Staff Papers Series

Staff Paper P85-11

March 1985

SOCIAL RATES OF RETURN TO PUBLIC
INVESTMENT IN AGRICULTURAL RESEARCH
AND THE UNDERINVESTMENT HYPOTHESIS:
AN AGNOSTIC VIEW

Glenn Fox

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

Staff Paper P85-11

March 1985

Social Rates of Return to Public Investment in Agricultural Research and the Underinvestment Hypothesis: An Agnostic View*

Glenn Fox**

While preparing this paper, the author's research was supported by Experiment Station Project 14-064, Technical and Institutional Sources of Change in Agriculture, and by a Resources for the Future Dissertation Fellowship Grant in Food and Agricultural Resource Use Policy.

Abstract

The view that the level of public investment in agricultural research in the United States is too low has become well established in the Agricultural Economics literature. This proposition is based on a set of estimates of social rates of return to past investments which have been quite high. This paper argues that there are two important limitations to the evidence assembled in support of the underinvestment hypothesis. The first limitation is that the standard of comparison for public investments is the social rate of return to private investments, and not the private rate of return to private investments. The second limitation is that measurement of the costs of public expenditures on research for agriculture have been biased downward by a failure to account for the marginal excess burden of the tax collection system. When these two factors are taken into account, the evidence in support of the underinvestment hypothesis is weakened considerably.

I. Introduction.

The current environment of fiscal restraint has precipitated several claims of serious consequences of underfunding of particular public programs. Hulten and Peterson (1984) recently discussed the evidence that public investment in infrastructure in the U.S. is lagging behind appropriate levels. White and Havlicek (1982) have studied the consequences of inadequate levels of public expenditures on agricultural research and Knudson and Tweeten (1979) have computed an optimal public investment schedule for agricultural research which calls for an increased real rate of growth of expenditure. In addition, a wide variety of less formal discussions have taken place as real rates of growth of public expenditure in aggregate have fallen and specific component shares of expenditure have changed.

This paper focuses on the proposition that the United States is underfunding public agricultural research at the present time. The reason for the agnosticism expressed in the title is that the available arguments in favor of what I call the underinvestment hypothesis are not as strong as we have been lead to believe.

The view that the United States is underinvesting in its own public agricultural research system has become increasingly popular among agricultural economists. A recent exchange between Ruttan (1980, 1982a) and Pasour and Johnson (1982) affirmed, although not without controversy, that the level of public investment in agricultural research undertaken by the USDA and the State Agricultural Experiment Stations (SAES) is indeed too low. The underinvestment argument is based, in the main, on the finding that estimates of the marginal social internal rates of return to past public investments in agricultural research have been high. This is interpreted to imply that the marginal value products of society's investment resources have not been equated across invest-

ment opportunities.

The underinvestment hypothesis really comes in a strong and a weak version and many discussions in the literature fail to distinguish between the two. The weak version states that, at the margin, public investment in agricultural research has a higher rate of return than other areas of public expenditure and that a re-shuffling of fiscal priorities is in order, within a fixed total public budget. The strong version claims that public investment in agricultural research is so productive, again at the margin, that it is worthwhile to expand the tax base and use the additional revenue to fund agricultural research. This is identified as a strong version because it implies that agricultural research is not only a better investment than alternative public expenditures but that it is also more productive than the private investment and consumption that would have been undertaken in the absence of additional taxes.

The underinvestment hypothesis is important for several reasons. At the level of public policy formulation, if the advocates of this view can persuade legislators of the veracity of their contention, then a rearrangement and/or an expansion of public expenditures could result. If the underinvestment hypothesis is not valid, this alteration of expenditure could be welfare diminishing and not welfare enhancing as its proponents insist. At the level of scholarly discourse, the underinvestment hypothesis has been used as a counterexample to models of public choice in the tradition of Niskanen (1971, 1975) that generally anticipate oversupply of publicly provided goods and services.[1/] Among those authors who support the hypothesis, effort is now being channelled into finding an analytical framework to rationalize undersupply. As an example see Pray (1983; pp. 62-70).

The purpose of this essay is to examine the conceptual foundation of this hypothesis. The point of the exercise is to show that much of the evidence com-

monly claimed to support the hypothesis really doesn't give very conclusive support at all. The question of whether underinvestment is the case is more problematical than many analysts have acknowledged.

It should be noted that refutation of either the strong or the weak version of the underinvestment hypothesis would do nothing to undermine the collective good rationale for the public provision of agricultural research. The question under consideration is not whether governments should fund agricultural research; a wealth of theoretical and empirical evidence suggests that they should, but whether the present level of funding undertaken in the United States is high enough.

II. Evidence of Underinvestment.

We begin with a brief survey of statements of the underinvestment hypothesis. Taken as a group, these statements illustrate the widespread assent to the underinvestment hypothesis that is present in the agricultural economics literature. Peterson (1967, p. 669) provides an early example in the concluding discussion of his study of rates of return to U.S. poultry research.

