The Structure of Research and Transfer Policies in International Agriculture: Evidence and Implications

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Abstract: This paper addresses the well-known paradoxes of high rates of protection, underinvestment in agricultural research, and relatively high productivity that characterize developed country agriculture, while developing country agriculture is typically characterized by taxation of the sector, research underinvestment, and low sectoral productivity. The paper tests the proposition emerging from political economy theory that productive policies (e.g., research) and redistributive policies (e.g., subsidies) can be viewed as complementary in that the latter compensate producers who lose from the price-reducing effects of the former. The economic relationships between agricultural research expenditure, total policy transfers, sector productivity, and other variables are examined for a sample of developed and developing countries. The results confirm the complementarity hypothesis and show that increased relative rates of research expenditure are associated with higher agricultural productivity, higher country incomes, and higher rates of agricultural protection found in developed countries. The reverse is shown to occur in low-income countries. The results suggest that both policy and trade reforms in developed countries and increased agricultural research allocation and sector productivity in developing countries may be harder to accomplish than previously thought due to the complementarity phenomenon.

Introduction

Agricultural economics research has consistently demonstrated that governments significantly underinvest in publicly supported agricultural research (Ruttan, 1982; and Peterson and Hayami, 1977). Various reasons for this underinvestment have been advanced, ranging from a host of institutional and political factors (Ruttan, 1987) to theoretical arguments pertaining to the joint social provision of agricultural research and subsidies (Alston, Edwards, and Freebairn, 1988; and de Gorter, Neilson, and Rausser, 1990). With few exceptions, however (e.g., Pardey, Kang, and Elliott, 1989), empirical evidence on the underlying relationship between agricultural research expenditure and total government interventions in agriculture across countries, while widely speculated upon, has been left unexamined.

This paper reports the results of an examination into the empirical relationship between agricultural research support and total economic transfers in a sample of developed and developing countries. The evidence is shown to provide empirical support for recent theoretical contributions to the agricultural economics literature (Rausser and Foster, 1990; and de Gorter, Neilson, and Rausser, 1990) that have used political economic arguments to advance the notion that agricultural research and subsidy-type transfers can be viewed as jointly provided complementary policies. This argument suggests that agricultural subsidies serve, in part, to compensate producers for the potential losses induced by productivity-enhancing but price-reducing research policies. The international evidence reported here provides empirical foundation for the view that trade and policy reforms aimed at reducing agricultural subsidies may be harder to effect than is sometimes thought.

Agricultural Research—Theory and Practice

Since Griliches' seminal work on hybrid maize in the late 1950s, a long tradition of agricultural economics research has established that the rates of return to agricultural research are typically very high. Arndt and Ruttan, for example, cite the results of 20 major studies of agricultural research in a variety of developing and developed countries covering periods ranging from 1880 to 1973. The annual internal rate of return estimates calculated in these studies range up to 90 percent and average in the 40–60 percent range. Many other studies, too numerous to mention, have demonstrated similar results.

Given rates of return of these magnitudes, the obvious policy prescription is for governments, as well as the private sector, to devote significantly more resources to

agricultural research. Since "underinvestment" in agricultural research is chronic and widespread, the corollary question becomes, *why* do governments universally underinvest in agricultural research? Common answers to this question have been many (Ruttan, 1987): spillover effects to other countries, regions, and consumers; inefficient resource allocation in research; anticipated adverse socioeconomic effects from research-induced productivity enhancement; or difficulties in generating political support.

Despite the longstanding acceptance of the "underinvestment" hypothesis, recent research has begun seriously to question, largely from a theoretical perspective, both the extent of and reasons for research underinvestment. Lindner and Jarrett (1988) and Norton and Davis (1981), for example, show how analytical assumptions regarding the shape and shifts in underlying supply (and demand) functions will lead to widely varying estimates of research effects. Alston, Edwards, and Freebairn (1988) and Oehmke (1988) both show how interactions between agricultural research and subsidy programmes tend to increase the social costs of the latter, meaning that the benefits of research may be significantly overstated when measured in isolation from other policy effects. The implications of this and related research are that, while underinvestment may indeed exist and may be remedied by public policy changes, the gains from research suggested by many earlier studies may be both substantially overstated and lead to improper policy solutions.

