WHY DO FARMERS DO WHAT THEY DO?
A HEURISTIC MODELLING CASE STUDY IN MEXICO.

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ABSTRACT

With whole-farm models, it is usually hard to know how representative the models are of reality. No rigorous validation procedure seems to have been proposed. There has always been a dilemma between descriptive power and tractability. The outcome has been to resort to a confused mix of expert opinion and normative attitude. Discrepancies between model output and farmers' behaviour have usually been interpreted in disfavour of farmers, by considering them to be in some way sub-optimal, or insufficiently informed. In traditional systems where the rationale of production behaviour can vary widely, it may pay to first understand their rationale before applying normative principles or recommending new technologies. We use a case study in Mexico to illustrate a procedure allowing for such an assessment of our understanding. The procedure, though based on the use of linear programming, is independent of the modelling technique.

Key words: Whole-farm modelling; Heuristic approach; Mathematical programming; Model validation; Farming systems; Mexico.

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Introduction

In the modelling of whole-farm production systems, one usually has to strike a difficult compromise between representing reality and remaining simple enough to stick to the key issues. Whichever way one goes, however, there always is the challenge to check what exactly we are modelling, and how "right" our models are. This is the problem of model validation, but it is also more than that. Are we only making sure that the data we have are consistent with the assumptions and the results of our model? Or do we also wish to go for more data to increase our understanding of the processes at work? If so, what data should we go for? Are we ready to modify our assumptions and perhaps our framework to achieve this better understanding? Do we prefer to have reality fit our models or vice versa?

These considerations beg the question: what exactly do we mean by a better understanding of reality? As far as modelling goes, it is widely accepted that results must be close to observed values. However, as far as whole-farm modelling goes, this is no simple matter, due to complex system interactions, to human behaviour and to other than strictly economic factors being at play (Nugent, 1970). With dynamic system simulation models, J.B.Dent observed (1975) that the variables were too many and too interdependent to allow any model to achieve a realistic analysis of decision making. With LP (linear programming) models, the normative approach has implicitly or explicitly prevailed, even if the optimal solutions have been used as benchmarks rather than for direct recommendations. Still, any difference between model and reality was, implicitly or not, most often attributed to some sort of farmer deficiency. The second issue at stake is the validity of the normative approach in farm management. J. Dillon (1978, p.23) thought production economics had lost or must irretrievable lose touch with farming realities.

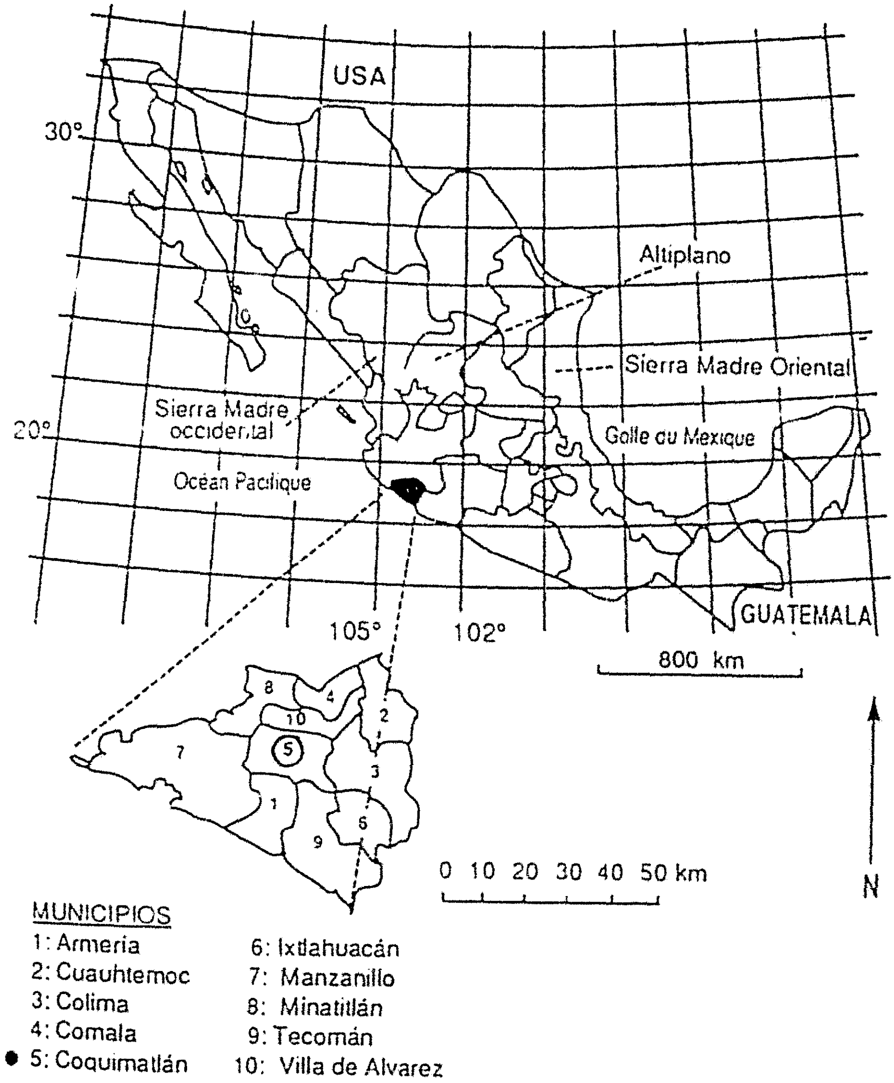
We present a procedure which may be called *heuristic*, in that it leads to sequentially identifying the factors explaining agricultural production decisions. Although it is based on the use of linear programming, the procedure is independent of the modelling technique. A similar approach was used by Kutcher (chap.11, p.327-33) in Norton & Solis (1983), but for model validation purposes in a study of aggregate Mexican agriculture. I am not aware of similar attempts for industrialised agricultures, other than risk attitude elicitation. In the case of traditional Mexican agriculture, understanding farmers' rationale certainly seems a case in point.