> As a rough approximation, it appears that past investment in poultry research has been yielding a return of about 20 to 30 percent per year from the date of investment. If a 10-percent return were considered an acceptable return to ordinary investment, one would be justified in concluding that past investment in poultry research is paying high dividends. This has an important bearing on the economic growth issue. There is little fuel for economic growth in investments yielding 3 or 4 percent. The high-pay-off investments, those which yield a high rate of return, hold the key to economic growth in both developed and developing nations.

Later statements of the hypothesis become more direct, but even in this early version we see the implicit comparison of social rates of return to public investment with what seems to be private rates of return to private investment.

Schultz (1971; pp. 241-245) is more overt in his statement of the underinvestment hypothesis.

> The social rate of return to investment (expenditures) in nonprofit agricultural research is, in general, high relative to that in most alternative investment opportunities...
>
> The studies at hand support the validity of this proposition. As a bench mark for comparing the estimated rates of return to agricultural research, I turn to alternative investment opportunities, including schooling. The estimates by Jorgenson and Griliches (1967) of the implicit rates of return for the private domestic economy of the United States, after profit taxes and before personal income taxes, for selected years between 1949 and 1963-1965, range from about 10 to 15 percent. For education, the estimates by Becker (1964) of the private rates of return for college graduates (white males) after personal income taxes, range from 12 to 15 percent for selected years between 1939 and 1958; for high school graduates, his estimates show an increase in the private rates of return after personal income taxes from 16 percent in 1939 to 28 percent in 1958. The estimates of the social rates of return to agricultural research are, in general, higher than the bench-mark rates cited above for the particular alternative investment opportunities mentioned. . .
>
> In principle, the sources of these misallocations are the same as the sources that account for the disequilibria of other economic sectors under rapidly changing dynamic conditions. I shall do no more than mention some of them: (1) Overall, there is an underinvestment in nonprofit agricultural research in view of the relatively high social rates of return to this activity. (2) This underinvestment is in substantial part a result of the obsolete organization of public finance.

Clearly, the rates of return with which comparison is made are the returns accruing only to those who make the investment and not to the economy in total. However, it is the total net benefit regardless of who receives it that is being measured in the estimates of returns to agricultural research.

Boyce and Evenson (1975, pp. 116-117) extend the claim of underinvestment to include developed and less developed countries.

> Nonetheless, the extraordinarily high rates of return that have been measured in virtually all of the studies of agricultural research productivity must be taken to show that investment levels have been too low to represent efficient allocation of scarce resources. Even granting a considerable margin of error in the estimates and allowing for the fact that short-run returns above the long-run equilibrium returns are consistent with optimality, the levels of estimated returns are sufficiently high to justify this statement. It appears to hold in both the high-income countries and in the low-income countries.

This argument is also developed in Evenson and Kislev (1975, Chapter 9).

In their Science paper of 1979, Evenson, Waggoner and Ruttan assert that high rates of return to agricultural research are indicative of underinvestment. They go on to suggest that spillovers across regions may inhibit this category of public investment, which would help to account for apparent niggardliness of regional governments.

Recently, Ruttan (1980) has cited the underinvestment argument as a counterexample to the Niskanen (1971, 1975) model of oversupply of bureaucratic services. The essence of his argument is that available estimates of marginal social internal rates of return to agricultural research are high and that they exceed rates of return in other investments. He goes on to assert that "There is little doubt that a level of expenditure that would push rates of return to below 20 percent would be in the public interest" (Ruttan, 1980, p. 531).

To complete this brief synopsis of underinvestment claims, Pray (1983) asserts that inadequate levels of agricultural research were made in India before and after independence; Habib, et al (1981, p.1) alleges the hypothesis holds for Bangladesh, Nagy and Furtan (1978, p. 14) do the same for Canada and Pinstrup-Anderson (1982, pp. 104-105) and Ruttan (1982b, pp. 241-254) identify widespread underinvestment in many other economies. Most recently, Bonnen (1983, p. 960), Ruttan (1983, pp. 419-428) and Rose-Ackerman and Evenson (1983) renew indictments of the U.S. system.

III. On the Interpretation of Social Rates of Return.

There are two important senses in which the implicit comparisons of rates of return to capital and public agricultural research performed to date have been misleading. First, it is likely that the social rate of return to conventional capital has been undervalued by neglecting benefits that do not

accrue to the investor. According to Harberger (1971, p. 72):

> in measuring the private-sector rate of return, social benefits which do not accrue to the private investors themselves but are attributable to their investments must be counted as part of the return to capital. This simply reflects the fact that government decisions on the uses of public funds within the public sector can (and should) be governed by weighing against their costs the total benefits produced by such projects; thus in order to place private-sector investments on a comparable basis the same procedure should be used. This entails attributing as benefits(a) such taxes as are paid out of the income generated by investments, (b) any net increment to consumer surplus that would result from a typical marginal investment in the private sector, (c) any excess of wages paid over the alternative earnings of the workers employed, and (d) any external benefits associated with private-sector investments.

