Soviet Postwar Economic Growth and Capital-Labor Substitution

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The postwar record of the Soviet economy constitutes a largely unexplored case study for the measurement of aggregate production functions and their application to explaining economic growth. In the Soviet case high growth rates of capital and the absence of business cycles combine to create a relatively rich sample of full employment capital-labor and capital-output ratios. This results in greater statistical power than is typically available in the records of most Western economies for testing the appropriate *form* of an aggregate production function.

Because of weak theoretical underpinnings the aggregate production function at best yields an incomplete or even an ambiguous picture of an economy. The absence of appropriate aggregation theorems notwithstanding, the aggregate approach may be one of the few useful ways of piecing together an overall account of economic growth. It is in this spirit, rather than with misplaced notions of rigor, that aggregate production function identification and applications are undertaken in the present paper.

Granted that the somewhat nebulous concepts of aggregate output, capital, and labor have been fairly represented by the values cited in this paper and that functional forms have been correctly specified, I will argue that aside from a geometric time trend the postwar Soviet growth record is adequately accounted for by a constant elasticity of substitution (*CES*) production function with elasticity of substitution significantly less than one. Such a finding has certain implications for past and future Soviet growth, some of which are discussed. Results of a few alternative specifications are reported. Where they are relevant, some comparisons are made with the record of *U.S.* postwar economic growth.

I. *Basic Facts of Soviet Postwar Growth*

The primary series utilized in this study is displayed in Table 1. The estimates are for "industry" (mining, manufacturing, power) from 1950 to 1969 and rely directly on Soviet data. An industrial output index is obtained by aggregating official Soviet constant price gross value of output series for industrial sectors, using synthetic 1960 value-added weights. Official Soviet figures on "industrial productive basic funds" (July 1, 1955 prices) form the index of gross fixed industrial capital stock. Industrial man-hours worked forms the labor series.

Mainly to test the invariance of results with respect to somewhat different indexes, a series which is primarily of Western origin was also examined. Table 2 presents estimates of output, fixed capital services (gross), and man-hours worked for the nonagricultural nonservice economy (industry, construction, transportation and

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TABLE 1—INDEXES OF OUTPUT, CAPITAL, AND LABOR FOR SOVIET INDUSTRY, 1950–69

(Mining, Manufacturing, Power—Direct Soviet Sources, 1960=100)

Year	Y	g_Y[b]	K	g_K[b]	L	g_L[b]
1950	33.15		33.77		79.92	
1951	38.20	15.2	37.59	11.3	84.52	5.8
1952	42.56	11.4	42.35	12.6	87.60	3.7
1953	47.35	11.3	46.96	10.9	91.41	4.3
1954	53.46	12.9	52.18	11.1	95.83	4.8
1955	60.34	12.9	58.64	12.4	97.61	1.9
1956	66.33	9.9	65.64	11.9	96.32	−1.3
1957	73.01	10.1	72.50	10.5	96.60	.3
1958	81.29	11.3	80.45	11.0	99.14	2.6
1959	90.56	11.4	89.67	11.5	100.66	1.5
1960	100.00	10.4	100.00	11.5	100.00	− .7
1961	109.56	9.6	111.59	11.6	99.54	− .5
1962	120.27	9.8	123.93	11.1	102.81	3.3
1963	131.21	9.1	138.10	11.4	106.44	3.5
1964	141.78	8.1	154.31	11.7	110.91	4.2
1965	153.41	8.2	170.42	10.4	115.65	4.3
1966	167.09	8.9	186.13	9.2	118.66	2.6
1967	183.65	9.9	201.73	8.4	122.55	3.3
1968	199.91	8.9	217.68	7.9	126.62	3.3
1969[a]	215.2	7.6	235.1	8.0	130.6	3.1

[a] Preliminary.
[b] Annual percentage rate of growth.

TABLE 2—INDEXES OF OUTPUT, CAPITAL, AND LABOR FOR THE SOVIET UNION, 1950–66

(Aggregated Industry, Construction, Transportation and Communications, and Distribution—Western Estimates, 1960=100)

Year	Y	g_Y[a]	K	g_K[a]	L	g_L[a]
1950	38.84		37.87		80.79	
1951	43.66	12.4	41.35	9.2	84.51	4.6
1952	47.47	8.7	45.13	9.2	87.09	3.1
1953	51.99	9.5	49.39	9.4	89.71	3.0
1954	57.80	11.2	54.30	9.9	93.87	4.6
1955	64.36	11.3	59.93	10.4	95.47	1.7
1956	70.26	9.2	66.55	11.0	93.65	−1.9
1957	77.60	10.4	73.93	11.1	94.50	.9
1958	84.71	9.7	81.86	10.7	98.10	3.8
1959	92.38	9.1	90.51	10.6	100.88	2.8
1960	100.00	8.2	100.00	10.5	100.00	− .9
1961	107.54	7.5	110.49	10.5	98.73	−1.3
1962	115.51	7.4	121.96	10.4	100.96	2.3
1963	122.76	6.3	134.22	10.1	103.87	2.9
1964	131.12	6.8	147.33	9.8	108.01	4.0
1965	141.96	8.3	161.27	9.5	112.38	4.0
1966	151.97	7.1	175.86	9.0	114.90	2.2

[a] Annual percentage rate of growth.

communications, and distribution) over the years 1950–66. Because the highly aggregated investment data of R. H. Moorsteen and R. P. Powell (1966, 1968) underlie the capital stock series of Table 2, I was forced to include all activities of the nonagricultural economy consistent with the principle of excluding service outputs which are measured directly in terms of factor inputs (like education or housing). The output series is aggregated over indexes of Western origin using synthetic 1956 value-added weights. Capital services are built up out of constant-price investment data.

A more detailed description of the data sources is reserved for the Appendix.[1] Having experimented with a variety of output indices (with various price bases, diverse interest rates, different imputations for value-added weights, etc.) and alternative measures of capital, I can report that results are not much changed. Limitations of space preclude a more detailed report of the alternatives, but there is not much difference.[2] The two series presented here were selected for their contrasting coverage and somewhat different origins. The first one is considered to be of primary interest because the scope is limited to industry, coverage is believed more accurate, and it extends over more years. Where not otherwise noted, specific regression results will refer to data from the first series, although in all cases I have checked that similar conclusions hold for the second set of data also.

Both series show similar trends. The rate of growth of output apparently has declined somewhat over time. Capital

[1] The Appendix is limited to explaining the origins of the primary series of Table 1. Derivation of the Table 2 indexes is discussed in the appendix of my discussion paper of 1968.

