BEBR

FACULTY WORKING PAPER NO. 1460

Productivity Paralysis and the Complexity Problem: Why do Centrally Planned Economies Become Prematurely Gray?

Abhijit Banerjee
Michael Spagat

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

BEBR

FACULTY WORKING PAPER NO. 1460

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

June 1988

Productivity Paralysis and the Complexity Problem:
Why do Centrally Planned Economies Become Prematurely Gray?

Abhijit Banerjee
Harvard University

Michael Spagat, Assistant Professor
Department of Economics

Productivity Paralysis and the Complexity Problem:

Why do Centrally Planned Economies Become Prematurely Gray?

Abstract

We give a theory of the Soviet productivity slowdown showing how a significant component of it can be explained by the increasing difficulties encountered by systems of central planning as the economy becomes more complex. Shortages can become more disruptive than ever as the economy modernizes giving rise to decreasing productivity for reasons not encountered in other systems.

Abhijit Banerjee
Littauer 200, Harvard University
Cambridge, MA 02138
June 15, 1987
and
Michael Spagat
University of Illinois
Department of Economics
Box 111
330 Commerce Building (West)
1206 South Sixth Street
Champaign, IL 61820
217 333-0120

This paper has benefited from conversations with Rick Ericson, Andreu Mas-Colell and Bob Whitesell. I am further in debt to participants in the Russian Research Center Comparative Economics Seminar at Harvard. Finally I thank the Social Science Research Council for providing me with financial backing while this research was in progress.

Section One-Introduction

The most striking characteristic of the Soviet postwar growth record has been the secular decline in the growth rate.[1] Since 1976 the decline has been particularly steep.[2]

The rate of growth of Soviet factor productivity which was never very high[3] has also fallen. In fact, since 1976 Soviet total factor productivity according to many analysts has actually fallen.[4]

There are a variety of factors cited in the literature as contributing to these trends. Among them are major cutbacks in the growth rate of investment, underproduction of various raw materials and energy, transportation bottlenecks,[5] decreasing returns to capital, low elasticity of substitution of capital for labor, declining rates of technological innovation and diffusion,[6] a declining rate of urbanization,[7] increasing marginal costs of resource extraction[8] and declining labor discipline.[9]

---

1. For statistics and general discussions see Bergson (1978a), (1979), (1982) and (1983), Brada (1985), Desai (1987) chapters 1,2 and 3, Gomulka (1986) chapters 6, 7 and 8, Levine (1982), Schroeder (1985), Weitzman (1970) and (1983) and Whitesell (1985).
2. Papers which focus on this latter period include Bergson (1982), Levine (1982), and Schroeder (1985).
3. See Bergson (1978b).
4. See Levine (1982), and Schroeder (1985).
5. These are the three main factors cited in Schroeder (1985).
6. See Levine (1982), page 154. Weitzman (1983) and Brada (1985) frame the whole issue in terms of deciding whether declining rates of technical progress or a low elasticity of substitution of capital for labor is behind the slowdown.
7. Levine (1982), page 157.
8. According to Bergson (1983, p.43) this effect is small

Levine recently has mentioned an intriguing possibility:

> ...in a developed economy, many activities and programs which are required to improve efficiency and productivity growth involve interbranch relationships and coordination. The Soviets have talked about such "specific purpose programs" and "territorial-industrial complexes" which require inter-ministerial coordination and administration, but the existing system of branch ministerial organization has resisted such changes. ... as an economy grows in size and sophistication, centralized planning and control become more difficult and errors have more of an effect. The centralized supply system in the Soviet economy intensifies these problems by reducing the ability of decision-makers at the periphery to respond flexibly to errors and imbalances in the economy." (Levine (1982))

Bergson has observed:

> "Proverbial deficiencies in the Soviet system of "centralist planning" (defective incentives for enterprise management, and resulting managerial aberrations; bureaucratic lapses in direction and coordination at higher planning levels) could also have played a part in this trend. Even though the deficiencies were of long standing, they became more costly as plants and products grew more numerous and tolerances more exacting with continuing industrialization." (Bergson (1978a), emphasis my own).

While the view that it is particularly difficult to deal with an incredibly complex modern economy within the framework of central planning is widely held[10] Ericson (1986) has been the only attempt to model the problem of complexity in centrally planned economies.

