PN-ABC-544

April 25, 1988

ISN 61138

THE EXCESS BURDEN OF TAXATION AND PUBLIC AGRICULTURAL RESEARCH

Dana G. Dalrymple

For Presentation at
Agricultural Technology Management Workshop
Sponsored by Rutgers and ISNAR
New Brunswick, N.J.
July 6-8, 1988

Dana G. Dalrymple is an agricultural economist with the Office for International Cooperation and Development, U.S. Department of Agriculture, Washington, D.C. He is on detail to the Office of Agriculture, Bureau for Science and Technology, Agency for International Development. The views expressed in this paper are his own and not necessarily those of his employers.

The author wishes to acknowledge the continuing and valuable counsel provided by Willis Peterson during the preparation of the paper and the helpful review comments provided by B. R. Eddleman, J. S. Davis, Robert Evenson, Glenn Fox, Vernon Ruttan and Charles Stuart. None are to be held responsible for any remaining shortcomings.

To tax and to please, no more than to
love and be wise, is not given to men.

-Edmund Burke, 1774

I. INTRODUCTION

In a recent article about investment in agricultural research in the United States, Fox introduced the concept of deadweight loss (also known as excess burden, welfare cost, or social loss). This loss allegedly arises from distortions in factor and product markets which occur when governmental expenditures are financed by traditional tax procedures.

Fox went on to suggest that these losses "...need to be charged against public expenditures to obtain the true opportunity cost of public programs" (p. 809). Some recent estimates of such losses are then used to indicate the impact on internal rate of return estimates. Fox focuses on marginal rather than average losses on the basis that the share of public expenditures spent on agricultural research is small.

There is something old and something new in Fox's paper. The general notion of welfare costs and the term deadweight loss have been used quite widely in agricultural policy and trade analyses (Currie, Murphy and Schmitz; Gardner; Runge and Meyers). But Fox is the first, to my knowledge, to apply them to the evaluation of agricultural research supported by general tax funds.

This is a significant step, and merits further study. Yet other economists may find that it is a difficult subject to track down. Neither Fox nor the references he cites provide any particular background. Moreover, the subject is not mentioned in many general economics texts. It is more readily found, and then with some limitations, in welfare economics and public finance texts.[1/]

This relative anonymity is puzzling. Excess burden would appear to be an important concept of broad relevance. It could also be quite timely in view of current interest in tax policies and constraints on government spending.

Taxes have, of course, long provided a major portion of the funding for agricultural research.

It would seem useful to know more about the concept and how it relates to agricultural research. This paper, therefore, attempts to provide a relatively balanced introduction. Three steps are involved: (1) a review of the literature pertaining to the concept of excess burden and its measurement, (2) an examination of data on the past level of public expenditure for agricultural research in the United States, and (3) a discussion of the application of the concept.

Although the focus is on agricultural research in the United States, the issues raised could apply to a wider range of public activities and to other countries.

II. THE CONCEPT OF EXCESS BURDEN

While some taxpayers would be willing to accept the notion of excess burden sight unseen, it is not intuitively obvious to many. And it is difficult to introduce briefly and convincingly in words. Here an evolutionary approach is utilized which focuses on the development on the concept, its measurement, and a few associated problems. Fairly heavy reliance is placed on some simple diagrams.

A. Origin and Early Development

Although the idea of an exess burden might appear to be of recent and conservative origin, this is hardly the case. Its roots run deep into the history of classical economics. It is part and parcel of the theory of economic or consumer surplus. Five eminent economists were involved in its development.

The concept was, as far as can be told, first suggested by the French engineer and economist Dupuit. In a note to his classic rticle "On the

Measurement of the Utility of Public Works" published in 1844, Dupuit analyzed the welfare effects of the imposition of an excise tax, as shown in Figure 1. [2] He stated that "A small tax of pp' will yield the rectangle pp'n'q and the utility lost both to the taxpayers and the fisc [treasury] is the small triangle nqn'" (p. 54; italics added).

Marshall took up the same issue in his classic book, first published in 1890. He differentiated between constant, diminishing, and increasing returns. The first two are of principal interest here.

-Constant Returns. His analysis basically followed Dupuit's, and his diagram was essentially the same (except that the horizontal price lines were treated as supply "curves"). Marshall noted that the loss of consumers' surplus is smallest for those commodities which have the most inelastic demand elasticities.

-Diminishing Returns. This situation is shown on a now familiar diagram (Figure 2). The tax is levied at the rate aE on each unit, with the result that output is reduced from OH (or CA) to Oh (or CK). In this case, Marshall stated that the gross receipts, cPEa, are greater than the loss of consumers' surplus, cCAa. He was not, however, very explicit about changes in producers' surplus and overall social gain or loss. [3]

A fuller discussion was provided by Hotelling in 1938. He used Marshall's basic diagram, but changed the notation (Figure 3). His comments on the effect of a tax may be summarized as follows (using his terminology):

	Original Equilibrium	After-Tax Equilibrium
Consumers' surplus	ABD	KLD
Producers' surplus	SBA	RLK (=SNM)
Government revenue		MNLK
Total net benefit	SDB	SNLD

Dupuit's Analysis of the Effects of a Tax, 1844.

