YOSHIHIKO SUGAI AND A. R. TEIXEIRA FILHO

*Impact on Farmers' Decision-Making by Farm Management and Computer Sciences in the Turbulent Economy**

INTRODUCTION

The basic concept of agricultural development means getting more production of agricultural products with the existing resources. This process is satisfied by increasing the productivity of the production factors through the application of scientific knowledge. The high productivity is based on new technology which is created by the research institutions, as well as by capable people and competent agricultural producers. It is of fundamental importance to use the new knowledge, materialising it in the form of modern inputs that can be treated with adequate skills.

The farmer is the principal agent of changes in agriculture. He materialises the available knowledge and combines the available resources to increase the efficiency of his farm. Increasing producer capacity for using the modern technologies in order to be efficient is a fundamental prerequisite of development. Agricultural development requires availability of the technological knowledge that removes physical and social restrictions imposed by nature and society respectively.

Useful knowledge is incorporated into the human component of the productive process. It defines the production characteristics of land as basic inputs; the characteristics of the mechanical factors of production, machinery and equipment; the reproductive properties of the various species, seeds and varieties (in the case of plants) and breeds and races (in the case of animals).

Possible innovations from the new knowledge depends on farmers' actions. In administering the farm business the characteristics of the productive inputs which limit production growth are shown. These become the targets of new scientific investment and technological progress. Man as receiver of the benefits and agent of changes that characterise development, converts himself into the fundamental actor in

*This paper was presented by Philippe Lambrecht.

the process and becomes the convergency of the knowledge that makes development possible.

THE PROCESS OF TRANSFORMATION OF THE FARMING SYSTEM

In the adjusting procedures of dynamic agricultural development, rural producers show wide ranges of performance in adapting to the new conditions that technological progress and the market present to them. Those more sensible to signs of progress appear in front. They capture economic rent, incorporate new resources, capitalise the change and materialise progress. Others leave changes without great distortions, they compose the middle status group. The third group release their resources to be absorbed by the growth of their partners. They leave the sector and change activities.

The following scheme introduces some evaluations where the objectives of growth and equity in the sector bring up some questions:

1. What is the efficient utilisation of the production resources of the lower-income stratum, whose stability can be more intimately affected by progress, that will be able to bring up substantial increases in production and income?
2. Which factors of production are mainly responsible for the great differences in the behaviour of rural producers?
3. In which conditions can agricultural investment compete with other investment options?
4. How does the technology prescription to promote underdeveloped agriculture differ from that which is attractive from the viewpoint of the progressive producer?

The answer to the first question permits one to verify if a farm, or a group of similar farms, is accompanying or absorbing the dynamic context of the equilibrium-disequilibrium that the economic transformation imposes on the agricultural sector, through the decision-making processes of farmers.

The second question points out the direction of the different capacities of the producers as the important factor to explain the differences in total and in the rate of production growth with which each group of producers contributes to the global production increase. To what extent can the agility given to the decision-making process be the important component of these differences?

The third and fourth questions look for the identification within various groups of the producer population of the elements that make up their decision scheme or their utility function. The identification of these elements will allow an evaluation of the components of the progress which interests the various types of producers. It shows also the way to make a more accurate evaluation of the business with which the producers are involved.

Progress within the agricultural sector will depend on the improvement of capital, on the possibility of use of the land and fundamentally on the capability of the producers to use these modern factors adequately.

Acknowledgement of the importance and necessity of making investments in the physical elements that generate increases of productivity and economic progress in agriculture has been registered in the developed countries. Farmers' capacities for use and hire of new productive factors has received less attention and resources from the agencies of development. The work of the technological agricultural research agencies generates the various components of the progress that express itself in better seeds, more efficient machines, more appropriate techniques, more productive animals, etc. All these changes will be adopted by the producer. These decisions on the productive process will require complete knowledge about all these techniques. While the farmer acts according to economic criteria, his knowledge about the market forces acting on what he buys and sells becomes crucial.

While progress in the various technical fields that deal with agricultural production is reached through specific actions, its final utilisation in production demands global knowledge by the farmers in the administration of their business. This characterisation shows the necessity for specific investments in the preparation of the farmer for his decision making process. The refinement of the ability of the farmers for business administration depends on his education and cultural characteristics. These dimensions will affect the composition of technologies that he will be willing to learn and use. Knowledge of all these components as well as their interrelationships is reached through research on farm management, which is taken as the process of combining known techniques of production under defined market conditions related to the basic arrangement of resources, and it has made substantial progress with the utilization of the electronic computer.