It would be a difficult task to estimate the combined effects of (a), (b), (c) and (d). In particular, the magnitude of effect (b) could be very important, and yet we have no estimates available. To see the potential of this effect, refer to Figures 1 and 2. The first figure depicts short run market equilibrium for commodity Q. The area OAP represents rents to fixed factors and profits accruing to suppliers of Q. The private rate of return relates this area to the costs of acquisition of the fixed factors and depreciation allowances. The total social gain from trade in Q, however, is the area PAC plus the area OAP, and only when suppliers can act as perfectly discriminating monopolists can they appropriate all of these gains from trade.

Turning to Figure 2, we have a situation where an investor has increased the capital stock, which shifts supply from S^o to S^1. What is the total social benefit? Consumers gain P^oABP^1 and producers gain OCB less P^oACP^1. The net social gain is OAB. This is the maximum gain that the investor could expect if he could act as a perfectly discriminating monopolist. The degree to which Harberger's effect (b) makes the social rate of return to investment exceed the private rate will be determined by the extend that OAB exceeds OCB less P^oACP^1.

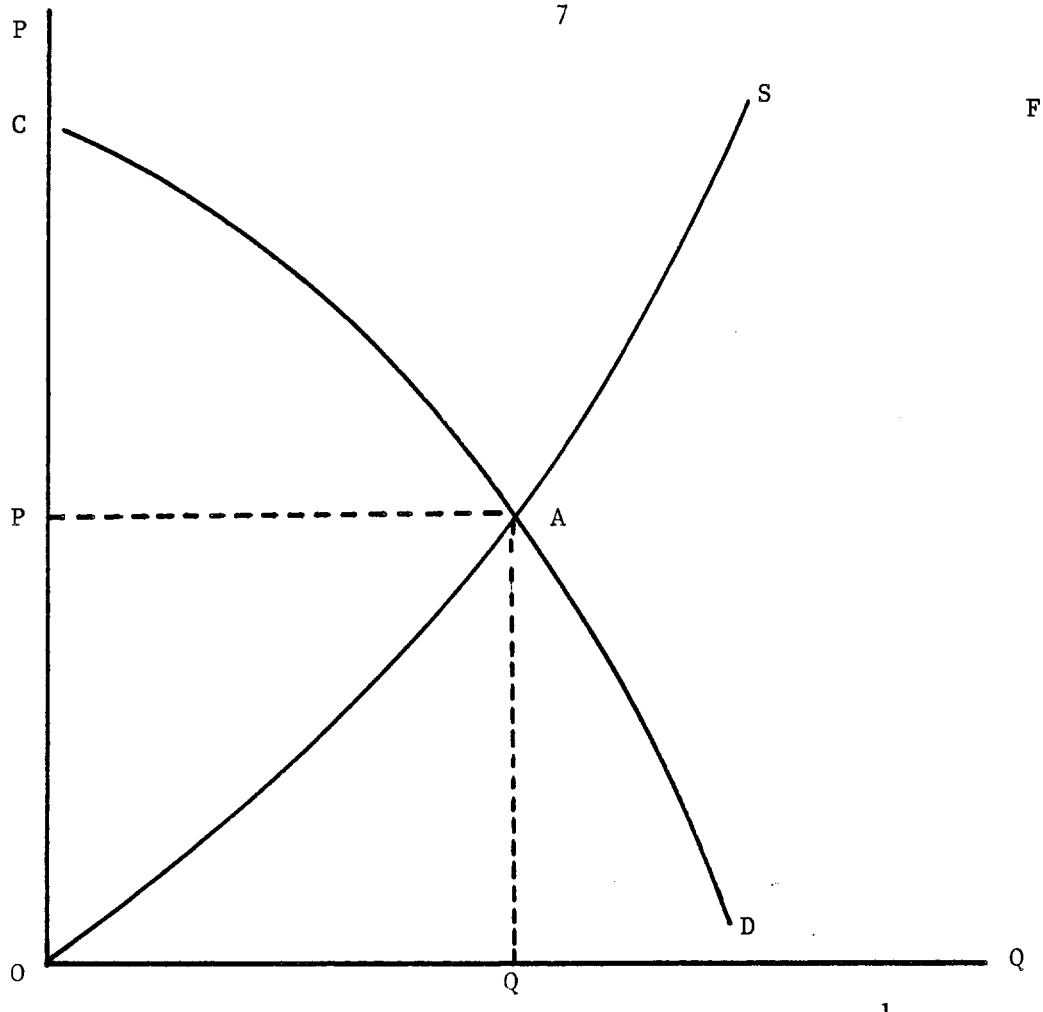

Figure 1

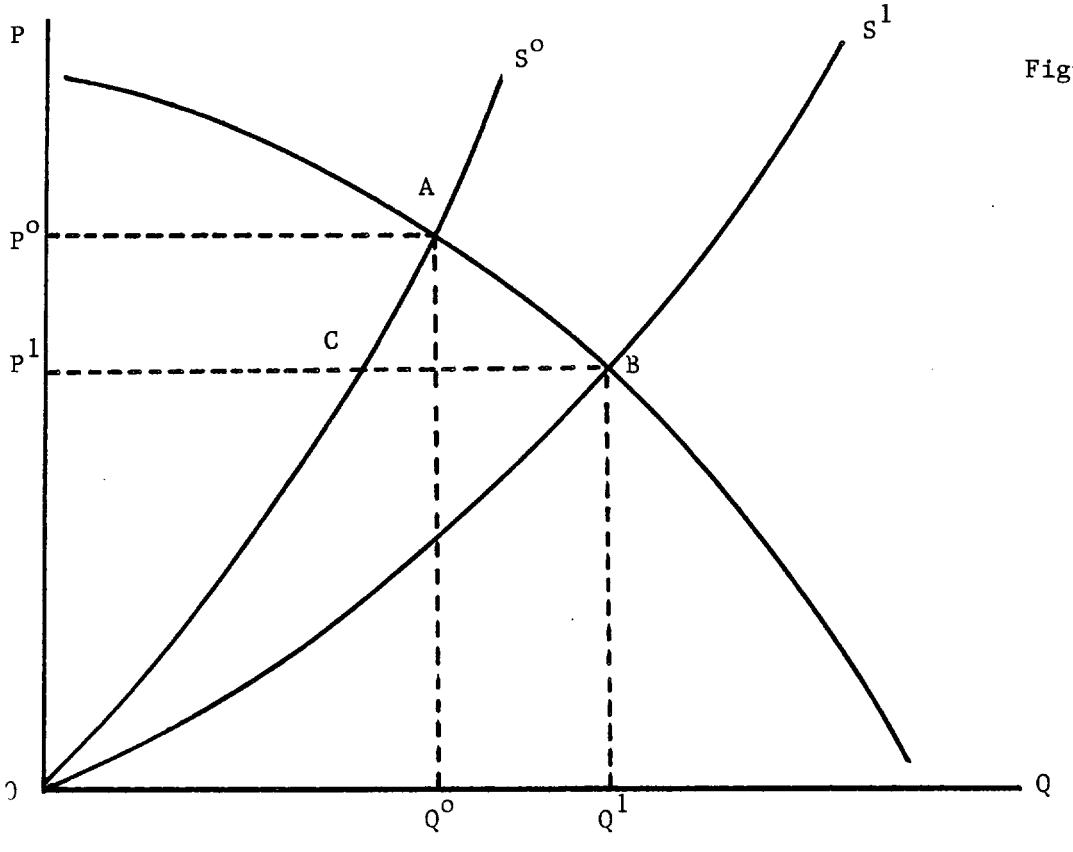

Figure 2

Adjustment for effect (a) is more straightforward. We want an estimate of rates of return to investment gross of taxes. Forbes (January 14, 1985) has recently reported five year averages of rates of return to equity for 1000 firms in the U.S. The median