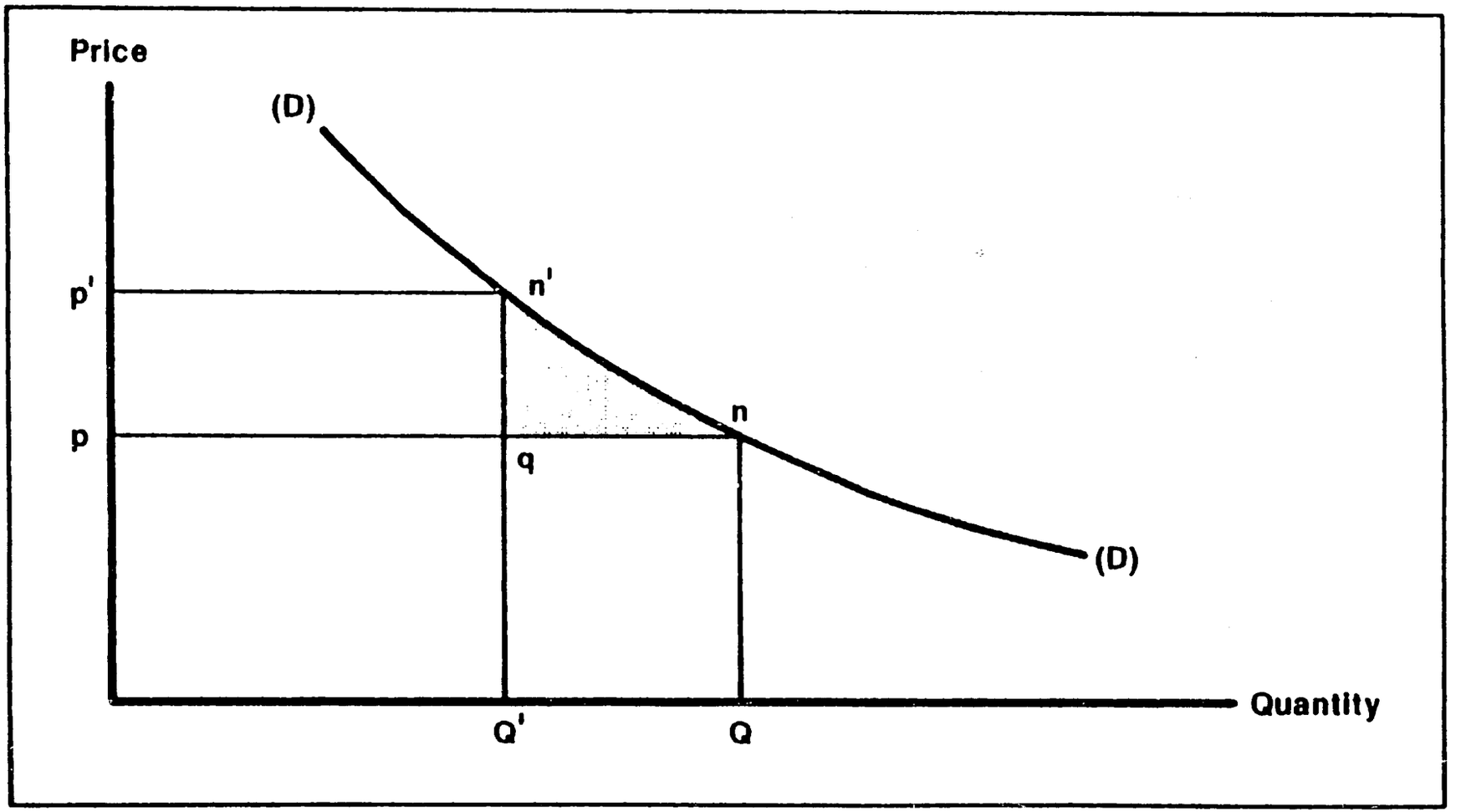

Figure 1.

Marshall's Analysis of the Effects of a Tax, Diminishing Returns, 1890 (or Later).

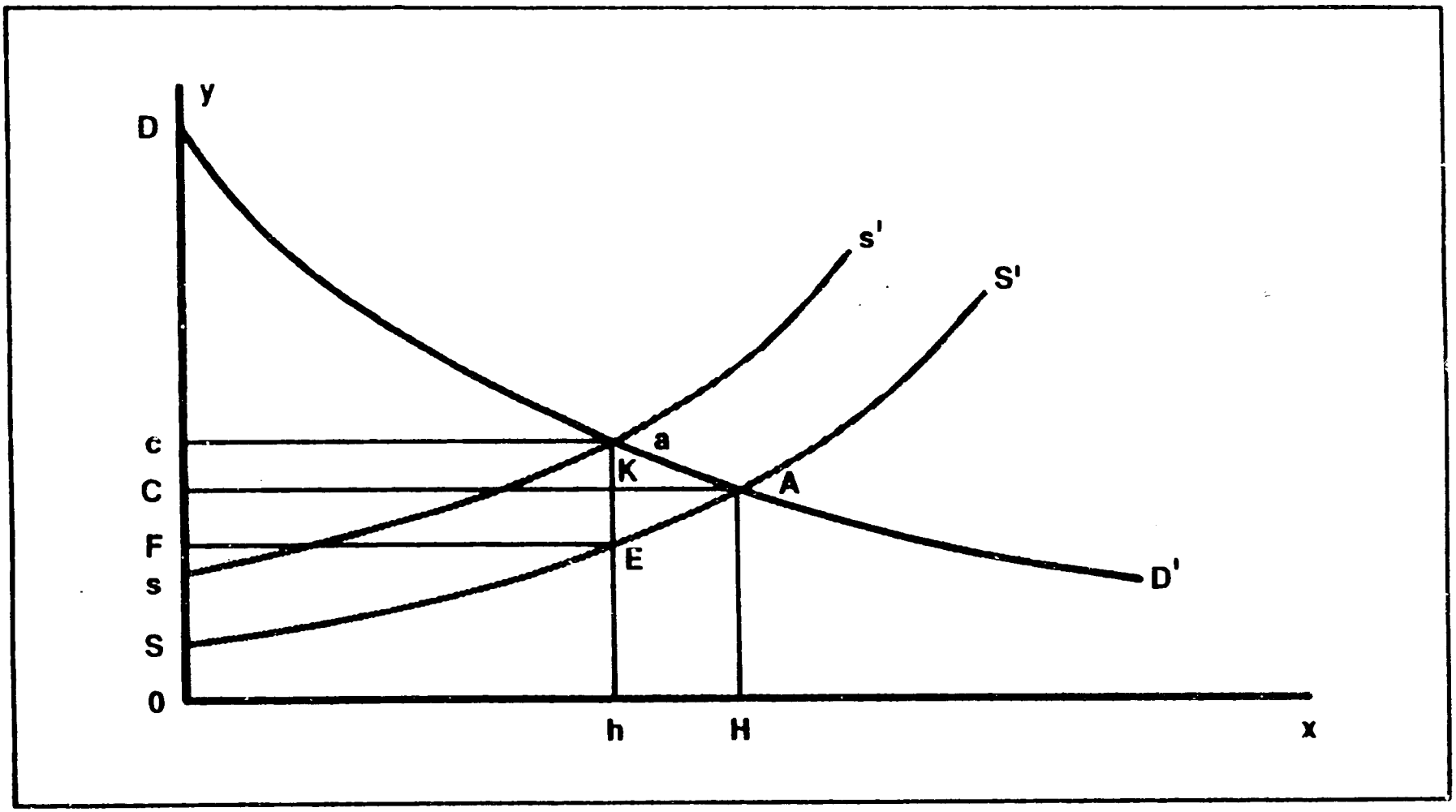

Figure 2.

Hotelling's Presentation of the Effects of a Tax, 1938.