[2] Most of the difference shows up in the form of a slightly altered estimate of the rate of growth of technical change. Estimates of the other parameters remain about the same.

grows in a steady manner, also decelerating toward the end of the period. Manhours employed grows erratically. The low growth rates of labor from 1956 to 1960 are mostly due to the reduction of the length of the work week. The growth of the labor force is curtailed in the early 1960's as a result of sharply lower wartime births. Capital-output ratios remain roughly constant or decline slightly up to the mid 1950's but rise more or less steadily thereafter. The trend of an increasing capital-output ratio would be more sharply established if one could expunge the effects of technical change from output.[3]

II. *Explanations of Soviet Growth*

The observation that a retardation in output growth has taken place without a slowdown of the same magnitude in the growth of inputs has been the starting point for several discussions of the residual's somewhat paradoxical behavior.[4] When output is divided by a (usually geometrically) weighted index of inputs, it is discovered that the growth of total factor productivity, while volatile from year to year, has declined over the long run. Of course the magnitude of productivity growth is influenced by the choice of factor weights, but almost no matter what figures are used, growth of the residual seems to decline over time. By process of elimination output deceleration is implicitly attributed to the stalled growth of efficiency, technical change, or whatever else is believed to stand behind the residual.[5]

It is important to bear in mind that this approach relies on what in effect are some hidden assumptions about the aggregate production function. Basically it is presumed that the expression

$$Y(t) = A(t)F[K(t), L(t)] \tag{1}$$

is a serviceable approximation relating aggregate output Y to aggregate capital K and labor L at time t. In order to get at the unknown residual $A(t)$, the form of F is explicitly postulated, usually to be a Cobb-Douglas production function with prescribed weights. In this paper an alternative specification is emphasized.

III. *Role of the Elasticity of Substitution in Explaining Soviet Growth*

A widely accepted measure of the ease with which K and L can be substituted for one another is the elasticity of substitution, σ, which is defined as follows when the production function is homogeneous of the first degree:

[3] Detrended capital-output and labor-output ratios for industry are calculated in the first two columns of Table 3 with $\hat{\lambda}$, the growth of technology, equal to approximately 2 percent per year.

[4] See, e.g., Bela Balassa, Norman Kaplan, Moorsteen and Powell (1966, 1968), and J. H. Noren.

[5] As an explanation for the decreased growth of the residual, Moorsteen and Powell stress the notion that after 1953, productivity at first rose very rapidly while the economy broke away from the "rigidities and irrationalities" of Stalinism. However, ". . . by the late 1950's the more manageable inefficiencies of the economy had been largely remedied, and resistance to further movement toward the frontier, at least within existing institutional arrangements, had become severe" (Moorsteen and Powell 1968, p. 9). Kaplan (p. 302) emphasizes possible post-1958 declines in organizational efficiency due to the increased complexity of resource allocation. These arguments may well contain important elements of truth. However such strongly declining growth rates of $A(t)$ as result from specifying $F[K, L]$ as Cobb-Douglas with assigned factor weights strike me as unlikely. First of all, technological progress is at least partially a result of research and development, which is best thought of as a round-about method of production typically favored as capital becomes more plentiful and real rates of return decline. Also, the Soviet literature has been paying steadily increasing attention to questions of efficiency since the mid-1950's. Whether this is reflected in practice is difficult to say, but the ideas of Liberman, Kantorovich and others would appear to have influenced economic policy to a certain degree, especially lately. These considerations would appear to justify an *increase* in the growth of technical change over the period of the 1950's and '60's. Unfortunately, the sad truth must be that we really have no good independent information on this question.

$$\sigma \equiv \frac{\frac{\partial F}{\partial L}\frac{\partial F}{\partial K}}{F\frac{\partial^2 F}{\partial K \partial L}}$$

A 1 percent change in the ratio of prices or in the marginal rate of substitution between capital and labor is associated with a σ percent change of factor ratios in the opposite direction. As is well known, a production function additive in the two factors has an infinite elasticity of substitution, the Cobb-Douglas has unit elasticity, and a fixed coefficients production function has zero elasticity of substitution.

Because there is a basic identification problem in distinguishing between $A(t)$ and $F[K, L]$, a unit elasticity of substitution production function and $A(t)$ declining in growth over time is not the only way of explaining the Soviet growth record.[6] If the elasticity of substitution for the function $F[K, L]$ were of the appropriate magnitude (it would have to be less than one), a slowdown in the growth of output could be accomodated with both exponential growth of A and with the capital and labor series presented.

This is most easily seen by differentiating (1) and dividing by Y to obtain

$$g_Y = g_A + \eta_K g_K + \eta_L g_L \tag{2}$$

The rates of growth of Y, A, K, L are denoted, respectively, by g_Y, g_A, g_K, g_L. Also

$$\eta_K \equiv \frac{K\frac{\partial Y}{\partial K}}{Y} = \frac{K\frac{\partial F}{\partial K}}{F}$$

and

$$\eta_L \equiv \frac{L\frac{\partial Y}{\partial L}}{Y} = \frac{L\frac{\partial F}{\partial L}}{F}$$

are the imputed competitive shares of capital and labor. Note that if $F[K, L]$ exhibits constant returns to scale, as we shall assume, then $\eta_K + \eta_L = 1$.

So long as the elasticity of substitution were less than unity, the condition $g_K > g_L$ would imply that η_L would increase over time, and η_K would decline.[7] It follows that g_Y would tend to decline over time due to the increasingly heavy weight of the slower g_L. This is in contrast with the Cobb-Douglas function where the factor share weights remain constant. Such an effect might be quite pronounced in the Soviet case because g_K is very high relative to g_L.

For the purposes of this paper, it is useful to think of the elasticity of substitution as a measure of the rate at which diminishing returns sets in as one factor is increased *relative* to the other. A less than unit elasticity of substitution implies eventual difficulty in increasing output by primarily incrementing one factor, because diminishing returns set in strongly and rapidly. Such a situation would have special relevance for the Soviet case because capital has grown so fast relative to labor.

[6] For a more explicit discussion of this point, see Marc Nerlove who also presents some interesting survey material on empirical measurement of the *CES* function.

[7] Proof: Let $k \equiv K/L$, and $f(k) \equiv F[K/L, 1]$. Then

$$\sigma = \frac{-f'(f - kf')}{kff''}, \quad \text{and} \quad \eta_L = \frac{f - kf'}{f}$$

(assuming constant returns to scale). Differentiating η_L,

$$\frac{d\eta_L}{dk} = \frac{-kf''}{f} - \frac{(f - kf')f'}{f^2}$$
$$= \frac{-kf''}{f}\left(1 + \frac{f'(f - kf')}{kff''}\right) \gtreqless 0$$

according as $\sigma \lesseqgtr 1$. Naturally η_K $(=1-\eta_L)$ moves in a direction opposite to that of η_L.

IV. *Fitting a CES Production Function*

Because it is not possible to identify both $A(t)$ and $F[K, L]$, one cannot proceed further without assuming explicit functional forms. For reasons that will become clear, the constant elasticity of substitution (*CES*) production function was thought to be a superior specification for the production side.[8] This production function can be written in the form

$$(3) \qquad F[K, L] = \gamma[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-1/\rho}$$

with $\sigma = 1/(1+\rho)$ the (constant) elasticity of substitution.