of the average rates was 15.1%. With a medium debt equity ratio of 0.4, this translates into a median five year average rate of return to assets of 10.8%. For the purposes of computing social rates of return to capital, this figure is conservatively biased for two reasons. First, the five years covered by the Forbes data were not a period of outstanding profitability. Secondly, the 10.8% rate is returns to assets, and the asset base would be expected to be larger than the level of capital invested.

The Forbes profitability rate reported is net of corporate taxes and dividends to preferred shareholders. Let i' denote the net rate of return, in our case 10.8%. Let t be the corporate tax rate and δ be the rate of dividends paid to preferred shareholders as a percent of pre-tax corporate income. When, if the pre-tax or gross rate of return is i, it follows that

$$i' = i(1 - t - \delta) \tag{1}$$

or

$$i = \frac{i'}{(1 - t - \delta)} \tag{1'}$$

Feldstein, Poterba and Dicks - Mireaux (1981) estimated the effective U.S. corporate tax rate to be 47.2% over the period 1975-1979. King and Fullerton (1983) report a range of ratio from 37-50%. Data on δ is not available, but a rate of 2½% will be assumed for purposes of illustration. Under these assumptions, the gross rate of return to assets ranges from 17.8% to 22.8% per year. Again, this can be viewed as a lower bound to the social rate of return to capital in the 1000 firms covered by the Forbes data. It should be noted that these 1000 corporations span 42 industries and include services, textiles, motor vehicles, data processing and food processing. This is a broad cross section.

