PROCEEDINGS OF THE THIRTEENTH INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS

held at the University of Sydney
Sydney, New South Wales, Australia

21–30 AUGUST 1967

The Economist and Farm People in a Rapidly Changing World

LONDON
OXFORD UNIVERSITY PRESS
NEW YORK TORONTO
1969

II. ASPECTS OF FARM PRODUCTION ECONOMICS AND MANAGEMENT

APPROACHES AND FINDINGS OF FARM-PRODUCTION ECONOMISTS IN THE U.S.S.R.

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FIFTY years ago, after the Great October Revolution of 1917, the country began treading the socialist path of social development and the reconstruction of agriculture was begun on a socialist basis, on the basis of Lenin's co-operative plan. To solve the problems presented a most difficult and complicated task.

The industrialization of the country created the necessary material basis for economic independence for the technical reconstruction of all branches of the national economy, and for the transition of agriculture to a new base, i.e. the basis of large-scale production and of new socialist relations of production. Even in the initial period of the development of socialized agriculture scientific economists played an active part in conducting experiments and evaluating effective methods for equipping agriculture with modern production machines and for developing large collective farms with the help of a tractor-stations network. Thorough and comprehensive research made it possible to establish scientific principles for the management of the collective farm (*kolkhoz*) which proved to be the most expedient form of social management, as it made possible the combination of the public and personal interests of farmers. The scientific basis for the organization of large socialist state enterprises in agriculture (*sovkhoz*) was also worked out.

During these years the development of agricultural production in the U.S.S.R. was based on planning in conditions of the socialist relations of production and also the social ownership of the means of production. At present there are over 48,000 such basic agricultural enterprises in the U.S.S.R., including 12,200 large state farms with an average area of 25,000 hectares, and 36,300 collective farms with an average area of 6000 hectares.

Under the new five-year plan (1966–70) a great deal of attention in economic research is devoted to the further intensification of agriculture. It is planned to raise the level of mechanization of production, to increase the use of chemical fertilizers, to carry out large-scale land-reclamation work, to improve agriculture as a whole, and thus to increase the volume

of agricultural output by 25 per cent as compared with the previous five-year period.

Scientific research on the problems of the economy and organization of agriculture is carried out by a large network of scientific or combined scientific and production agencies. They include 22 all-union scientific research institutes and 9 republican institutes, 79 branch and regional institutes, 111 state agricultural experiment stations, about 160 scientific normative and normative stations, and a large network of prospect institutes. Furthermore, research on agricultural economy is conducted by chairs in economics at 98 high agricultural educational establishments. This system of scientific agencies develops the general lines of economic research, the major problems and subjects, approves the most important results of production experience and scientific conclusions, and draws up the necessary recommendations for their application in production.

The research work is co-ordinated by the All-Union Ministry of Agriculture and by the All-Union Lenin Academy of Agricultural Sciences through the problem councils of the large scientific research institutes. The All-Union Scientific Research Institute of Agricultural Economics is the main research agency for co-ordinating the economics and organization of agriculture.

Since the advent of the Soviet regime the economic research agencies have solved many important problems of agricultural production. The establishment of large state enterprises and collective farms on the basis of very small farm units has made it necessary to solve problems of organizational structure, rational size, specialization of production and combination of branches, use of machinery, and also to solve problems of sales, prices, of scientific organization and remuneration of labour and material incentives, and many others. All these problems were scientifically solved by economists on the basis of experiments, and exchange of experiences.

The wide programme of agricultural economic research is being carried out in accordance with the tasks to be fulfilled by the agriculture of the country.

Scientific economists are engaged in research on the following important problems:

1. *The economic bases for the intensification of agricultural production*

To this end, studies are being carried out on the following points—methods of determining and raising the economic effectiveness of capital investment in agriculture; the economic basis of complex mechanization and electrification of agricultural enterprises; the economic organization and management basis for the further intensification of agriculture.

2. *The development and the specialization of agriculture, and the system of management of agriculture by zones of the country*

To this end, research is being carried out to establish the areas for the most profitable production of the principal types of produce on a basis

of a perspective for 10–15 years ahead; to determine the level and structure of production, on the basis of the natural and economic zones in the country; to determine the economic basis of inter-farm and intra-farm specialization of agricultural production, rational utilization of the land fund, and the economic basis of collective and state farm management.

3. *Economic measures affecting the efficiency of the development of agricultural production*

These studies deal with the following—improvement of the planning of state purchases; conditions and forms of sales by state and collective farms; improvement and cost reduction of the material and technical equipment of agriculture; the scientific basis for the rationalization of prices for farming produce.

4. *Cost of production and profitability of enterprises*

These studies deal with the following points—self-financing and self-repayment and remuneration profits; measures for improving annual and short-run planning; measure for the rational organization of state and collective farm management; financing and credit for agriculture, and accounting within agricultural enterprises; and measures for strengthening and developing the economy and raising the profitability of state and collective farms.

5. *Economic research within individual branches of agriculture*

This includes—production of grain, meat, milk, and other products; determination of proportions in the production of farming and animal husbandry produce; problems of specialization and transfer to industrial methods of production.

6. *Scientific organization of labour. The principles of remuneration and use of labour resources*

This includes the following—improvement of methods of determining labour productivity in agriculture and study of the reserves for raising this productivity; labour resources in agriculture and improvement in their utilization; rational organization of labour and operation processes; improvement of the forms and systems of remuneration and material incentives for agricultural workers.

7. *Investigation on the introduction of a unified information and computing systems for planning, recording, and accounting in agriculture*

These studies deal with the following: principles of establishing a unified information and computing system, establishment of basic scientific experimental computing systems on a district basis; (a unified system of book-keeping and economic records, connected with records in other branches of the public economy, is being developed and experimentally tested on collective and state farms); studies and tests dealing with typical models and methods for solving economic and mathematical problems concerned with optimal current and long-term planning in agriculture.

8. *Social and economic problems of the development of agriculture*

This problem includes—social and economic or organization and management questions connected with the development of collective and state farms; social and economic conditions of labour, culture, and life on collective and state farms; improvement of the relations between industry and agriculture, etc.

Within this programme of scientific research on agricultural economics much effort has been concentrated on working out recommendations dealing with the problems of material incentives for agricultural workers, on research into new and much better methods of planning and management in agriculture, the use of cost-accounting methods in collective and state farm management, etc. as the most important problems of agricultural production. On the basis of this research work, government agencies have taken the necessary decisions on these problems.

The improvement of the methods of economic research is of great importance for raising standards. Various methods are used in economic research:

Study and generalization from mass data related to the operation of collective and state farms, using economic and statistical methods.

Monograph study of the experience of advanced collective or state farms.

The use of estimation variables, which are especially important in long-term planning.

Mathematical methods with the use of computers.

Method of conducting economic experiments under production conditions.

Economic research leads to the application of its results in production. But each such application is preceded by a thorough experimental testing of this research, and by the elaboration of technical and organization projects. Institutes have special stations which are used as bases for conducting experiments on economics and the organization of production. Such stations are located on collective and state farms in various zones of the country.

On the basis of these studies and experiments, economic research agencies of the U.S.S.R. can solve a number of important problems which are of great importance for the development of agriculture and for raising the efficiency of collective and state farms' production.