On the side of the residual, I can hope that Hicks neutral disembodied exponential technical change

$$(4) \qquad A(t) = e^{\lambda t}$$

is not too bad a description of reality.[9]

It goes without saying that I have no good a priori reasons for believing in this specification over and above some reasonable alternatives. A few other specifications were also tried, and some of these will be reported. But in the final analysis the relatively simple form

$$(5) \qquad Y(t) = \gamma e^{\lambda t}[\delta K(t)^{-\rho} + (1-\delta)L(t)^{-\rho}]^{-1/\rho}$$

$$\rho = \frac{1-\sigma}{\sigma}$$

was felt to explain the data as well as any other expression tested, and better than most.

Because (5) is non-linear in the parameters, identification is often accomplished by utilizing factor price data to estimate a linear form. For example, under perfect competition the relevant parameters can be estimated by regressing the *log* of labor productivity on the *log* of wages and on time. Personally, an aggregate production function has always impressed me as being a tenuous enough concept even without depending for its measurement on first derivatives and a marginal productivity theory of distribution. At any rate, this is out of the question as a meaningful alternative for the present model. Instead, equation (5) was estimated directly by using a non-linear regression program which chose parameter values to minimize the sum of squared logarithmic residuals,[10] defined as

$$\Phi = \sum_t \left\{ \log Y(t) - \left[\log \gamma + \lambda t + \frac{\sigma}{\sigma - 1} \log(\delta K(t)^{-\rho} + (1-\delta)L(t)^{-\rho}) \right] \right\}^2,$$

$$\rho \equiv \frac{1-\sigma}{\sigma}$$

A logarithmic form was chosen because it seems sensible to assume a multiplicative error term in (5).

Results for the data of Table 1 (industry—direct Soviet sources, 1950–69) are[11]

[8] See Kenneth Arrow, et al.

[9] From here on I use the terms "residual," "total factor productivity," "technical change," and "technological progress" interchangeably. Residual is really the best term because it most aptly conveys the notion that what is being identified is *any* contribution to growth other than capital and labor as conventionally measured and combined subject to constant returns to scale.

[10] The I.B.M. Share program 309401 (revised 8/15/66) entitled "Least Squares Estimates of Non-Linear Parameters" was used. It is based on an algorithm devised by D. W. Marquardt. While this algorithm can at best obtain only a *local* minimum, converging to the same parameter values with different initial estimates makes me confident that the estimates given here in fact globally minimize the error sum of squared residuals. If the multiplicative errors associated with (5) are independently identically distributed log normal random variables with mean one, the parameter values chosen to minimize the sum of squared logarithmic residuals will also be maximum likelihood estimates.

[11] Numbers in parentheses denote the standard errors of the coefficients to a linearized regression about the optimal parameter values. Let the non-linear model be expressed in the general form $Z = g(X, \beta) + \epsilon$ with ϵ assumed normally distributed, Z dependent and

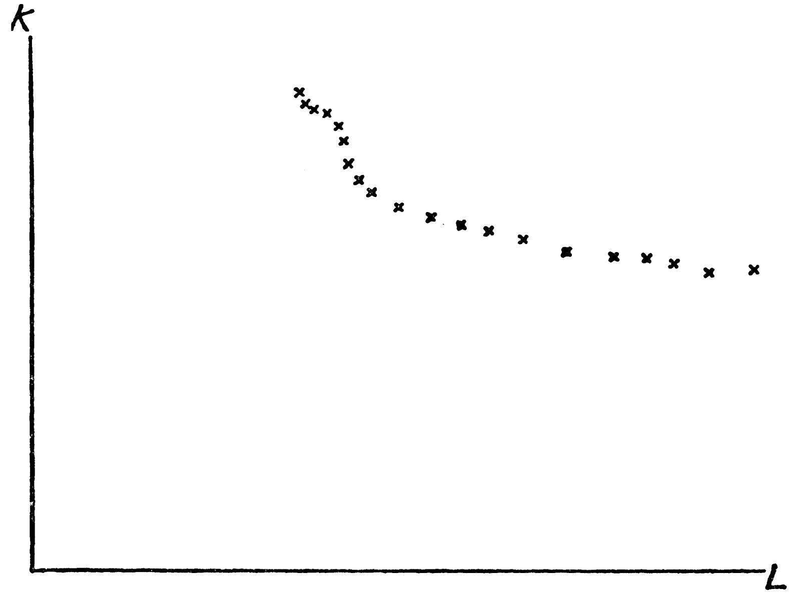

FIGURE 1. PRODUCTION ISOQUANT FOR SOVIET INDUSTRY, 1950–1969.

$$\hat{\sigma} = .403 \quad \hat{\lambda} = .0205$$
$$(.030) \quad (.0053)$$

$$\hat{\delta} = .639 \quad \hat{\gamma} = .804 \quad \bar{R}^2 = .9995$$
$$(.070) \quad (.044)$$

The outcome of this regression[12] can be interpreted to mean that given the specification (5), an elasticity of substitution significantly less than one has an important

X independent observations and β parameters. Let $\hat{\beta}$ be the minimizer of $\|Z-g(X, \beta)\|^2$. Standard errors reported are those of the least squares estimator of β in the linear regression model

$$Z = g(X, \hat{\beta}) + B(\beta - \hat{\beta}) + \omega,$$

ω normally distributed and $B = \partial g/\partial\beta|_{x,\hat{\beta}}$. The least squares estimate of β is $\hat{\beta}$. Standard errors so obtained, i.e., the diagonal terms of the matrix $[B^TB]^{-1}$, are valid only asymptotically as the sample size goes to infinity, or as the function g is close to being an inner product in X and β. I have looked into the accuracy of this approximation for parameters σ and λ by moving out two standard errors in both directions and ascertaining the increase in mean square error after subminimizing the error sum of squares over all possible values of the free parameters. The increase in mean square error was close to that predicted by the linearized model. Even the properties of this more refined test are large sample as far as using an F-statistic is concerned. With the present state of non-linear estimation theory there does not seem to be a more feasible alternative to assuming with tongue in cheek that large sample properties can be used in this case for hypothesis testing. As usual, $\bar{R}^2$ denotes the percentage variance explained by the (non-linear) regression, corrected for degrees of freedom. The Durbin-Watson statistic for this regression was $d = .81$. The low value of d was at first considered disturbing and the regression was rerun in weighted first differences to investigate a possible first-order autoregressive error. The coefficient point estimates and linearized standard errors hardly changed no matter what weights were chosen. The d statistic did not appreciably improve either. My tentative conclusion is that the low value of d coupled with a very high value of $\bar{R}^2$ indicates more the difficulty of parametric curve fitting than the presence of stochastic autocorrelation per se. It is a frequent tale in the folklore of empirical curve fitting that a very tight fit is often associated with a poor Durbin-Watson statistic. In this particular case the low value of d is due primaily to unexplained poor economic performance in the immediate pre-reform years 1964–66 rather than to the strong presence of autocorrelation throughout the postwar period. In any event, the reported linearized standard errors should be interpreted with even more caution than they otherwise might be.