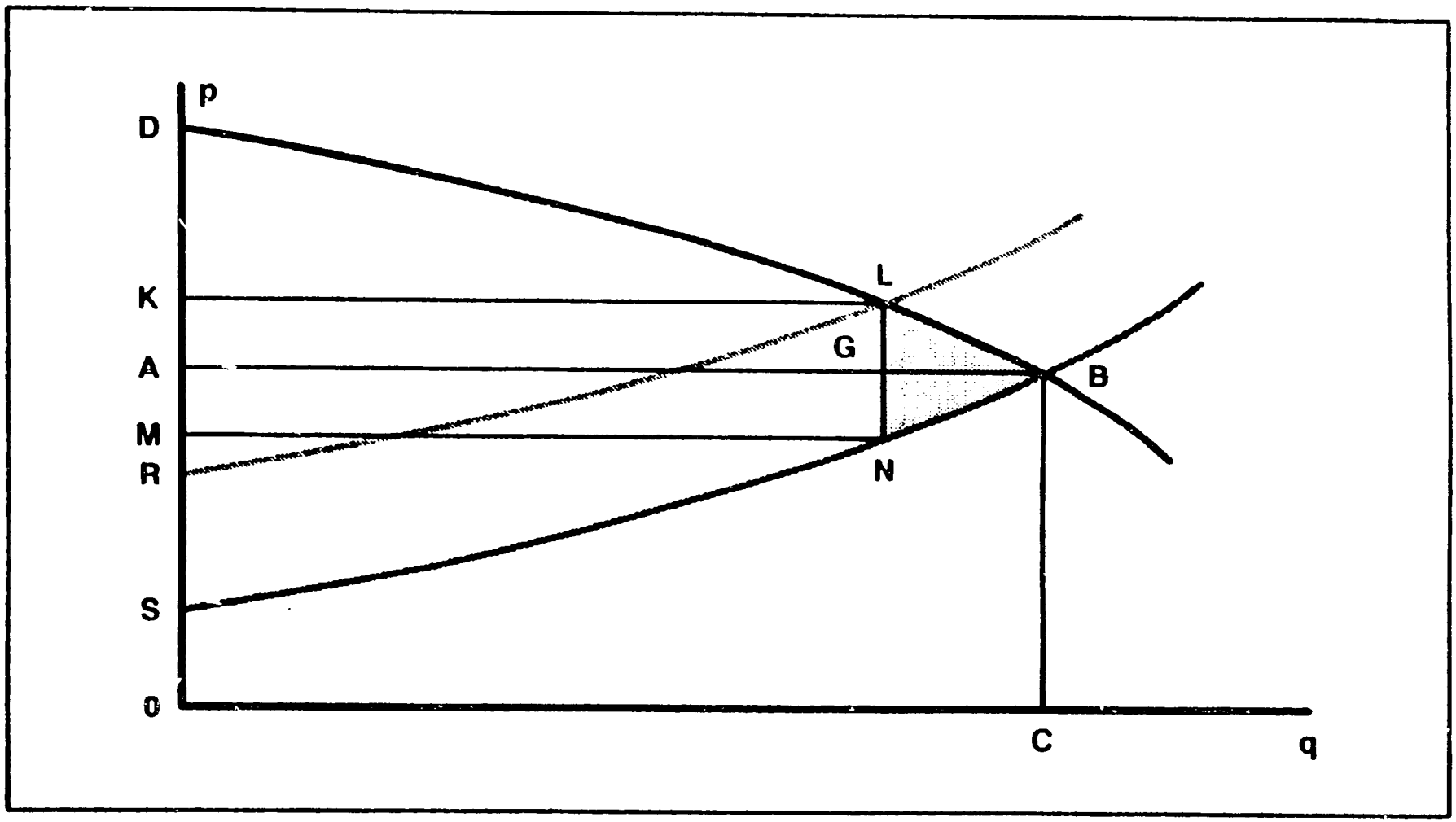

Figure 3.

The difference between SDB and SNLD is the triangular area, NBL, the "net social loss." Hotelling went on to develop an algebraic expression of the approximate loss. He also referred to the loss accruing from shifting from a system of income taxes to excise taxes (or from sales at marginal cost) as a "dead loss," and reviewed tax systems for minimizing this loss. In a subsequent exchange of views with Ragnar Frish he emphasized that he was referring to the "...social loss from a system of excise taxes in contrast to more efficient types..."(p. 154).

In 1941, Hicks took up the question of social loss in a more general paper about consumers' surplus. He noted that the triangle results from a loss in both consumers' and producers' surplus and is only an approximate measure because it assumes a constant marginal utility of money. "It measures the social loss invloved in producing a non-optimum instead of an optimum amount" (p. 114). He referred to it as the "social loss" and said that it depends partly on the gap between price and marginal cost and partly on the effect of that gap on output. It can be measured as 1/2 (tax per unit) x (reduction in output).

There the matter largely rested, aside from some references in highly theoretical papers, until the early 1960's. In 1964, Harberger expanded the area of analysis from the usual excise or sales tax case to the effect of income taxes on labor income (1964b, pp. 45-46). This is illustrated in diagrammatic form in Figure 4: LL is the supply curve of labor, W is the prevailing wage, rw (=AC) is the amount of tax per unit of labor, and DA is the net income per unit of labor. The reduction in the amount of labor performed as a consequence of an income tax at the rate r is BC. The overall reduction in gross money income to the worker is DEBC. The worker will have gained leisure value of DEBA. This leaves the net welfare cost of the tax as the triangle ABC. [4/]

Harberger's Diagram for Evaluating the Effects of an Income Tax on Labor Income, 1964.

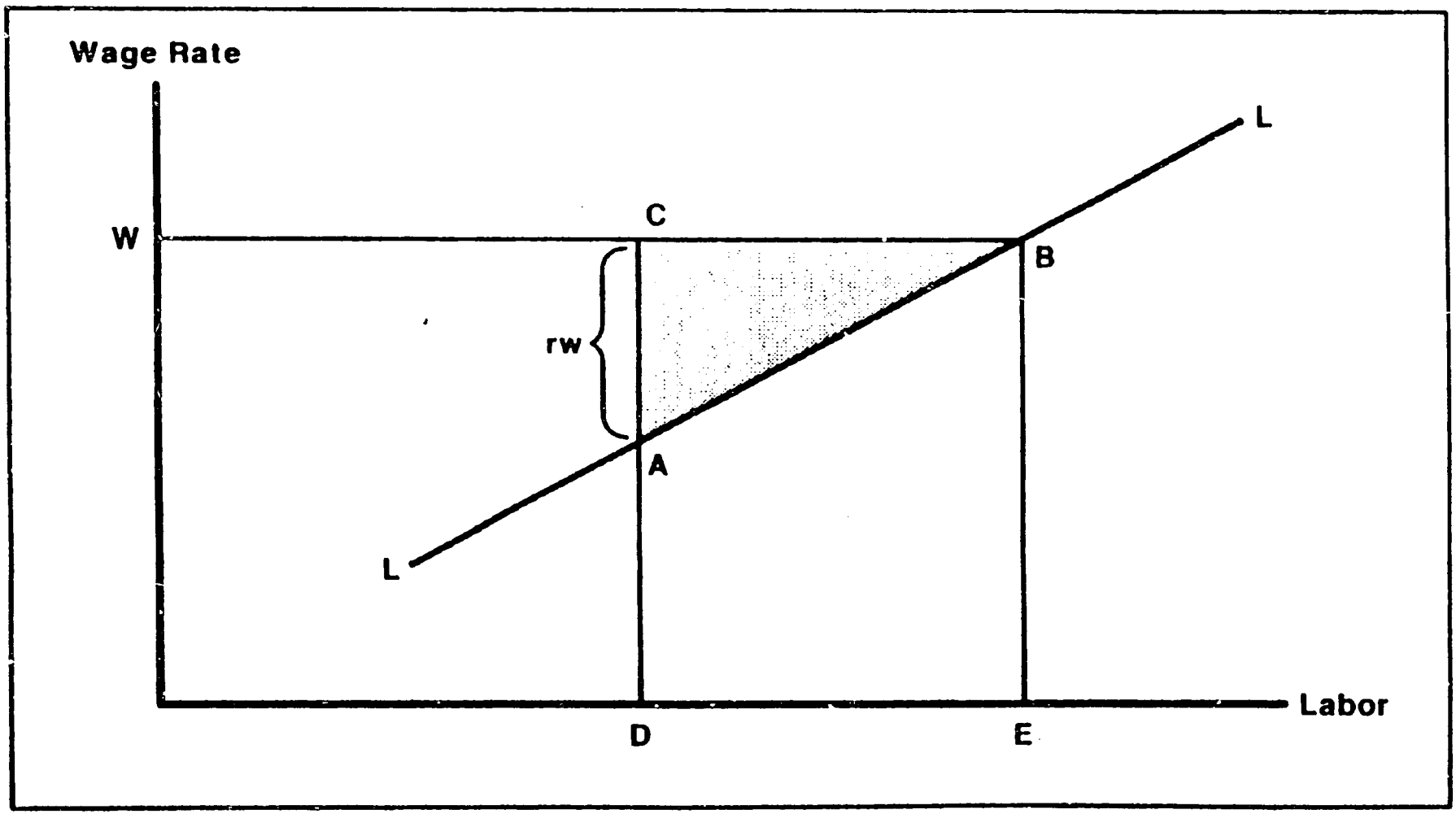

Figure 4.

B. Measurement of Excess Burden

As so often occurs, it proved easier to propose the concept than to measure it. Through 1964 little happened in terms of deriving specific estimates. In that year, Harberger commented that the economics profession had not given the concept the attention it deserved (it was "...the province of only a handful of economists rather than at least the occasional hobby of a much larger group"). He acknowledged three possible reasons for its "apparent unpopularity": (1) the difficulty of obtaining numerical values for key elasticity variables, (2) the difficulty in taking account of other distortions, and (3) a more general suspicion of the theory of consumer surplus (1964a; pp. 59, 60).

