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PERSPECTIVES ON ASSESSING THE IMPACTS OF IMPROVED AGRICULTURAL TECHNOLOGIES IN DEVELOPING COUNTRIES

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While the role of technical change in agriculture is seen differently by protagonists of different theories of development, the processes of technology generation and uptake are widely seen as progressive. In this vein, agricultural technology assessment is seen as contributing to research policy and management and also to the formulation, monitoring and evaluation of broader rural development policies and programs. A need for both farm-level and aggregate-level assessments is identified, and methods applied at each level are reviewed. At the farm level, some insights are provided by the farming systems research approach leading to recognition of a changed role for economists in farm-level impact assessment. At the aggregate level, the problems of tracing out all the important consequences of a technical innovation can be severe. Analysts will generally need to account for general equilibrium effects, distorted prices and welfare considerations, as well as the dynamic interaction between technology and institutions. In the light of the discussion, an agenda of unfinished business for agricultural economists is suggested.

New agricultural technologies have been appearing for many centuries but have a central significance for the long-run sustenance of the world's growing population. Investment in agricultural research and extension has been receiving rapidly increasing attention (Arndt, Dalrymple and Ruttan 1977; Barker 1981; Evenson 1981; Pinstrup-Andersen 1982; Ruttan 1982; Trigo, Piñeiro and Ardila 1982) but, many would argue, still not enough.

As in any research, the experience of agricultural research in developing countries includes clear successes, overt failures and many rather indeterminate achievements. Particularly among the donor communities that support such work, but also among the countries themselves, there is growing concern about the extent of achievement, the wider impacts of new technologies and desirable directions for change in the future. It is in this context that we consider the place of agricultural research in the vista of development, examine its assessment at both micro and macro levels, and pose challenges for the profession to address.

Technologies and Development

Conventional views

Many theories of development that provide different views of the nature and importance of technical change in agriculture have been postulated. What is perhaps the predominant view is based on the notion that resource-poor farmers the world over behave rationally. Whether

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categorised as 'poor but efficient' (Schultz 1964) or as 'optimising peasants' (Lipton 1968), poor farmers in the developing countries are seen as being caught in a low productivity trap wherein, given the prices and factor availabilities they face, the methods available to them, and their limited capacities to take risks, there is little scope for them to reallocate their resources appreciably to increase their incomes (see, for example, Stevens 1977). Given the seeming impracticality in many developing countries of materially moving prices in farmers' favour, the logical implication of the theory is that the low productivity trap can best be escaped by making available agricultural methods that are more productive than the existing set. The immediate policy prescription, therefore, is to strengthen national and international agricultural research activities.

The above analysis and prescription is often coupled with a concern to enable the mass of the rural populations of developing countries who are now in poverty to attain the basic human needs of livelihood. It is recognised that not all introduced methods necessarily contribute to the achievement of this goal; indeed, some, like labour-saving mechanisation, can add to rural unemployment and so may be counterproductive for some affected groups. Consequently, there is concern to ensure that the methods developed are 'appropriate' to the needs of poor farmers and to economic conditions in the target areas. Most policies for agricultural research for development, especially those of the International Agricultural Research Centres, are intended to reflect this concern.

Radical views

While the 'optimising peasant/basic needs' rationalisation of the importance of agricultural research and development is widely accepted (especially by involved researchers themselves), there are some other views. For example, Clayton (1983) argues, on the basis of empirical evidence, that there is no justification for a specific orientation to 'basic needs' through income redistribution strategies such as emphasis in research on the development of 'appropriate' technology for small farmers. Emphasis, he argues, should be on growth in productivity and output however it can be achieved. From this, small farmers will gain through the exercise of their natural enterprise, ability and energy. Another view that we believe will inevitably gain ground is that, as developing countries move into the situation of having a majority of their population non-rural (as has already happened in Brazil), food production for the urban majority will become the dominant concern. In consequence, research emphasis might then best be on high-input technology for medium-scale to large-scale production with the welfare problems of small farmers being left to other policy instruments.[1] The difficulty, of course, is that in most developing countries (such as Brazil) welfare policies *per se* are non-existent.

Another contrasting view to the 'optimising peasant/basic needs' approach is that of Marxist theory. This sees the particular techniques used

[1] This would imply, for example, a switch in bean research away from plant architecture for low-input associated cropping and hand harvesting to an architecture suited to high-input monoculture and mechanical harvesting.

in production ('the forces of production') as related to and to some extent determining the social organisation of production ('relations of production') manifested chiefly as class relationships.

There is, however, much disagreement among Marxists about the consequences of technical change in the agriculture of developing countries. The conventional Marxist-Leninist stance is to view technical advances within peasant agriculture as being likely to lead to differentiation of a class of wealthy capitalist farmers on the one hand, and a rural proletariat on the other (Lenin 1899). The former would be the natural enemies of the proletarian revolution. According to this view, it is therefore seen as desirable to forestall these social changes in the countryside by directly replacing backward peasantry by large state or communal farms that can be expected to reap advantages of scale and that should make it easier to extract the capital surplus required for industrial development. Improved methods can clearly assist in the development of commercialised (perhaps large-scale) farming, although obviously there is no need to emphasise scale-neutral methods, and more attention can be given to exploiting the supposed scale advantages, for example through mechanisation.

One critic of Lenin's theory of differentiation of the peasantry is Chayanov (1925) who has argued on the basis of observed changes in Russian peasant agriculture that 'middle' peasants were more resilient than Lenin had supposed, and that this resilience could hold up the hypothesised process of rural class differentiation. He suggested instead a theory of 'demographic differentiation' whereby the farm size and relative prosperity of households could be correlated with family structure in the family life-cycle. Chayanov saw the modernisation of peasant farming as involving neither a capitalist nor a socialist transformation but as being based on raising the technical level of agricultural production through agricultural extension and the development of co-operatives, within an institutional framework of small family holdings. Since he was not persuaded of the existence of substantial size economies in agricultural production, he saw socialist development of agriculture as being confined to the progressive concentration of capitalist functions into agricultural co-operatives that could be made subordinate to state control.