[12] Results for the data of Table 2 (industry, construction, transportation and communications, distribution—Western estimates, 1950–66) were similar. They are:

role to play in explaining the postwar pattern of Soviet growth. To see this graphically, a scatter diagram of the implied industry production isoquant after technical change has been detrended from output is presented in Figure 1. The data are from the first two columns of Table 3. For each year (1950=0), values of

$$\frac{K(t)}{Y(t)e^{-\hat{\lambda}t}} \quad \text{and} \quad \frac{L(t)}{Y(t)e^{-\hat{\lambda}t}}$$

are plotted, with $\hat{\lambda}$ the least squares estimate of λ. The scatter isoquant of Figure 1 reveals the presence of significant diminishing returns.

TABLE 3—DETRENDED CAPITAL-OUTPUT AND LABOR-OUTPUT RATIOS AND THE IMPUTED SHARES OF CAPITAL AND LABOR FOR SOVIET INDUSTRY

Year	$\frac{K(t)}{Y(t)\, e^{-\hat{\lambda}t}}$	$\frac{L(t)}{Y(t)\, e^{-\hat{\lambda}t}}$	$\eta_K(t)$[a]	$\eta_L(t)$[a]
1950	1.018	2.411	86	14
1951	1.005	2.259	88	15
1952	1.037	2.144	84	16
1953	1.055	2.053	82	17
1954	1.059	1.946	81	19
1955	1.077	1.792	79	21
1956	1.119	1.642	75	24
1957	1.146	1.527	72	27
1958	1.166	1.437	70	29
1959	1.191	1.337	68	32
1960	1.227	1.227	65	37
1961	1.276	1.138	62	41
1962	1.318	1.093	59	44
1963	1.374	1.059	55	46
1964	1.450	1.042	51	47
1965	1.511	1.025	48	48
1966	1.546	.986	46	51
1967	1.556	.945	46	54
1968	1.575	.916	45	57
1969	1.612	.896	44	59

[a] Percent.

fn. 12 ctd.

$$\hat{\sigma} = .274 \quad \hat{\lambda} = .0134 \quad \hat{\delta} = .587 \quad \hat{\gamma} = .875$$
$$(.018) \quad (.0029) \quad (.041) \quad (.026)$$
$$\bar{R}^2 = .9998 \quad d = 1.78$$

Some of the difference in estimates is due to unequal time coverage—cf Figure 1 without the last three years.

It can be shown that for the *CES* type production function (5),

$$\eta_K(t) \equiv \frac{K \dfrac{\partial Y}{\partial K}}{Y} = \delta\gamma^{-\rho}e^{-\lambda\rho t}\left(\frac{Y(t)}{K(t)}\right)^{\rho},$$

and

$$\eta_L(t) \equiv \frac{L \dfrac{\partial Y}{\partial L}}{Y} = (1 - \delta)\gamma^{-\rho}e^{-\lambda\rho t}\left(\frac{Y(t)}{L(t)}\right)^{\rho},$$

where $\rho \equiv (1-\sigma)/\sigma$. The implied time-series of imputed factor shares for industry is shown in the last two columns of Table 3. Note that the sum $\eta_K(t)+\eta_L(t)$ fails to add up to exactly one because of the error term in the specification (5). In 1950 a 10 percent increase in capital would have increased output by almost 9 percent but by 1969 the output response has dropped to nearly 4 percent. Such results help to quantify a significant transformation of the Soviet economy from a near labor surplus situation in the early 1950's to a position now where labor scarcity is an important fact of economic life.

V. *Some Alternative Specifications*

This section tests the appropriateness of the *CES* production function with disembodied exponential Hicks neutral technical change against some alternative specifications. In all cases we use as the test statistic for a more restricted hypothesis the percentage increase in the error sum of squares (corrected for degrees of freedom) after reminimization under the more restricted hypothesis. This statistic will be asymptotically distributed as an F-statistic when the sample size is sufficiently large. Somewhat arbitrarily, we use the 95 percent confidence level as our cutoff point.[13]

Forcing $\sigma=1$ in (5) yields the more restricted hypothesis of a Cobb-Douglas type production relation

$$(6) \qquad Y = \gamma e^{\lambda t} K^{\delta} L^{1-\delta}$$

The error sum of squares (*ESS*) increases by 374 percent, easily rejecting the specification (6) at the 95 percent confidence level. This result was anticipated by our remarks about the strong curvature of the scatter isoquant in Figure 1.

In an effort to test for a systematic decrease in the rate of growth of the residual, the model

$$(7) \quad Y = \gamma e^{\lambda t + l t^2}[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-1/\rho}$$

was examined. The rate of growth of the residual, $\dot{A}/A$, is $\lambda + 2lt$ which would decrease over time provided l were negative. The model (7) is one particular parametrization for testing the more usual explanation of the slowdown of the Soviet economy in terms of a decreasing growth rate of the residual.

The more restricted hypothesis $l=0$, which reduces (7) to (5), increases the *ESS* by 22 percent. At the 95 percent confidence level, we cannot reject the hypothesis that (5) is the true functional form. On the other hand, the more restricted hypothesis $\sigma=1$ increases the *ESS* by 89 percent, rejecting by a large margin at the 95 percent confidence level the hypothesis that

$$Y = \gamma e^{\lambda t + l t^2} K^{\delta} L^{1-\delta}$$

is the true functional form. Thus, we are inclined to say that (5) offers a better explanation of the data than does the more usual explanation in terms of a Cobb-Douglas production function with decreasing growth of the residual (at least with a residual of the form $A(t) = e^{\lambda t + l t^2}$.

Also tested in an effort to probe the appropriateness of specification (5) were the following three models: (i) two separate rates of factor augmenting disembodied technical change—labor augmenting at rate λ_1 and capital augmenting at rate λ_2; (ii) uniform returns to scale in which the right-hand side of (5) is raised to the power μ; (iii) variable elasticity of substitution of the form $\sigma = \sigma_0 + \sigma_1 t$. In all three cases the more restricted hypothesis that (5) is the true functional form could not be rejected at the 95 percent confidence level.[14]

VI. *A Few Comparisons with the American Economy*

In order to compare the results obtained here with those for the *U.S.* economy, a direct estimate of a production function of the form (5) for American manufacturing data was made.[15] (I have also included a multiplicative term of the form $e^{\theta U}$, U = unemployment, θ = a parameter to be estimated, for some of the regressions). Although the data covered the years 1919 to 1967, various subperiods were also tried (especially 1950–67), and runs were made omitting recession years and/or war years.

[13] Let n be the number of observations and k the number of coefficients to be estimated under the hypothesized functional form H. Let H' be the more restricted hypothesis that the i^{th} coefficient β^i equals $\bar{\beta}_i$. Let *ESS* be the error sum of squares. The statistic

$$\psi \equiv (n-k)\frac{ESS_{H'} - ESS_H}{ESS_H}$$

will be asymptotically distributed as an F-statistic with (1, n-k) degrees of freedom. We fail to reject H' if ψ is below the upper 5 percent point of $F_{1,\,n-k}$. The proposed F-test is equivalent to a likelihood ratio test.

[14] The existence of embodied capital augmenting technical change was also examined. Results were disappointing because the reduction in the *ESS* was insignificant. For details, see Weitzman.