1. Partial Equilibrium Approaches

Harberger went on to explore a variety of possible partial equilibrium ways to measure the deadweight loss (which he called "welfare cost of a tax system" elsewhere; 1964b). In the process he built on previous work and developed a basic formula for measuring welfare change; several variants were also explored. [5/]

One of the first, and perhaps the most widely cited, application of the Harberger formula was reported by Browning in 1976. He calculated that the marginal excess burden for taxes on labor income in the United States was from 9 to 16 cents on the dollar in 1974. Numerous other studies followed. [6/]

The partial equilibrium approach, however, had several limitations. As noted by Stuart, these were: (1) it is exact only in the neighborhood of an undistorted equilibrium, (2) the Harberger formula is conceptionally inadequate for measuring marginal excess burden, and (3) it does not consider the effect of taxation on the tax base.

Stuart went on to note under point (2) that while the formula correctly measures the cost of failing to use lump sum taxation, this is not the

alternative forgone in raising an additional dollar of tax revenue:

> To calculate the welfare cost of raising an additional dollar of revenue, one wishes to compare changes in utility and revenue as the economy moves from an equilibrium before a tax increase to one after the tax increase (p. 352).

Moreover, Stuart, writes:

> ...since the equilibrium level of tax revenue generally depends on the way in which the government spends the revenue, the value of the marginal excess burden cannot itself be independent of the type of marginal spending (p. 353).

Stuart and Hansson also subsequently noted that:

> ...the full equilibrium response of the economy to a balanced budget increase in public spending depends in part on how the marginal spending influences private demands and supplies. Such influences...are referred to as "expenditure effects"... (p. 332) 7/

2. General Equilibrium Approaches

A broader approach was needed. This was provided by general equilibrium models. Four of particular significance will be noted here. The first two were cited by Fox.

Stuart calculated the marginal excess burden (MEB) from taxes on labor income in the United States. He limited government expenditures to only two items: (1) redistribution to the household, and (2) government consumption. The former was treated as a perfect substitute for private consumption of taxed-sector output. The latter is assumed to have no influence on the marginal rate of substitution between the outputs of the two sectors. His "benchmark" MEB figure was 20.7 cents per dollar (variants ranged higher and lower; Fox cited only the upper range). When the model was rerun to direct all the tax revenue into government consumption, the MEB dropped to 7.2 cents, or by two thirds. Stuart noted that the size of this reduction "...provides strong confirmation that the ultimate use of public funds matters" (p. 359).

A subsequent general equilibrium study by Ballard, Shoven and Whalley covered all taxes. They assumed that the government uses its revenues to (1)

provide transfer payments to the household sector, and (2) make exhaustive expenditures that do not directly affect consumer utility or the structure of production. Like Stuart, their model does not allow for complementarity between public goods and private goods (a relationship previously suggested by Atkinson and Stern). They note that if this were done, the MEB might be reduced. Their estimates varied, according to elasticity assumptions, from 17 to 56 cents; they expressed most confidence in a mid-range figure of 33 cents (p. 135).

The same two variables were also studied by Hansson and Stuart using Swedish data for 1979. They found that the marginal cost of public funds which were redistributed to taxpayers was nearly 36% higher then than for expenditures which had no influence on private behavior. Moreover, "the marginal cost "...for a given marginal fiscal program can be less than one or infinite depending on the specific characteristics of the program." The low-end result shows that "...tax increases can in some instances be anti-distortionary'" (p. 333). The authors also found that the cost of public funds was influenced by the specific tax instruments used and the initial levels of the tax rates.

A more flexible app. ach was taken by Hansson in another study when he added a third category of government expenditures: infrastructure that increases productivity in the taxed sector (INF). These expenditures give a proportional upward shift in the production function in the private sector. On the basis of Swedish data for 1979, the marginal cost of the infrastructure expenditures was close to zero. In the author's words: "This implies that a marginal benefit of unity is sufficient to rationalize this type of expenditure" (p. 129).

Hansson did not define the components of INF, but certainly they would include technological change. Harberger briefly considered this possibility

in 1971. He stated that "when technological advance occurs, the resources thus freed are enabled to increase total welfare" (p. 793). In diagrammatic terms (Figure 5), a reduction in unit costs from OA to OB would produce a benefit of ABCD in the absence of distortions. 8/

3. A Rejoinder

Browning, noted earlier as having made the first calculations of MEB using a partial equilibrium approach, recently returned to the subject in the light of subsequent work with general equilibrium models (1987). He noted the higher estimates derived from these models and the assumption that they capture some essential elements that are missing in the partial equilibrium approach. He does not believe that this is the case. Once a correction is made in the partial equilibrium model, which raises the estimate of MEB, virtually all the differences in results can be traced to different assumptions about key parameter values. His preferred revised estimates of the MEB range from 32 to 47%, depending on what assumption is made about the extent to which taxpayers benefit from the marginal government spending. While he acknowledges that other things being equal, the general-equilibrium model results are to be preferred to partial equilibrium results, the latter approach has two important advantages: (1) it is more easily understood, and (2) it is easy for other investigators to perform sensitivity analysis.

C. Some Points of Interpretation

Clearly, the concept and measurement of excess burden has undergone some changes over time. The precise terminology tends to vary with the author, as reflected here. Along with this have gone subtle and not so subtle changes in meaning. Some economists take a broad view; others a narrower view.

This was nicely illustrated in an early exchange between Frisch and Hotelling in 1939. Frisch in commenting on Hotelling's paper (cited earlier) said that "The relevant question is, of course, what the government does with

Harberger's Demonstration of the Effect of Technological Advance, 1971.