In addition while there now exists a burgeoning literature on supply disruptions (shortages) in centrally

---

9. Bushnell (1979) would seem to suggest that this effect is large but Schroeder disagrees.
10. See Goldman (1987) for a very recent work containing this view as its central thesis. Also see Kaplan (1968) and Desai (1983).

planned economies[11] there has never been any attempt to link this literature to the literature on the Soviet productivity slowdown. This is true despite the fact that according to Nove in the Soviet economy:

> Shortages have become more serious, disequilibria and imbalances, which have always existed, have reached intolerable levels, and by intolerable I mean that the leadership itself is alarmed and is not prepared to tolerate them (though it has yet to devise a cure)." (Nove (1983))

Therefore we feel that this paper fills a large gap in the Soviet economics literature. Below we give a theory of the increasing propensity of supply disruptions (shortages), which have always existed, to drag down final goods output as the economy becomes more complex. We show how this complexity effect can play a large role in explaining the Soviet productivity slowdown.

We use a very simple notion of complexity in the model. The idea is that as the economy matures it takes more and more intermediate products to produce a final product. We believe that centrally planned economies are particularly ill suited to deal with this type of complexity. Their "all thumbs no fingers"[12] approach to economic decision making makes them incapable of carrying out the delicate adjustments required in a a modern economy with highly differentiated products.

To support this conclusion in section four we show in our model that as the number of inputs to production grows

---

11. See particularly Kornai (1980), Kornai and Martos (1983) and Davis and Charemza (forthcoming).
12. The term in from Lindbloom (1977).

the production process becomes more delicate i.e. vulnerable to supply disruptions. In section five we use our model to critique the standard empirical analyses of Soviet productivity. In section six we show that the degree of vulnerability will depend on the form of production functions for final goods, in particular on possibilities for substitution between different inputs.

A strand of empirical research that dovetails very nicely with our theory is the work of Bergson on international comparisons of productivity growth.[13] His main finding is that if one adjusts for level of development so that only the historical experiences of countries at roughly the same level of development are compared, then the Soviet and East European factor productivity growth performance has been "undistinguished". This means that the centrally planned economies have been falling further and further behind the West in factor productivity when comparison is made at the appropriate stage of development. If one posits that each country was introducing roughly the same technologies at the same stage of development this suggests that the centrally planned economies have been becoming progressively less efficient relative to the West.[14] Our theory provides a very nice micro foundation for these empirical results.

---

13. See Bergson (1978) and the references given there.
14. This is the finding of Kemme and Whitesell in their research in progress.

We feel that the theory can be used to develop quantitative estimates of the magnitude of the efficiency loss[15] due to supply disruptions in the Soviet economy and of the impact of these disruptions on the productivity slowdown. We defer this task for future research. Here we provide the theoretical foundation for future quantitative work and use our theory to critique the literature on the Soviet productivity slowdown.

Section Two-Production Function Studies[16]

In this section we do not attempt a comprehensive survey of production function studies.[17] Instead we explain them well enough so that the reader can understand their basis and our critique.

The method involves postulating an aggregate production function, usually of the form,

$$Y(t)=A(t)F(K(t),L(t)).$$

There are time series available for aggregate output Y aggregate capital K and aggregate labor L in the Soviet economy.[18] A is a Hicks neutral residual term sometimes referred to as a measure of technological change.

---

15. For research attempting to measure efficiency losses in the Soviet economy see Desai and Martin (1983) and Whitesell (1987).
16. The following section relies heavily on Weitzman (1983).
17. For surveys see Brada (1985) and Desai (1987).
18. One could include other factors of production. For example Desai (1987, ch. 2) includes an index of "raw materials".

There are myriad ways to specify the function F but two have dominated the literature. They are the Cobb-Douglass and the CES specifications.[19]

If one assumes a Cobb-Douglass specification with factor shares close to those which prevail in the West and if the A(t) terms are calculated as true residuals, then one finds that the growth rate of A(t) declines rather rapidly over time.[20] A CES specification allows an elasticity of substitution less than one to take the heat off of the A(t) terms so that one can get a very nice fit with an elasticity of about .5 (as in Weitzman(1983))[21] and a constant but slow rate of growth of A(t). The reason this works is because in the data capital grows much faster than labor and the CES specification allows diminishing returns to capital to set in much more sharply in these circumstances.