Some elements of Chayanov's views can be found today in the rural development strategies of a number of developing countries (for example, Bangladesh and Indonesia) which have sought to preserve the existing institutional structure of peasant farms but have tried to encourage the transformation of traditional agriculture, especially through the introduction of improved methods, by means of state-promoted and controlled agricultural co-operatives.

An interesting if somewhat contentious interpretation, within a basically Marxist paradigm, of the process of agrarian change is provided by Warren (1980) who noted that an advanced technical revolution in the agriculture of less developed countries can be associated with a transformation of rural social relations. This transformation can be viewed as part of the process of development of capitalism that will lead eventually to a crisis causing collapse of the capitalist system and its replacement by a socialist system. According to this view, the development and promotion of improved methods for poor farmers in precapitalist agriculture is progressive because it provides a necessary stepping stone to a preferred organisation of society.

By contrast with Warren's view, many of today's neo-Marxists see capitalism as the cause of poverty in the Third World, not as part of the solution.[2] They view the causes of poverty in the 'periphery' (notably the agricultural sectors of developing countries) as arising from the process of capital accumulation at the 'centre' or 'core' of the developed countries' economies (Sweezy 1968; Gurley 1975; de Janvry 1977). The process of 'unequal exchange', whereby the rich exploit the poor, means (according to this theory) that almost all the benefits of technical change in agriculture at the periphery will be captured by the central extractors of surplus value. The prescription that follows from this view is that political reform of the economic system, perhaps falling short of its revolutionary overthrow, must precede attempts to use technical innovations as instruments to reduce rural poverty in developing countries.[3]

Market effects

A different but somewhat related source of pessimism about the value of improved production methods in fighting rural poverty arises from the recognition that, at least for semi-commercial agriculture producing a surplus sold in markets with inelastic demand, the main beneficiaries of innovations causing outward shifts in supply are more likely to be consumers than producers. While poor urban consumers and the rural landless may benefit from lower food prices, gains in such circumstances also go to better-off urban consumers, at the expense of producers. In the case of an export crop, the majority of the beneficiaries may be foreigners (Edwards and Freebairn 1982). In other words, this strongly neoclassical view can lead to somewhat similar conclusions to those of the neo-Marxists about the potential, at least under some market conditions, for using improved technology as an instrument to reduce rural poverty.

Market prices occupy a central position in the minds of a group of economists who argue that many of the problems of agriculture in developing countries can be traced to distortions from free market prices caused by misguided policies. In particular, it has been argued that technical changes, and even institutional changes, will be 'induced' in response to prevailing price and resource situations (Binswanger and Ruttan 1978).[4] Although advocates of this theory recognise a need in practice for some planned intervention in the processes of research and development, they tend to suggest that such intervention should be confined to cases of market failure. By implication, in an 'ideal' world in which all prices and quasi-prices, such as incentives to research administrators and scientists, were set consistently with competitive market equilibria, the level of research and development would be presumed to be optimal in the Pareto sense.

[2] For a useful summary of the difference between Warren and the neo-Marxists, see Cole, Cameron and Edwards (1983, p. 287).

[3] For expositions of this viewpoint see, for example, Amin (1976), Frank (1981) and Griffin (1979).

[4] In a somewhat related context, Boserup (1965) has hypothesised that technical change in agriculture is induced by changes in population pressure on land and other resources.

Impact assessment

All these different views of new methods in agriculture can contribute to the formation of a perspective on the task of impact assessment. In framing our perspectives, however, we have pinned most of our faith on the 'optimising peasant/basic needs' model. Certainly this model is widely encountered in the literature on the role of improved agricultural methods and is often involved in justifying the maintenance and further development of the International Agricultural Research Centres.[5] Research centres in this network, and their client national agricultural research programs working in parallel with them, are mostly working to mandates that emphasise the development of technology appropriate to the needs of poor farmers (Oram and Bindlish 1981). It is assumed that, given adequate delivery of the necessary inputs (including informational and infrastructural inputs), the target groups will adopt these methods after they are released, and that thereby the welfare of the rural poor will be improved (but see Benito 1976, and Biggs and Clay 1983). 'Appropriateness' in the methods is usually interpreted to mean scale neutrality, which is held to conform with the historical emphasis on germplasm improvement to increase yields, principally by improving responsiveness to fertilisers—a strategy that has clearly had appreciable success with the development and adaptation of the high-yielding varieties of wheat and rice (Pinstrup-Andersen 1982).[6]

The need for technology assessment (Koppel 1979) arises chiefly as an input into the processes of directing and managing agricultural research (although, as argued later, impact studies can also have implications for general rural policy). It is necessary to decide what level of resources to allocate to research, which types of research to favour, and which particular production methods to develop and promote. Research planning and management can be guided by *ex ante* appraisal of prospective methods[7] and by ongoing evaluation of newly developed methods (Wise 1978; Shumway 1981; Anderson and Parton 1983). Research policy, particularly decisions about the overall level of resource allocation to research, can be guided by *ex post* evaluation of past research. Such *ex post* studies typically show the average or marginal rates of return on (historical) investment in research (Boyce and Evenson 1975; Kislev and Evenson 1975; Schuh and Tollini 1979; Scobie 1979; Judd, Boyce and Evenson 1984).

The task for the technology assessor can therefore be seen as involving two central components:

(a) predicting or evaluating acceptability of a new method and hence forecasting or measuring the extent of adoption (including any differential adoption by different groups); and
(b) appraising or evaluating the social costs and benefits of a new method and assessing the degree of conformity of the socio-

[5] The rationale for establishing at least the first few International Agricultural Research Centres was somewhat more technocratic.

[6] Not everyone views the Green Revolution as a success; see, for example, Griffin (1979) and Pearse (1980).

[7] Anderson and Hardaker (1979) have categorised prospective new methods into 'notional' or 'quarter-baked' and 'preliminary' or 'half-baked'. They contrasted these with 'fully-baked' new methods.

economic consequences of its uptake with national (or other) objectives.