An additional piece of evidence that puts the social rate of return estimates for agricultural research in context, is the growing set of estimates of social rates of return to private research. Peterson (1976) argues that the social rates of return to private research and development exceed the private rates of return to those investments. Mansfield, et al (1977) attempted to measure social and private rates of return to a set of manufacturing innovations and found that social rates of return clustered around 50% per annum and median private pre-tax rates were about 25%. Extending the Mansfield approach, R. Nathan and Associates (1978) computed social and private internal rates of return of 70% and 36% respectively for a set of 20 privately funded research and development initiatives, and Tewksbury et al (1980) also report high social rates of return to private R&D. Coupled with the broader measures of social profitability of corporate assets examined earlier, these figures make the social rates of return to agricultural research that have attracted so much attention seem less imposing.

A second limitation of the rate of return evidence used to support the underinvestment hypothesis is that all of the available estimates of rates of return to public investments in agricultural research have a potentially serious upward bias. This bias arises from the assumption that $1.00 of public expenditure has a social opportunity cost of $1.00. However, when government expenditures are financed by tax collection, distortions are introduced in factor and product markets that create deadweight losses. These deadweight losses can be large as a share of tax revenue collected, and need to be charged against public expenditures to refute the time social opportunity costs of public programs.

Browning (1976) computed estimates of the marginal[2/] cost of public funds for the U.S. tax system. The range of estimates was from 9¢ to 16¢ of deadweight loss per dollar of tax collected. The 16¢ estimate was derived under assumptions of a progressive tax above personal exemptions which approximates the U.S. tax structure more closely.

More recently, Stuart (1984) has developed a simple general equilibrium model with a representative household to compute a more general set of estimates than Browning. Omitting Brownings figure of 2-2½% for compliance costs, Stuart generates a range of estimates of 20¢ - 50¢ under his more plausible assumptions on tax rates and labor supply elasticity.

The most recent and most general attempt to measure the marginal excess burden of the U.S. tax system, undertaken by Ballard, Shoven and Whalley (1985), indicates that the range of marginal welfare costs per dollar of tax income collected to be in the range of 17¢ to 56¢. The advantage of the approach of Ballard et al is that sales and capital taxes are included in the analysis. Their conclusions highlight the implications of their findings for cost-benefit analysis of public projects. In particular, they assert that "If this dead-weight loss is as large as we suggest, it is possible that many projects accepted in recent years on the basis of favorable cost-benefit ratios should not have been undertaken."

To illustrate the impact on internal rate of return estimates of neglecting the full social cost of public expenditure, consider a hypothetical project. A cash cost of C_o is incurred in year zero and a stream of benefits is generated, denoted by $\{B_t\}_{t=1}^{T}$. Suppose that the benefit stream is uniform, that is $B_t = \overline{B}$ $\forall$ t = 1, 2, ... T. It should be acknowledged that empirical studies of the benefit pattern from agricultural research do not find uniform benefit streams, but this illustrative exercise is intended only to show the

effect of failure to acknowledge the marginal excess burden of tax collection. The estimated internal rate of return, $\tilde{\rho}$, solves

$$- C_o + \overline{B} \sum_{t=0}^{T} (1 + \tilde{\rho})^{-t} = 0 \qquad (2)$$

However, the true social cost of the project is $(1 + \tau)\ C_o$, where τ is the marginal excess burden of the tax collection instruments available. The true social internal rate of return, $\hat{\rho}$, solves

$$- C_o\ (1 + \tau) + \overline{B} \sum_{t=0}^{T} (1 + \hat{\rho})^{-t} = 0 \qquad (2')$$

By rearranging this expression, we obtain

$$\left[\frac{(1 + \hat{\rho})^{T+1} - 1}{\hat{\rho}(1 + \hat{\rho})^{T}} \right] = \frac{C_o\ (1 + \tau)}{\overline{B}} \qquad (3)$$

which describes an implicit relationship between $\hat{\rho}$ and τ.

Much of the empirical literature on agricultural research in the U.S. indicates that a 16 year lag closely approximates the pattern of benefits from research expenditure. For purposes of this illustration, T=16 will be used. In the studies summarized by Ruttan (1982, pp. 242-246), the most recent estimates of rates of return for the overall U.S. agricultural research system range from 28% to 37%.[3/] If this value is substituted for $\hat{\rho}$ in our hypothetical project, and if a value of $C_o = 100$ is assumed, this implies an annual gross benefit of $\overline{B} = 27.17$. By substituting successive values of τ into equation (3), the schedule depicted in Figure 3 can be generated.