Statement of the problem and case study

The goal of the study was to improve the understanding of the rationale underlying production decisions by Mexican farmers in Colima, a State on the western (Pacific) coast of Mexico (Figure 1). The area investigated was the *municipio*([1]) of Coquimatlán, where farms were chosen along an agroecological transect. The study was part of a larger scheme aiming to introduce new technology and management techniques on non-irrigated, poor yielding land (Schilizzi, Rey, Galina-Hidalgo, 1994). This land was mostly held by traditional, poorly

[1]) The municipio is an administrative unit similar to the Australian shire.

Figure 1 : The State of Colima in Mexico



endowed and poorly performing farmers, organised in *ejidos*([2]). Previous research had concentrated on the main agroeconomic potential of the region held by the more productive farmers: fruit growing on irrigated land (CONAFRUT, 1982; SARH, 1983b, 83-85, 85-87), coffee on higher ground (IMMECAFE, 1985) and cattle on large ranches (SARH, 1983a; Alvarez Macias, 1987). The distribution of land with respect to number of farmers was such that most of it was in the hands of a minority of big farm businesses (CEPAL, 1982; Cochet, 1984; SPP, 1986). It was suspected that with appropriate technology and extension packages, there was room for much improvement with the smaller farmers too, with or without access to irrigation (Leger, 1985; SARH, 1985; SARH-INIFAP, 1986; ICRA, 1987). Before extending technological packages, it remained to be seen if this group made its production decisions according to the rationale assumed in standard economic studies and, secondly, to what constraints they were most sensitive.

Methodology

This application of the heuristic approach involved two stages: processing of survey data into appropriate statistical entities and analysis with a whole-farm model.

Combining structural and functional typologies

Because farms in the study area varied widely in size, resource endowments, enterprise mix and performance (Tello-Reus, 1984; Leger, Lemus, & Jaubert, 1987; Lemus, 1989), it was necessary to group them into more homogenous categories (Boulier, 1986). Seventy-two (72) farms in one area were surveyed in depth , of which 56 ended up having reliable enough data (farmers do not keep records and some are not alphabetised). A typology was built by intersecting a structural and a functional description of farms (Table 1).

The functional typology is obtained by using farm enterprises as the discriminating factors. In this case, there were four, as shown on Table 1: maize only, maize and cattle, maize and fruit trees, and all three together. The cattle enterprise includes fodder production, and fruit trees refer to lime, tamarind and coconut.

A structural typology is obtained by using fixed factor endowments as the discriminating variables, mainly land, labour and machinery. A statistical procedure, allowing for both quantitative and qualitative variables, such as Factorial Analysis of Correspondences (Benzecri, 1974) must be used to determine the most discriminative factors. The discriminating factors are those which account for most of the variance. In this case, three factors accounted for most of the structural variance: land area endowment, quality of land, and the land-labour ratio; or put otherwise, access to land, water, and labour (Boulier, 1987). Land came into three qualities: "mountainside", "*temporal*" and "*riego*". Mountainside land refers to steep slash-and-burn slopes where fertility allowed by forest regrowth is used to grow maize or graze cattle. It is referred to as "*desmonte*" if cropped and as "*agostadero*" if grazed. If cropped, it is done with purely manual tools: the slopes do not allow for the use of animal driven implements or machinery. "Temporal" refers to non-irrigated arable land, used for growing maize or for grazing. "Riego" refers to irrigated land and is amenable to all uses. There are two seasons, the wet and the dry. Only on "riego" are crops also grown in the dry season.