These central components inevitably and quite properly are likely to lead technology assessors into other associated activities. One perspective on these activities is given in Figure 1. This indicates how assessment of the uptake of new methods by farmers and the socio-economic consequences thereof can lead to specifying redesign criteria for currently 'inappropriate' techniques and to recommending changes in rural policies that are found to be impeding uptake.

It follows from the framework of Figure 1 that it is logical to review the processes of technology assessment at the farm level and at the aggregate level separately. This is done in the succeeding two sections.

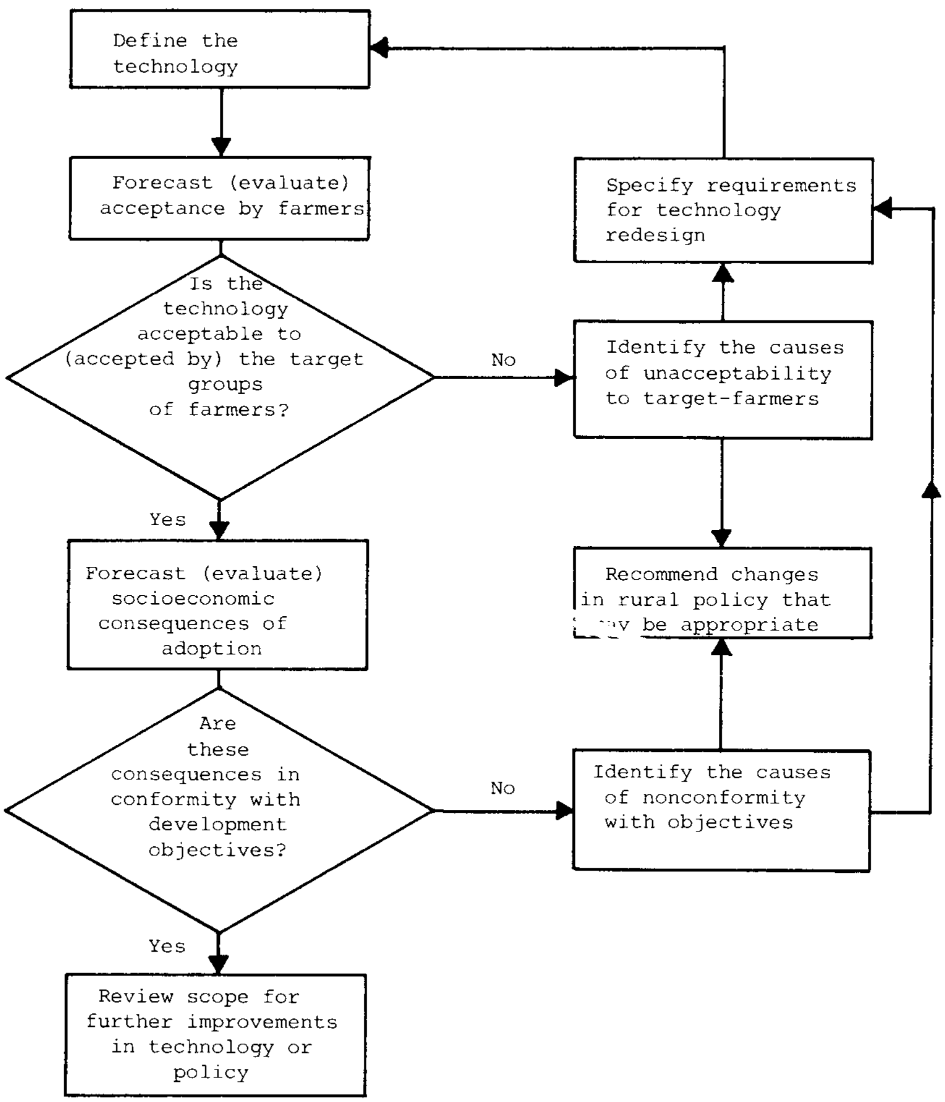

FIGURE 1—A Framework for Technology Assessment.

Assessment at the Farm Level

Anderson and Hardaker (1979) and Sanders and Lynam (1982), amongst others, have presented a conventional view of the farm-level role of economists in the design of improved technologies for poor farmers. Anderson and Hardaker deal with assessment primarily in an *ex ante* context and draw a distinction between what they call *in vitro* and *in vivo* analyses, according to whether the assessment is performed in abstract or in relation to actual farm circumstances. They point to the difficulties of *in vivo* analyses arising from the locational specificity (see also Menz and Knipscheer 1981 and Jarrett 1982) and diversity likely to exist within the target group of farmers in resource endowments, production opportunities, skills, beliefs and preferences, and, more importantly, from the complexity of small farm systems themselves. As they noted:

> The complexity of small farms has its roots in the number of separate and composite activities undertaken; the number of effective constraints impinging on these activities; the crucial temporal interdependencies among activities; the poor formal records and information base for decision making; the number of attributes that contribute to the farm family's utility; and last, but by no means least, the inevitable lack of certainty in nearly all facets of production, marketing, and life (Anderson and Hardaker 1979, p. 11).

Anderson and Hardaker reviewed the modelling techniques that might be used in *in vivo* analyses at the farm level, dealing especially with mathematical programming methods, but also with budgeting and simulation. Because of their focus on *ex ante* impact studies, not to mention their occasional scepticism about the utility of econometrics, they gave little attention to econometric farm-level models such as production functions and their extensions (see, for example, Hopper 1965; Dillon and Anderson 1971; Yotopoulos and Lau 1973; Davis 1981*a*; Norton and Davis 1981). They did, however, discuss the use of intuition in technology assessment, concluding that intuition is 'underrated, underconfessed, and generally underrecognised as a useful activity' (Anderson and Hardaker 1979, p. 25).

While, by and large, we do not feel it necessary to amend the conclusions of that review within the context in which it was written, we do believe that the recent spate of publications on the farming systems approach to agricultural research places the processes of development and assessment of technology in a somewhat different light. (See, for example, Dillon, Plucknett and Vallaeys 1978; Byerlee and Collinson 1980; Gilbert, Norman and Winch 1980; Norman 1980; Zandstra, Price, Litsinger and Morris 1981; Byerlee, Harrington and Winkelmann 1982; Collinson 1982; Lagemann 1982; Rhoades and Booth 1982; Shaner, Philipp and Schmehl 1982; ICRISAT 1983*b*; Biggs 1984; Dillon and Anderson 1984).