Clearly, as values for τ of the magnitude reported by Stuart or by Ballard et al are considered, the bias of $\tilde{\rho}$ compared to $\hat{\rho}$ is substantial. If $\tau = .30$, then the Davis' (1979) estimate of 37% for $\tilde{\rho}$ translates into a value of about 26% for $\hat{\rho}$. Furthermore, Davis' estimation period is 1964-1974, and the set of studies reported by Ruttan which computed rates of return for specific time

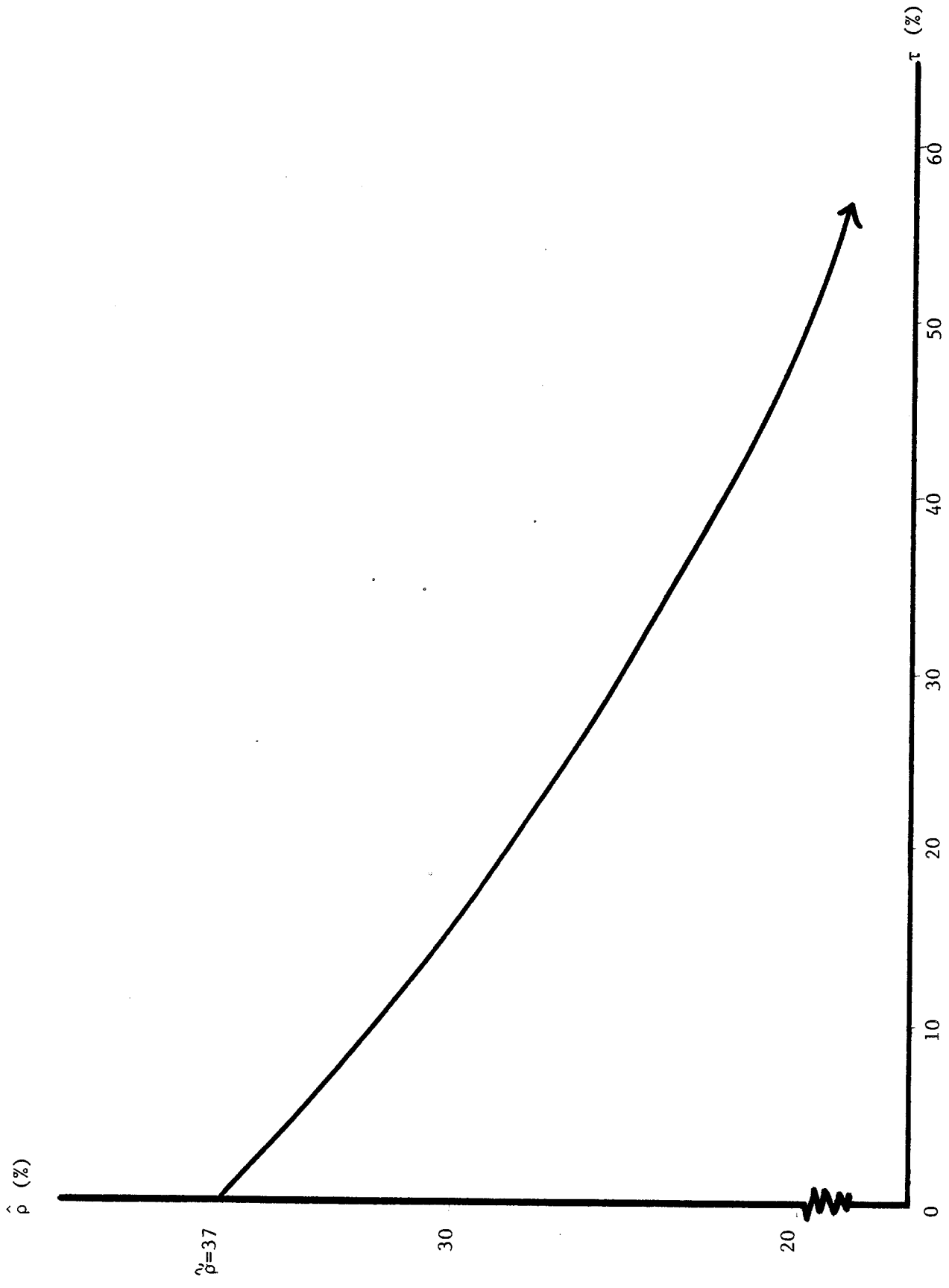

Figure 3. The Effect of Deadweight loss from taxation (τ) on Internal Rate of Return (ρ).

periods in the U.S. indicate a pronounced downward drift as the time periods become more recent. It would seem safe to infer, then, that 26% represents an upper bound on the true social internal rate of return, and this is not substantially above the social rate of return to corporate assets derived from the Forbes data, which, it was argued above, is an under estimate.