At present a large-scale experiment is being carried out in the U.S.S.R. concerned with the transfer of a large group of state farms to a completely self-supporting system. The methodological basis for this experiment has been prepared with the active participation of scientific economists. The study of the results of this large-scale economic experiment will make it possible to approach in a new way a number of important problems connected with the further development of state farms.

Economists are now working out new methods for determining complex norms of labour consumption in agriculture. In accordance with these

methods, norms of labour consumption are established on the basis of the technological complex of all operations in farming and animal husbandry, taking into consideration the production conditions of individual zones of the country. Norms of labour consumption per head of cattle, hectare of crop and cental of production have been established for all republics and zones of the country. They are used for determining labour consumption in agricultural production, estimating labour requirements, finding reserves for increasing the labour productivity, and for other purposes.

The results of research work, performed by economists, are implemented in various ways:

By means of scientifically based recommendations in the form of advice for collective and state farms, for example, recommendations 'On the introduction of intra-farm cost accounting in collective and state farms'; 'On the scientific organization and remuneration of labour'; 'On the economic efficiency of machinery application and capital investments'; 'On material incentives for agricultural workers' and so on.

By the publication of scientific monographs on the results of economic research, and also books, booklets, and articles in magazines and newspapers.

By means of direct assistance to farms for the proper and effective application of the recommendations.

The scientifically based recommendations on the economic problems in the development of soviet agriculture are used by the Ministry of Agriculture and other organizations in drawing up development plans and determining the optimal volume of production, in introducing economic technology into production, raising the efficiency of mechanization and irrigation, providing material incentives in production development, securing scientific organization of labour and management on collective and state farms, etc.

Scientific and technical progress, and the need to increase the efficiency of agricultural production place ever new demands on the character and subjects of agricultural economic research. Economic research is constantly widening its field and collecting new data, generalizing experience on a larger scale, and working out the theoretical bases for the further development and improved efficiency of agricultural production on collective and state farms.

APPROACHES AND FINDINGS OF FARM-PRODUCTION ECONOMISTS IN NORTH AMERICA[1]

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My invitation requested me to relate my remarks 'to the actual conditions, particularly of North America . . . and the particular problems, logic and analytical practices that have developed there'. With respect to the logic and analytical practices, I shall take the liberty of annexing Australia! Nine months of recent and close contact with Australian literature and personnel have revealed to me little or no difference in frames of reference, approaches used or quality of findings. On the other hand, I exclude Mexico, out of my ignorance of progress there in matters relevant to this paper.

In North America, thus defined, production economics has come to occupy a dominant position in the conception of problems and formulation of models by farm economists. The result has been to introduce considerable analytical rigour into the treatment of an array of problems rather truncated from that considered by farm management researchers of earlier years. On the other hand, the increased *analytical* generality thus acquired has led the modern investigator into problem areas not considered by his predecessors. An interesting consequence has been to reduce to near insignificance the disciplinary boundaries that once separated farm management from other areas of agricultural economics. Our title provides a convenient boundary for our review, yet it is less confining than might seem apparent. We will, however, exclude uses of production economics by marketing economists.

In preparing my remarks I have benefited considerably from proceedings of two conferences that are particularly relevant to my topic: *Structural Changes in Commercial Agriculture* (2) and *Production Economics in Agricultural Research* (1). The first provides a convenient summary of changes experienced and in prospect in the structure of commercial farms in the U.S., the environmental factors to which the changes are related, and implications of the changes for marketing, financial, and educational institutions associated with farms. Most of the changes and their implications hold for Canada as well. For Australia there are interesting departures, as will be noted later.

The second proceedings provides a more or less comprehensive statement of contributions made with production economics toward research investigations into economic organisms and processes in agriculture. I have no reservations in extending this to include all the geographical

[1] Thanks are due to Dr. B. R. Davidson, University of Sydney, for reading an early version of this paper, though he is in no sense responsible for any errors and oversights that remain in the paper.

area assigned me. My debt will be evident to those already familiar with these proceedings. Others may find it useful to consult one or the other on details of points treated only cursorily below.

Structural changes in commercial agriculture

In the past twenty years adjustments have occurred at an unprecedented rate in the structure of commercial agriculture. Urbanization, already proceeding at a rapid rate, accelerated in this period. Nearly one farm in three disappeared in the U.S. between 1950 and 1960, most land thus liberated was absorbed by remaining farms. Mechanization, already well advanced in crop production, accelerated in livestock enterprises. Major field crops had long since been mechanized, though the size of equipment continues to grow with increase in land-size of farms. Increase in the number of tractors has now slowed off but increase in the amount of horsepower has not, thanks to innovations in size of tractor and the use of self-propelled machines. Most of you are familiar with mechanization in our speciality crops that have featured in the 1960s. Inventions appear more responsive than ever before to economic opportunities, but more of this later.

Mechanization has increased scale economies, first in crop production but more recently in livestock production as well. The result has been to enhance the payoff from horizontal growth of firms—through the accumulation of land, in the case of crop farms, through the addition of facilities, in the case of livestock farms. Both are becoming more specialized although reductions in the real cost of transport are diminishing market-related comparative advantages.

Substantial changes have also occurred in the use of inorganic fertilizers and herbicides in crop production; and through oestrogenic and antibiotic materials in livestock production. Finally, the commercial farmer has turned almost completely to purchased genetic material in both crops and livestock. Again, crops led the way but livestock is not far behind. Indeed, control of breeding stock, plant or animal, has now become an element in co-ordinating practices and contractual relations between farms and farm-related firms, along with price negotiations and production regulations. The result has been to enhance the payoff from vertical integration in certain cases (e.g. speciality crops and egg production). In other cases, such purchased inputs, available through factor markets, may help preserve the independence of the established commercial farmer. An example may be the swine producer. Much appears to depend upon the structure of markets and the location of research that generates the inventories of technology from which innovations are made.

Statistics that quantify these changes are readily available (2). Effects of the changes are profound and far-reaching. The capital required for an economically viable farm firm has increased manyfold since 1940. Despite a considerable response in the financial community, entry into farming remains more dependent on inheritance than does entry into any other

major economic sector. Such a characteristic hardly accords with the economic and social mobility that otherwise is a significant feature of the economies included in this review. Entry into farming remains a serious problem; again, one to which we return later.

Changes in production organization have altered the financial structure on farm firms in other ways. Displacement of resources originating on-farm by resources from off-farm has increased the percentage of costs that are cash without reducing the proportion of costs that are fixed. Also, many inputs are now highly specific in use. Few alternatives exist for a broiler plant, a mechanical cotton picker, or an auger feed bunk. So resources committed with respect to time are also increasingly committed with respect to use. The consequences of price uncertainty are thus increased and investment problems have assumed greater prominence. To counter the effects of price uncertainty, innovations have been made in marketing techniques: forward price commitments, future contracts and certain types of public policy. Investment problems have stimulated increased interest in investment planning and financial strategies. Innovations in the financial organization of farm firms may well be expected in the next twenty years.

The above summary centres principally on the U.S. though most of the broad tendencies in structural change apply equally to Canada. Indeed, many apply also to Australia. But in Australia there are relevant departures. The disparity between farm and non-farm incomes is by no means as great in Australia. Development still is a pervading economic issue in both farm and non-farm sectors. Controversies rage on allocation of public resources in economic development (11). But the literature abounds with examples of individual farm development as well (34). Agriculture's location and role as a major exporter also is reflected in problems that engage the attention of the farm production economist.