Some of the features that distinguish farming systems research are that it is:

(a) applied research which is problem-solving in orientation, which is ongoing and includes evaluation and impact assessment as part of its procedure;
(b) holistic in outlook;

(c) both multidisciplinary and interdisciplinary, and involves the co-ordinated use of base data, surveys, on-farm trials and on-station field and laboratory experiments and modelling (perhaps via computer simulation);
(d) focused on the problem of identified and relatively homogeneous groups of farmers;
(e) based on farmer participation with emphasis on bottom-up communication and recognition of the farmer as the key element of the farming system;
(f) concerned to ensure effective links to and influences upon related basic research;
(g) a dynamic, action-oriented and adaptive approach wherein tentative solutions to identified problems are tested and modified, redesigned or rejected on the basis of accumulating knowledge, understanding and experience (one view of the cyclical or feedback nature of farming systems research is depicted in Figure 2); and
(h) assessable by the extent to which it leads to the development of

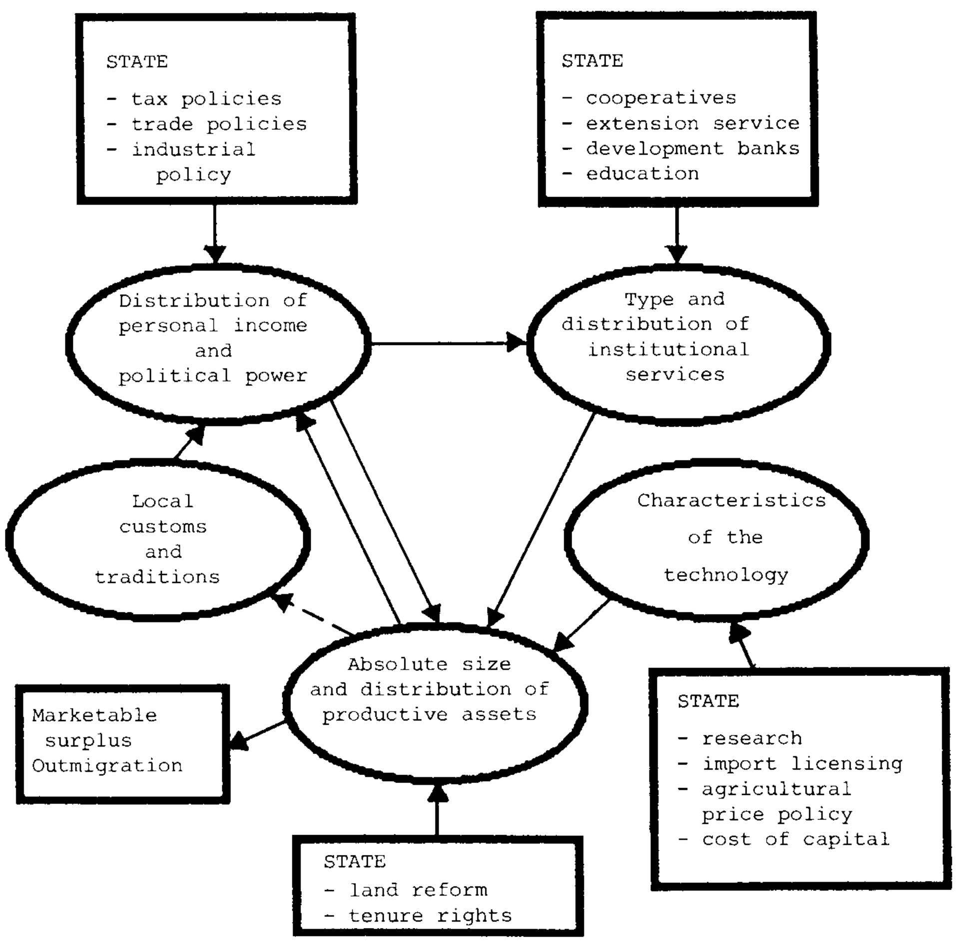

FIGURE 2—Schematic View of Farming Systems Research Method (after Collinson 1982).

cost-effective and socially desirable farming techniques that are readily adopted by its specified groups of client farmers (usually small farmers).

In a sense, of course, there is nothing particularly novel about a systems approach to agricultural research. As Dillon and Anderson (1984) emphasise, some institutions or research groups can properly claim that they have been following this approach for many years. Nor should the discovery of the value of an integrated approach which includes impact assessment blind us to the institutional and other problems that will often inhibit the effective pursuit of farming systems research. As well as its newness, these problems include interdisciplinary and interpersonal rivalries and misunderstandings, inappropriate organisational structures, unsuitable reward systems for researchers and inadequate funding, all of which can, in particular, lead to the two intersecting circles of on-farm and station-based research of Figure 2 failing to intersect in practice (Dillon, Plucknett and Vallaeys 1978; Biggs 1984). In particular, there are signs of a 'bandwagon' problem which may bring farming systems research into disrepute. This is particularly so in East, West and Southern Africa where some aid agencies are currently promoting the farming systems research approach despite the lack of experienced staff to service such projects. Nevertheless, the 'discovery' of the value of farming systems research does give some new insights on the role of agricultural economists in the research and development process. In particular, via co-operative involvement in all of the activities shown in Figure 2, farming systems research provides a framework for co-operation among agricultural economists, agronomists, animal scientists and other researchers.

It is apparent that a principal task for agricultural economists in their role as members of the multidisciplinary farming systems research team is to assist in identifying and defining the circumstances of the target groups of farmers. Dillon and Anderson (1984) suggest that the most important such matters to be addressed are: (a) the social milieu in which farm decisions are made, including customs of sharing and bequest; (b) the institutional setting and policy environment in which farming is conducted, including land tenure, credit and taxation; (c) the economic environment of farms, including long-term market prospects for inputs and outputs and, most importantly, understanding of the opportunity costs and transaction costs faced by farmers; and (d) the attitudes and personal constraints of farmers, including their desire or otherwise for change, for leisure, for education, for safety and for different foods, and their human and other capital.