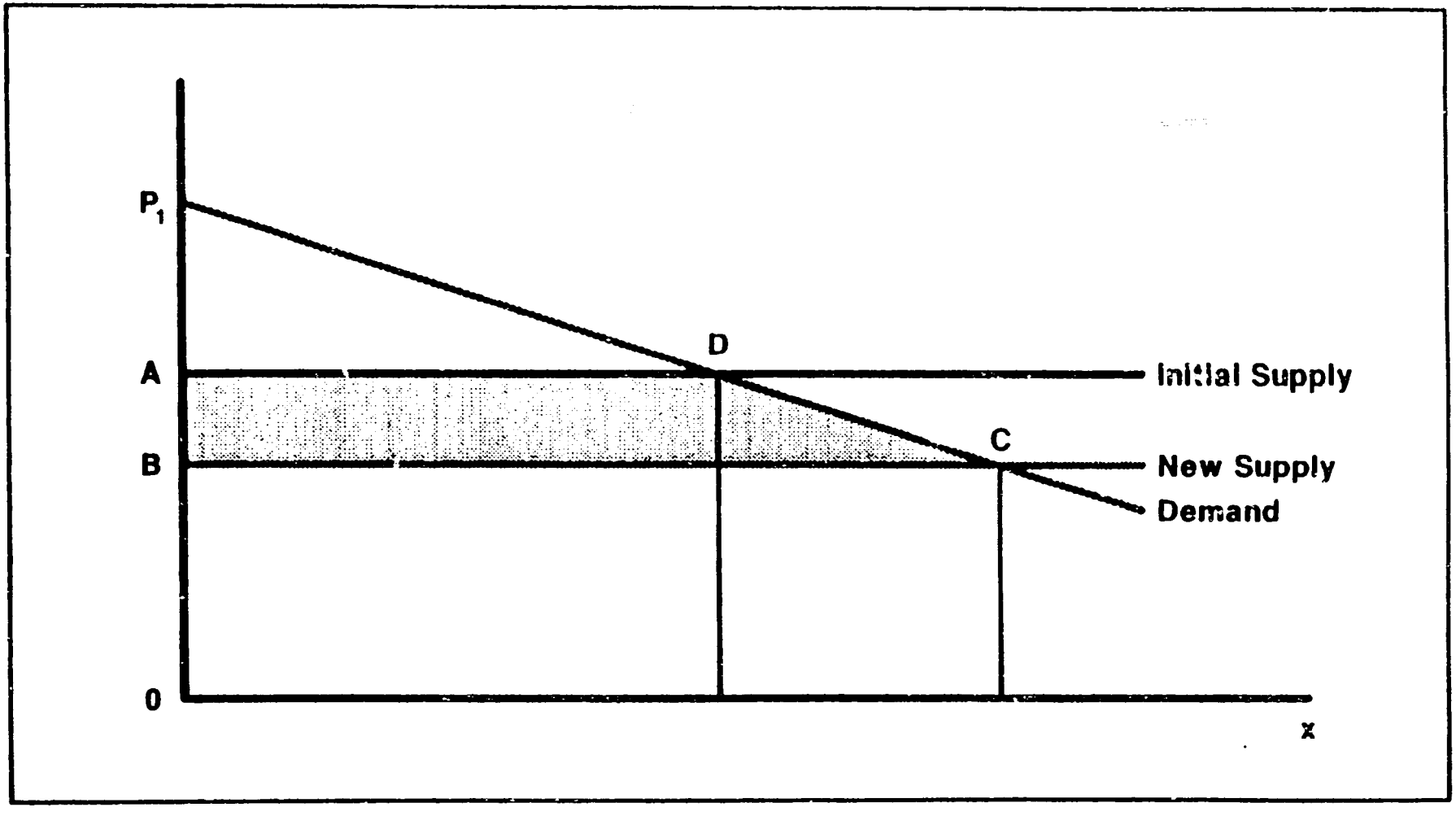

Figure 5.

the money," and "If this is done, there will not be any 'net social loss', but possibly a great gain" (he was perhaps optimistic) (p. 150). In response, Hotelling stated that his statistical expression of the social loss applied to "...a system of excise taxes in contrast to more efficient types, regardless of what the government does with the money" (p. 154).

In discussions such as this, one person may be thinking of what could be called gross excess burden and the other of net excess burden. The immediate effect of a tax might be called the gross burden and this is the same no matter what use is made of the taxes. The longer term effect, taking use of tax funds into account, might be called the net excess burden. The net figure may be quite different from the gross figure. An awareness of this simple yet subtle point could help reduce some of the confusion which often seems to surround discussion of excess burden.

Another aspect which should be kept in mind is the existence of some skepticism about the concept and its measurement, both by economists and by the public. Some economists, such as Cochrane, do not subscribe to the basic theory of consumers' surplus, and have indicated that they think it of greater theoretical interest than of practical value. 9/ When Harberger presented the welfare cost idea in 1963 to a tax conference, the response was mixed; most of those who attended evidently agreed but some did not. The conference summary noted that "...welfare aspects of taxation are not settled doctrine" (Chase, pp. 297-298). The excess burden concept met somewhat the same reaction at another tax conference in 1979 (Aaron and Pechman, p. 24).

III. PUBLIC APPROPRIATIONS FOR AGRICULTURAL RESEARCH IN THE UNITED STATES

So far we have largely dealt with general conceptual matters. We now turn to more specific and empirical issues relating to public agricultural research. This will be done by examining long-term data on public

appropriations in the United States. The review provides an introduction to available data and trends at the national level and set the stage for considering Fox's statement that "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" (p. 809, fn 3).

We will be concerned with total public appropriations at the federal and state level. [10/] These data are then normalized on several different bases. Four steps are involved. The computations themselves are quite ordinary, but have not, to my knowledge, heretofore been taken at the national level. [11/] The interrelations between the data and theory will be taken up in the final section of the paper.

A. The Time Period and the System

Data have assembled for public appropriations for the 70-year period from 1915 to 1984. The earlier date was set by the ready availability of data, but is also an appropriate starting point in terms of the emergence of the federal-state research system. Federal research was quite modest until the arrival of James Wilson as Secretary of Agriculture in 1897; by the end of his term in 1913, the Department of Agriculture had been built into a significant research organization. Most states established research programs somewhat earlier, but were largely supported by federal funds under the Hatch Act, passed in 1887. About 55% of their funding from 1889 to 1915 came from federal funds. After 1915, non-federal funds, primarily state appropriations, became a much more important source of funding and federal funding subsided to the 19 to 30% range. [12/]

B. Total Appropriations

In terms of current dollars, total federal-state appropriations for agricultural research expanded very sharply from 1915 to 1984. This is shown in summary form in Table 1, column 1. [13/] On the surface, there would seem

Table 1

Total Federal and State Appropriations for Agricultural Research, Total and Per Capita, Current and Constant Dollars, United States, 1915 to 1984

Five-Year Period	(1) Average Total Appropriation Current $ -millions of dollars-	(2) Average Per Capita Appropriation Current $ -cents-	(3) Constant $ -cents-
1915-19	9.92	9.66	7.53
1920-24	14.35	13.32	7.56
1925-29	20.89	17.53	10.14
1930-34	27.23	21.84	15.28
1935-39	30.23	23.40	16.78
1940-44	38.97	29.25	18.50
1945-49	62.00	43.27	19.95
1950-54	101.26	64.90	25.03
1955-59	165.69	96.69	34.48
1960-64	260.76	140.18	45.41
1965-69	413.68	209.31	62.22
1970-74	573.55	274.14	64.03
1975-79	938.43	425.89	68.92
1980-84	1,441.31	621.35	65.96

Sources:

Column 1. Calculated from federal and state data provided in: Robert G. Latimer, "Some Economic Aspects of Agricultural Research and Education in the United States," Purdue University, Ph.D. dissertation, January 1964, pp. 171, 224 (1915-1962 period); [Dana G. Dalrymple] "Statistics on Research Funding," in An Assessment of the United States and Agricultural Research System, Congress of the United States, Office of

(Table 1 con't)

Technology Assessment, December 1981, pp. 201-203 (1915-1967 period); Funds for Research at State Agricultural Experiment Stations, U.S., Department of Agriculture (USDA), Cooperative State Research Service (CSRS), annual, 1963-1967, Tables 3 and 4; and data provided by John R. Myers, Director, Current Research Information Systems, CSRS/USDA, April 29, 1986 (1968-1984 period).

Column 2. Column 1 divided by total resident population obtained from: Historical Statistics of the United States, Colonial Times to 1970, U.S. Department of Commerce, Bureau of the Census, Part 1, 1985, p. 8; and, for later years, annual issues of the Statistical Abstract of the United States, U.S. Department of Commerce, Bureau of the Census.

Column 3. Column 2 divided by the consumer price index (1914=100). Data for 1915 to 1960 obtained from Historical Statistics..., op.cit., p. 164. Data for subsequent years obtained from annual issues of the Statistical Abstract..., op. cit. and recalculated on 1914 base.

to have been an enormous expansion in public funding for agricultural research.

But if the data are normalized on the basis of population, growth, and inflation, the situation becomes somewhat more muted. Accounting for population growth (Table 1, column 2) reduces the figures by more than half since the mid 1960's. Accounting for inflation, by use of the consumer price index, makes an even more substantial reduction (Table 1, column 3): the constant dollar figure for the 1980-84 period was only slightly over 10% of the current dollar figure.

Even so, the per capita appropriations in constant terms rose significantly, from 7.5¢ in the 1915-19 period, to 68.9¢ in 1975-79. Then, for the first time, they dropped in 1980-84. If the 1915-34 period is compared with the 1965-84 period, the appropriations increased 6.4 times.

C. Appropriations Relative to Income

While appropriations were expanding, there was also a growth in individual wealth. How does the increase in wealth compare with the increase in the funding for agricultural research? To determine this, per capita appropriations for agricultural research were calculated as a proportion of per capita personal income (both in current dollars). Unfortunately, the personal income series does not start until 1929, so the period of coverage is shortened somewhat.