A second very distinct line of economic research has, over the past decade, addressed what is typically considered to be an unrelated paradox in international agriculture; i.e., the simultaneous protection of agriculture in developed countries and taxation of agriculture in developing countries. A number of empirical studies, most notably the World Bank's 1986 *World Development Report*, have shown this pattern to occur widely, although these outcomes have been attributed to a variety of different contributing factors: the relative returns from protection gained by producers vs. consumers (Balisacan and Roumasset, 1987), existing comparative advantages (and disadvantages) in agricultural production (Honma and Hayami, 1986), and the potential employment effects of removing price distortions (Bale and Lutz, 1981). Research on agricultural protection and its removal has become important in recent years with market-oriented structural reforms in many developing countries and the current debate over multilateral trade reform in the GATT.[2]

A key to the resolution of these two paradoxes—i.e., underinvestment in agricultural research and protection vs. taxation of agriculture in developed vs. developing countries—is suggested by recent theoretical developments in the political economy of agriculture. Wicksell, Mueller, and Rausser have all recognized the usefulness of distinguishing between public policies designed to improve allocative efficiency ("productive" policies) on the one hand and policies designed to generate economic transfers to various groups ("redistributive" policies) on the other. Public agricultural research expenditure can be argued to belong in the former group (even though it may ultimately affect the distribution of welfare among producers and between producers and consumers) because they promote greater sector productivity and efficiency. Agricultural subsidies and related transfers clearly belong in the category of redistributive policies.

Based on this distinction, Rausser and Foster (1990) have shown that redistributive policies can be welfare *increasing* if they are treated not in an isolated fashion but combined with productive policies that, by themselves, would be impossible to implement due to insufficient political support. Their proposition is based on the notion of government maximizing a political preference function, $PPF = w\ (C) + (1\text{-}w)\ (F)$, where C and F are consumer and producer surplus measures, respectively, and w and $(1\text{-}w)$ are the associated preference weights. They derive the further theoretical result that "the expansion of total social welfare biased towards one group ... leads to a change in the degree of wealth transfer in favour of the other group" (Rausser and Foster, 1990, p. 650). These results suggest that the coexistence or complementarity of both productive (e.g., research) and redistributive (e.g., subsidy) policies is not a perverse but a rational response to conflicting demands by support-maximizing governments.

Most recently, de Gorter, Neilson, and Rausser (1990) have developed a similar, though more comprehensive, theoretical argument specifically applied to the joint determination of

agricultural research and subsidies. Their comparative static results show that the observed policy mix can be shown to depend on the relative welfare weights of producers and consumers, relative elasticities of supply and demand for the affected commodities, and the marginal producer response to research inputs. They conclude that "by providing a vehicle through which to compensate producers for losses incurred as a result of research expenditures, production subsidies may be necessary components of potentially Pareto-improving portfolios of policy instruments" (de Gorter, Neilson, and Rausser, 1990, pp. 28–29). Their thesis of research and subsidy complementarity (for methodological details, see de Gorter, Neilson, and Rausser) is briefly applied to and finds partial support in US agriculture. They end by calling for an examination of the robustness of the complementarity hypothesis through application to the widely varying conditions characterizing developing countries.

This paper provides such an examination. Sample data for 23 developed and developing countries (see Table 1) are drawn together to examine cross-country relationships among agricultural sector performance, protection, research expenditure, and other key variables. These key variables and associated data sources include: agricultural research expenditure from the recently published ISNAR data base on national agricultural research systems; agricultural value-added data from the World Bank's *World Development Report* (recent issues); agricultural labour force data from FAO's *Production Yearbook* (recent issues); and agricultural protection data derived from Webb, Lopez, and Penn (1990). Further methodological details, including underlying regression estimates, are contained in Lee and Rausser (1991).