Production economics in agricultural research

In an applied field it is only natural that professional activities reflect at least in part a response to problems in the empirical world. The research-education responsibility of the land-grant university in the U.S. facilitates response among research personnel to changes in farm and farm-related sectors. Hence it is important, when reviewing analytical practices developed by farm-production economists, to relate the developments to changes that have occurred in these sectors. The practices may or may not be relevant in countries with different institutions and different structural changes.

Though real-world changes have been massive, those in the research world of the farm-production economist have been no less so. Perhaps the most significant change has already been mentioned. The production economist's theory of the firm now has been incorporated all but universally in the formulation of models with which to analyse problems in production organization. Production economics has become a basic ingredient in the graduate programme of nearly all potential agricultural

economists, whether their intended working areas include farm firms, marketing firms, or even non-firm orientations, for example, economic development.

A second change has been an accelerated acceptance and adaptation of quantitative methods in research. The use of crude cross-classification techniques had given way to single equation regression models long before the start of our twenty-year review period. The combination of statistical methods and production economics in the Cobb–Douglas production function in 1928 (9) anticipated wide-scale applications in agriculture in the 1940s and later. Adaptation of the method, with a wide variety of algebraic forms, to the estimation of whole-farm production functions has contributed to the explanation of differences in economic performance of farms between areas and types of farms (17). The method also has proven useful, though limited, in estimating aggregate supply functions (29).

Heroic attempts have been made to use estimated whole-farm production functions to prescribe courses of actions for farmers (27), though even the most ingenious (19) must be judged somewhat disappointing. The aggregation of inputs necessary to conserve degrees of freedom courts problems in heterogeneity in the aggregates (37), specification bias (15), and limited operational usefulness for purposes of the individual farmer's policy problems. To find a relatively large marginal value product for 'operating expenses' may have little utility in prescribing a relevant course of action. Prescriptive inferences are still more vexing for a multi-product farm.

A more lasting development may be the estimation of production surfaces in sub-firm units. Optimizing principles of production economics provide immediate use for estimates of marginal rates of substitution between inputs that can be varied in producing a given output. Hence a substantial effort has gone into the estimation of crop-production surfaces, with dimensions in soil fertility, water, tillage, and other inputs. A major problem has been the empirical generality of surfaces estimated for given conditions. Experimental control seems nearly imperative to generate observations required for tolerable error criteria. Yet the conditions in which most experiments are designed provide a limited basis for inference into a population of soil conditions, etc. different from the experimental site and/or heterogeneous as compared with the homogeneity commonly sought in the experiment. The problem is being attacked by improved experimental design (35) and by a wholesome trend toward acceptance by plant scientists of the obligation to estimate marginal rates of substitution (35). Hence, the resources available for the task are greatly expanded.

Estimation of livestock production surfaces has developed more slowly. Sources of variation are at least as numerous as in crops and are more difficult and costly to manage and/or measure. Yet an inventory of production surfaces is beginning to emerge, especially for meat, wool, and milk production (22), with respect to feed inputs that are in common use.

Large-scale cattle-feeding units have made it commercially profitable to estimate marginal rates of substitution for highly specific feedstuffs locally available (30). It might be useful to examine results now available for empirical generalities that are possible (13). Perhaps a more useful way to put the suggestion is to find terms in which inputs must be measured to attain generality. If inputs must be measured in terms that are unobservable by the decision maker, or that are not related to the market in which feedstuffs are obtained, such generality may be of little prescriptive use.

In the depression years of the 1930s a considerable emphasis was given to budgeting. There was a growing awareness of prescriptive limitations from cross-classification analyses of survey and records data, and even the few examples of regression analyses that can be found in these and earlier years. It was recognized even then that (*a*) variables that were manageable were inevitably highly aggregative, compared with instrumental choices open to the farmer, and (*b*) at best, one's prescriptions could safely relate only to the range of events that generated the basic data. Hence the analyst was confined to past experience as a basis for prescriptions. Units of the Farm Credit Administration and the Farm Security Administration (now Farmers Home Administration) began to experiment with budgeting methods to supplement loan analyses and, in the case of the latter, development plans. Budgets also were used in planning procedures of the Soil Conservation Service. The objective sought was a reliable basis for predicting outcomes from changes introduced into a farm firm that lie outside the past experience of the firm.

So appealing was budgeting that behavioural applications also were attempted. Perhaps the most elaborate was a study of inter-regional competition in milk production (28), an example of considerable interest for its methodological properties as well as its substance. In substance, it compares rather favourably with more recent studies of the same problem with far more sophisticated techniques. But the more spectacular extensions of budgeting have entailed operations research methods, and have been oriented principally toward prescriptive applications.

It would be a rare issue of a *Journal of Farm Economics* or either the *Canadian* or *Australian Journal of Agricultural Economics* that would not contain an example or two of a prescriptive use of linear programming, single or multi-period (the latter, recursive or non-recursive); a suggestion for dynamic programming; a game model; a queue or an inventory model; a non-optimizing simulation model; or some other example from a rapidly expanding inventory of analytical alternatives commonly grouped under 'operations research'. The flexibility of such models has made it possible to incorporate implications of the rapidly developing behavioural theory of the firm (38) as well as important constraints from the marketing (5) and financial setting (6) of the farm firm. There seems little doubt that the past twenty years have produced an array of analytical alternatives with, in principle, considerable payoff in specific prescriptive application. Exciting attempts now are in progress to apply some of the simpler of the

models in individual farm planning programmes (4, 12). The future looks most exciting.

All this development has placed a considerable strain on sources of information commonly available to the analyst. Hence we find a renewal of interest in behavioral research. Farm records projects, long slighted, have become the focus of intense interest (24). Computer programmes have been written to speed up the analysis of records data, widen the range of coefficients that can be obtained, and improve their relevance for modern prescriptively applied models (36). A modern renaissance also can be seen in basic managerial research (18). The capacity to formulate operational models, enriched in alternatives, constraints, and objectives of decision makers, has driven the production economist to search for improved descriptions of decision behaviour and how it varies among farmers and among problems (23). Results are needed to improve models used prescriptively, with respect to individual farmers and behaviourally as well, in macro applications. Behavioural research is also needed, for the former, to supply estimates on constraints and alternatives relating to factor and product markets (5) and responses in financial alternatives (6).

In such a context it is not surprising to find a considerable activity in improving estimation models with ready behavioural applications. Examples are in multiple-equation regression models (20) and analysis of residuals by stagewise sequence of least squares estimation (3). A most interesting development is the combination of prior information with sample data in formulating estimators (25). Less has been done to improve observational methods, though a start has been made with respect to financial data relevant in decision models (7).

Even a brief review must include studies of inter-sector (26), inter-region (39), and inter-commodity (14) or industry (31) relations. In such studies the farm-production economist may be only one of a team in a large research enterprise. Yet it is a matter of curious fact that the farm-production economist often is the innovator in such studies and ordinarily plays a leading role. Again, an analogy may be drawn from the estimation of micro-unit production surfaces. In post-innovation phases one may expect the farm-production economist to play a decreasing role in applications of input-output models, transportation models, and other models with which relations are depicted among such aggregates as sectors, regions, industries, and commodities. Yet for the foreseeable future these activities will continue to claim a significant share of resources available to the farm-production economist.