These activities alone constitute a substantial challenge but are by no means the end of the matter. The farming systems research approach implies a need for agricultural economists to work closely not only with research scientists but also with farmers. The purpose of developing such working relationships is, first, to ensure a socio-economic perspective in systems appraisal and, second, to identify and assess, at least tentatively, breakable constraints and exploitable opportunities within the existing farming system. Third, agricultural economists should be able to contribute to the formulation of tentative technical improvements and their practical development and testing, particularly on farms. To understand real farming systems it has long been held that agricultural economists need to get mud on their boots, but the farming systems research perspective suggests that they also need to get more dirt on their hands in the process of developing practical technology and assessing its impact.

Some writers on farming systems research might be criticised (see Harriss 1982, p. 17) for emphasising solely technical solutions to social problems in agriculture. With their perspective on a farming system, economists should be able to recognise those circumstances where institutional or policy changes are prerequisites to improved methods producing desired social improvements (see Figure 1). This suggests a need for agricultural economists to become actively involved with groups of farmers, assisting in and encouraging the formation and operation of institutional innovations such as village co-operatives and research liaison committees, at least on a pilot-scheme basis, and also in interceding on behalf of farmers with government agencies and policy makers.

Finally, agricultural economists should be able to take a broad view of the impact of farming systems research, being willing and able to judge whether the work is achieving the desired social objectives. As already pointed out, this may involve tracing out the impacts of technical and other changes beyond the specific primary target groups of farmers.

All this, of course, adds up to a list of very tall orders, and no doubt all these functions cannot, and perhaps, realistically, should not, be fulfilled by agricultural economists in every farming systems research program (Dillon 1979).

Limitations of time and other resources, as well as other realities of the work situation, must obviously be considered. Nevertheless, two perspectives provided by the farming systems research approach seem particularly important. These are, first, the need for economists to understand and communicate to their scientific colleagues the wider reality of farming systems, and second, the need for them to be prepared to engage, in co-operation with their scientific colleagues, in pilot-scale action-oriented research.

Assessment at the Aggregate Level

In assessing the impact of improved production methods at the aggregate level, a decision must be made about the extent of aggregation to be considered, whether village, district, regional, national or global. In systems' parlance, it is necessary to define the boundary of the system being studied to determine which components are to be treated as endogenous and which as exogenous. Self-evidently, this decision will be conditioned primarily by the purpose of the analysis, for example, impact on whom? The nature of the new technology itself is also relevant, since this will affect the extent and spread of its impact, chiefly according to how readily it is widely adopted (Wicks and Crellin 1979). Also relevant is the degree of economic integration, expressed chiefly as market integration, between the farmers adopting the new technology and other economic agents within and beyond the target area. Rural labour markets, for example, are often poorly integrated so that a shift in labour demand within a region, and even within one village, may be reflected primarily in effects on local employment and wage rates, rather than on migration of workers. Of course, due to lags in the flow of information and economic response, the level of market integration will also depend on the time horizon considered.

Price effects

A primary source of difficulty in any aggregate-level analysis is the need to account for price effects arising from technology-related shifts in farm supply of outputs or farm demand for inputs. Clearly, supply and demand elasticities at least are normally required for all relevant markets for such price effects to be determined. This information is commonly unavailable, especially at regional or district level. Nor is it usual to find an abundance of suitable data from which the required parameters can be derived reliably.

Subject to the limitations of model specification and aggregation bias (Day 1963; Miller 1966; Buckwell and Hazell 1972; Hazell 1982), results of farm-level programming models of representative farms can be aggregated to provide schedules of product supply and input demand before and after uptake of new methods (Hardaker 1983*a*). Without doing an injustice to the builders of such aggregative programming models, however, we suggest that usually it would be good research practice to seek to compare and contrast such results against estimates derived by econometric methods from observed behaviour (Shumway and Chang 1977; Wicks and Dillon 1978).

Aggregative programming studies can provide at best only half of the information needed to model market impacts. Estimates of the demand for marketed surplus and of the supply of farming inputs are also needed. These must often be obtained using econometric analysis which, in the context of new technology with associated changes in policy (for example, for credit policy) and infrastructure (for example, increased distribution points for credit and fertiliser), can hardly be regarded as reliable.

Aggregation to the national level may reduce analytical difficulties since time series data on relevant prices and quantities are (usually more easily) available at this level. On the other hand, a compounding of data problems will occur if disaggregated effects, at regional or district levels, are to be dissected from a more aggregated national-level analysis.

Benefit-cost appraisal

Most aggregate-level studies of the effect of technical change in agriculture have made use of the economic surplus model. In this model the benefits of a technology-induced shift to the right in an industry supply curve or, although not yet analysed empirically, the prevention of a shift to the left in the case of 'maintenance' research (Peterson and Fitzharris 1977, pp. 71, 74-5) to overcome disease-induced genetic obsolescence in crops, can be measured and broken down into the component producers' and consumers' surpluses (Currie, Murphy and Schmitz 1971; Hertford and Schmitz 1977; Lindner and Jarrett 1978; Davis 1981*b*).

Despite the wide adoption of the surplus model, it has not been without its critics. The concept of producers' surplus in particular has been questioned (Mishan 1968; Rose 1980). Wise (1981) has suggested an alternative approach based on component benefits which, he claims, allows for greater disaggregation of the costs and benefits.