Table 1—Countries Used in Analysis

Argentina	Colombia	Mexico	South Korea
Australia	Egypt	New Zealand	Thailand
Bangladesh	India	Nigeria	Turkey
Brazil	Indonesia	Pakistan	USA
Canada	Japan	Poland	Yugoslavia
Chile	Kenya	Senegal	

Results

Looking first at overall agricultural protection among the sample countries, a measure of protection that has been widely used in recent research by the US Department of Agriculture, OECD, and others is the "producer subsidy equivalent" (PSE). This measure estimates the value of direct and indirect government policy transfers to producers of specified commodities and has been calculated for a wide range of developed and developing countries (Webb, A.J., Lopez, M., and Penn, R., 1990). Figure 1 shows average aggregate PSEs for the sample countries in 1982–86 plotted against a measure of national wealth, the natural logarithm of each country's average per capita GNP. The general result of developed countries protecting and developing countries taxing their agricultural sectors (positive and negative PSEs, respectively) is confirmed for the sample countries as well.

In terms of agricultural research specifically, Figures 2 and 3 show two measures of research expenditure across the sample countries. Gross agricultural research expenditure (in log terms) is plotted against agricultural GDP in Figure 2, with the expected result that countries with larger agricultural sectors (in absolute terms) are shown to devote more resources to agricultural research. In Figure 3, a relative measure of research expenditure (i.e., research's proportion of agricultural GDP) is plotted against average per capita GDP for 1983–85. Boyce and Evenson (1975) and Pardey, Kang, and Elliott (1989) have termed this latter measure "agricultural research intensity." A clear positive correlation is evident,

confirming, for this sample, those authors' earlier findings that wealthier countries are able to devote a greater share of the wealth generated by agriculture to reinvestment in its productive potential. Low-income sample countries, by contrast, are shown uniformly to exhibit an agricultural research intensity of less than two percent.

Before turning to the policy dimensions of agricultural research, it is necessary briefly to define and examine the behaviour of the specific measure of agricultural sector performance used in this analysis. Following recent research by Houck and Rossman (1990) and de Janvry and Sadoulet (1988), the productivity measure used here is "agricultural value-added per agricultural worker." The methodological limitations of not using a multiple factor productivity measure here are well known, but generating such measures requires extraordinarily extensive data, which in practical terms are virtually impossible to get for most low- and middle-income countries. Use of the value-added measure does avoid one of the major limitations of partial productivity measures by excluding the value of purchased inputs. Agricultural sector performance, using this measure, is shown in Figure 4 to demonstrate a very distinct linear relationship to per capita GNP.