The figures, reported in Table 2, show relatively little variation over the 55-year period. There was a drop during World War II (1940-44), and the proportion peaked during the 1965-69 period. In recent years it has dropped somewhat. The proportion in the 1980-84 period was only 17.9% higher than 50 years earlier in the 1930-34 period. The marginal change in appropriations in these terms has been slight.

Table 2

Appropriations for Agricultural Research
as a Proportion of Personal Income, Per Capita,
United States, 1930 to 1984

Five-Year Period	Average Proportion -percent-
1930-34	.0475
1935-39	.0437
1940-44	.0345
1945-49	.0404
1950-54	.0384
1955-59	.0474
1960-64	.0587
1965-69	.0654
1970-75	.0595
1975-79	.0579
1980-84	.0560
Average	.0501

Source: Calculated by dividing per capita appropriations for agricultural research (current), summarized in Table 1, by per capita personal income (current) as reported in Historical Statistics..., op. cit., p. 225 and subsequent annual issues of the Statistical Abstract.

Another dimension is that different income groups in society carry different tax loads: the wealthier pay more in absolute terms than the poor. Recently, White calculated the total taxes paid for agricultural research per family in the United States in 1980. The result was as follows:

Income Class	Total Tax
Under $10,000	$2.41
$10,000-14,999	6.36
$15,000-19,999	9.70
$20,000-24,999	11.98
$25,000-34,999	16.63
Over $35,000	41.46

The benefits of research from the consumers' point of view did not increase nearly as sharply as taxes. [14] The poor, because they spend a larger proportion of their income on food, gain relatively more than higher income groups. And some producers or land owners may gain more than others. Thus agricultural research does have a redistributive element to it.

D. Appropriations Relative to Tax Revenue

The final step is to examine the relationship between governmental appropriations for agricultural research and governmental tax receipts. This is also done by computing the former as a proportion of the latter. The results are summarized in Table 3 and in Figure 6. [15]

The average proportion allocated for agricultural research, two-tenths of one percent (0.21%), showed virtually no trend over the full period. [16] The annual variation was fairly wide prior to 1960 (high during the depression; low during World War II and in the immediate post-war years), but was much reduced after that. The peak figure in recent years was obtained in 1965.

Clearly, again, changes in appropriations for agricultural research as a proportion of tax receipts have been quite modest. It is unlikely that future years will see much change in this pattern; if anything the chances of a decline in appropriations presently seem greater than for an increase.

Table 3

Appropriations for Agricultural Research as a Proportion of Government Tax Receipts, United States, 1922 to 1984

Years/Period	Average Proportion -percent-
1922	0.197
1927	0.210
1932,34	0.313
1936,38	0.254
1940,42,44	0.191
1946,48	0.125
1950,52-54	0.143
1955-59	0.175
1960-64	0.209
1965-69	0.233
1970-74	0.216
1975-79	0.224
1980-84	0.219
Average, periods	0.215
Average, individual years	0.207

Source: Calculated by dividing per capita appropriations for agricultural research (current) summarized in Table 1 by total federal, state, and local tax receipts as reported in Historical Statistics..., op. cit., Part 2, p. 1119, and subsequent annual issues of the Statistical Abstract.

Proportion of Governmental Tax Receipts Spent on Agricultural Research, United States, 1922-1984.

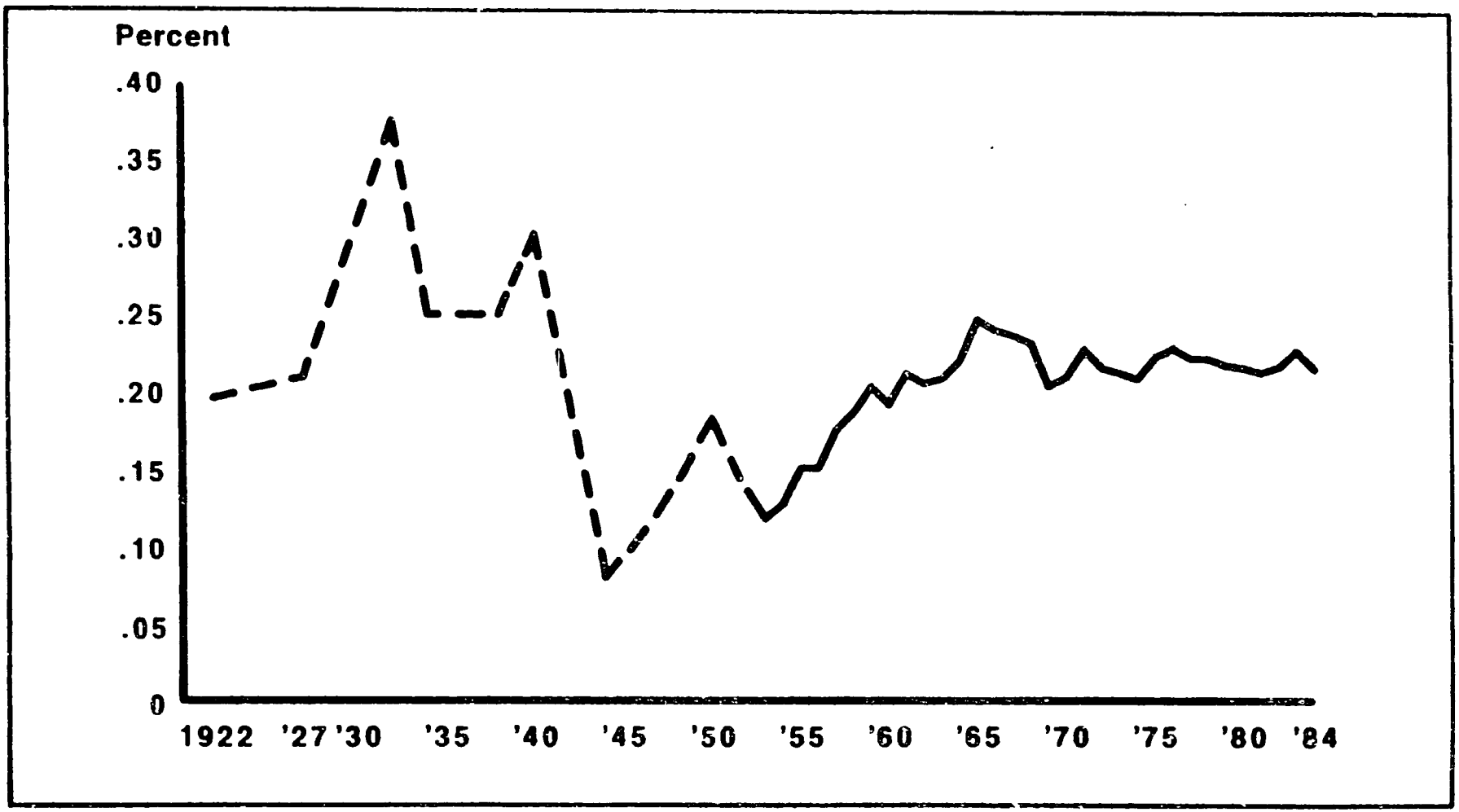

Figure 6.

IV. DISCUSSION

The concept of an excess burden of taxation has a long and noble lineage, but has occupied a back room for most of its life. It, like the theory of consumers' surplus from which it derives, is an intriguing concept but is difficult to measure or apply.

Public agricultural research would, however, seem to be an appropriate potential candidate for application of the concept. Much (slightly under half) of the agricultural research conducted in the United States is financed with tax funds.[17/] Appropriations appear to have increased significantly over time. Moreover, many studies have been made of the rate of return to investment on this research. Should these returns be discounted to some extent, as Fox suggests, to take into account the excess burden associated with the collection of taxes?