Investments in agricultural research directed toward the production of improved technology are no different in principle from other types of public investment. It follows that benefit-cost project appraisal methods (which have the economic surplus model at their base) are as appropriate for appraisal or evaluation of new technology as for other agricultural investment projects. Modern literature on investment appraisal in developing countries reflects a growing emphasis on the modification of the basic economic surplus model in two main ways. First, it is recognised that prices in many developing countries are distorted from their equilibrium levels by various forms of government intervention or for other reasons. For example, prices of basic foodstuffs may be held down by subsidising imports, while the prices of other internationally traded goods may be distorted by the maintenance of an overvalued exchange rate, tariffs or other barriers to trade. Institutional factors may also impinge on labour markets so that wage rates may not correctly reflect the opportunity cost of labour in labour-surplus economies. The use of shadow prices to correct for such biases in domestic prices when appraising investments is now well established (see, for example, Little and Mirrlees 1974). However, this still leaves the problem that, unless policy is implemented to make market and shadow prices converge, farmers' decisions on technology and product mix will still be made on the basis of biased market prices—as will also be research activities aimed at the design of new technology and improved farming systems.

Another argument for adjusting the basic economic surplus model in project appraisal is not directly based on economic logic. Rather, it is based on humanitarian values[8] (and the assumption of interpersonal comparisons of utility). Binswanger and Ryan (1977) advocate weighting benefits going to poorer income groups within the economy higher than those going to richer income groups. Most developing countries and international aid agencies have declared objectives of reducing poverty and inequality. Project appraisal techniques that permit greater weight to be assigned to income gains of poorer groups than to those with higher income levels have therefore been developed (Squire and van der Tak 1975).

In appropriate circumstances, both techniques, that is, use of shadow prices and of distributional weights, are clearly relevant in assessing the impacts of improved technology in developing countries. However, with the notable exception of the recent study of new rice technology in northwest Malaysia by Bell, Hazell and Slade (1982, pp. 198-216), there seem to be few impact assessment studies that have employed these procedures. For instance, Wise (1981) reports that he could find only one study, by Schmitz and Seckler (1970), in which it was not implicitly assumed that all displaced resources could be valued at their full prices. Similarly, while the question of the distribution of the benefits from improved technology has been of considerable concern, most analysts have

[8] Some would argue that, at base, the values involved are either those of self-preservation (that is, it is better to give up a little peaceably than to lose everything in a bloody revolution) or of self-satisfaction (that is, 'do-gooders' gain utility by trying to do 'good') or of self-interest—as the President of the World Bank said recently: 'The industrial world has everything to gain from economic growth in the developing world; it has everything to lose from stagnation and decline there . . . Can we not agree, then, that to help the developing nations help themselves is an act of enlightened self-interest?' (Clausen 1983, p. 13).

been content to partition gains between consumers, tenant farmers, landlords and landless labourers (see, for example, Scobie 1976; Scobie and Posada 1976; Hayami and Herdt 1977; for a more comprehensive approach, see Lipton 1978). Today, the situation remains largely unchanged from that observed by Bieri, de Janvry and Schmitz (1972) in that there has been little empirical use made of distributional weights in such economic assessment though there has been increasing emphasis on such issues in *ex ante* appraisal of commodity research portfolios (see, for example, Pinstrup-Andersen, de Londoño and Hoover 1976).

The economic surplus model and the benefit-cost procedures that flow from it are partial equilibrium models. It is evident that a major and widely adopted shift in methods of agricultural production, such as that embodied in the green revolution, has effects that spread throughout the whole national economy and beyond. In such a case it can be argued that partial equilibrium techniques are inadequate to model what is happening.

> The partial equilibrium model neglects general equilibrium feedback loops via the overall factor availability in an economy, and via the demand effects arising from the income effects due to technical change. Taking those into account can lead to distributional implications of technical changes that differ from those derived in partial equilibrium models (Binswanger 1976, quoted in Ruttan and Binswanger 1978, p. 371).

On the other hand, the task of tracing out these general equilibrium effects is a stiff one. A well-refined model of the whole economy is required (see, for example, Karim 1983). The informational needs for such a model are substantial and beyond the data and other resources of many developing countries. In addition, as Srinivasan (1982, p. 248) observes, '. . . the consistency of the general-equilibrium model is bought, in any case, at great cost in terms of untestable assumptions and compromises to fit available data into a computable model.' We expect that impact studies will largely continue to be based on partial equilibrium analysis, but we look forward to more efforts being made to trace the impact beyond the first-round effects. Hazell and Röell (1983) argue that agricultural growth linkages to the nonfarm economy are predominantly due to increases in household consumption expenditure. They support the contention of Mellor (1976) that, because much of the received wisdom on development strategy ignores these consumption linkages, it has tended seriously to underestimate the potential importance of agriculture and its role in development. More studies tracing out these consumption effects may help to correct the existing bias in thinking. Aspects related to consumption for particular groups include human nutrition (Pinstrup-Andersen, de Londoño and Hoover 1976) and, especially for landless labourers, employment effects (Krishna 1979; Bell and Hazell 1980; Ahammed and Herdt 1983).

Gainers and losers

The debate about who gains and who loses from improved agricultural technology has been conducted to date largely along battlelines drawn in ideological terms. It now seems clear, and in retrospect perhaps not surprising, that, at least at first, better-off farmers tend to obtain more direct benefit from improved methods than do poor farmers, even for supposedly scale-neutral methods. While no doubt there are exceptions, this general conclusion is supported by the theoretical work of Feder and O'Mara (1981), who also review empirical studies of the relationships among farm size, adoption of new technology and income distribution. What is less clearly established (see, for example, Clayton 1983) is whether and under what circumstances poor farmers and landless labourers also benefit. Perrin and Winkelmann (1976) argue that the pattern of adoption among large and small farms is generally consistent with the proposition that small farms may lag behind large farms in the early stages of adoption but soon catch up. Similarly, Byerlee and Harrington (1983), marshall evidence on the favourable impacts of new wheat varieties in ultimately reducing poverty and inequality in Mexico, South Asia and elsewhere. In investigating these questions, the dynamic aspects of the rural economy need to be accounted for. There are claims, supported by some evidence, that improved technology leads to increasing concentration of landownership, perhaps associated with immiserisation of the dispossessed. Ruttan offers the following generalisation about the effects on income distribution of the green revolution:

> . . . a technology that is essentially neutral with respect to scale has been introduced into environments in which economic, social and political institutions have varied widely with respect to their neutrality [between income classes]. Where the technology has been introduced in areas characterized by a reasonable degree of equity in the distribution of resources, the effect has been favourable in terms of productivity and equity. When the technology has been introduced in areas characterized by great inequality in the distribution of resources, the productivity impact has been weak and the pattern of inequity has been reinforced (Ruttan 1977, p. 17).