Some analysts have criticized the CES studies for producing unrealistic parameter values.[22] For example some of the studies yield extremely low implied capital shares in later years. On the other hand Cobb-Douglass studies yield what some consider to be an implausibly rapid retardation in rates of technical change. These seem to be symptoms of the shortcomings of production function studies rather than the root causes.

---

19. Whitesell (1985) tries a huge number of different specifications and actually concludes that the good old Cobb-Douglass with a constant rate of technical progress is the best.
20. See Weitzman (1983, p.186).
21. ibid. p. 187.
22. See particularly Bergson (1979).

The biggest problem with these explanations is that they operate at such a phenomenally high level of aggregation. At this level it is not at all clear even what capital is or what labor is, let alone what it means to substitute one for the other.

Furthermore we feel that it is on the micro level that centrally planned economies experience many of their most severe difficulties (see Banerjee and Spagat (1987)). Therefore it seems imperative to develop a sound microeconomic theory of productivity to stand behind aggregate productivity studies.

In the next section we do present a rigorous microeconomic theory of production which does allow for the construction of aggregate inputs and an aggregate output. However in our model there does not exist a conventional aggregate production function like F above. However there are manipulations that can be done to construct a different type of aggregate production function that incorporates the microeconomic considerations of the model (see section five). It is this production function that we feel can be useful in future econometric studies of Soviet productivity.

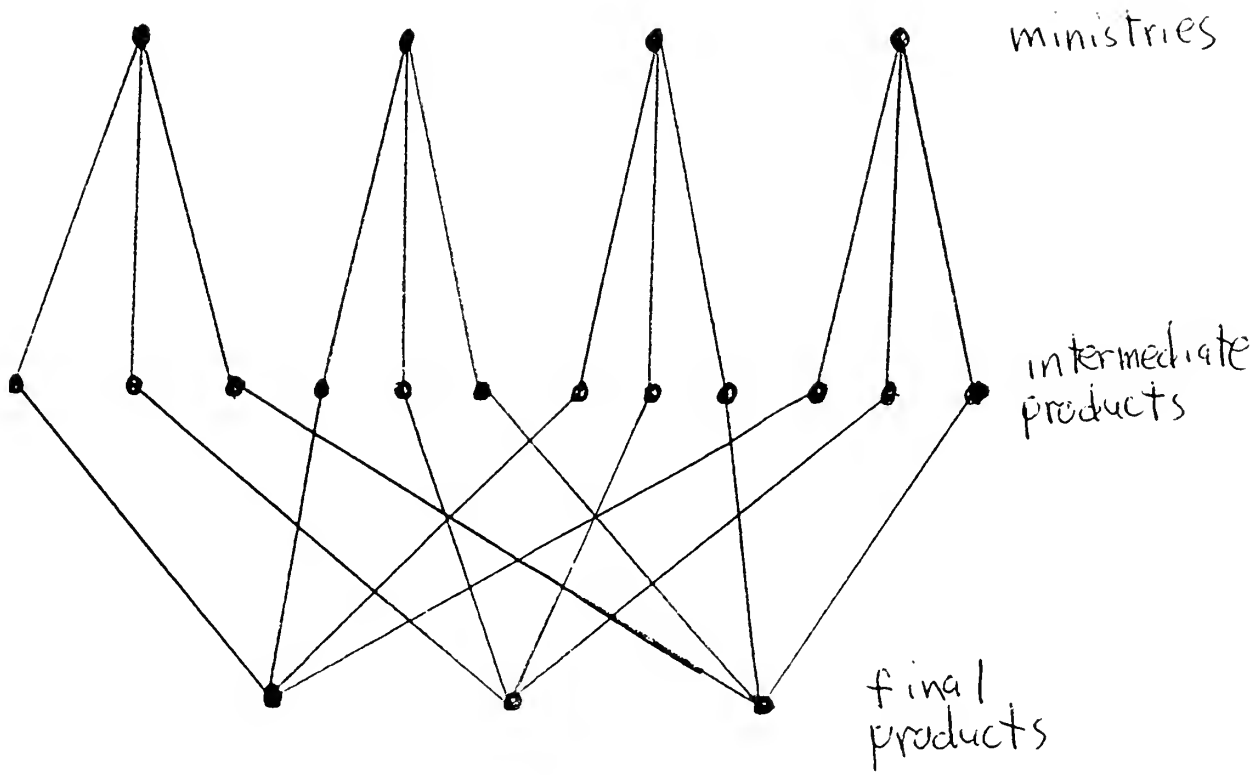
Section Three-The Model of Production[23]