A closer look at the concept of excess burden suggests a number of theoretical and practical questions which need to be considered before it is used. Some economists, as noted, have reservations about the realism of consumers' surplus.[18/] And in the case of excess burden, a number of assumptions do have to be made which limit the applicability of the concept. Some of these constraints may be eased by shifting from a partial to general equilibrium type of analysis, but other complexities are introduced. Most models have not allowed for the possibility that tax funds may be used for production-enhancing activities, such as research.

The latter is an important consideration in the case of public agricultural research. The purpose of most (but not all) of this research is to shift the supply curve to the right and to reduce the per unit cost of production. Essentially all of this production is carried out in the private sector. Also, the public sector research usually complements research done by the private sector (Wilke and Sprague). Thus agricultural research clearly

belongs in the technological change classification of Harberger and the infrastructure category of Hansson. And government-sponsored research is clearly a public good. 19/

In applying the concept of excess burden to agricultural research, however, is important to differentiate between gross and net measures. The former, as we have suggested earlier, refers only to the effect of the tax irrespective of use. The latter figure takes the use of the funds into account. In his analysis of agricultural research, Fox drew a deadweight loss estimate from approximately the midpoint of the range cited by Ballard, Shoven, and Whally (30 cents) and used it to discount returns to research. 20/ This deadweight loss range, as we have noted, did not allow for (1) infrastructure or productivity-enhancing use, or (2) complementarity between public and private goods. Hence it appears to have been a gross estimate and perhaps suitable for discounting rate of returns. But was it the most appropriate gross estimate? The figures vary widely, depending on how they are calculated, and is not at all certain which would be most appropriate for this purpose.

There is also a question whether a marginal or average figure should be used. 21/ Fox suggests that a marginal figure is justified because the share of public expenditure spent on research is small. This seems quite likely, but was not documented. Review of data on public appropriations for agricultural research in the United States over the past 70 years suggest substantial increases in appropriations, but when these are normalized on the basis of population growth and inflation, the figures are considerably reduced. They are lowered further when changes in personal income are taken into account. And when appropriations are considered as a portion of total tax revenue, very little change is apparent. Moreover, appropriations for agricultural research represent only a small proportion of income or tax

revenue. Thus both the marginal changes and average levels appear small. As is probably true in other sectors, the wealthier pay more for agricultural research and receive relatively less than the poor.

While all of this suggests that agricultural research is a relatively minor user of public funds in the United States, and a highly productive one at that, it does not mean that it is excused from the need for a certain amount of discounting when the time comes to calculate cost-benefit ratios or rates of returns. The big question is what estimate of excess burden is most suitable for this purpose. Another question, which in part depends on the figure chosen, is the degree to which it will influence the outcome of the return calculations.

Although excess burden has been reviewed here in the context of agricultural research in the United States, the issues are equally relevant for public research in other nations and for other forms of government expenditure. Obviously it would not be appropriate to discount only the returns from research in making comparisons with returns from other forms of government investment: all, or none, would have to be discounted. The issue can quickly become a larger one.

Thus for some students of agricultural research the concept of excess burden may not be entirely welcome. It provides theoretical complexities. It is difficult to explain. It is not easily measured. And its degree of influence on rates of return is uncertain. In short, it may appear to be more trouble than it is worth. But it cannot be readily dismissed by those who use the theory of consumers' surplus to measure returns to research. It is the other side of the coin that needs to be examined more closely.

V. NOTES

1/ The fullest treatment found in general economics texts is provided by Fischer and Dornbusch. In the case of welfare economics texts reviewed, coverage was usually scattered and highly theoretical: Just, Heuth and Schmitz, however, provide a brief but clear introduction. In the case of public finance texts, particularly good coverage is provided in: Musgrave and Musgrave; Rosen; and Stiglitz. Most texts provide no historical background, focus on partial equilibrium effects, and give little attention to social benefits from government expenses.

2/ Actually Dupuit's original presentation had price on the horizonal axis and quantity on the vertical axis. They have been switched here to conform with current practice. The diagram is similar to one presented by Currie, Murphy, and Schmitz (p. 766) but retains Dupuit's original notation.

3/ This was in part because he did not refer to producers' surplus at this point in the text (and did not discuss it in diagrammatic form, and then in a different context, until Appendix H, p. 668) or to the social cost.

4/ The diagrams used in this section have moved, with variations, into common use in textbooks. Reference is, however, now usually made to compensated demand curves. Excess burden may also be analyzed in terms of indifference curves, but they are not a useful device for measurement.

5/ The formula is provided in 1964a, p. 61. Harberger notes that the basic expression "...pops up in one form or another all through the literature on the measurement of welfare costs..." (1964a, p. 62). He provides a more general formula for measuring welfare change in his 1971 paper; it includes a policy variable, which in this case is a tax (p. 789).

6/ Many are summarized in St-Hilaire and Whalley, pp. 44-47. Most of these are based on a comparison with lump-sum taxation, which essentially doesn't exist (one example is a poll tax). Hence it is not a particularly realistic base, although it does represent the "optimum" in terms of minimal distortion (and a minimum in equity).

7/ Expenditure effects had previously been noted by Lindbeck.

8/ Harberger also discussed the impact in algebraic terms (pp. 793-794).

9/ Considerable literature exists on the limitations of theoretical welfare economics (see Runge and Meyers).

10/ Funds from other sources are excluded. Hence the data do not include fees, sales, miscellaneous sources and special funds. In recent years the totals include some new federal appropriations for forestry and veterinary research, but these figures are quite small compared to the total (the same situation may occur in some of the state data). The appropriations are for domestic programs only: foreign aid funds for international agricultural research activities, some of which are of benefit to the Unted States, are excluded.

11/ In the past, expenditure data have generally been disappregated and normalized at the state or commodity level. State data have, for instance, been normalized on the basis of state population, farm income, number of farms, etc., and used to facilitate comparisons between states (see Dalrymple, 1962, for an early example). Commodity data, both federal and state, have been normalized on the basis of value of production, value added, etc. (see Ruttan, 1983, for a recent example).

12/ Calculated from data used in the preparation of figure 7 in [Dalrymple], 1981, p. 43.

13/ Actual expenditures, representing funds from other sources (such as earned income), would have been higher. Over the period, 66.6% of the funds came from federal sources and 33.4% came from state sources. The federal proportion was 70.5% during the first half of the period and 62.7% during the second half.

14/ The average benefits per family were calculated as, respectively: $26.75, $30.61, $34.19, $39.26, $44.22, and $53.47.

15/ Unfortunately, consistent data on total federal and state tax receipts are not readily available for every year prior to 1952, so that the time series is incomplete. The reference here is general tax revenue: it excludes

other forms of general revenue ("charges and miscellaneous"), income from utilities and liquor stores, and insurance trust revenues. In 1982, tax revenue represented 77.6% of total general revenue.

16/ When the federal and state data were separated for the 1968 to 1984 period, it was found that only a slightly higher proportion of federal tax funds were appropriated for research (0.233) than was true at the state level (0.200). This is remarkably close.

17/ The public proportion has generally been thought to average about 50%. However, when calculated using the appropriation data cited in this report (which are less than expenditures), the proportions are slightly lower - about 43.9% in 1965 (based on private sector data reported in Wilke and Sprague), and 43.1% in 1984 (Agricultural Research Institute data). Based on expenditures, the 1965 proportion was 46.1%. It is not certain whether the private sector data include producer checkoffs or levies on individual commodities for research; these are, in any case, of minor overall importance in the United States but are understood to be considerably more significant in Australia and Israel. For a further discussion of private sector research, see: Peterson; and Ruttan (1982).