THE FARM MANAGEMENT SYSTEM

In the process of choosing and combining technological resources and economic factors which characterise the farm business, the farmer will detect at any moment the factors that restrict technical behaviour and the profits generated by the farm. These technical constraints and the farm environment are sketched in Figure 1.

The farm management system considered three main inputs: Natural Environment variables, Price and Policy variables and Existing Farm Resources. After these are combined, the results are shown in terms of cost and profit structures, technical constraint evaluations through shadow prices and technical activity structures. Once farmers obtain these results and analyse them, the needed changes are made through feedback to the three main input variables. In Brazil the proposed procedure can be performed by 'PROFAZENDA'.

Showing this procedure for individual farmers with specific agroclimatic conditions, this system assists the farmer's decision making process

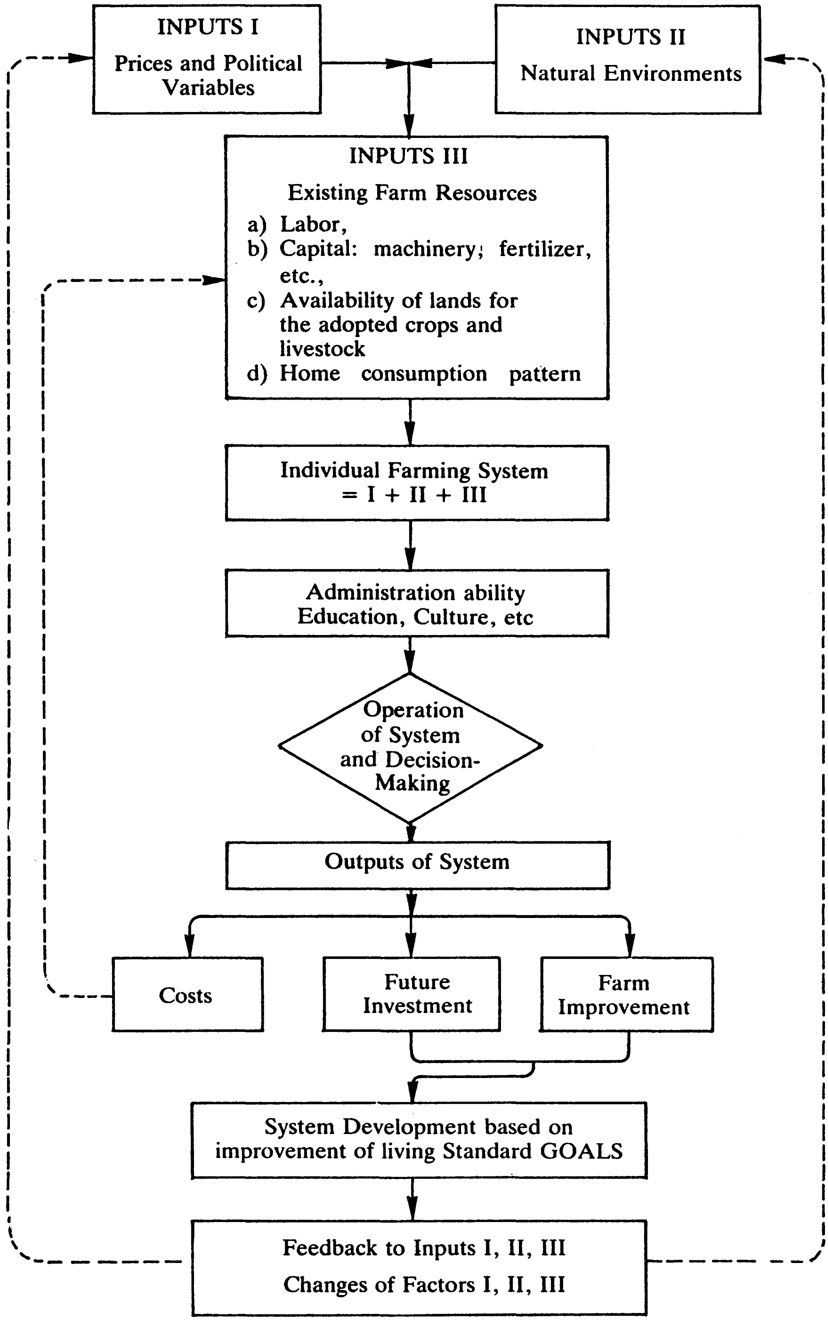

FIGURE 1 *The PROFAZENDA system*

TABLE 1 *Result of the sample of the farms participating in the PROFAZENDA, by stratum of the area and by state, 1983–84*

