. We presume that as far as the consumer goods industries are concerned, the observed profit share may be an overestimation of the contribution made by capital stocks. If this overestimation is corrected, the estimate of the growth of total factor productivity for the consumer good industries will increase and will come close to the rate for the producer goods industries.

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