Production is organized by N ministries which are indexed by n. Each ministry controls M distinct commodities (which the reader may identify with firms if she likes). We think of each ministry as controlling a branch of the economy with the M goods it controls as differentiated goods within its branch. X_{mn} gives the production of the mth good of the nth ministry. $X_{mn}=X_{mn}(u_{mn},a_n)$ where u_{mn} is a random shock and a_n denotes the action taken by the nth ministry which must be a member of its action space A_n. The aggregate output for a ministry is simply the total, $\sum_{m=1}^{M} X_{mn}$

Each of the N ministries are producing intermediate products that feed into various final goods production functions. There are M such final goods processes indexed by m given by $C_m(X_{m1},\ldots,X_{mn},\ldots,X_{mN})$ for m equals 1 through M. Aggregate production of final goods is given by, $\sum_{m=1}^{M} C_m$. A scheme of the organization of production is given below for a case with four ministries and three final goods.

---

23. This is only a sketch of the model. For a full development and treatment of its properties see Banerjee and Spagat (1987).



To produce crisp results we assume that each ministry controls a large number of small scale producers. In fact it is usually convenient to go to the limit and let M approach infinity while the size of the individual producers approaches zero. This procedure creates a situation where each action for a minister leads to a certain (nonstochastic) total (aggregate) output for the ministry. Nevertheless output in individual categories can be effectively highly variable, wreaking havoc on the micro level.[24] Ministries which concern themselves with maximizing aggregate output do not concern themselves with micro level

24. The reader should consult Banerjee and Spagat (1987) for a full understanding of these ideas.

variance since it disappears on the aggregate level. Ministries treat their different products as if they were interchangeable (perfect substitutes) when from the point of view of final goods production they are not substitutable for one another at all (see the diagram). This creates shortages or mismatching of intermediate products, dragging down the production of final products. This shortage induced inefficiency is the focus of our paper.

Section Four--The Complexity Problem

In this section we will be forced to make some rather restrictive assumptions but we will indicate where generalization should be possible.

We assume that ministries are identical and their action spaces can be described as follows. All actions lead to distributions of output in individual categories that are independent and uniform. The possible distributions are given by the minimum and maximum points in their supports which we denote a and b(a). There is a trade-off between mean and variance so that b'(a) is negative and (b(a)-a)/2 is decreasing in a. The ministry can pick any a between $\underline{a}$ and $\bar{a}$. This choice of a determines b. It is convenient although not necessary to assume that $b'(a)=-\infty$ at $\bar{a}$. We also require that and $b''(a)<0$.

It should be possible to drastically generalize the action spaces of ministries. The essential property we need is that there is a trade-off between mean output and the

variability of output.

We assume that ministries are very large so that ministers maximize the expected output of their individual products (see Banerjee and Spagat (1987) again). This immediately implies that they set $a=\underline{a}$.

Finally we assume that the final goods production function is a symmetric Leontief function, i.e. $C_m(X_{m1},\ldots,X_{mN})=\min((X_{m1},\ldots,X_{mN})$. This restriction appears to be quite necessary (see section six) although we feel it is defensible. We are thinking of a very short run production function and generally there are rather limited substitution possibilities available to producers in the short run. Furthermore one can think of the above production function as a reduced form where each input is produced from several other inputs where substitution possibilities are present.

Now consider what happens when N, the number of ministries, grows. This corresponds to increasing the number of inputs feeding into local production functions. Note that as the number of ministries grows the actions taken by individual ministries remain the same. Ministries simply maximize the expected output in each category.

It is clear that as N tends to infinity the expected final goods output tends to $\underline{a}$. It is also clear that from the social point of view it would be best to chose a close to $\bar{a}$ for large N.