[15] The coverage of the American and Soviet data are not entirely comparable. Soviet industry includes power, mining, fishing, and logging, all of which are excluded from *U.S.* manufacturing. The capital series are from Robert Gordon, updated by Commerce figures. Output is from Gordon, based on Kendrick's and *O.B.E.* data, and updated by the latter. The labor series is man-hours worked in manufacturing, *B.L.S.*, based on establishment data. Unemployment rate is from *O.B.E.* data.

The general picture which emerged did not seem to be terribly dependent upon which permutation of *ad hoc* adjustments was used.

Even the best fits were generally worse than in the Soviet case (standard errors about three times as large.) This is undoubtedly largely due to the much greater stochastic element in *U.S.* production because business cycles cause capacity utilization to vary a great deal. It may also be due, at least in part, to the relatively more important role of technical change. This role, it might be reasonable to assume, is probably one of the most poorly specified parts of the production function model. One might suspect that a model reflecting a situation with greater growth of technical change relative to output growth would inherently possess greater output variance because much of the "error" could be due to the undetected swings of technical change, now much wider, in an unobserved variable merely assumed to grow smoothly over time.

Estimates of λ were uniformly close to each other in every regression (about 2.3 percent per year with standard errors of only about .2 percent). However, the elasticity of substitution has such a large asymptotic standard error that it looked as if it could easily have been anywhere between 0 and 1.5. This was partially verified by directly fixing a few values of σ and subminimizing the error sum of squares. Thus, for example, $\sigma=.3$ gave as good a fit as $\sigma=1$. It was also observed in a scatter diagram analogous to Figure 1 that the hoped for "isoquant" really looked more like the interior of an ellipse. There is simply too much autocorrelation (and too high a standard error) in the *U.S.* data to be able to pull out even a reasonably precise estimate of the elasticity of substitution, at least by the methods employed here. If capital and labor grow at comparable rates, the growth of output is not much affected by the elasticity of substitution, which can hardly be expected to be measured with precision in such situations. The Soviet case, with its greater variety of input configurations and less erratic growth record affords a much better experiment for measuring a second-order parameter of curvature like the elasticity of substitution.

It is instructive to ask why the Soviet economy has exhibited a slowdown while nothing comparable has occurred in the *U.S.* economy. This is undoubtedly a question deserving of fuller study, but in the spirit of the analysis carried out here several answers suggest themselves. Although no statistical evidence could be found one way or another, the *U.S.* elasticity of substitution may well be greater than the Soviet, so there is little to explain along the lines of the argument that diminishing returns should have caused a slowdown. Or, technical change in the United States may really be labor augmenting. However, even if these differences and several others did not exist, there would still remain important contrasts between the two economies. In Equation (1), λ is such a larger percentage of g_Y in the American case that the overall effect of changes in η_K (or η_L) on output are reduced. Furthermore the American capital-labor ratio grows so much slower relative to the Soviet that changes in η_K and η_L would tend to be much more gradual.

As a matter of fact, in situations where capital does not grow appreciably faster than labor, little is to be gained by going over from the Cobb-Douglas to the *CES* model because the drag due to even a low elasticity of substitution would be minimal.[16] A major finding of the present paper is that this is not the appropriate case for the Soviet postwar economy.

[16] See Richard Nelson who carried out a Taylor series expansion of a *CES* function in order to demonstrate this conclusion.

VII. *Conclusion*

Data on Soviet industrial output, capital, and labor have a distinct air of diminishing returns about them. This is clearly visible in the detrended isoquant scatter diagram of Figure 1. Given the structure which was imposed by equation (5), the regression results point to an identifiable elasticity of substitution which is significantly less than one. The rate of growth of technical change, estimated at about 2 percent per year, is respectable if not spectacular by world standards.

What kind of story is told by these findings? Accounting for somewhere around 15 to 25 percent of average output increases, technical change is not nearly so significant a determinant of economic growth as in some other economies. The Soviet postwar record looks very much like a classical model of economic growth with high rates of capital accumulation serving as the prime mover.

A low elasticity of substitution makes labor look in the early 1950's as if it were practically surplus, output going up almost proportionally with capital. By the late 1960's this is no longer the case, as is obvious from the tabulations of η_K and η_L in Table 3. By this time a low elasticity of substitution seems to imply that capital accumulation has outstripped labor growth by a wide enough margin that the drag due to diminishing returns is significantly cutting into output growth. In the mature Soviet economy, labor scarcity appears to be a reality.[17] We again stress that the present emphasis on diminishing returns is very different from the somewhat more usual factor productivity approach. In that story the sharply diminished growth of factor productivity usually emerges as the main reason for the Soviet slowdown.

Having come this far with a *CES* model, there is a great temptation to speculate on the implications for future Soviet growth. Unfortunately, there has to be a wide margin of error associated with even short-run projections of this type. But *if* Soviet industry is accurately described by the aggregate production function (5), *if* the parameter values have been accurately identified, and *if* they do not change very much in the near future, then it would appear that a strategy of strong capital accumulation must be considerably less successful for the present relatively mature Soviet economy than for its labor surplus predecessor.

Although a continuation on the same scale of a strategy of capital deepening can still yield growth rates which are high by Western standards, the days of relying almost exclusively on capital formation for producing 10 to 15 percent annual increases in industrial output would appear to be over.[18] Instead of capital, labor and technical change will have to be increasingly relied upon as alternative sources of future economic growth.

Labor is more important these days because the great past accumulations of capital have combined with a sufficiently low elasticity of substitution to increase its marginal product dramatically. But can the growth of man-hours be stepped up? Probably not. Demographers estimate that the growth of the working age population will not increase in the near future.[19] Nor can industrial laborers be so easily drawn out of agriculture as they might have been in the past. It seems safe to say that the growth of the industrial labor force cannot

[17] A. Nove (p. 167) believes it a fair current generalization to say that "the period of labor abundance is drawing to a close." He goes on to cite Strumilin, who attributes the new interest of Soviet economists in obsolescence (a concept whose very applicability to the U.S.S.R. was denied before 1955) to the change in the relative scarcities of capital and labor.

[18] In any case, it does not appear likely that the previous scale of capital accumulation will be kept up, since the rate of growth of capital has slackened lately.

[19] See, e.g., M. Feshbach, pp. 713–14.

in the near future rise significantly above what it has averaged in the past five years.

This rests the spotlight, finally, on technical change. If the Soviets want to continue high rates of growth into the future, they will have to encourage more actively the residual element.[20] In terms of equation (2), the most appealing way of raising g_Y is now to increase $g_A(=\lambda)$ because g_L is more or less fixed and the low (relative to the past) current value of η_K now dampens the effects of large g_K. With increased λ, the Soviet growth scenario would resemble a little more closely the contemporary expansion of Japan and a few Western countries. The distinctive feature of high rates of growth of capital and output would likely remain but technical change would be doing more of the pushing.