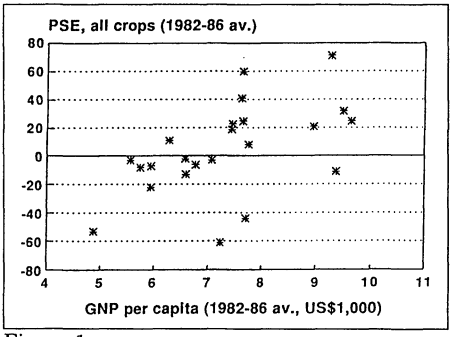

Figure 1

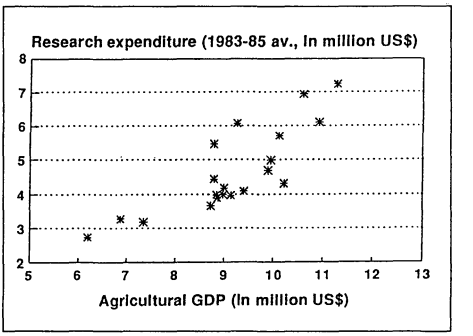

Figure 2

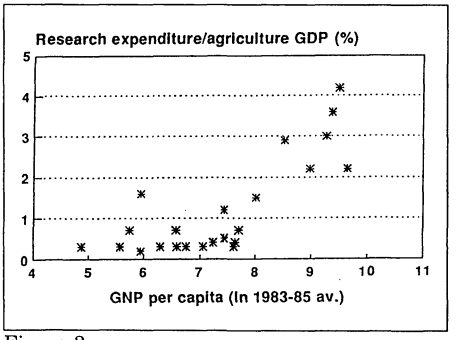

Figure 3

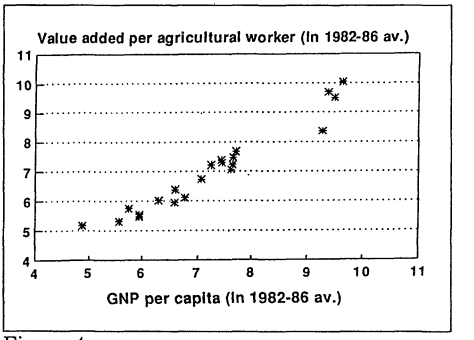

Figure 4

Using the same productivity measure, Figure 5 relates agricultural productivity to research expenditure across the sample countries. The demonstrated relationship is again predictable, given that agricultural research expenditure has long been argued to be a significant determinant of agricultural performance. While research impact on productivity has been argued to extend over as many as 30 years (Pardey and Craig, 1989), Figure 5 shows that even in the short run higher research allocations are strongly associated with higher agricultural productivity.

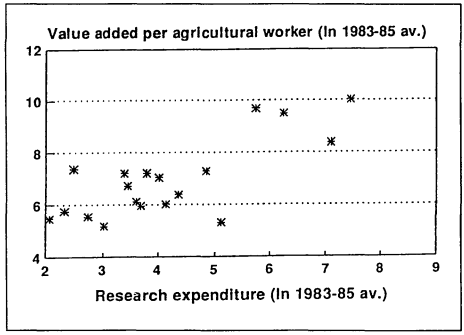

Figure 5

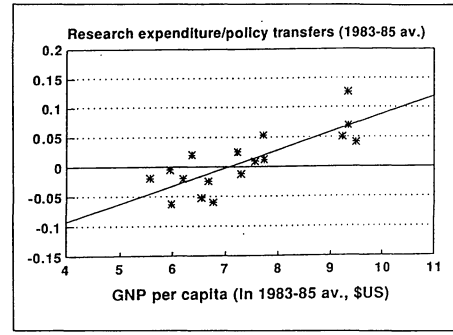

Figure 6

Given these intermediate results, let us consider the two results of primary interest in light of the earlier discussion. One of the key issues concerns the mix of agricultural research and transfer policies and whether complementarity between the two exists, for the reasons enumerated above. As seen above (Figure 1), it is clearly evident that subsidy-type transfers increase in absolute terms as country incomes increase. However, addressing the issue of the mix of productive and redistributive policies suggests that it is the *relative* contribution of each type of policy to total policy interventions that is the key. More specifically, the issue is whether the relative contribution of research increases simultaneously with subsidy levels as country income increases. If not, then research expenditure and subsidies can be viewed as "substitutes"; if so, the two can be viewed as "complements." The policy implications of this distinction are important, since if the latter is true, producers who are likely to suffer from research-induced long-term price reductions are likely to oppose policy reforms aimed at reducing transfers and subsidies. If the former is the case, then policy and trade reforms are likely to be far easier to accomplish.

The evidence in Figure 6 indeed shows that the ratio of research expenditure to subsidy-type transfers unambiguously increases with country income levels (the regression relationship is also given). The same result (not shown) can also be demonstrated to apply with respect to protection levels themselves. This lends strong support to the argument that agricultural subsidies can be viewed, at least in part, as mechanisms for compensating producers for their potential losses from productivity-enhancing but price-reducing agricultural research. The result is robust, extending over a wide range of low, middle and high-income countries.

The second key result relates to the relationship between agricultural performance (i.e., productivity) and the same relative measure of agricultural research intensity. Given the productivity effects of increased agricultural research, one would hypothesize that, as research expenditure increases in magnitude relative to welfare-reducing subsidy levels, agricultural sector performance itself should increase. Figure 7, which relates productivity to relative research expenditure, shows that this is in fact the case. This suggests that one reason for the record of strong productivity growth in developed country agriculture is that, despite a strong tendency towards increased protection, these countries show evidence of a complementary tendency towards support for agricultural research, with the resulting performance effects.