To make things more precise consider what happens when all N ministers take action a. Then the expected output of an individual final good is,

$$(1)\quad \frac{N}{(b(a)-q)^N}\int_q^{b(a)} x(b(a)-x)^{N-1}dx$$

Integrating by parts we can rewrite this expression as,

$$(2)\quad \frac{b(a)+N\cdot q}{N+1}$$

The first order condition for a maximum can be written as,

$$(3)\quad b'(a) = -N$$

It is easy to check that the second order condition holds if $b''<0$ which we have assumed. Furthermore it can be seen by inspection that the a that solves (3) is an increasing function of N.

Also clear by inspection is the fact that the social welfare gap of the optimal action (the action that solves (3)) minus the social welfare of a increases with N. As the number of ministries grows (i.e. the economy becomes more complex) the ministries high risk actions become increasingly counterproductive. From the social point of view it would be preferred for the ministries to pay less attention to aggregate output and more attention to being reliable suppliers as the production process becomes more delicate. But the behavioral patterns of ministries causes the level of economic inefficiency to grow over time.[25]

25. The idea that the Soviet economy has been operating increasingly far from the production possibility frontier is consistent with recent preliminary empirical results of Whitesell and Kemme using frontier production function analysis.

It is important to note why this complexity effect is a particular problem in centrally planned economies. The reason is that buyers of intermediate products find themselves in such a weak position in these systems.[26] In Western economies as the production process becomes more delicate producers will demand more stable supplies. They generally will have to pay more for this stability but as the value of stability grows producers are willing to pay the price. In centrally planned economies suppliers are producing to please their superiors. Buyers are almost powerless to influence the production decisions of their suppliers. So as the economy evolves and buyers come to require more stable performance they find their suppliers unwilling to shed old habits.

Note that these new more delicate technologies are introduced because they can be use to produce higher quality goods. This should be reflected in higher prices for final output. These higher prices which reflect social value make the new technology better than the old even though with the new technology the economy is operating further from the production possibility frontier than with the old. Obviously we can make the rate of growth of productivity whatever we like if we can choose arbitrary rates of growth prices of final goods. The most interesting normalization is to make comparisons with Western economies operating at the same level of production and introducing the same technologies.

---

26. See Spagat (1987) and references cited there.

The theory would tell us that there will be an increasing productivity gap between the two systems since the complexity effect would be one factor in the Soviet productivity slowdown that would be absent for Western economies. This prediction is consistent with the work of Bergson (1978) and others.

Section Five-Aggregate Behavior of Inputs and Outputs

Within the framework of this model it is easy to construct aggregate time series for inputs and outputs. One can even collapse the many inputs to production into two called capital and labor. It is clear that one can construct two time series with the following properties. There is identical behavior of all inputs and output in the two series (with the number of inputs growing), but when inputs are further aggregated into labor and capital the two more aggregated inputs grow at the same rate in the first series but capital grows faster than labor in the second series. In fact the relative growth rates of capital and labor could exhibit any pattern we like depending on how the line is drawn between capital and labor in their definition.

In each case the complexity effect would be contributing in exactly the same way to a growing gap between actual and efficient performance of the economy. However aggregate production function studies would treat

these two situations entirely differently. In the case where capital grows faster than labor one would conclude the productivity slowdown is driven primarily by a low elasticity of substitution of capital for labor. In the case where capital and labor grown at the same rate one would conclude that the rate of growth of total factor productivity was declining (perhaps due to a decreasing rate of growth of technological change). In both cases the productivity decline would stem from the increasingly destructive effect of microeconomic imbalances but our ability to see these imbalances would be swept away through aggregation.[27]

Within the framework of the present model the standard methods of construction of aggregate measures of capital and labor through linear aggregation of more basic products wipes out the complexity effect. However we believe that it is possible to do econometric studies based on aggregated data that can quantify and control for the complexity effect. Suppose one had data on aggregate output by ministry in the present model. There does not exist a conventional production function that can give aggregate final goods output as a simple function of these aggregate inputs. This is because everything depends on how the aggregate output of each ministry is disaggregated into individual components. We need to know how to perform this disaggregation. But the