Results of the structural typology are shown in Figures 2a-2c. Thirty-nine (70%) farms had access to irrigated land, of which ten (18%) could be entirely irrigated. The other seventeen (30%) only had non irrigated land, of which three (5%) only had mountainside land. These were poor farmers mainly having to work on other farms as hired labour in order to survive. Four had

[2]) Mexican system, and unit, of public ownership of small farmland holdings. The *ejido* farmer is granted lifelong farming rights but cannot sell or lease his "land endowment" or holding.

Table 1 : Structural and functional typologies

FUNCT. :	A	B	C	D	
	MAIZE ONLY	MAIZE & CATTLE	MA'ZE & FRUIT T.	MAIZE CATTLE & FRUIT	TOTAL
STRUCT.					
Group 1	3				3
Group 2	3	6			12
Group 3		2			2
Group 4	2	4	6	12	25
Group 5		4			4
Group 6	1	1	6	2	10
TOTAL	9	20	13	14	56

relatively big farms, with more than 25 hectares, and six had strong labour constraints with respect to farm size.

Land also falls into another important categorisation. "Land endowment" refers to land taken away from the earlier "haciendados" (land barons) and given to the peasants by the 1910 Mexican Agrarian Reform. "Land commons" usually refers to previously forested mountainous land cleared for cropping or grazing purposes. *Desmonte* and *agostadero* "mountainside land" belong to this second category. Until recently, it was a free good. Today, population pressure and lack of appropriate legislation have made it a source of local conflicts (Leger, 1991).

The structural typology categorises farms by their fixed factor endowments or production potential. In this case six types were defined:

- group 1 defines the "avecindados" who need to sell their manpower to other farms
- group 2 defines the "small farmers" who also need some external income to survive
- group 3 defines the "extensive farmers" without access to irrigation but with strong labour constraints
- group 4 defines the "middle farmers" who have small farms but with some access to irrigation
- group 5 defines the "big farmers", with the largest areas, partly irrigated, but insufficient labour
- group 6 defines the "intensive farmers" who can irrigate all their land.

Intersecting the functional and structural typologies, an unusual procedure, lies at the basis of the present heuristic model. The assumption is that if fixed factor endowments alone determine the mix of enterprises, then all the farms must be arranged in Table 1 as close to a diagonal as possible: for any structural group there should be but one functional type. The more the farms depart from a diagonal arrangement, the more external factors, such as access to credit, to land commons, to hired labour or to networks of power, are at play. Table 1 shows that such is not the case for groups 2, 4 and 6. Before drawing any further conclusions however, three hypotheses were made, in accordance with Nugent's (1970) earlier considerations:

CRITERIA FOR STRUCTURAL TYPOLOGY
(as a result of factorial analysis of correspondencies)