This line of reasoning opens up some fascinating, if highly speculative issues. For example, there has always been a suspicion that Soviet emphasis on yearly, quarterly, and monthly plan fulfillment leads to a fear of uncertainty which has discouraged innovation on the local level. Does this mean that a greater degree of local autonomy on issues related to innovation and risk taking would help increase growth of the residual? More generally, what economic changes, if any, might be needed to coax out increased rates of technical progress? With their demonstrated commitment to rapid economic growth, the Soviet leaders may well continue their recent policy of hammering out those pragmatic organizational compromises considered necessary to secure future growth.[21] If so, the question of what administrative structure would be most conducive to stepped up technical change looms as an important one for Soviet economic society.

Appendix

Data Sources and Compilation

The purpose of this Appendix is to explain in some detail compilation of the labor, capital, and output series for Soviet industry which appear in Table 1. Limitations of space preclude a similar treatment of the data of Table 2, but the interested reader will find an account in the appendix of Weitzman.

Almost all of the raw data is obtained from Soviet statistical handbooks. As is to be expected, figures appearing in one year are sometimes later revised, typically by an insignificant percentage. The general principle followed here is that data from the more recent publication takes precedence in cases of duplication. When a date is associated with the annual *Narkhoz* (*Narodnoe Khoziastvo SSSR*) or *Tsifrakh* (*SSSR v Tsifrakh*) volumes, it always specifies the date to which the yearbook pertains, *not* the date of publication (which is almost always the following year).

The starting date for the present study was not made earlier than 1950 to be sure of not getting involved with the erratic postwar recovery. By 1950 industry was producing at well above prewar output levels.

Labor

The industrial man-hours per year series of Table 4 forms the labor input index of Table 1. For each year it is calculated as the product of the number of industrial

[20] It is at this point that our ignorance of what constitutes the residual becomes really annoying. What is it that should be pushed—increasing returns, labor skills, new inventions, optimal use of resources, better organization, or what? Naturally, I evade the issue. A few courageous researchers have tried to make a more specific breakdown of the residual (see, e.g., E. R. Brubaker). Their approach is suggestive, but an overpowering amount of *ad hoc* calculation is sometimes involved in cooking up the relevant figures.

[21] I am thinking mostly of the "New Economic System." The main emphasis of this reform has been on increased efficiency in combining resources and on the quality of production. This is likely to result in change of the static once-and-for-all variety which does not really get at the issue of increasing the residual over time. Effects of this reform can be read (or is it our imagination?) in some of the "wiggles" of the Figure 1 isoquant.

workers and personnel with the average number of days worked per year with the average length of the working day.

The number of industrial workers and personnel is based on a new series which appeared with the 1968 *Narkhoz* (p. 548) and differed slightly in coverage from the series presented in previous yearbooks. Only the years 1960 and 1965–68 were covered in the '68 *Narkhoz*. Fortunately Murray Feshbach was kind enough to provide me with the complete new series from 1958 to 1968 inclusive (this series will be cited in a forthcoming Joint Economic Committee study on the U.S.S.R.). In 1958 the difference between the "new" and the "old" series is .86 of one percent, and it is undoubtedly less for earlier years. I have taken the difference between the new and the old series in 1958 (181,000) and reduced it by a multiplicative factor of 2/3 for each year preceding 1958, adding the result to the old series of *Trud v SSSR* (p. 81). The 2/3 factor is the ratio of the 1958 to 1959 differences between new and old figures. It would make very little difference if almost any other reasonable method of extrapolation were used, since the differences are so insignificant before 1958.

TABLE 4—MAN-HOURS WORKED PER YEAR IN SOVIET INDUSTRY

Year	Industrial Workers and Personnel (millions)	Average Number of Days Worked Per Year	Average Length of Working Day (hours)	Industrial Man-Hours Per Year (billions)
1950	15.324	276.3	7.96	33.703
1951	16.241	275.7	7.96	35.642
1952	16.889	274.8	7.96	36.943
1953	17.641	274.5	7.96	38.546
1954	18.535	273.9	7.96	40.411
1955	18.922	273.3	7.96	41.164
1956	19.641	272.1	7.6	40.617
1957	20.312	267.4	7.5	40.736
1958	20.988	268.0	7.433	41.809
1959	21.670	266.5	7.35	42.447
1960	22.620	266.9	6.985	42.170
1961	23.820	264.2	6.67	41.976
1962	24.677	263.4	6.67	43.355
1963	25.442	264.5	6.67	44.885
1964	26.313	266.5	6.67	46.773
1965	27.447	266.4	6.67	48.771
1966	28.514	263.1	6.67	50.039
1967	29.448			51.678
1968	30.428			53.397

The second column of Table 4, average number of days worked per year, is from the Promyshlyennost section of *Narkhoz* under the title "Ispolzovanie Kalendarnovo Vryemyeni Rabochikh v Promyshlyennosti."

Column three lists the average scheduled number of hours worked per day per wage worker in Soviet large scale industry. From 1950 to 1955 the average work day was 7.96 hours (*40 Years of Soviet Power*, p. 296; *Strana Sovietov za 50 Let*, p. 223). In February of 1956 the Twentieth Congress of the C.P.S.U. called for a program to gradually reduce the standard work week from 48 to 41 hours. In March of 1956, hours worked on Saturdays and before special holidays were reduced from 8 to 6. Thereafter the changes were somewhat more gradual. The mid-1956 effective working day was 7.6 hours (*40 Years of Soviet Power*, p. 296); mid-1957 was 7.5 hours (57 *Tsifrakh*, p. 420); end of year 1958 was 7.4 hours (58 *Narkhoz*, p. 665); end of year 1959 was 7.3 hours (59 *Narkhoz*, p. 596); end of year 1960 was 6.67 hours (60 *Narkhoz*, p. 645). Middle of the year figures from 1961 on are steady at 6.67 hours. Middle of the year figures from 1958 to 1960 are obtained as a linear combination of figures from the two nearest preceding and following dates.

In 1967, changeover to the five day working week began in earnest. Since the length of the work week was intended to be about equal before and after the change, I have assumed that the 1966 hours worked per worker per year applied to years after 1966.

Strictly speaking, the average established length of the working day applies to large scale industry only. Using it as a proxy for all industry is probably fairly safe, especially after 1959 when the producers' cooperatives were abolished. But its utilization in composing the labor series of Table 2 is far more conjectural since it is known, e.g., that work week reductions in nonindustrial sectors lagged behind their introduction in industry.

In using hours worked as an index of labor inputs, we are in effect operating with a hidden assumption that labor efficiency per hour is unaffected by the reduction over time of total hours worked. To the extent that this is untrue, the labor index presumably ought to grow more rapidly in the period 1956–60.

I have chosen to work with unadulterated man-hours as an index of labor inputs without attempting to correct for quality differences between economic sectors or job classifications. This is primarily because it is difficult to find a good indicator of quality differences. Using wage rates to mirror marginal productivities does not strike me as appropriate to the Soviet scenario where, e.g., coal miners and fishermen make almost twice as much as the average industrial worker not because they are more "productive," but because their work is considered more dangerous and undesirable. One could try to measure and include so-called "human capital," which has undoubtedly grown very rapidly along with educational attainment in the U.S.S.R., but any estimates would have to contain a powerful amount of subjective judgment. I am left with raw man-hours not because I believe in this measure for any good a priori reasons, but simply because the alternatives seem less viable from a practical standpoint.