18/ Clearly this group would not include the many economists who have made use of producers' and consumers' surplus to evaluate returns to research.

19/ Mills notes that this is more nearly the case for basic than for applied research. He indicates that about 65% of a basic research and 45% of applied research is sponsored by the national government (pp. 40-41).

20/ In a subsequent study, Fox (1987) calculated the effect of increasing the MEB from 35 to 50 cents on the optimal level of research expenditures for crops and livestock: they were reduced by an average of about 10 percent.

21/ A more formal definition of each is provided in Ballard, Fullerton, Shoven and Whalley (pp. 9, 237).

VI. REFERENCES

Agricultural Research Institute. A Survey of U.S. Agricultural Research by Private Industry, III. Bethesda, Md., July 1985, 1-16.

Aaron, Henry J. and Joseph A. Pechman. "Introduction and Summary." In How Taxes affect Economic Behavior, edited by Henry J. Aaron and Joseph A. Pechman. Washington, D.C.: The Brookings Institution (Studies of Government Finance), 1981, 24.

Atkinson, A. B. and N. H. Stern. "Pigou, Taxation, and Public Goods." The Review of Economic Studies, 41 (1974), 119, 122, 126.

Ballard, Charles L., John B. Shoven, and John Whalley. "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States" American Economic Review, 75 (March 1985), 128-138.

Ballard, Charles L., Don Fullerton, John B. Shoven, and John Whalley. A General Equilibrium Model for Tax Policy Evaluation. Chicago: University of Chicago Press, 1985, 9, 237.

Browning, Edgar K. "The Marginal Cost of Public Funds." Journal of Political Economy, 84 (1976), 283-298.

——— "On the Marginal Welfare Cost of Taxation." American Economic Review, 77 (March 1987), 11-23.

Chase, Samuel B. Jr., "Summary of Conference Discussion." In The Role of Direct and Indirect Taxes in the Federal Revenue System. Princeton: Princeton University Press, 1964, 295-313.

Cochrane, W. W. "Some Noncomformist Thoughts on Welfare Economics and Commodity Stabilization Policy." American Journal of Agricultural Economics, 62 (August 1980), 508-511.

Currie, J. M., J. A. Murphy, and A. Schmitz. "The Concept of Economic Surplus and Its Use in Economic Analysis." The Economic Journal, 81 (December 1971), 765-767.

Dalrymple, Dana G. "Comments in Public Purpose in Agricultural Research and Extension." Journal of Farm Economics, 54 (May 1962), 445-453.

[Dana G. Dalrymple] "The Role and Development of Public Agricultural Research," "Statistics on Research Funding." In An Assessment of the United States Food and Agricultural Research System. Washington, D.C.: Congress of the United States, Office of Technology Assessment, December 1981, 29-49, 201-203.

J. Dupuit. "De la Mesure d'utilite des Travaux Publics" (On the Measurement of the Utility of Public Works). Annales des Ponts et Chaussees, 8:2e partie (1844). Translated from the French by R.H. Barback for International Economic Papers, London, 2 (1952), 83-110; reprinted in Transport: Selected Readings, edited by Denys Mumby. Baltimore: Penguin Books, 1957 (especially 52-57).

Fischer, Stanley and Rudiger Dornbusch. Introduction to Microeconomics. New York: McGraw Hill, 1983, Chapter 17 ("The Government and Resource Allocation"), 417-435.

Fox, Glenn. "Is the United States Really Underinvesting in Agricultural Research?" American Journal of Agricultural Economics, 67 (November 1985), 806-812.

Fox, Glen, and A. K. Enamul Hague. "A Model of Optimal Public Investment in U.S. Agricultural Research: Further Results." Guelph: University of Guelph, Department of Agricultural Economics and Business, Working Paper 87/12, October 1987, 36-38.

Frisch, Ragnar. "The Dupuit Taxation Theorem." Econometrica, 7 (1939), 145-150.

Gardner, Bruce. "Efficient Redistribution Through Commodity Markets." American Journal of Agricultural Economics, 65 (May 1986), 225-234.

Hansson, Ingemar and Charles Stuart. "Marginal Cost of Public Funds for Different Tax Instruments and Government Expenditures." Scandanavian Journal of Economics, 86 (1984), 115-130.

Hansson, Ingemar. "Tax Revenue and the Marginal Cost of Public Funds in Sweden." Journal of Public Economics, 27 (1985), 331-353.

Harberger, Arnold C. "The Measurement of Waste." American Economic Review, 54 (May 1964), 58-76.

——— "Taxation, Resource Allocation, and Welfare." In The Role of Direct and Indirect taxes in the Federal Revenue System. Princeton: Princeton University Press, 1964, 25-70.

——— "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay." Journal of Economic Literature, 19 (September 1971), 785-797.

Hicks, J. R. "The Rehabilitation of Consumers' Surplus." Review of Economic Studies, 8 (1941), 112-114.

Hotelling, Harold. "The General Welfare in Relation to Problems of Taxation and of Railway and Utility Rates." Econometrica, 6 (1938), 243-246, 254.

——— "The Relation of Prices to Marginal Costs in an Optimum System." Econometrica, 7 (1939), 151-155.

Just, Richard E., Darrell L. Hueth, and Andrew Schmitz. Applied Welfare Economics and Public Policy. Englewood Cliffs: Prentice-Hall, 1982, 159-160.

Lindbeck, Assar. "Tax Effects Versus Budget Effects on Labor Supply." Economic Inquiry, 20 (1982), 473-489.

Marshall, Alfred. Principles of Economics. London: Macmillan, 8th edition, 1959, 387-389 (8th edition originally published in 1920).

Mills, Edwin S. The Burden of Government. Stanford: Hoover Institution Press, 1986, 40-41.

Musgrave, Richard A. and Peggy B. Musgrave. Public Finance in Theory and Practice. New York: McGraw-Hill, 4th edition, 1984, Chapter 14 ("Excess Burden and Efficiency"), 289-313.

Peterson, Willis L. "A Note on Social Returns to Private Research and Development." American Journal of Agricultural Economics, 58 (May 1976), 324-326.

Rosen, Harvey S. Public Finance. Homewood: Richard D. Irwin, 1985, 275-299.

Runge, Carlisle Ford and Robert J. Myers. "Shifting Foundations of Agricultural Policy Analysis: Welfare Economics When Risk Markets are Incomplete." American Journal of Agricultural Economics, 67 (December 1985), 1010-1016.

Ruttan, Vernon W. Agricultural Research Policy. Minneapolis: University of Minnesota Press, 1982, 181-214.

——— "Agricultural Research Policy Issues." HortScience, 18 (December 1983), 809-818.

St-Hilaire, France and John Whalley. "Recent Studies of the Efficiency and Distributional Impacts of Taxes: Implications for Canada." In Tax Options in the 1980's, edited by Wayne R. Thirsk and John Whalley. Toronto: Canadian Tax Foundation, Canadian Tax Paper No. 66, February 1982, 28-64.

Stewart, Charles. "Welfare Costs per Dollar of Additional Tax Revenue in the United States." American Economic Review, 74 (June 1984), 352-362.

Stiglitz, Joseph E. Economics of the Public Sector. New York: W.W. Norton, 1986, 103-105, 368-387.

White, Fred C. "The Benefits and Costs to U.S. Consumers in Various Income Categories of Investment in Agricultural Research." Athens: University of Georgia, Department of Agricultural Economics [April 1986], 1-11 (unpublished).

Wilcke, H. L. and H. B. Sprague. "Agricultural Research and Development by the Private Sector of the United States." Agricultural Science Review, 5 (Third quarter 1967), 1-8.