Farms (ha)	Equilibrium/ disequilibrium	Present plan net return Ad (Cr$) A	Optimum PLAN net return Ad (Cr$) B	Total area (ha)	Increased percentages B/A* 100(%)
I – Less than 100					
1.	DF	3,563,428	3,712,304	2	4
2.	DF	2,439,359	6,583,350	7	170
3.	DF	7,052,079	11,823,455	26	67
4.	DF	50,973,312	73,006,416	31	43
Subtotal		64,028,178	95,125,525	66	48.6
Average of Class I		16,007,045	23,781,381	17	–
II – 100 to 1000					
1.	PR	18,741,400	190,178,000	312	915
2.	PR	669,680,630	839,224,564	782	25
3.	PR	177,557,072	319,467,776	950	80
4.	PR	362,055,000	385,688,000	720	9
5.	PR	−148,252,624	−132,450,176	260	11
6.	PR	125,595,232	214,198,000	280	71
7.	PR	87,868,100	129,000,000	708	47
8.	PR	8,904,310	76,986,500	582	765
9.	PR	−32,322,400	−28,760,500	150	11
10.	PR	179,727,829	196,513,344	328	10
11.	PR	−12,035,327	−5,946,627	296	51
12.	PR	4,101,841	5,189,839	162	27
13.	DF	−1,702,096	1,354,000	420	180
14.	DF	37,775,056	49,472,000	121	31
15.	DF	−352,129	892,717	315	354
16.	DF	721,369	8,529,202	525	1,082
17.	DF	4,966,824	8,413,172	370	69
18.	GO	−46,327,584	−17,281,782	350	63
19.	SP	−2,207,504	34,115,056	241	1,645
Subtotal		1,434,494,999	2,274,783,085	7,872	58.8
Average of Class II		75,499,737	119,725,426	414	–

III – 1000 to 10000

1.	SC	−8,176,656	11,740,320	1,626	244
2.	PR	704,579,072	1,417,529,090	7,194	101
3.	PR	120,028,976	350,472,960	4,714	192
4.	PR	382,869,760	509,565,696	1,535	33
5.	PR	732,987,136	1,042,316,290	4,034	42
6.	PR	194,374,000	306,244,000	1,087	58
7.	PR	146,752,944	570,558,720	1,000	289
8.	PR	−15,841,024	217,374,176	15,761	1,472
9.	PR	193,964,096	399,241,984	1,020	106
10.	PR	108,400,000	132,247,000	1,085	22
11.	PR	−61,062,400	29,558,900	2,352	147
12.	PR	−80,918,463	−80,918,463	1,000	0
13.	PR	6,147,646,540	6,194,376,700	2,844	1
14.	DF	235,706,128	235,793,376	1,057	0.04
15.	DF	26,486,656	68,243,648	1,054	158
16.	MS	40,787,280	61,272,368	4,371	50
17.	MG	146,014,848	157,867,504	1,404	8
Subtotal		9,014,598,893	11,623,424,259	53,138	28.9
Average of Class III		530,270,523			–
TOTAL		10,513,122,070	13,993,392,879	61,076	33.1
Average of Total		202,228,052	349,834,222	1,527	

through a concrete farm operation system. Further, the shadow price analysis points out the bottlenecks of the whole farming system.

The characteristics of the electronic computer make possible quick and repeated runs for the farm analysis as well as for simulation analysis. This facilitates the analysis of the changing agricultural sector for both the price system and technologies.

RESULTS OF THE UTILISATION OF THIS SYSTEM

Preliminary results are shown by survey samples from the farms participating in the 'PROFAZENDA' system.