Capital

The industrial fixed capital stock index of Table 1 is based directly on official series. Soviet "industrial productive basic funds" appear in most official statistical books as a July 1, 1955 constant price series expressed as an end of the year index with the end of 1940 equal to 100. The series measures capital stock gross of depreciation existing at the end of a given year. It is reproduced in Table 5 along with a citation of origin. This is not the place to go into details about how the capital estimates are made by the Soviets. There is still a great deal that is unknown about the process. However, it is reasonably clear that the Soviets could, if they wanted to, put together a good capital stock series. Data on constant price purchases and retirements of capital are known to be centrally collected from each industrial enterprise. In addition, an exhaustive capital stock inventory of industrial organizations (and others) was undertaken at the end of 1959. Neither of these kinds of information are available, e.g., to estimators of American industrial capital stock.

TABLE 5—OFFICIAL SOVIET END OF YEAR CONSTANT PRICE INDUSTRIAL PRODUCTIVE BASIC FUNDS (1940=100)

Year	Industrial Productive Basic Funds	Source
1949	130	64 *Promyshlennost*
1950	141	67 *Narkhoz*
1951	161	64 *Promyshlennost*
1952	179	64 *Promyshlennost*
1953	198	64 *Promyshlennost*
1954	221	64 *Promyshlennost*
1955	250	67 *Strana Sovietov*
1956	277	64 *Promyshlennost*
1957	305	64 *Promyshlennost*
1958	341	65 *Narkhoz*
1959	379	64 *Promyshlennost*
1960	424	68 *Narkhoz*
1961	472	62 *Tsifrakh*
1962	523	63 *Narkhoz*
1963	586	64 *Narkhoz*
1964	653	65 *Narkhoz*
1965	715	68 *Narkhoz*
1966	779	68 *Narkhoz*
1967	840	68 *Narkhoz*
1968	907	68 *Narkhoz*

It has been noted by a few Soviet economists that official reporting of real investment may have been overstated by varying amounts (especially since 1960) because of hidden price increases.[22] Then there are the usual difficulties with new types of capital—if these are introduced at too high prices, as is sometimes alleged, there will also be a tendency to inflate growth rates of capital stock. Without inside knowledge of the situation it is difficult to evaluate which claims or counter-claims are relevant.

On the other side of the coin, to the extent that one really wants capital *services* (with imputed rentals as weights) as opposed to capital *stocks* (with capital prices as weights), the growth rates of capital stock presented in Table 1 are biased downwards. With the amount of shorter lived equipment increas-

[22] See, e.g., V. P. Krasovsky.

TABLE 6—DERIVATION OF 1960 VALUE-ADDED WEIGHTS FOR INDUSTRY

Sector	Number of Employees (thousands)	Average Yearly Earnings (roubles)	Social Insurance Deductions as percent of Earnings	Total Payments to Labor (billion roubles)	Mid-1960 Fixed Capital (billion roubles)	Interest plus Amortization Charges (Percent)	Imputed Gross Returns to Capital (billion roubles)	Total Imputed Factor Payments (billion roubles)
Electricity	339.6	1124.4	6.3	.406	11.610	12.6	1.463	1.869
Fuels	1557.2	1849	8.9	3.131	14.215	16.59	2.358	5.489
Ferrous Metals	1047.2	1401.6	7.9	1.584	8.892	13.51	1.201	2.785
Nonferrous Metals	464	1600	7.9	.801	4.276	13.51	.578	1.379
Wood and Paper	2597.5	1040.4	4.7	2.829	5.278	15.83	.836	3.665
Construction Materials	1493.4	1027.2	6.1	1.628	5.279	14.45	.763	2.390
Chemicals	739	1167.6	8.4	.935	5.084	13.54	.688	1.624
Glass and Ceramics	226.3	1027.2	6.1	.247	.418	13.8	.058	.304
Machine Building and Metal Working	7064.6	1119.6	7.5	8.503	16.505	13.71	2.263	10.766
Soft Goods	3893	790.8	6.8	3.288	4.174	13.6	.568	3.856
Processed Foods	2146	877.2	6.8	2.011	8.224	13.64	1.122	3.132

ing over time relative to longer lived structures, an ideal index of capital services would presumably grow faster than the one presented here.

In the capital series as presented, no adjustment was made for capital utilization, a standard headache in most production function estimates. The reduction in the length of the work week has probably cut back the "capital hours" input in non-continuous process industries over the period 1956–60, but by how much is difficult to say since data on utilization rates are not available. Our disregard of this factor is equivalent to assuming that the same capital stock could be spread out evenly over the new working hours, which is probably true of capital intensive processes since they are usually multi-shifted to begin with. At the opposite extreme would be the assumption that capital hours are diminished by the same percentage as the working hours reduction. Casual playing with numbers suggests that since the changes are limited to non-capital intensive processes for the years 1956–60, overall differences in capital estimates are not significant. To some extent the fact that we have not credited the possible increased efficiency per hour of labor working fewer hours per week tends to offset possible overestimation of capital inputs due to unaccounted reductions in the length of the work week.

Let $J(t)$ be the capital stock at the *end* of year t. Exponential interpolation is performed to obtain the average capital stock during year t. The average capital stock during year t, $K(t)$, is $J(t-1)\int_0^1 e^{\gamma t}dt$ where $e^\gamma = J(t)/J(t-1)$. This yields the interpolation formula $K(t) = (J(t) - J(t-1))/(\log J(t) - \log J(t-1))$ which is the figure indexed in Table 1 for year t, except for normalization to $1960 = 100$.

Output

With the exception of nonferrous metals in years past 1959, the sources of the industrial output index of Table 1 are official Soviet sectoral gross value of output series. These are aggregated with synthetic 1960 value-added weights to form an index of industrial production. The sectoral series are displayed in Table 7 normalized to $1960 = 100$.

The underlying sectoral indexes are composed by the Soviets for each sector by adding together physical output units weighted by constant wholesale prices. From 1950 to 1955, January 1, 1952 prices are used; from 1955 on, July 1, 1955 prices. Our industrial production index is thus a "hybrid" mixture of gross value of output sec-

TABLE 7—SOVIET INDUSTRIAL PRODUCTION (DIRECT SOVIET SOURCES, 1960=100)