---

27. This is the essence of Kornai's critique of the disequilibrium school's macroeconomic approach to shortages. See Kornai (1980) and Davis and Charemza (forthcoming).

present model provides us with just enough structure to allow disaggregation. We can deduce micro level quantities from the action spaces of ministries. In the model of section four there is only one ministerial action consistent with each possible level of ministerial aggregate output. In the slightly more general model of Spagat and Banerjee (1987) which allows for effort at the ministerial effort we can deduce ministerial actions from aggregate outputs by picking the effort minimizing action consistent with that aggregate output. By thus establishing disaggregation rules it is theoretically possible to quantify the role of the complexity effect in the Soviet productivity slowdown.

Section Six-The Local Elasticity of Substitution

It seems intuitive that aggregate output of final goods will depend on the micro level substitution possibilities. We are able to obtain nice results to support this intuition in the limiting case where the number of inputs into each local production function C_m grows to infinity and the local production function remains of the CES variety.

Suppose that all the ministries in the model are identical and produce independent and bounded output distributions. Let their number N grow large. For each N let

$$C_m(X_{m1},\ldots,X_{mN}) = \left(\sum_{n=1}^{N} X_{mn}^{\beta}/N\right)^{1/\beta} \quad \text{for } m=1,\ldots,M.$$

As β moves from 1 to negative infinity the production function moves from an additive form to a Leontief form.

Application of the law of large numbers (recalling that ministries are producing i.i.d. output distributions) implies that in the limit, production process m will yield a certain output of $(E[X^{\beta}])^{1/\beta}$ for m=1,...,M.

Proposition One- $(E[X^{\beta}])^{1/\beta}$ is increasing in β.

Proof- Let $\alpha>\beta$.

Let $X^{\alpha}=Z$ so that $X^{\beta}=Z^{\beta/\alpha}$.

Note that $\frac{d^2 Z^{\beta/\alpha}}{dZ^2} = \beta/\alpha(\beta/\alpha-1)Z^{(\beta/\alpha)-2}$.

Case One- $\alpha,\beta>0$ which implies $0<\beta/\alpha<1$.

$Z^{\beta/\alpha}$ is concave so,

$E[Z^{\beta/\alpha}]<(E[Z])^{\beta/\alpha}$ which implies,

$$\frac{(E[Z^{\beta/\alpha}])^{1/\beta}}{(E[Z])^{1/\alpha}} < \frac{(E[Z])^{1/\alpha}}{(E[Z])^{1/\alpha}} = 1$$

which proves the result.

Case Two- $\alpha>0$, $\beta<0$.

$Z^{\beta/\alpha}$ is convex so

$E[Z^{\beta/\alpha}]>E[Z]^{\beta/\alpha}$ which implies since β is negative

$(E[Z^{\beta/\alpha}])^{1/\beta}<(E[Z])^{(\beta/\alpha)(1/\beta)}=(E[Z])^{1/\alpha}$ proving the result.

Case Three- $\alpha,\beta<0$.

$Z^{\beta/\alpha}$ is again convex and β is negative so the proof of case two is good.

This comparative statics results displays quite clearly how limiting results worsen as micro level substitution possibilities decline. It can give a theory of the

productivity slowdown if one posits that the economy has long been large enough to apply the approximation of infinite N (an infinite number of intermediate products) and that the elasticity of substitution ($1/1-\beta$) has been falling over time. This is obviously different from blaming the slowdown on the increase in the number of intermediate products feeding into each local final goods production function. This explanation would rest on the notion that at one point in time various parts of a machine or tool were relatively easily substitutable for each other, but as time passed machine components became very specialized and nonsubstitutable. Alternatively one can imagine that at an early stage of industrialization a single machine tool could be used for many purposes but with a more sophisticated production process each task requires a specialized machine tool. While it seems possible that a decreasing local elasticity of substitution plays some role in the slowdown we are not inclined to push this explanation too hard. However some empirical work on this question may be worthwhile.

Section Seven- Conclusion

This paper gives a microeconomic theory of shortages that we believe can be used to develop a quantitative empirical theory of the effect of increasing complexity (of a very particular type) on the Soviet productivity slowdown. Spagat (1987) provides theoretical support for the proposition that this effect should only operate in centrally planned economies so the idea is interesting from the point of view of comparative economics.