The sample of around 40 farms distributed in six states of Brazil was processed and analysed with the use of the 'PROFAZENDA' system. All these farms have had utilisation of their resources calculated at the optimum level. These, compared with the situation in which the farmers were adopted, made possible an increase in the net income of 33.1 per cent for all groups, as shown in Table 1. This could be reached with the same level of available resources and the same level of technology, permitting only the change characterised by the introduction of the electronic computer that executes the quick and precise calculation printing the comparison of results with various levels of input uses.

These results, even though taken only superficially, give an idea of the investment impact that the electronic computer can have as a tool in the agricultural sector for the change of attitude of the farmer decision-making.

The potentiality of 'PROFAZENDA', as a technological device to be incorporated into farm management practice, can be estimated by the volume of requests received from various parts of Brazil.

CONCLUSIONS

The use of the electronic computer makes it possible to realise detailed and quantitative analyses for farm management activities with quick and precise procedures, especially repeated uses. The characteristics of the electronic computer (high velocity and precise calculation) have shown it to be very useful for analysis in a turbulent economy, just like Brazil which is living with around 200 per cent inflation. Furthermore, there are increasing opportunities for farmers to face a variety of technologies. A computerised system makes easy the problems of technology choices in the whole farming system context.

The concrete results of the farm management analysis help to change the farmer's behaviour. The electronic computer with adequate utilisation has made possible a system for repeated uses as well as various simulations within a short period of time.

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DISCUSSION OPENING I – PHILIPPE LAMBRECHT

I would like to split up my presentation in two parts, first concentrating on the papers of Professors Sonka and Harsh which are largely supportive of one another and, secondly, give some comments and some food for thought in relation to Professor Sugai's paper.

The papers by Professor Sonka and by Professor Harsh provide an excellent synoptic view of the present situation of computer applications in agriculture and of the state of the art developments and challenges for the future. It can not be denied that computers, and especially microcomputers and the available software packages, have contributed to the development of agricultural economics by providing us with a powerful tool for the storage, processing and analysis of data sets. The very rapid evolution of computer technology in the last decade has considerably increased the computational power and has put it within reach of large numbers of people. This evolution, however, underlines the divergence in agricultural development between industrial countries, where agriculture has entered the high tech world, and the LDCs, where agriculture is still predominantly traditional.

When looking closer at the evolution of computer applications in agriculture, several observations can be made, and have been made to some extent by the authors.

1. The lower than anticipated adoption of computers in US commercial agriculture points at the uncertainty about the investment returns that can be obtained, as was explained by Professor Sonka, but this is probably less important than the uneasiness of potential land-users with this modern tool. Professor Sonka wonders whether we did not miss the point when calling for more and better training of people on how to use computers rather than designing computers to be more appropriate for use by people. This is a very pertinent question but when we look in both papers at developments and challenges, we are confronted with:

the development of ever more sophisticated and complex computer systems, such as Expert Systems and Decision Support Systems, which are likely to narrow even further the potential audience;

the need for computer information systems adapted to the widely varying and specific conditions of individual farms. This requires flexible systems that can be tailored to the particular situation of the end user by that very person; self flexible systems are inherently more difficult to use though and narrow the potential audience.

My question then is, does not this defeat the very objective of making computer information systems more manageable?

2 A second consideration relates to database quality. The importance of good reliable databases is well established, and so are the specific problems of agricultural databases. The automation of data recording could prove an excellent solution to the tedious and costly manual recording. Whilst this seems at the experimental state in animal husbandry, automated recording systems for crops are still remote. Is there not a danger that automated recording will raise expectations too high since the margin of error introduced during analyses would largely exceed the margin of error contained in the database which may be very costly to establish.

3 Third, computer models tend to lack transparency. With statistics, nearly anything can be proved by selecting the appropriate database and time horizon, but at least, the rules of the game are known. Computer models usually include one or more parameters that are arbitrarily valued or simply estimated. Moreover, model builders often provide only scant documentation reducing the usefulness of the model by making it next to impossible to adjust the model and its parameters to ever changing economic and environmental conditions. This should furthermore be linked to the lack of deep understanding of the many factors that influence the physical production process and their interactions. The use of incorrect models may prove more damaging than the advantage of speedy and repeated calculations. Our Elmhirst lecturer, Professor Sen, has already warned us against blind faith in computer systems because of this lack of deep understanding of agricultural processes and because of the limitations of models that are not only technical but also the result of the imagination and comprehension limits of the model builders and of their communicative skills to transmit the message. It is our task to assure a widespread understanding that computer information systems and models, and the solutions to problems they provide us with, are merely decision aids but that people have to make ultimate decisions, be they right or wrong.