	Weights[a]	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Electricity	5.01	27.58	31.71	35.69	41.15	46.61	53.98	60.77	67.70	77.43	89.23
Fuels	14.73	41.08	45.04	49.58	53.82	58.92	66.57	71.39	77.62	86.12	92.35
Ferrous Metals	7.47	37.03	42.68	48.12	53.56	59.00	65.48	71.55	76.36	82.43	90.38
Nonferrous Metals	3.70	33.88	39.25	46.42	51.47	58.79	65.96	71.01	76.06	84.36	91.69
Wood and Paper Products	9.84	46.60	52.45	55.44	57.82	64.39	69.39	72.96	78.57	86.73	95.24
Construction Materials	6.42	18.51	23.32	27.16	31.06	35.99	42.95	49.18	59.07	71.22	84.92
Chemicals	4.36	25.42	30.87	35.41	40.86	46.95	56.29	63.81	71.73	80.93	89.75
Glass and Ceramics	.82	27.40	31.15	35.19	39.36	45.76	53.69	61.34	68.85	77.61	88.73
Machine Building and Metal Working	28.89	23.81	27.91	32.34	37.43	43.52	51.61	58.69	66.45	75.64	86.93
Soft Goods	10.35	40.00	47.86	51.79	57.14	65.36	71.07	76.43	80.71	86.79	93.93
Processed Foods	8.41	42.54	48.25	52.63	58.77	64.91	68.42	75.00	82.02	87.28	95.61
Index of Industrial Production	100.00	33.15	38.20	42.56	47.35	53.46	60.34	66.33	73.01	81.29	90.56

	Weights[a]	1960	1961	1962	1963	1964	1965	1966	1967	1968
Electricity	5.01	100.00	112.30	127.29	143.66	160.03	177.88	193.66	210.77	233.04
Fuels	14.73	100.00	105.67	111.33	119.83	128.90	137.11	145.33	154.67	161.47
Ferrous Metals	7.47	100.00	108.37	117.57	126.78	137.03	146.86	157.74	168.83	178.45
Nonferrous Metals	3.70	100.00	108.86	118.48	127.95	137.81	149.60	162.71	178.35	191.09
Wood and Paper Products	9.84	100.00	104.08	109.18	115.31	122.45	127.55	131.97	141.84	149.66
Construction Materials	6.42	100.00	111.81	120.79	129.38	140.74	153.08	167.77	184.01	198.35
Chemicals	4.36	100.00	112.58	128.79	149.29	171.47	194.68	220.10	249.16	279.38
Glass and Ceramics	.82	100.00	111.68	123.50	134.49	149.93	161.34	176.22	194.02	214.19
Machine Building and Metal Working	28.89	100.00	115.06	132.56	149.72	164.01	179.51	200.78	225.47	252.27
Soft Goods	10.35	100.00	104.29	107.50	109.64	112.86	113.57	123.93	137.50	149.64
Processed Foods	8.41	100.00	106.58	116.23	122.37	125.88	142.54	149.12	160.53	169.74
Index of Industrial Production	100.00	100.00	109.56	120.27	131.21	141.78	153.41	167.09	183.65	199.91

[a] 1960 value-added weights in percent.

toral indexes weighted by sectoral value-added. There are, of course, objections to the use of a gross value of output sectoral index. Among other things, such an index need not be invariant with respect to the degree of aggregation. But under the circumstances not much in the way of a feasible alternative can be used, since even the Soviet production indexes calculated in the West are composed along similar lines.

For most sectors with standardized products, the Soviet indexes of Table 7 differ but slightly (growth rates less than 10 percent different) from the latest Western estimates based on a price weighted sample of products reported in the yearbooks in physical units.[23] I choose the Soviet indexes for

[23] See, e.g., Noren. Note that most Western estimates of Machine Building and Metal Working (but not Noren's) are based on a sample of products which does not include any military equipment. This accounts for much of the difference between the two indexes.

one reason only—their more comprehensive coverage of products. Western critics argue that growing specialization and a high rate of introduction of new products into the index on a dubious price basis overstate growth in advanced multiproduct sectors like Chemicals or Machine Building and Metal Working. The Soviets retort that it is in just these sectors that the Western "sample" of products expressed in physical units is most limited to unrepresentative standard old fashioned models or types, and point out the same discrepancies in *U.S.* production indexes.[24] In any case, the difference is not that great (taking into account that Western indexes are limited to civilian production), and the same trends are evident in both series.

The Soviet sectoral indexes are listed in terms of 1940=100 in every *Narkhoz*, *Tsifrakh*, and *Promyshlyennost* volume under the title "Tyempi Rosta Valovoi Produktsi Promyshlyennosti po Otraslyam." The rule that the figures appearing in the latest yearbook take precedence is more important here because minor revisions have occurred from time to time. These sector indexes are listed in Table 7 normalized to 1960=100.

After 1959, the Soviets stopped reporting a nonferrous metals index. The nonferrous metals series linked to 1959 was constructed by James Noren, who was kind enough to supply me with an updated copy. Noren's nonferrous metals series is a weighted index of the production of thirteen nonferrous metals aggregated in July 1, 1955 enterprise wholesale prices. Estimates of metal output are computed from reports in the daily press, and from economic and technical journals.

The derivation of the sector of origin value-added weight used in aggregating the sectoral indexes into an overall industrial production index is detailed in Table 6. Number of employees is from *Trud v SSSR* (p. 86) except for nonferrous metals employment, estimated by Noren (p. 280). Yearly earnings is largely on the basis of *Trud v SSSR* data on page 140 plus educated guesses about the situation in nonferrous metals and glass and ceramics. Social insurance deductions are based on the information in Noren (p. 304). January 1, 1961 fixed capital stock is estimated on the basis of information contained on pages 215–16 of 67 *Narkhoz* for industry as a whole (88.73 billion roubles) and for all sectors except nonferrous metals and glass and ceramics. The latter are obtained as a percentage of total industrial capital stock on January 1, 1960 based on the input-output data of Joint Economic Committee (1968, p. 147) and then multiplied by 88.73 to convert to January 1, 1961 stock. Middle of the year capital stock is interpolated on the basis of the information in 64 *Promyshlenost* (p. 69). To obtain capital charge percentages, an assumed interest rate of 10 percent is added to amortization rates (excluding capital repairs) according to the new norms introduced on January 1, 1963. Nonferrous metals amortization of 3.51 percent is assumed identical to that for ferrous metals.

The industrial production index appears to be remarkably insensitive to changes in the value-added weights caused by somewhat different assumptions used in composing them. For example, using 7 percent or 15 percent as an interest rate instead of the assumed 10 percent makes very little difference on the index of industrial production. The 10 percent figure seems about right for Soviet industry in 1960, reflecting a somewhat higher degree of capital scarcity than would be present in *U.S.* industry. But it is difficult to be dogmatic about this issue, and a different value might well be more appropriate (although any reasonable value would not materially change the index of industrial production presented in Table 1).

In pretending that industrial output is a function of capital and labor alone we are introducing an error by omitting industrial purchases of inputs from other sectors, principally transportation and agriculture. My distinct feeling is that such omissions

[24] A. P. Revenko (ch. 2) presents a very worthwhile account of comparing Soviet and *U.S.* production indexes of differing origin. He concludes that production indexes of Soviet origin have no more of an inherent upward bias over time than do the standard American production indexes.

turn out to be empirically irrelevant for industry as a whole. In any case it is difficult to obtain year to year input-output type data of the kind needed to test the importance of this omission.

Data for 1969

All data for this year are preliminary. They have been obtained from the report on fulfillment of the 1969 plan from the January 25, 1970 edition of *Pravda*, and may be subject to later revision. 1969 data were included at the last minute only to bring the Table 1 series used in this study as up to date as possible.

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