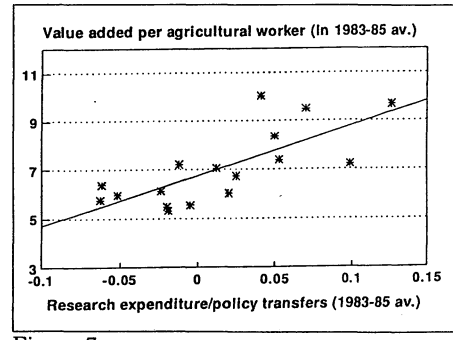

Figure 7

Implications

The complementary provision of productive (e.g., research) and redistributive (e.g., subsidy) policies by governments provides perhaps the only consistent explanation for the otherwise paradoxical outcomes of developed countries (which generally *protect* their agricultural sectors while investing more in agricultural research and generating *higher* levels of agricultural productivity), compared to developing countries (which typically tax their agricultural sectors, invest *little* in agricultural research, and demonstrate generally *low* levels of agricultural productivity).

The implications of these outcomes are numerous, but two are particularly important. First, the obstacles to proposed policy reforms—particularly stemming from GATT-type sources—are likely to be even greater than is often thought, given that producers, primarily in developed countries, receive positive rates of protection in part as compensation for the adverse price and income effects induced by productivity-enhancing agricultural research. Given that the latter originates from both public and private sources and can be slowed but can never be "stopped," its adverse impacts are inevitable and can only be offset (if deemed necessary) by public policy interventions.

Second, for developing countries, the obstacles to increasing agricultural research and productivity are reinforced by a "vicious cycle," wherein low research allocations (along with other factors) lead to low agricultural productivity, creating no need for compensation for adverse effects. This, along with other factors, perpetuates the "taxation" of agriculture and provides little incentive (or political support) for increased research allocations.

Notes

[1]Cornell University and University of California (Berkeley), respectively. The research reported herein was initiated while Lee was on leave with the US Agency for International Development and the US Department of Agriculture and while Rausser was at the US Agency for International Development. The senior author wishes to acknowledge the support of both institutions while holding neither responsible for the views or any errors or omissions contained within.

[2]It is worth noting that most GATT-related agricultural trade liberalization research has included research expenditure in aggregate measures of trade protection (e.g., Webb, Lopez, and Penn, 1990), although research and subsidy policies in fact have widely different functions and impacts.

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Discussion Opening—*Shankar Narayanan* (Agriculture Canada)

The large amount of positive protection for agriculture primarily in the developed countries in the mid-1980s (subsidy/transfer policy) emanated essentially from the market effects (i.e., price and income reducing effects) of a combination of policies: own productive policy, competing country's farm policy (trade war), and weather. Affordability of protection remained a non-issue for these countries with very high national income and a low agriculture GDP share because the absolute level of subsidy (protection) to agriculture, in spite of being very large, formed only a very minute fraction of the total GDP in relative terms, generally less than one percent. The inference that the positive protection is induced *in part* by productivity-enhancing agricultural research is valid, but is it robust? Further empirical validation is needed to determine the exact weights of the productive policy effects on protection. The data from the 1980s appear deficient in this respect as protection (subsidy and non-tariff barriers) during this period was driven mainly by the trade war. One should

perhaps examine the mid-1970s data for North America, when the returns from investment in agriculture were higher than from investment in stocks.

Developing (low income) countries with a predominant agriculture sector providing a 30- to 40-percent share of GDP and a greater then 50-percent share of employment cannot *afford not to tax agriculture* as a source of revenue. The perpetuation of "taxation," however, is contingent upon the long-term continuation of a structure dominated by low income, and the result was a structure dominated by low income and by the agricultural sector, which may change as the economies develop. Historical growth models of industrialized countries also show that the agricultural sector provided the capital for their early economic development.

The limit to research allocation (agricultural research intensity) is set by its relative share to agricultural GDP. In absolute terms, this may lead to low allocations, especially in the developing countries, even where there is a predominant agriculture GDP contribution. It is therefore hard to generalize about what is and what is not low.

The suggestion of low productivity being a response to "low" research allocation in the developing countries may be dubious. Low productivity may be due rather to inappropriate application of research results (e.g., high capital and knowledge requirements generally constrain the effective implementation of new techniques in the developing countries).