Let me turn now to the paper presented by Professor Sugai, taking into consideration the above comments. Professor Sugai presents the application of a computer-aided farm management system in a developing country, where even more care has to be taken in providing solutions to problems since farmers do not have a cushion against risks or failing innovations. The limited time and space available for the presentation of the

'PROFAZENDA' system made it impossible to go into detail and therefore the following questions should not be seen as questioning or minimising the value of this system but rather as a concern in view of what was said before, a concern that should be shared by the model builders themselves.

1. Does the database utilised justify the analyses performed (enterprise budgets)?

2. Can one model optimise resource utilisation for as wide a range of farms with sizes ranging from 1–100, 100–1000 and 1000–15000 ha and most likely different enterprise mixes and technology levels, or 'have aggregation rules been adhered to'?

3. There exists a gap between research results and farmers' results when introducing new technology. It is unclear how new technologies have been evaluated and there is a contradiction between the statements on page 740: 'This percentage of net income could be reached maintaining the same level of technologies' and 'The computerised system utilisation made easy the problem of technology choices'.

4. What optimisation objective is the most appropriate? Production, income or resource allocation?

Let me give two examples of computer model utilisations I came across during this conference and which show a lack of commonsense in the interpretation of results, that as such are rather unrealistic.

The first was a two-year simulation model based on recall labour use data collected after the agricultural season and where results indicated a decrease of labour inputs from year one to year two of 2 per cent.

The second was a LP model to identify the optimum farm size and enterprise in a developing country where the solution recommended involves an increase in farm size by factor 5, an increase in fertilizer use by a factor of 12 and to hire 350–400 additional man days per year in a country where fertilizer availability is limited and labour supply is scarce during the peak operation periods.

I would like to conclude with a slightly modified quotation from Dr Sen's address: 'Agricultural economists should be careful when using and developing computer-aided farm management systems to avoid being found with their boots dangling in the air and their heads deeply buried under piles of computer printouts.'

DISCUSSION OPENING II – GERHARD SCHIEFER

The papers by Sonka and Harsh, Kuhlmann and Burg provide a comprehensive introduction into the field, together with an overview of current problems and suggestions for future research activities. Instead of discussing individual aspects of their presentations I would like to complement the discussion by focusing attention on two issues which I believe are important for getting the papers and the discussion about the use of computers into a proper perspective:

(a) Computers as tools for administrative v. managerial tasks,

(b) The intergration of computer-oriented research and traditional farm management research.

There is a general agreement in both papers that 'the introduction of computers has the potential to enhance management efficiency', but that the potential is not adequately reflected in the limited success of computers on farms. This prompts the question asked by Sonka: 'Will the promise be fulfilled?'. Both papers deal, in principle, with this question and answer it with a definite 'no – at least if we don't do something'. It is argued that for farms the perceived advantage of using presently available microcomputer-based data processing systems is not high enough to initiate a widespread acceptance. From this common ground, the authors discuss potential areas for research and development efforts aimed at facilitating the realisation of the perceived potential.

Computers as tools for administrative v. managerial tasks

It must be noted, however, that both papers concentrate on the utilisation of computers for management purposes (e.g., planning, control, etc.) and not so much on their use for administrative purposes (e.g., accounting, payroll, etc.). This is in line with the fact that for farms the administrative duties are of less importance than for non-farm business firms. But we should keep in mind that the success of computers is usually initiated by their capability to automate administrative tasks, i.e., to reduce manual labour input. These are areas where the advantage of computer use is usually obvious.

With regard to the use of computers for management purposes we cannot draw on much experience in the farm or non-farm business sector. A successful realisation will depend on the development of new and innovative approaches for the interaction between the farm manager and the computerised data processing system. This communication aspect is the crucial element in the development of computer-based farm management systems as it is the principal new aspect as compared to the use of management models on off-farm computer systems. Its consideration, however, will require a redesign of traditional planning procedures.