Our review must remain brief to allow for suggestions of unresolved problems. Happily for employment of farm-production economists, no shortage is in sight! Research proliferates problems more rapidly than solutions. Acceding to the request to list 'unresolved problems' forces me to be presumptuous. My list is best read as illustrative of problems to which I ascribe substantial importance in the next twenty years. In accord with the preceding review, they are partly substantive and partly methodological.

Unresolved problems

The farm-production economist in U.S., Canada, or Australia will be forced to place a high priority on research into managerial behaviour. Lack of relevant knowledge on variations by problem and farming situation now limits the achievements of the farm economist in micro-prescriptive research. His capabilities to formulate relevant models exceed the information available to him for the task. His responsibilities in macro-behavioural research will reinforce such a priority. There is every reason to expect the farm-production economist to be asked increasingly to predict farmer responses as well as to prescribe courses of action for farmers as individuals or groups.

Interdependency of production with financial and marketing choices will expand the research domain of tomorrow's farm-production economist. Solutions of models now available describe joint equilibria among all three sectors of the firm. However, empirical requirements imply research into lender behaviour and market limitations that has, as yet, hardly begun. The task will be increased with greater development of multi-period models. A division of labour might be predicted in the long run. But if research in estimation of production surfaces provides a useful analogy, the short run will find farm-production economists in research fields now largely unfamiliar to them.

The relation of the micro production unit to macro units of economic relevance is an ancient problem. With changes in market structure the problem will become increasingly urgent in the future, in both prescriptive and behavioural aspects. Prescriptively, the farmer faces choices where price data are so modified as to have little independent relevance. Contractual obligations may so tie prices to performance and financing practices that all must be considered jointly. Behaviourally, macro inferences based on aggregation of individual firm responses will become less useful. Hence methods will be sought to incorporate the properties of individual firms and macro units in single models. Specification problems will be demanding but not, in principle, unsurmountable (39).

Technologies available for innovation are generated largely from within the economies included in our review. In other economies they may be imported. It is reasonable to assume that imports are motivated by economic expectations. Inventive activity also may be partially so motivated. Thus the tomato harvester and mechanical cotton picker represent economic responses to expensive labour. Yet for a considerable fraction of inventive research it is difficult to relate relative resource commitments to economic payoff that is socially relevant. To do so would be extraordinarily difficult. Yet one may well expect so important a task to be attempted in the future.

In under-developed economies restricted resource mobility between traditional and modern sectors constrains aggregate growth. The counterpart in a developed economy lies in the complex of capital formation, technological change, and asset replacement. Rapid technological change

requires, in most aspects, rapid asset replacement, the more so as production is increasingly capital intensive. But in turn, the rate of capital formation is retarded and hence the aggregate growth-rate as well. Though small in terms of labour, the farm economy is far from small in terms of capital in any of the developed economies in our review. Moreover, the percentage of capital that is replaceable increases each year. Hence the effects of technological change suggest the importance of this area for tomorrow's farm production economist. It complements investment and financial planning in his micro-prescriptive domain.

By request, we have deliberately excluded developments in other world regions. In all three countries considerable commitments to problems in less-developed countries can hardly avoid influencing professional progress. In many ways the commitments are competitive and retard progress on domestic problems. Yet in other ways there is a high degree of complementarity. Decision-making is observed over a far wider range of conditions than would otherwise be possible. Development alternatives are analysed and tried, also over a wider range than is available domestically.

The objective in all such programmes is to enhance rates of economic growth in the less-developed economies. Yet the benefits are not all in one direction. Understanding of economic behaviour generally is improved in the process. Perhaps the important point here is that the record of achievement and failure be so kept that understanding *is* enhanced. Surely this is a useful function that might be performed by the International Association of Agricultural Economists. An important part of the record might be comprised of studies of economies that *have* developed, as well as those that have not.

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APPROACHES AND FINDINGS OF FARM-PRODUCTION ECONOMISTS IN ASIA[1]

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F.A.O.

THE length of the paper allocated to me does not permit comprehensive coverage and exhaustive discussion. Asia is a big and heterogeneous continent and farm-production economics is a new and not well recognized field of study. It is therefore difficult to decide what particular subjects should be selected and on what basis the various approaches and findings of the different production economists in the many Asian countries should be singled out for quotation.

In the following pages only illustrative cases will be presented. Since the same approaches to research may be followed by several economists, it seems unfair to mention by name only those who happen to be known to the writer, as either praise or criticism, implicit or explicit, might cause wrong impressions and misunderstandings.

Approaches to farm data collection

Farm data can be collected by two main approaches: (1) record and book-keeping and (2) farm interviews. In Asia both approaches have been adopted and considerable data have been accumulated.

It is very interesting to note that the Swiss approach to farm accounting has been taken up in Japan since the 1920s. As most Japanese farmers have had a certain amount of schooling, farm book-keeping has made great progress, not only in the development and perfection of the methodology suitable for popular Japanese adoption, but also in producing an enormous amount of data for use in studying rural economic problems and formulating government agricultural policies. Moreover, many

[1] Paper presented by Dr. M. C. Agrawal in the unavoidable absence of the author.

farmers in Japan have found farm book-keeping essential for making management decisions. The leading institute which has promoted this development is the Research Institute of Farm Accounting of Kyoto University. The Annual Report of Farm Accounting, published in Japanese, gives detailed figures on family composition, land area, crops, livestock, assets, receipts, expenses, gains, and losses by individual holdings. Since the 1950s the Japanese Government has launched a Farm Business Management Survey[1] covering more than 200 farm holdings by the book-keeping method. Statistical reports are issued annually, in Japanese, giving detailed information for all the individual holdings, grouped by types of farming, which include paddy farming, upland farming, sericulture, animal production, fruit and vegetable farming, tea culture, and mixed farming. Since 1960 the Research Institute of Farm Accounting at Kyoto has also issued, in English, annual reports entitled 'Farm Economy Analysis Reports', separately for rice farms, poultry farms, dairy farms, and vegetable farms, covering altogether over ninety holdings in the Kinki district. These reports represent a big improvement over the earlier ones because for the first time the relationship between income and the various management factors are analysed.

Apart from Japan a considerable amount of work on farm book-keeping has also been done in Taiwan, China, under the auspices of the Provincial Department of Agriculture and Forestry. As farmers in Taiwan have not had so much schooling as Japanese farmers, more assistance must be given in keeping these books. The practice there is to employ students in the vocational schools. Each year one student is responsible for the book-keeping of one or two farms, with which he can establish a close relationship.

It should also be mentioned that farm-accounting work was started very early in the 1920s in the Indian continent by the Board of Economic Inquiry at Lahore, Punjab. However, since most farmers there were practically illiterate, progress was slow. The number of holdings participating in this work varied from one in the first year to twenty-six in the fourteenth and last year in 1937/8. After Independence the programme of farm accounting was resumed in India as a part of the Farm Management Inquiry by the Directorate of Economics and Statistics in the Ministry of Food and Agriculture and the Research Programme Committee of the Planning Commission. Six states[2] were selected, representing different agro-economic regions and soil crop patterns. In each region ten villages were selected at random and ten farm holdings were chosen in each village to be visited daily by investigators who kept detailed records. Comprehensive and carefully analysed reports for the different regions were issued separately by the Directorate.