This generalisation needs to be investigated in further studies with a view not only to testing its validity but to establishing the necessary conditions for the potential benefits of the new methods to be reaped (see Hayami and Kikuchi 1981; Quizon and Binswanger 1983). The scope for ideological biases to influence the conclusions of such studies is, unfortunately, considerable. It is also particularly difficult in analyses of impact to segregate the changes that have arisen as a consequence of the uptake of new methods from other changes that have occurred in parallel. For example, uptake of the high-yielding seeds/fertiliser technologies has been accompanied in some areas by an increase in the use of irrigation and labour-displacing mechanisation. There is uncertainty, however, as to whether the latter is a consequence of the former or whether it represents a secular trend to increased tractorisation provoked, perhaps, by distortions in relative prices such as the provision of subsidised credit for machine purchase (Duff 1978).

Institutional change

The difficulty of associating effect with cause appears to be made more difficult if one gives credence to the theory of induced innovation (Binswanger and Ruttan 1978). According to this theory, institutional change may be induced by the demand for more effective institutional performance that is associated with economic growth (and so with uptake of new technology). It is also hypothesised that institutional change may occur as a result of advances in the supply of knowledge about social and economic behaviour, organisation and change. In other words, the processes of studying technological impact, as well as technology itself, may lead to institutional changes. Moreover, those very institutional changes are likely to influence the distribution of the benefits and costs of technical change, as well as the processes of further research and development.

In a related vein, Gotsch (1972) provides a perceptive review of the relationships between technology, institutions and people at the community level. He points out that the distribution of the benefits of technical change is strongly influenced by the distribution of rural assets. The allocation of benefits alters the distribution of political power in the rural community, which is important because access to rationed inputs usually favours the powerful. Thus there is an important feedback whereby changes in the income and power distribution provoke parallel changes in the distribution of assets. Moreover, those with political power are able to influence the type and distribution of institutional services provided to farmers, which in turn bear on the size and distribution of assets. Gotsch notes that power of position and power of wealth may be different, particularly in traditional societies, but that, in the longer run, customs and traditions are likely to be modified to bring the distribution of power more into conformity with wealth distribution. Gotsch summarises his conception of these relationships in a diagram, redrawn as Figure 3. The figure also shows some of the opportunities for the state to influence the dynamic interactions depicted.

The chief point that Gotsch (1972, p. 327) makes is that '. . . prognoses about the distributive effects of agricultural technology are of little help unless they are explicitly related to the social and political institutions of the countryside.' This view is strongly supported by the work of Anderson (1981). Bell (1972), too, argues that the causes of changes in inequality lie only partly in the nature of innovations, and that, to understand the mechanisms producing such changes, one must place the innovation process in the context of the prevailing economic and social system. Clearly, if these authors are right, analysis of the impact of improved agricultural technology confronts economists with substantial problems with which they (and, unfortunately, others) may be ill-equipped to deal.

Unfinished Business

In this concluding section, we summarise what we have identified in the above reviews of farm-level and aggregate-level analyses as the outstanding challenges facing agricultural economists in technology assessment.

We find the arguments about the merits of the farming systems research approach to research and development very persuasive, but we see difficulties ahead in making the approach work, particularly in making it work at large. There already exists an abundance of manuals and reports purporting to describe how farming systems research can be implemented. There are also many farming systems research projects under way around the world, several of which are showing encouraging