Traditional farm management research and computers: a need for integration

Both papers attempt to outline a framework for the development of computer-based farm management systems but use a different approach for their discussion. Sonka uses a dynamic stochastic programming problem to represent the planning problems of a farm and to identify areas where the value of computer use could be improved by appropriate research activities. Harsh, Kuhlmann and Burg, on the other hand, seem to have a more extensive software development background and discuss a broader range of issues related to the realisation of approaches. However, despite these differences they arrive, in principle, at quite similar recommendations which support the need for intensive research efforts.

However, for a discussion in this audience I missed more specific proposals about how to integrate those recommendations into ongoing traditional farm management research activities. If we consider computers as important tools for farm management, their introduction will affect all areas of farm management research. It will require the development of integrated data and information processing systems (see Figure 1) for farms which include as elements:

- data flow and data processing systems (which are open for computerisation),
- non-data information flow and processing systems (which depend very much on the farmer's capability) and
- procedures for the communication between farmer and computer, i.e., between the data and the (non-data) information processing elements (which depend on the design of appropriate interfaces).

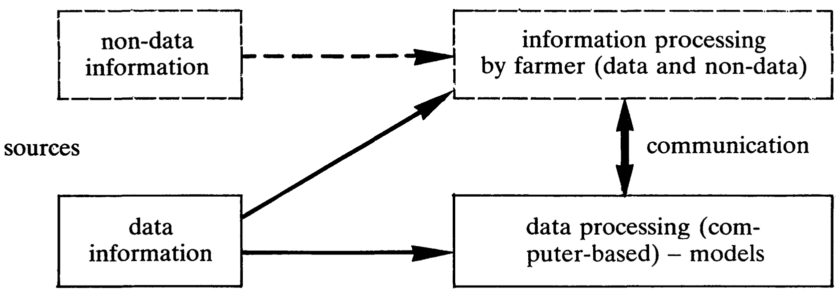

FIGURE 1

The discussion about the use of computers and their integration into farm management activities must then be part of a wider discussion which does not focus on what has to be done around computers but which focuses on new directions and priorities from computer-oriented researchers to farm management economists who integrate these data processing tools into their research framework as they integrated mathematical modelling approaches around 20 to 30 years ago.

GENERAL DISCUSSION – RAPPORTEUR: VINUS ZACHARIASSE

In answer to the discussion openers the speakers Steven T. Sonka and Stephen B. Harsh agreed with the statement that there might be a difference in the use of the microcomputer in developed compared to developing countries. By applying expert systems, the negative elements for adoption in the developing countries might be avoided however, and their advantage in using the new technology could be even greater. Both speakers supported a request for establishing new research programmes in this field of new technology. Another speaker asked for the authors' assessment of the likely consequences of farm microcomputers on the availability of farm-level data for the agricultural research institutes. Many farmers are willing now to pass their financial data to them because the data can be processed. The current development might bring them more autonomy and certain farmers might become more reluctant to pass on their data, besides having the fear of possible links with a central database. The speakers stated that it was necessary to return highly valued information to the farmer, otherwise the statement could be right. An important link with the central systems is the presence and capability of an adviser, who analyses the farmer's data and compares them to those of other farmers in the central data system. Another speaker wondered if the economists' conventional framework for the valuation of a new improvement is relevant to study the uptake of microcomputers. Sonka stated that for all types of new technology our framework of evaluation has proved to be an appropriate one. He also pointed at the challenge to defend this framework of valuing the new technology in answer to a comment that two theoretical approaches might be applicable, such as the use of diffusion models and the concept of returns to better farm management through better information. Bad management will replicate itself as the computer does not overcome the need for discipline in data management.

To several questions concerning the importance of the use of microcomputers, the speakers answered that software for microcomputers was becoming more sophisticated. The present software had to be improved by co-operating with other (agro-) disciplines. The software improves in the sense that the farmer is going to understand the science behind it, that is the science incorporated in the model used in the software. The role of extension officers must be that farmers are going to believe in the relevance of their (own) processed information, so their task is to help farmers to analyse the data, etc. Both speakers disagreed with the statement that the role of agricultural universities was to test and not develop software and held that the universities should develop prototypes in a continuing process in order to improve and so to move forward to the 'ideal' software in agriculture.

Participants in the discussion included Philippe Lambrecht, Gerhard Schiefer, Laurent Martens, Tahir Rehman, Bill Kinsey and Ulf Renborg.