Other countries in Asia have undoubtedly done some work in farm accounting but the above will suffice to illustrate the situation. This

[1] To be distinguished from the 'Farm Household Survey' which includes more than 5,500 households and has been conducted for more than fifty years.

[2] The programme was extended later to cover sixteen regions.

approach to data collection has certainly produced an enormous amount of information but the data or material presented in the various reports have seldom been systematically analysed. Other reports contain a tremendous amount of analytical work but the techniques employed and the manner in which the results are presented are not always suitable for either policy formulations or decision-making in farm management. The most serious shortcoming in farm accounting as an approach to data collection is the practice of using a very small and biased sample of farm holdings to represent the conditions of a much larger universe.

The second approach to data collection is the interviewing method developed in the U.S.A., which had been introduced in Asia as early as the 1920s when the Department of Agricultural Economics of the University of Nanking started to make farm-management surveys in China. For each survey about 100 farms were visited by a university student with questionnaires or schedules prepared under the guidance of the professor. The survey represented part of the thesis for a B.Sc. degree. Over the years many farm surveys have been conducted in this way, a lot of farm-management data collected, and many reports issued. Increasing support has been given by government departments and banking institutions for carrying out farm-management surveys in the various parts of the country. In 1930 a publication was issued entitled *Chinese Farm Economy* covering a total of 2,866 farms in 17 localities and 7 provinces. A few years later, just before the war, *Land Utilization in China* appeared dealing with a total of 16,786 farms and 38,256 farming families in 168 localities and 22 provinces of China. Farm interviews provided most of the information.

After the war farm surveys on a considerable scale were also carried out in Thailand, the Philippines, China (Taiwan), India, and Pakistan. In India the survey method for data collection is used in conjunction with the accounting method in order to compare their advantages and disadvantages, as part of the Farm Management Inquiry mentioned above, but the number of farms covered has been doubled and the investigators visit the farms four or five times a year instead of daily (as in the accounting method). According to the reports of the Inquiry, there is still no definite conclusion as to the relative merits or demerits of the survey and book-keeping methods. Thus the choice of the proper approach to follow must depend on the purpose of the study, type of material to be collected, the co-operation and capability of the farmers, and the competence and reliability of the field investigators.

With the conditions prevailing in Asia, the interview method will have to be relied upon as an important means of collecting farm-management data, but farm book-keeping should also be encouraged in order to obtain information precise and comprehensive enough to help farmers make management decisions. Such information is also useful for making periodic comparisons and historical studies.

Cost determination

Production costs used to be a popular subject for farm economic study

and cost accounting was considered the only appropriate technique for determining such costs. However, in the Far Eastern region some studies on production costs of agricultural products have been carried out through the survey method instead of by keeping daily records, because a large sample of farms had to be covered to ensure the representativeness and reliability of the results.

In India before Partition the Board of Economic Inquiry in Punjab had conducted a series of cost surveys from 1923, covering only one or a few farms each year. At the same time other institutes like the Gokhale Institute of Politics and Economics at Poona, Bombay, and the Visva-bharati University in West Bengal also carried out cost studies. An inquiry into the cost of production of agricultural products was undertaken and financed by the Indian (Imperial) Council of Agricultural Research and the Indian (Imperial) Central Cotton Committee in 1933 in the principal sugar-cane and cotton-growing regions in India, covering all the major crops growing in these areas. Village investigators were engaged to keep records for the selected cultivators in each village.

After the war a pilot inquiry into the cost of production of cotton, sorghum, and ground nuts in the Akola district of Medhya Pradesh was carried out during 1953/4 by the Indian Council of Agricultural Research with the co-operation of the Central Cotton Committee and the Central Oilseeds Committee. It was found that a sample of about thirty villages at the rate of four holdings per village would suffice to achieve a reasonable degree of significance (a standard error of less than 5 per cent) for cotton and sorghum, but in the case of ground nut a somewhat larger sample would be necessary.

In Japan surveys on the production cost of agricultural products commenced in 1921, first for rice and later for silk cocoons and other farm products. These surveys were conducted by technicians of the Agricultural Associations. After the war a cost-of-production survey was started on a considerable scale in 1958 for rice, wheat, barley, naked barley, and silk cocoon and for other important agricultural products, covering almost 10,000 farm holdings each year, under the auspices of the Central Bureau of Economics and Statistics of the Ministry of Agriculture and Forestry. For rice alone the number of households surveyed varied from 3,000 to 5,000 in different years; for silk cocoon about 1,000 farm holdings were covered each year. Recently milk has also been included and 800 to 1,300 farms have been investigated each year. Other farm products for which production cost has been studied include fruit, vegetables, poultry, and meat animals, the size of the samples varying from a few dozen to 1,000. The cost of production per unit of product and per unit of cultivated area is calculated. Comprehensive reports are issued giving detailed figures on land, labour, animals, farm requisites, expenses, products, etc., by farm, district, and region. The reports provide an enormous amount of information, needed in framing government-subsidy and price-stabilization policies. Research workers have found the basic data included in these reports most useful for advanced studies.

Production costs of rice and several other major agricultural products, including two newly introduced crops—mushrooms and asparagus, have also been surveyed and reported on in Taiwan.

It may be pointed out that no absolute significance should be attached to the figures for production cost, no matter how meticulously the records have been kept and how carefully the calculations are made. Their value depends not only on the selection of samples but also on the methods of valuation and allocation. As a matter of fact, differences between producing farms and regions in the unit production costs thus determined are so great that one doubts the meaningfulness or value of such calculations. For instance, in 1953 the average production cost of paddy rice among 2,980 farm households in Japan was 7,530 yen per 150 kilograms (U.S. $1 = 360 Japanese yen), but the lowest was 1,847 yen and the highest 212,384 yen (130 times greater). Since the market value of paddy rice was about 9,000 yen, one wonders if there was even a remote relationship between the market price and the marginal or average production cost.

It has also been observed that for many agricultural products the producing farms often show a net loss year after year; undoubtedly the calculated production cost has been much exaggerated by the imputation of the cost of family labour, land rent, interest, and depreciation. Economists may find it paradoxical that farmers continue to produce, and even increase the production of, farm products which have shown calculated production costs higher than their market value. Such a paradox is certainly not due to the farmers' lack of judgement; more land, labour, and capital resources will naturally be used on enterprises from which farmers expect to receive the highest returns. Since an imputed value is assigned to all family labour and capital resources, which may not have other and better uses, the unit production cost thus calculated does not really represent the true cost of these products to the farmer. In other words, the concept of opportunity cost should receive more attention.

Studies on production cost seldom attempt to make systematic analyses and draw practical conclusions, and there is much scope for production economists to make full use of the basic information collected for problem-solving and decision-making purposes.