Figure 2a

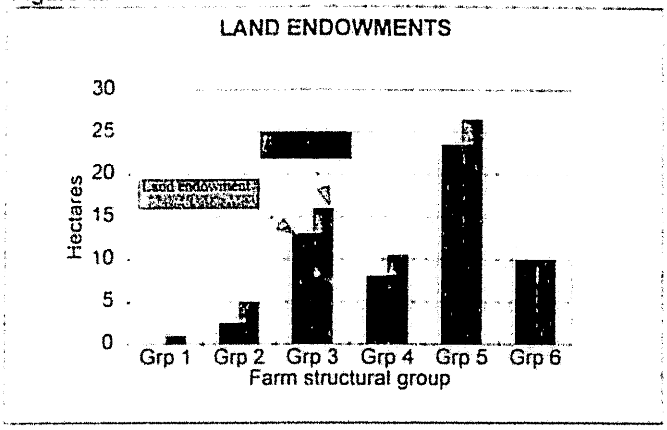


Figure 2b

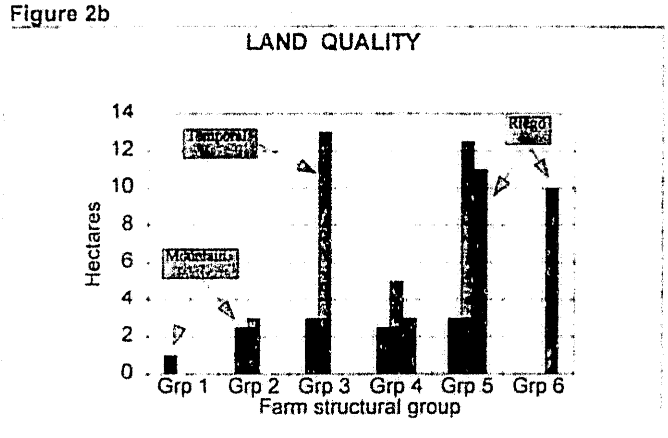


Figure 2c

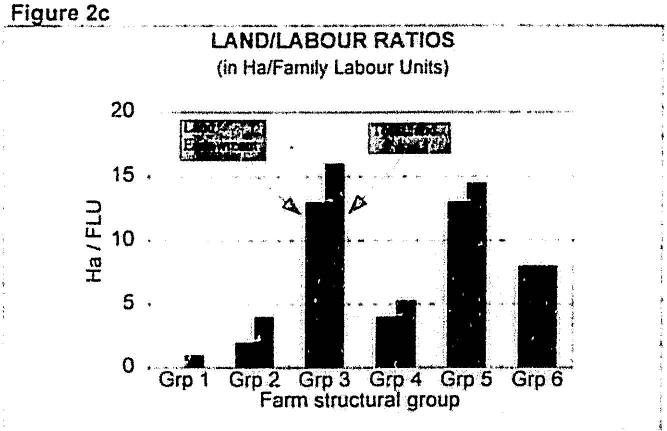


Figure 3 : The LP matrix (summarised)

TITLES		CROPPING SYSTEMS						WORKFORCE			LIVESTOCK			EXCHANGES				FINANCIAL SYSTEM				
Activities		Mountain soils	Mountain cropping	Mountain grazing	Temporal crop/fal'w	Annual irrig crop	Perennial irrig crop	Maint'ce Populat	Maint'ce Machinry	Maint'ce Horses	Cattle	Pasture	Crushing corn ears	Pasture leasing	Imports	Exports	Wages	Dry ssn credit	Wet ssn credit	Trade balance	Financial balance	Consump balance
	Units	1 Ha	1 Ha	1 Ha	1 Ha	1 Ha	1 Ha	1 CU	1 Tract	Team of 2	10 Hds	1000 FU	1 TM	1000 FU	( )	( )	10 Days	1 TM	1 TM	1 TM	1 TM	1 TM
SOIL TYPES																						
Mountain	Ha	1	-1	-1																		
Temporal	Ha				-1																	
Riego	Ha					-1	-1															
AGRIC PROD																						
Maize	TM		+A		+A	+A		-A					-1			-A						
Pasture	FU		+A		+A	+A	+A					-1000										
Forage	FU			+A		+A				-A	-A	1000	+A	1000								
WORKFORCE																						
Human labour	HL days		-A	-A	-A	-A	-A	+A			-A	-A	-A	-A		-10	10					
Animal draft	AD days		-A		-A	-A				+A												
Machine work	MW days				or -A	or -A			+A						+A	-1						
FINANCES																						
Wet S income	TM		-A	-A	-A	-A	+A	-A	-A		-A			-A	-A	-A	-A	1				
Dry S income	TM						+A	-A	-A		-A			or -A	or -A	or -A	or -A	1 05	1			
Gross profit	TM															+A			1 05	-1		
Net financ.benef	TM			-A			-A		-A	A										1	-1	
Family consum	TM																					-1
Total revenue	TM																				1	1
BALANCES																						
Capital	TM			+A			+A		+A	+A	+A											
Total labour	HL days		+A	+A	+A	+A	+A				+A	+A		+A		(+10)	+A					
Total expenses	TM		+A	+A	+A	+A	+A		+A		+A		+A	+A	+A		+A	1 05	1 05			
Total income	TM						+A				+A					+A						

Legend:

TM : tonnes of maize (numeraire)
FU : Forage units (energy)
CU : Consumption Units
fal'w : fallow
Dry/Wet ssn : season
Temporal : non-irrigated arable land

- Hypothesis H1: Farms are subject to different external constraints
- Hypothesis H2: Farmers may have different objective functions
- Hypothesis H3: There is an aggregation deficiency leading to structural differences.