But we would like to stress the more general point that it is possible to go beyond the bounds of traditional production function analysis and make constructive attempts to deal with problems of aggregation in the study of centrally planned economies. We feel that if the complexity effect can be isolated it will account for a significant amount of the Soviet productivity slowdown. We believe that may of the analysts cited in this paper would agree but have been unable to carry out this project. We hope that this paper has provided a place to start.

Bibliography

Banerjee, Abhijit and Spagat, Michael, "Incentives and Shortages in the Soviet Economy: A Model of a Three-Level Hierarchy," Chapter One in Spagat, Michael, Doctoral Dissertation, Harvard University, Department of Economics, 1987.

Bergson Abram, "The Soviet Economic Slowdown," Challenge, January-February, 1978a.

Bergson Abram, Productivity and the Social System: The USSR and the West, Cambridge, Mass.: Harvard University Press, 1978b.

Bergson Abram, "Notes on the Production Function in Soviet Postwar Industrial Growth," Journal of Comparative Economics 3, 116-126 (1979).

Bergson Abram, "Soviet Economic Slowdown and the 1981-1985 Plan," Problems of Communism, May-June, 1981.

Bergson Abram, "Technological Progress," In Abram Bergson and Herbert S.Levine (eds), The Soviet Economy: Toward the Year 2000, London: Allen & Unwin, 1983.

Brada, Josef C. " The Slowdown in Soviet and East European Economic Growth,"

Bushnell, John, "The New Soviet Man Turns Pessimist," Survey, Spring, 24 (2): 1-18, 1979.

Desai, Padma, The Soviet Economy: Problems and Prospects, Oxford: Basil Blackwell, 1987.

Desai Padma, and Martin, Ricardo. "Measuring Resource-Allocational Efficiency in Centrally Planned Economies: A Theoretical Analysis," In Padma Desai (ed), Marxism, Central Planning and the Soviet Economy, Economic Essays in Honor of Alexander Erlich, Cambridge: The MIT Press, 1983.

Davis Christopher, and Charemza Wojciech (eds), Modelling of Disequilibrium and Shortage in Centrally Planned Economies, Chapman and Hall, forthcoming.

Ericson, Richard

Goldman, Marshall I., Gorbachev's Challenge: Economic Reform in the Age of High Technology, New York, W.W. Norton & Company, 1987.

Gomulka, Stanislaw, Growth, Innovation and Reform in Eastern Europe, Madison: The University of Wisconsin Press, 1986.

Kaplan, Norman,"Retardation in Soviet Growth," Review of Economics and Statistics, 50, 293-303, 1968.

Kornai, Janos, Economics of Shortage, Amsterdam: North-Holland Company, 1980.

Kornai, Janos, and Martos, Bela (eds), Non-Price Control, Amsterdam, North-Holland, 1981.

Levine, Herbert S., "Possible Causes of the Deterioration of Soviet Productivity Growth in the Period 1976-80," in Joint Economic Committee, Soviet Economy in the 80's: Problems and Prospects- Part One, Washington, U.S. Government, 1982.

Lindbloom, Charles E., Politics and Markets, New York, 1977.

Schroeder, Gertrude E., "The Slowdown in Soviet Industry, 1976-1982," Soviet Economy, January-March, 1 (1): 42-74, 1985.

Weitzman, Martin L., "Soviet Postwar Economic Growth and Capital-Labor Substitution," American Economic Review, 60 (4): 676-92, 1970.

Weitzman, Martin L., "Industrial Production," In Bergson Abram and Herbert S. Levine (eds), The Soviet Economy: Toward the Year 2000, London: Allen and Unwin, 1983.

Whitesell, Robert S., "The Influence of Central Planning on the Economic Slowdown in the Soviet Union and Eastern Europe: A Comparative Production Function Analysis", Economica, 52, 235-244, (1985).

Whitesell, Robert S., "Comparing Allocative Inefficiency in Four Countries: U.S., USSR, Hungary and West Germany," Paper presented at the 3rd Annual Workshop on Soviet and East European Economics at Georgetown University, July, 1987.


ECKMAN
NDERY INC.
JUN 95
N. MANCHESTER,
INDIANA 46962