Analysis of factors affecting farm success

Farm-management surveys in Asian countries which follow the Cornellian approach invariably attempt to make some analysis showing the relationships between various measures of farm income and the different management factors, such as size of farm, rate of production, efficiency of labour and capital, price levels, and marketing costs. Before the war most farm-management studies in China used this approach. Since 1960 the Kyoto Research Institute of Farm Accounting has also adopted an analytical approach in their studies. In both India and Pakistan large-scale farm-management surveys, either by interview or by record-keeping, have also included analyses of this type. Research reports emanating from this approach have also appeared in the Philippines, Thailand, and elsewhere.

To depict the relationships between the various management factors and farm or labour income, two methods have been adopted—the tabular method and the regression or correlation method. The former is more extensively used in Asia, but in recent years the regression method has very often been adopted, as for instance in the Indian Farm Management Inquiries. As we all know, in the tabular analysis averages are relied on to show the relationship between two or three variables (or factors) in a table. In the regression analysis the least squares method is usually employed to determine the regression coefficients and multiple correlation coefficients between a dependent factor (output or income) and one or more independent factors (inputs or expenses and management ratios).

Such studies show that the factors affecting farm success or income in the U.S.A. and European countries have the same effect in Asia. However, because of the wide spread of the values in a scatter diagram, the small number of cases in the various sub-classes, and the occurrence of inconsistent relationships, the significance and reliability of the averages are questionable in many of the correlation tables.

Nor does statistical manipulation improve the reliability of the regression or correlation coefficients. On the contrary, linear or curvilinear multiple correlation analysis has very often produced absurd regression coefficients and shown great standard errors. Production economists today should not merely repeat the same type of analyses and parrot the same phrases and statements as research workers did thirty or forty years ago. They should understand the shortcomings of the method and adopt more rational practices. The writer thinks it essential that the scatter diagram should be studied carefully before any analytical techniques are chosen, and that deviations (instead of merely average values) of individual values from an assumed average or normal curve warrant further scrutiny and analysis.

To narrow the spread of values in the scatter diagrams or to minimize the standard errors, a farm survey should be made in a homogenous farming area or agricultural region, with an adequate sample of farms and a sufficient number of cases in each sub-group. Several studies carried out recently in Taiwan (China) by the Research Institute of Agricultural Economics of the Taichung Agricultural College provide examples of this approach.

Production function and marginal productivity

Since 1955 many notable studies have analysed production functions and the marginal productivities of different farm input factors. In the *Studies of the Economics of Farm Management* in India, this subject is elaborately treated in both physical and monetary terms. In Japan, the Philippines, and Taiwan (China) production economists have employed the same approach to study the input/output relationships of various farm enterprises. The data used to make these analyses were derived mostly from interviews and cost accounting.

Many thousands of tests and experiments have been conducted all over

Asia, either on cultivators' fields or on government research farms, to study the effect of fertilizers (N.P.K.) on the yields of several major crops, such as rice, wheat, maize, sweet potatoes, cotton, and sugar-cane. Similar experiments have also been carried out to study the effect of irrigation, seed rates, and frequency of weeding. The results of such experiments and tests have also been used extensively for input/output analysis.

Needless to say, data derived from such tests and experiments are all in terms of kilograms or other physical units, while the analysis of the data from farm surveys and cost accounting may be expressed in more complex terms and units, such as total value of input and output, expenses and income or, in rare cases, one or two factors may also be expressed in such terms as acres of land and days of labour. The equations employed by production economists in Asia have included multiple linear regression, Cobb–Douglas and quadratic functions.

Normally, in addition to the determination of the regression coefficients or the functions of the various production factors, the marginal rates which yield the maximum income are also calculated, as well as the coefficients of multiple correlation and standard errors. In some studies the production surface is determined and the marginal substitution rates of the two production factors ascertained, as well as their least-cost combinations.

As I have said, it is not the purpose of this paper to criticize specifically any particular study. I wish only to point out that in a study on production functions the less the various production factors and yields are manipulated, the more useful the analysis will be. Generally speaking, such analyses should be made in physical terms rather than in monetary values, to avoid the effect of prices and arbitrarily imputed figures for family labour, wages, inventories, depreciation, and interest costs.

It is extremely important that a research worker should define clearly the objective of his study and that his objective should be meaningful. Secondly, his hypotheses and assumptions must be logical. Thirdly, his information and data must be valid. In several studies the coefficients derived are absurd and inconsistent, and although the author may have failed to show these inconsistencies, the reliability of such functions becomes very doubtful. When two or three production factors are included simultaneously in a linear regression or a Cobb–Douglas equation, it is essential that these factors have no inter-relationship between themselves. Yet it is doubtful whether any input factor can be independent of others; thus it seems unthinkable that crop area, days of labour, and capital requirement can be independent. More complicated terms can be introduced to deal with the problem of interaction. It is, however, preferable to avoid the use of composite factors elaborately calculated and that only one or two simple production factors be used in an equation, and then in physical terms, so that the relationship between the product and the production factors can be comprehensible and applicable to management decisions.

This implies that, for the analysis of production functions, data from

trials and tests, or better still from controlled experiments, are more reliable than data from farm surveys and cost accounts. However, most fertilizer tests and experiments conducted in Asian countries do not cover an adequate range in levels of application of the input factor to give a complete picture of the production functions required in making management decisions. For instance, only two or a few different doses of fertilizers may have been applied, or only two or three different levels of irrigation tested. With such a crude experimental design only a straight line can be fitted and no diminishing return can be depicted. Another common drawback of such experiments and tests is that research workers are inclined to reduce the probable error by including too many tests and experiments, scattered over different areas with different types of soil and diverse climatic conditions. As a result the averages derived from such heterogeneous conditions may not be applicable to any particular farming area in any particular year.

Planning and budgeting

Practical farm planning for agricultural improvement in Asia did not begin until the 1950s. In the beginning some work was carried out for academic interest, but the subject has since received so much attention that within only a few years programmes in farm planning on a considerable scale have been launched in several countries where farm production economists play an important role. The Intensive Agricultural District Programme in India is built on the basis of farm planning. In the initial period only simple farm plans have been used, in order to incorporate all feasible practices and input factors to increase the production of a few major food products, such as wheat, rice, and sorghum. It is expected that as more workers are trained, farm plans covering the entire farm organization will be prepared and new farm enterprises and farming patterns may be worked out to maximize income. In the Philippines farm planning has also been employed to improve farm production and income in a few villages, as a pilot demonstration and research programme. In Japan farm planning and budgeting is becoming increasingly important in agricultural development, particularly since the promulgation and implementation of the Agricultural Basic Laws, to double the farm income in ten years. In Thailand farm plans have been employed for planning new farms in a pilot land reclamation and settlement scheme. In Pakistan and Taiwan farm planning is practiced in the planning and evaluation of development projects such as irrigation and farm development.

From the experience in Asia it can be stated that there is a great potential for improving farm productivity and income by practical farm planning. According to reports, farmers may increase their income by from 50 per cent to 200 per cent within one or two years as a result of realistic planning with whatever facilities and technical information are already available. Farm plans may also enable governments to determine the types and amount of supplies and services required by farmers for speeding up agricultural development.

Mathematical programming

It would be unthinkable that in such a big continent as Asia that a modern research technique such as mathematical programming could have escaped the attention of research workers. As a matter of fact, farm-production economists in Asia are more at home with mathematical manipulation than with simple farm planning. In recent years many studies have been published on linear programming in India, Japan, and Taiwan, and for Japan I have also come across a comprehensive report on a study using dynamic or multi-stage programming.