IV. Conclusion.

For the underinvestment hypothesis to be tested in either the strong or the weak version, a set of estimates of social rates of return to public and private investment is required. The public rates of return must be carefully constructed to reflect the true social cost of public expenditures, including the excess burden of the tax collection system. At the present time, we do not have such a comprehensive set of estimates of social rates of return. This is particularly true for expenditure categories within the public sector, making tests of the weak version of the underinvestment hypothesis problematical.

In this paper I have attempted a simple test of the strong version of the underinvestment hypothesis by adjusting the available estimates of internal rates of return to public agricultural research in the United States and comparing those rates with a lower bound to social rate of return to assets and to research and development in the corporate sector. The results of this test indicate that, given the associated magnitude of measurement error, agricultural research conducted at public expense in recent years has generated a social rate of return comparable to investments in the corporate sector, and neither under nor over investment seems to be the case.

Footnotes

* Helpful suggestions and comments on an earlier version of this paper were made by Vernon Ruttan, Willis Peterson, C. Ford Runge, Carl Pray, Phil Pardey and Bob Myers, as well as by members of the Workshop on Agricultural Research at the Department of Agricultural and Applied Economics at the University of Minnesota.

** Research Assistant, Department of Agricultural and Applied Economics, University of Minnesota.

1/ Niskanen's work has attracted considerable attention among students of public resource allocation. Miller and Moe (1983) have modeled the interaction between bureaucrats and legislators as a bilateral monopoly bargaining problem in contrast with Niskanen's formulation of budget maximizing bureaucrats and passive politicians. The bilateral monopoly formulation yields levels of output which are below optimal. This recent work illustrates a chink in Niskanen's model, because it is not obvious that bureaucrats would prefer to be budget maximizers and oversupply public services when they could earn rents as monopolists by reducing output.

2/ Since the share of public expenditure that is spent on agricultural research is small, the marginal social opportunity cost (rather than the average) is the relevant measure. This is especially true for the strong version of the underinvestment hypthesis.

3/ Ruttan (1982; Table 10.3) reports three studies which have estimated rates of return to the total U.S. agricultural research system for particular time periods. The range reported in the text encompasses Peterson and Fitzharris' (1977) estimte of 34% for the years 1957-1972, Cline's (1975, revised by Knudson and Tweeten (1979)) estimate of 28-35% for the years 1969-1972 and Davis' (1979) estimate of 37% for 1964-1974. Davis' estimate is used for the schedule depicted in Figure 3 since it represents the upper limit of the range of estimates and because the approach was deemed to be more reliable.

References

Ballard, C. L., J. B. Shoven and J. Whalley (1985), "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States," American Economic Review, Vol. 75, No. 1, March, pp. 128-138.

Becker, G. S. (1964), Human Capital, NBER, New York.

Bonnen, J. T. (1983), "Historical Sources of U.S. Agricultural Productivity: Implications for R&D Policy and Social Science Research," American Journal of Agricultural Economics, Vol. 65, No. 5, December, pp. 958-966.

Boyce, J. K. and R. E. Evenson (1975), Agricultural Research and Extension Programs, Agricultural Development Council, New York.

Browning, E. K. (1976), "The Marginal Cost of Public Funds," Journal of Political Economy, Vol. 84, No. 2, April, pp. 283-298.

Cline, P. L. (1975), "Sources of Productivity Change in U.S. Agriculture," Ph.D. Dissertation, Oklahoma State University.

Davis, J. S. (1979), "Stability of the Research Production Coefficient for U.S. Agriculture," Ph.D. Dissertation, University of Minnesota.

Evenson, R. E. and Y. Kislev (1975), Agricultural Research and Productivity, Yale University Press, New Haven.

Evenson, R. E., P. E. Waggoner and V. W. Ruttan (1979), "Economic Benefits from Research: An Example from Agriculture," Science, Vol. 205, September 14, pp. 1101-1107.

Feldstein, M., J. Potuba and L. Dicks - Mireaux (1981), "The Effective Tax Rate and the Pretax Rate of Return," NBER, Working Paper 740, August.

Forbes, Vol. 135, #1, January 14, 1985, pp. 260-262.

Griliches, Z. (1958), "Research Costs and Social Returns: Hybrid Corn and Related Innovations," Journal of Political Economy, Vol. 66, No. 5, October, pp. 419-431.

_____ (1980), "Returns to Research and Development Expenditures in the Private Sector," in New Developments in Productivity Measurement and Analysis (ed. J. W. Kendrick and B. N. Vaccara), NBER Studies in Income and Wealth, No. 44, University of Chicago Press.

Habib, M. A., D. Butterfield and S. Mestelman (1981), "An Ex-Ante Model for the Allocation of Research Expenditures Among Competing Crops," Working Paper 81-09, Department of Economics, McMaster University, April.

Harberger, A. C., (1971) Project Evaluation, Markham.