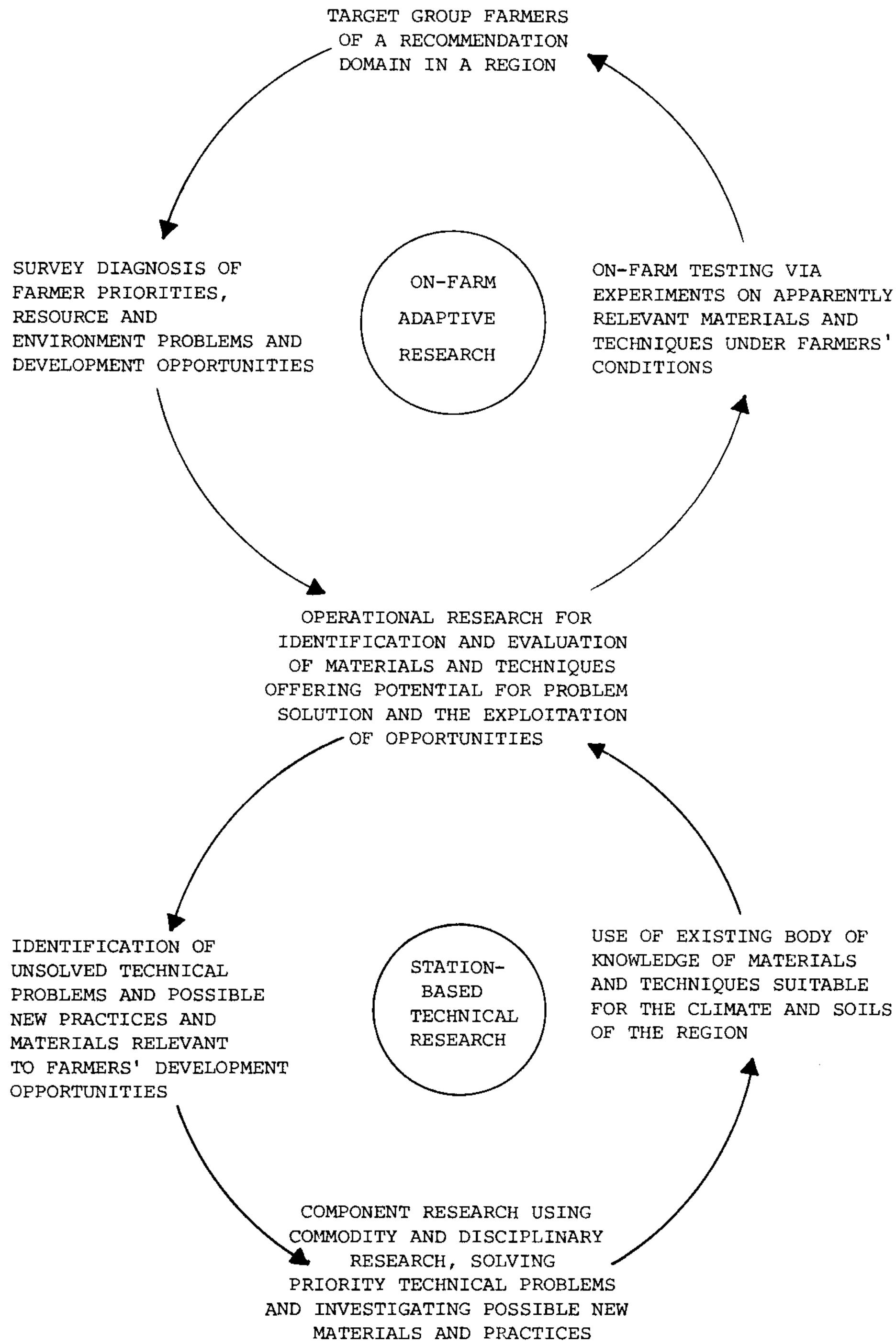

FIGURE 3—Flow Diagram of the Growth and Distribution of Farm Income at the Community Level (after Gotsch 1972).

results.[9] Many of the projects, however, are relatively well funded and are located within or associated with the International Agricultural Research Centre network. If farming systems research is to fulfil the promise claimed for it by its advocates, and so be a force for real improvement in the conditions of life of rural people in developing countries, the approach must be shown also to be effective in the context of less well-endowed national programs. A task exists, therefore, for agricultural economists to encourage, participate in, monitor and evaluate such projects.

In this context, there appears to be a need to establish whether the familiar methods of our profession, particularly modelling of farm systems, can be useful in the search for solutions to problems of underdeveloped agriculture. The collection of farm-level information is usually seen as an important function in farming systems research. It is our impression, however, that in some cases economists who have devoted commendable care to the accumulation of large banks of such data find themselves at a loss as to how these records can be productively analysed, not to describe the *status quo*, but to prescribe, or at least suggest, desirable system changes. Certainly, such data banks provide an excellent basis for farm budgeting, mathematical programming, simulation or other such modelling work. On the other hand, there is a school of thought that holds that potential lines of action to achieve rural development can be identified from much sparser data and with no need for fancy analyses. Indeed, 'rapid rural appraisal' (Carruthers and Chambers 1981; Rhoades 1982) has been advocated as the form of inductive analysis in rural development planning that is most 'appropriate' to the conditions and research resources of developing countries. While we doubt the existence of any universally applicable method of analysis, we do see a need to accumulate and evaluate more experience of alternative approaches to this important 'problem-solving' component of farming systems research. This understanding is important in its own right and as a guide to the training of agricultural economists who will be assigned to farming systems research work.

In aggregate-leval analyses, as we have noted, there is a need for more work extending the basic economic surplus model and adapting it better to the issues of impact assessment in developing country agriculture. We have noted the need to give more attention to accounting for distorted domestic prices and to place more emphasis on development goals relating to the fair distribution of the benefits of new technology. Moreover, with the rapid rates of urbanisation projected to occur in developing countries and the expectation this offers of growing numbers of urban poor, with attendant political implications, it may be unwise to focus technology assessment only on the rural poor.

The tracing out of the second-round and possibly the general

[9] The outstanding example is perhaps ICRISAT's new system for rainfed agriculture on deep black soils in India's semi-arid tropics. This new system, which is applicable to at least 5 million ha and possibly as much as 12 million ha, enables a doubling of crop yield and has shown a return to the farmer of over 200 per cent on the additional expenditure incurred. Usage has risen from 15 ha involving 14 farmers in one state in 1981-82 to some 4000 ha involving 1700 farmers in four states in 1983-84. The new system is highly socially relevant because of its rainfed orientation and its positive impact on employment. See ICRISAT (1983*a*), Ryan and von Oppen (1983), and Dillon and Anderson (1984).

equilibrium effects of uptake of new technology should also exercise the minds of economists. Paralleling some of the issues in farm-level analysis, the question here is whether the most productive approach to these issues is via large-scale economy-wide models (see, for example, Duloy and Norton 1973), or whether better insights cannot be gained from a series of less comprehensive models more directly focused on particular aspects of technology impact.[10] Again, the accumulation and evaluation of experience with each approach will lead to better judgments about the most appropriate approach.

Economists and other social scientists will need to continue to concern themselves with the seemingly crucial issue of the interaction between technical change and institutional change. Despite the prolonged ideological debate about the political economy of rural development, we see little evidence of real convergence of the conflicting views toward a truly powerful and compelling theory of rural change. The obviously Herculean nature of the task of producing such a general theory should not inhibit agricultural economists from seeking to contribute their own perspectives and insights toward that end.

We recognise that ideology will inevitably influence the way that anyone, including an agricultural economist, sees the world, and that consequently an ideologically neutral stance in research is Utopian. Nevertheless, we believe that the conclusions of too many analyses of the impact of new methods (and other development questions) have been overly coloured by the ideological viewpoints of their authors, whether these viewpoints were of the left or the right. We have argued elsewhere that complete objectivity in research is unobtainable (Anderson, Dillon and Hardaker 1977, ch. 2) but we also believe that all responsible researchers should strive, within the limitations of their own perceptions of reality, to be as 'objective' and as 'open' (see McCloskey 1983) as possible. Moreover, we see a clear distinction between this need for professional objectivity and the sense of commitment on the part of agricultural economists to the achievement of a better world, including a better lot for the poor in the developing world.

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[10] See Hardaker (1983*b*) for an argument in favour of a series of linked but separate models for technology assessment.

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