The objective of mathematical programming has naturally been the maximization of farm income. The processes or activities chosen were either single crops, or different crop rotational patterns as in one study made in Taiwan. As would be expected, the limiting resources assumed were crop area, labour force during the peak seasons, and capital. The results derived from these studies are straightforward and illuminating. In addition to solving the problem of optimum farm enterprise combination for income maximization, mathematical programming is useful for identifying the shadow prices of the different products and the opportunity cost of the various limiting resources.

I am not aware, however, that any programming study in Asia has been put into actual operation, in order to test its validity and practicability. After all, magic cannot be expected from mathematical manipulations. Results from programming cannot be better than the quality of the data used and the validity of the assumptions used.

Other approaches

Studies on land use and economic land classification have been made in China (Mainland before the Second World War and Taiwan after the war) and Japan. In Japan considerable impact has been made on the improvement of labour efficiency through work-simplification studies and the economic problems of farm mechanization and farm layout have also been extensively surveyed.

Case studies have been carried out and published in the Philippines, Japan, and China (Taiwan). There is no doubt that studies of this type will yield information and material more illuminating and intimate than that from any other approach. It has been observed that in Asia most farm-production economists are more competent in economics than in production and have little or no contact with local farms. Farm-management research projects often include a great number of farms in the sample. The general practice is to engage a group of much less qualified, lower-ranking workers as field investigators and it is they alone who contact the farmers for the required information. These investigators are supposed to work under the supervision and guidance of the high-ranking economists, but since the economists seldom visit a farm the amount of supervision and guidance that the field investigators can get from them is almost nil. Apart from the question of the reliability of the data collected, such study reports do not add many new and

significant findings, although they contain an enormous amount of data and a great number of charts and figures. In view of the difficult conditions that production economists have to face in Asia, they should be encouraged to undertake case studies, so as to acquaint themselves with the actual conditions and concrete problems of individual farms. Moreover, a report based on case studies can be both useful and enlightening.

In this connection I may mention a report (in Chinese) on the continuous progress of a single farm in Taiwan, during the last ten years, based on accounting records. It illustrates vividly and in concrete terms the decisions and actions which have accounted for the phenomenal progress in farm improvement in Taiwan.

Conclusions

Farm-management studies have made a great impact in Asia in recent years and the research techniques employed are quite up to date. This should dispel any doubts of Western economists as to the applicability of refined research techniques to conditions in Asia and the Far East, where the farms are small and subsistent and farmers are illiterate and conservative. It has also been proved that a well-prepared and conducted research programme can be very useful in improving farm income and facilitating agricultural development. The most serious shortcoming, as I see it, is that many of the production economists attempt to use complicated modern methodology in order to achieve prestige and academic recognition, rather than choosing the most appropriate procedures and techniques for the solution of concrete and recognized problems with the aim of helping farmers to make management decisions.

Farm-production economics is by nature an applied science. Therefore, the applicability and usefulness of the research results should be the real criteria in selecting appropriate procedures and methods for carrying out research programmes in farm management.

SUGGESTED REFERENCES

1. Those who are interested in learning more about some of the studies carried out in Asia may refer to the following publications (in English):

(i) *Farm Management and Planning* (Papers presented at the Farm Management Development Centre for Asia and the Far East, New Delhi, India, 1957)—issued by the Economic and Statistical Advisor to the Government of India, Ministry of Food and Agriculture, New Delhi, India.

(ii) *Farm Management* (Documents presented at the Fifth F.A.O. Development Centre on Farm Management for Asia and the Far East, Manila and Los Baños, Philippines, 1960)—issued by the Bureau of Plant Industry, Department of Agriculture, University of the Philippines, Manila, Philippines.

(iii) *Farm Management Manual* for the Use of Agricultural Extension Workers in Asia and the Far East—prepared by the Committee on the Preparation of Farm Management Manual, F.A.O. Regional Working Party on Farm Management for Asia and the Far East, 1965—issued by the F.A.O. Regional Office for Asia and the Far East, Bangkok, Thailand.

(iv) *Digest of Lectures* of the Malaya National Training Centre on Farm Management, College of Agriculture, Serdang, Selangor, Malaya, 1961—issued by F.A.O. Regional Office, Bangkok, Thailand.
(v) *Farm Management Training Manual*, 1963—issued by the Korea F.A.O. Association, Seoul, Korea.
(vi) *Proceedings of the National Centre on Farm Management*—issued by the Government of Pakistan, Ministry of Agriculture and Works, Department of Agricultural Economics and Statistics, Rawalpindi, Pakistan, 1962.
(vii) *The Role of Agricultural Economics in Economic Development* (Proceedings of First Conference on Agricultural Economics)—issued by the Agricultural Economics Society of Thailand; published by Chamras Ongcharit, Mongkol Karnpim Press, 101 Tani Road, Bangkok, Thailand, 1962.

2. The following periodicals (in English) sometimes include articles dealing with farm production economics studies:

(i) *Indian Journal of Agricultural Economics*, published by the Indian Society of Agricultural Economics, 46–8 Esplanade Mansions, Mahatma Gandhi Road, Bombay 1, India.
(ii) *Philippine Agriculturist*, published by the University of the Philippines, College of Agriculture, Laguna, Philippines.

3. Other national publications dealing with this subject are issued mostly in their national languages, such as Chinese, Japanese, Korean, and Thai. However, a number of monographs have been published in English; the following institutes may be contacted for further information:

(i) The Joint Commission on Rural Reconstruction, Taipei, Taiwan (China).
(ii) The Research Institute of Agricultural Economics, Taichung, Taiwan (China).
(iii) The National Institute of Agricultural Sciences, Nishigahara, Tokyo, Japan.
(iv) Department of Agricultural Economics of the Kasetsart University, Bangkok, Thailand.
(v) Office of Rural Development, Suwon, Korea.

4. The International Rice Research Institute at Manila, Philippines, is currently engaged in studying the economic aspect of rice production.

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I have the honour to open the discussion on these three papers, but I do not feel very happy because it is difficult to discuss the application of methods without knowing the circumstances under which they have been applied. The papers were not all available to me early enough to allow me to integrate the discussion as I would have wished.

I begin with some very short remarks on Dr. Kuvshinov's paper. The Soviet planning system has been undergoing great changes, especially in agriculture, since the reforms in 1965. The essential feature of these changes is the strengthening of the decision power of the individual firm.

Dr. Kuvshinov even reports on an experiment in which a large group of state farms were transformed into self-supporting units similar to capitalistic farms. This idea is not new; it has gained more and more importance in recent Soviet literature and even in 1938, Oscar Lange, the famous Polish economist had proved, at least theoretically, that the socialist economy could be run if the directors of the socialistic firms behaved like their capitalistic colleagues.

However, transferring at least part of the decision power from the

central government to the single firm, and asking the management to take decisions according to the principle of profit maximization, means the acceptance of the marginal value theory of the firm. Our Russian friends have done this already by accepting linear programming and other methods of finding optimum solutions which are based on marginal value theory. However, marginal value theory does not go together with the Marxian theory, unless one uses some very specific terms in the third volume of *Das Kapital*—which probably was written by Engels. I would therefore like to know how the change in the planning system affects the theory of the firm which is acceptable to the Soviet Union and how this change is to be integrated into Marxian economic theory.