Havlicek, J. Jr., and D. Otto (1982), "Historical Analysis of Investment in Food and Agricultural Research in the United States," in An Assessment of the United States Food and Agricultural Research System, Vol. II, Office of Technology Assessment, Washington, D.C., April.

Hulten, C. E. and G. E. Peterson (1984), "The Public Capital Stock: Needs, Trends and Performance," American Economic Review, Vol. 74, No. 2 May, pp. 116-173.

Jorgenson, D. W. and Z. Griliches (1967), "The Explanation of Productivity Change," Review of Economic Studies, Vol. 34, No. 3, July, pp. 249-283.

King, M. A. and D. Fullerton (1983), "The Taxation of Income from Capital: "A Comparative Study of the U.S., U.K., Sweden and West Germany - Comparisons of Effective Tax Rates -," NBER, Working Paper 1073, February.

Knudson, M. and L. G. Tweeten (1979), "Toward an Optimal Rate of Growth in Agricultural Production Research and Extension" American Journal of Agricultural Economics, Vol. 61, #1, February, pp. 70-76.

Mansfield, E., J. Rapoport, A. Romeo, S. Wagner and G. Beardsley (1977), "Social and Private Rates of Return from Industrial Innovations," Quarterly Journal of Economics, Vol. 91, No. 2, May, pp. 221-240.

Miller, G. and T. M. Moe (1983), "Bureaucrats, Legislators and the Size of Government," American Political Science Review, Vol. 77, No. 2, June, pp. 297-322.

Nagy, J. G., and W. H. Furtan (1978), "Economic Costs and Returns from Crop Development Research: The Case of Rapeseed Breeding in Canada," Canadian Journal of Agricultural Economics, Vol. 26, No. 1, February, pp. 1-14.

Nathan, R. R., and Associates (1978), Net Rates of Return on Innovation: Volumes 1-3, report prepared for the National Science Foundation, published by the U.S. Department of Commerce, National Technical Information Service, PB298-153, 152, 154, October.

Niskanen, W. A. (1971), Bureaucracy and Representative Government, Aldine, Chicago.

_____(1975), "Bureaucrats and Politicians," Journal of Law and Economics, Vol. 18, December, pp. 617-643.

Pasour, E. C., Jr., and M. A. Johnson (1982), "Bureaucratic Productivity: The Case of Agricultural Research Revisited," Public Choice, Vol. 39, No. 2, pp. 301-317.

Peterson, W. L. (1967), "Return to Poultry Research in the United States," Journal of Farm Ecnomics, Vol. 49, No. 3, August, pp. 656-669.

_____(1976), "A Note on Social Returns to Private Research and Development," American Journal of Agricultural Economics, Vol. 58, No. 2, May, pp. 324-326.

_____, and J. C. Fitzharris (1977), "The Organization and Productivity of the Federal State Research System in the United States," in Resource Allocation and Productivity in National and International Agricultural Research, T. M. Arndt, D. G. Dalrymple and V. W. Ruttan, eds., University of Minnesota Press, Minneapolis.

Pinstrup-Anderson, P. (1982), Agricultural Research and Technology in Economic Development, Longman, New York.

Pray, C. (1983), "Underinvestment and the Demand for Agricultural Research: A Case Study of the Punjab," Food Research Institute Studies, Vol. 19, No. 1, pp. 51-80.

Rose-Ackerman, S. and R. E. Evenson (1983), "Federalism, Reapportionment and Innovation: The Case of Agricultural Research and Extension," Center Discussion Paper No. 432, Economic Growth Center, Yale University.

Ruttan, V. W. (1980), "Bureaucratic Productivity: The Case of Agricultural Research," Public Choice, Vol. 35, No. 5, pp. 529-547.

_____ (1982a), "Bureaucratic Productivity: The Case of Agricultural Research - A Rejoiner," Public Choice, Vol. 39, No. 2, pp. 319-329.

_____ (1982b), Agricultural Research Policy, University of Minnesota Press, Minneapolis.

_____ (1983), "Some Lessons From Agricultural Research," Industrial Policy, Hearings Before the Subcommittee on Economic Stabilization of the Committee on Banking, Finance and Urban Affairs, House of Representatives, USGPO, Washington, D.C.

Schultz, T. W. (1971), Investment in Human Capital: The Role of Education and Research, The Free Press, New York.

Stuart, C. (1984), "Welfare Costs per Dollar of Additional Tax Revenue in the United States," American Economic Review, Vol. 74, No. 3, June, pp. 352-362.

Tewksbury, J. G., M. S. Crandall and W. E. Crane (1980), "Measuring the Societal Benefits of Innovation," Science, Vol. 209, August 8, pp. 658-662.

White, F. C. and J. Havlicek (1982) "Optimal Expenditures for Agricultural Research and Extension: Implications of Underfunding," American Journal of Agricultural Economics, Vol. 64, No. 1, February, pp. 47-55.