The benefits to consumers, who are the majority nationally and globally, in this spectrum of complementarity paradoxes should be also taken into account.

What are the limits to protection under these paradoxical situations and how are they set? Should productive research be slowed down or redirected in order to eliminate its counter-productive market effects? Are there farm subsidy policies that do not distort the national or international markets? Does the root cause lie in the saturation of food demand, leaving farm commodity supply much in excess? If so, what are the diversification implications?

[Other discussion of this paper and the authors' reply appear on the following page.]

General Discussion—*Ian M. Sheldon,* Rapporteur (Ohio State University)

Several comments and questions were raised in relation to the paper by Evenson and Cruz. Anderson questioned whether there was systematic bias in the results because of the exclusion of international spill-in contributions. Evenson agreed that this was the case, but indicated that it is difficult to obtain the relevant data. Sanint commented on the discrepancy in rates of return to agricultural research among the Brazilian states and compared to those of PROCISUR, as it raises questions about the effectiveness of EMBRAPA's role in Brazil and the possible duplication of research effort within Brazil. Belshaw wondered whether the PROCISUR experience provided an interesting example of what Eicher (ISNAR, 1989) has described as "technology-borrowing" activity as opposed to "technology producing" activity, which implies the possible centrality of "science and technology" policy within a multi-faceted agricultural research policy package. In response, Evenson agreed that PROCISUR did facilitate a broad diffusion of technological gains, e.g., weaker programmes in Paraguay and Uruguay were able to take advantage of stronger programmes in Brazil. In addition, a country such as Paraguay recognizes that it is a "technology borrower," and sees open trade as an opportunity rather than a threat in this respect. However, to be a good borrower does require a layering of internal science and technology production. Thomson asked what types of technology transfer were effective; had any research of this type been conducted for the EC and Eastern Europe; do PROCISUR-type activities work directly or indirectly? Evenson responded that PROCISUR programmes were very sharply focused, and he did not know of any research on such transfers within Eastern Europe.

The paper by Lee and Rausser also elicited several points from the audience. Sanint questioned whether the result that producers may be harmed by successful agricultural research was valid in a dynamic, general equilibrium context where demand is also shifting and the affected commodity develops strong links with the rest of the economy as output increases. Lee responded by saying that the paper did not promote the view that agricultural research should be slowed down because of harmful effects on producer prices; the focus of the paper is whether the effects of under-investment in agricultural research can be militated against through the use of agricultural subsidies. Colman thought it an attractive notion that it might be efficient for the public sector to compensate farmers for their losses from research expenditure through agricultural subsidies, if the benefits from such a policy exceeded the costs of compensation. But he also wondered whether detailed examination of the political process would reveal any such tradeoffs; e.g., in the UK both research and subsidies are being mooted as areas for reductions in public expenditure. He also asked whether the data used in the paper referred only to public research expenditure. If not, why should the public sector compensate losers from private research expenditure? Lee agreed that explicit modelling of the policy process was required and that the comment about private research was valid, but the data were often unavailable. Parikh wondered whether poor countries "disprotect" their agriculture because rich countries protect theirs, i.e., food imports are cheaper. Lee suggested that developing countries do not use subsidies because of the depressant effect on price. Thomson questioned whether agricultural subsidies may be triggered more often by trade crises than by the effects of research expenditure. In response, Lee agreed that there were many possible reasons for the use of agricultural subsidies. Kislev questioned whether the problem of under-investment in agricultural research ought to be embedded in a more general discussion of public under-investment. Lee accepted that the agricultural research expenditure literature has not focused on the general equilibrium analysis of investment. Lee also responded to comments by the discussion opener, suggesting that agricultural protection was not just affordable in the 1980s—such trade distortions are and have been a chronic issue. In addition, many developing countries cannot afford not to tax agriculture, although many LDCs have implemented structural adjustment programmes as a means of getting rid of export taxes.

Participants in the discussion included J. Anderson (World Bank), D. Belshaw (University of East Anglia), D. Colman (University of Manchester), Y. Kislev (Hebrew University), K. Parikh (Indira Gandhi Institute of Development Research), L.R. Sanint (CIAT), and K.J. Thomson (University of Aberdeen).