The heuristic analysis is meant to check whether these hypotheses are correct or not. In this study they were checked in that order. H2 being considered as residual with respect to H1, and H3 being residual to both H1 and H2. H3 turned out to be relevant only to the largest subgroup (4D).

A tool is needed to confront survey data to assumptions made about the economics of the farms. A convenient such tool is a linear programming whole-farm model. The LINDO-MacIntosh package was used, backed up by a series of EXCEL spreadsheets.

The heuristic use of a model

A compact simplified representation of the whole-farm model built for the analysis is shown in Figure 3. The model is a standard steady-state equilibrium representation of the farm. Because of rapid inflation in the 1980's, all values have been converted to maize-equivalents. Farmers in this region did indeed use maize as a numeraire for intertemporal comparisons. The financial system reflects the two growing seasons in each year, the dry and the wet (Levenson, 1988). A constraint in terms of consumption units reflects the need for the farmer to first feed his family before considering marketing of surplus.

The matrix of technical coefficients is assumed to be the same for all groups: all farms have access to the same technology. This is not a necessary assumption but it was an acceptable simplification in this case. On the other hand, resource endowments being specific to each group, one model per group is defined by changing the right hand side resource endowment vectors. The economic function is defined as profit maximisation. Results, particularly in terms of gross profit and enterprise mix, must then be compared to survey data. This comparison is made possible by "fitting" each model to its corresponding farm type. The fitting procedure consists in constraining each known variable or activity, as well as fixed factor endowments, to observed levels and finding the subset of unobserved variables which yield the highest profit. This can either be done through a simulation or an optimisation. In the latter case, care must be taken to avoid unfeasible (overconstrained) solutions. Usually, the subset of fixed constraints is more than it takes to define a single solution. This solution will be referred to as the *"fitted solution"*. The solution which optimises the levels of activities subject only to fixed factor endowments will be referred to as the *"reference solution"*.

The descriptive approach is content with the fitted solution, whereas the normative approach is content with the reference solution. The heuristic approach aims at identifying the factors which explain the difference between the two, and includes them in the reference model. When both models have been made to produce similar (ideally identical) results, the resulting model can be referred to as heuristic and be used in a normative or a prospective way.

In the context of this study, the first objective was to understand what factors were at work behind the fact that farms with similar production potential (belonging to a same group) had differing enterprise mixes. If the reference solution and the fitted solution were similar, then factor endowments explained most of the farms' performance; if the two solutions differed, then external factors were involved, and had to be identified.

Results

The weight of farm resource endowments

Farm resource endowments were obviously the most important factors in explaining enterprise mix for group 1,3, and 5 farms; to what extent will be demonstrated in the next section. For group 2,4,and 6 farms, these factors play varying roles.

Comparing the fitted solution (Figure 4a) to the reference solution (Figure 4b) for group 2 farms, it can be seen that the two differ significantly when compared in terms of annual farm profit.