The two other papers concentrate on tools rather than on subjects and hence they are as similar as one would expect, if experts like our speakers, who know their tools, are asked to give them. The basic similarity of the two papers underlines a fact which is known to economic theorists but is often questioned by empiricists. Different countries may have different economic problems at different or similar stages of development, but the theoretical background of the problem is independent of the countries, it depends on the nature of the problem alone. Since the application of specific tools in research is determined by the theoretical structure of the underlying problems, the use of tools is determined by problems and not by countries or regions.

In order to facilitate the discussion, it might therefore be useful to systematize the tools which are available to farm economists according to the problems which can be handled by them. One might distinguish methods for determining; (1) the income situation of the farmer or a given group of farmers; (2) input/output relationships for single enterprises or for the farm as a whole; (3) the reasons for income differences between farms; and (4) the optimal organization or optimal growth paths for single farms or group of farms.

For the first two problems, book-keeping will play its dominating role and I fully agree with Yang's statement that book-keeping should be encouraged in order to obtain information which will help farmers to make management decisions. However, book-keeping as it is done in almost all countries of the world is of very limited use for planning purposes. The hundreds and thousands of farm records which are annually produced all over the world are wasted effort in my opinion, they serve, at their best, to fill the opening pages of professor's papers. The reason is that the book-keeping has not been adapted to the needs of modern planning methods. I wonder if, in fact, no effort has really been made in this direction. If work has been done it should have been recorded at least in one of the papers, if there is none to report, it is very sad indeed for everybody!

In determining input/output data from experiments, production-function analysis will keep its place among the tools of the farm economist. Much of the recent work in this field is mainly concerned with problems of instability, and uncontrolled input data like weather, and with the transference of results from experiments to practical farming. It would

have been interesting to hear how this problem has been handled in different countries. Certainly, there should be differences between countries since the nature of uncertainty depends on the climate and on the economic system. But I wonder whether it is really possible to determine successful production function from cross-section data, especially if those data are gained by interview; I fully share Dr. Yang's critical attitude on this point.

Without any doubt, the most important tools of the farm economist are the methods of determination of the optimal farm plan. Fast progress has been made in this field all over the world. Besides the more complicated mathematical methods, simpler programme-planning methods which can be applied without electronic computers have been developed and certainly simpler budgeting methods can be applied successfully in many cases. I think so many tools have become available during recent years that the skill of the economists is not now determined by the knowledge of the methods, but by the formulation and selection of the special model which is most appropriate to the relevant problem. Therefore, it might be useful to systematize the almost innumerable models which have been developed in the last decade.

In order to do this, one should remember two well-known facts. First, any calculation problem on the farm level can be cast into tableau form, but it is not necessary or useful to solve this with linear programming procedures in every case. Therefore, one should distinguish between the formulation of the problem and the calculating procedure to solve it. Secondly, economic analysis requires a certain degree of abstraction from the real world and hence, economic models can be distinguished according to the degree of abstraction which is connected with their application. Decreasing the degree of abstraction always means increasing the size of the tableau by adding new rows or columns and decreasing the degree of abstraction means more complicated calculation procedures. Hence, the calculation procedure to be applied is determined by the grade of abstraction which seem to be useful or tolerable in a given case.

Usually abstraction is done by ignoring or isolating the following relationships or factors:

(*a*) the interdependence between enterprises on the farm;
(*b*) the interdependence between farms and between farms and the economy;
(*c*) the time factor;
(*d*) the space factor.

The interdependence between farm enterprises is isolated or neglected, for instance, if the exchange of a limited number of activities is taken into account and the rest of the farm organization is considered as an exogenous variable which is either given or to be changed exogenously. In this case, partial budgeting may be applied, or if one wants to speed up the procedure and consider a great number of possibilities of exchanging activities, one could use the Monte Carlo method. This should have been

mentioned in at least one of the papers; from my point of view it is nothing else but a speeded-up budgeting procedure.

If the interdependence between enterprises on the farm is to be taken into account, the calculation procedures aim at the determination of the optimal farm plan. Linear programming or programme planning are the methods to be applied.

If time is to be taken into account the one-period model has to be transformed to a multi-period model. The calculation procedure becomes rather complicated but problems can be solved either by multi-stage linear programming or, in a limited number of cases, by dynamic programme of the Belman type.

If space and the interdependence between farms is to be taken into account a multi-regional or a multi-group can be formulated. Again, either linear programming or quadratic programming can be applied, depending on the nature and handling of the supply and demand functions.

If space, the interdependence between farms and time are to be considered simultaneously, a rather complicated model arises, since it becomes necessary to formulate the primal and dual solution simultaneously. However, even this procedure has been followed successfully.

All the models which have been developed in the past and which have been discussed in the papers have two things in common. First, they aim at the determination of an optimal plan on given assumptions or, at least, they aim at an improvement of the given farm organization or a given structure of production. Secondly, they assume the input/output data as given and known with certainty. With respect to these assumptions one can fully agree with Yang's statement that the results of the calculations cannot be better than the quality of the data used. But this statement is true, not only for the complicated mathematical models, but also for any kind of calculation, even for the most simple kinds of budgeting or calculation of costs. However, the development of powerful mathematical tools which has opened the age of quantitative economics, has emphasized the shortcomings of the models which assume perfect information in a real world which is governed by incomplete information and uncertainty.

The call for improvement of data therefore became louder and louder. As important as the improvement of data may be the improvement of the calculation. One should become conscious of the fact that the stage of complete information and certainty can never be reached in reality, and even if it would be possible to reach this stage, it would not be economical to realize it because the improvement of information is a financial factor, too. Therefore, the theory of optimal model selection and the definition of the optimal degree of information which is required to solve the given problem, becomes more and more important. Under uncertainty, there is no optimal or general rational behaviour on which the selection of an optimal plan can be based. Rational behaviour can only be determined under given assumptions on the attitude towards risk.

The meaning of the management factor has been changed by this knowledge. So far, economists have usually treated management as a

factor which is responsible for the difference between the optimal plan on the assumption of profit maximization and the real farm plan. Now it will become one of the determining factors of the optimal farm plan, like price relations and natural conditions. Thus, one can only underline Baker's statement that research on management behaviour will have to attract the attention of the farm economist in the future. However, giving more importance to the management factor, one should distinguish clearly two fields. One field is the production of optimal plans or, more precisely, the production of results for optimal decisions in which other behaviour is taken into account besides the profit feature. Optimal, in this context, means rational. The farm economist wants to tell the farmer what he ought to do. He does not take actual behaviour as given and he must not take actual behaviour as given, because he is trying to change actual behaviour in a direction towards rational behaviour. In this field, therefore, the calculation procedures developed under the assumption of profit maximization will remain adequate tools. The other field is the study of actual behaviour for predictive purposes. In this field, which is of importance for supply analysis and prediction of production development, a number of methods have become available.

And again I can only underline Baker's statement that the use of normative models in positive research becomes more and more important. Besides the attempts which have been made with the application of recursive programming, one should try a combination of programming models with statistical expectation models, like simple trend models or Markov-chains.