Figure 4a

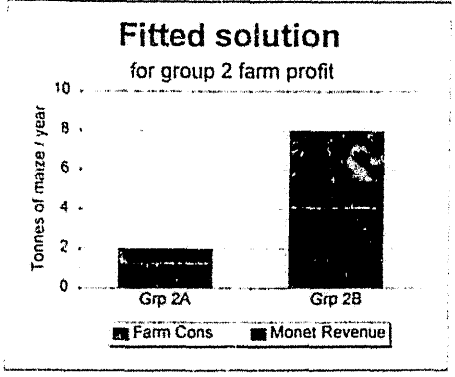


Figure 4b

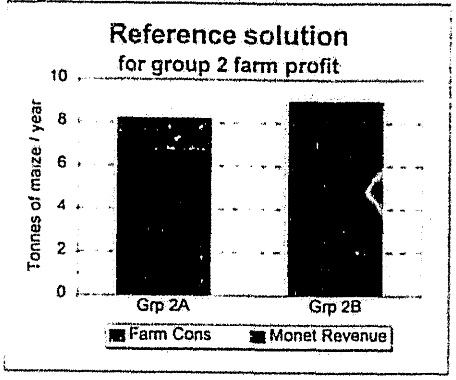


Figure 5a

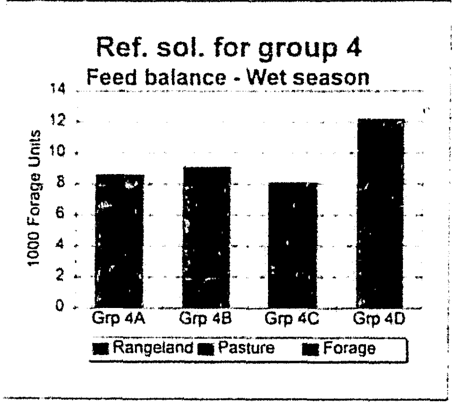


Figure 5b

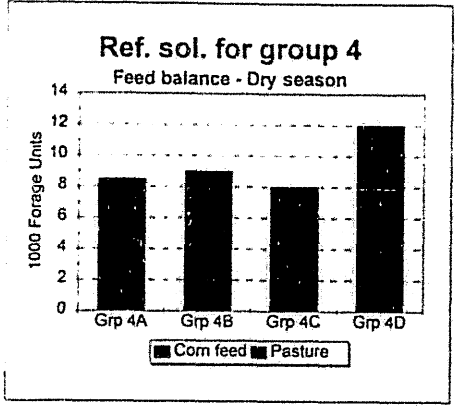


Figure 6a

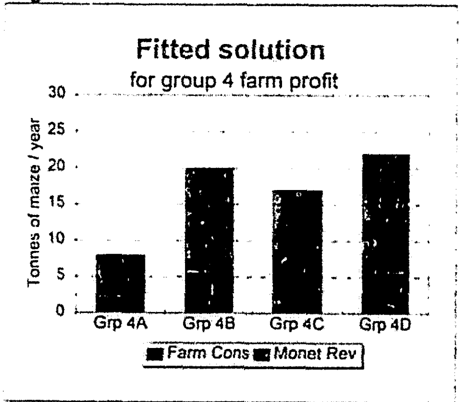
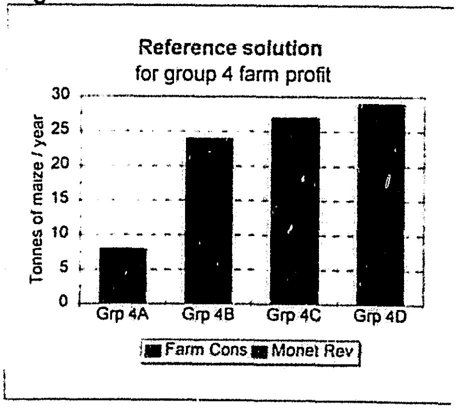


Figure 6b



LEGEND: Farm Cons = Farm Consumption (or expenses)
Monet Rev =Monetary Revenue
Ref. sol. = Reference solution

These farms were therefore (3 hypotheses) highly sensitive to external constraints, such as access to short term credit, or had different objective functions (aggregation bias is irrelevant given small group size).

Group 4 enterprise mix is on the other hand partly determined by resource endowments. These happened to be the same as the ones discriminating farm groups: land endowment, proportion of farm irrigated and land/labour ratio. Analysis revealed profound differences in animal feeding systems (Figures 5a & 5b), in spite of similar number of cattle. These differences are specific to the dry (irrigated) season, implying strong interactions between choice of cropping systems and timing of livestock grazing. The reference solution also exhibits less homogenous land and labour productivities than the fitted solution, implying that as these farms get closer to the optimal use of their resources, external factors increase their role. This is reflected in their economic performance (Figures 6a and 6b), where subgroup differentiation is greater under optimal conditions than observed.

Comparing solutions for group 6 farms showed that the main structural factor explaining enterprise mix was the land/labour ratio and that subgroups 6A and 6D could be opposed to 6B and 6C. The former respond to land productivity whereas the latter respond to labour productivity in peak periods of the wet season.

Analysis of reference solutions helped to explain the contribution of fixed resource endowments in the farms' enterprise mix, that is, the tendencies linked to production potential. They did not however help to reveal the rationale lying behind actual production decisions. These involved external factors or constraints.

The weight of external factors

The method endowed each of the 13 farm subgroups with their specific fixed resources (or production potential) in terms of land and labour, and determining the conditions leading to a solution similar to the fitted solution. This was done by analysing the difference between the reference and the fitted solution solutions through several aspects (cropping system, livestock feed balance, labour and financial constraints, etc.). There were basically two outcomes: either a missing constraint became quickly quite obvious (hypothesis H1), or the model was unable to reduce the gap without further input of information. Hypotheses H2 and H3 were involved in only three cases. However, the model did give indications as to what information was needed. This initiates a come-and-go procedure between heuristic model building and fieldwork, a major advantage of the approach as will appear below.

<u>Three basic illustrations</u>

Group 1,3 and 5 farms numbered only nine, or 16 % of the total. However, they share the common feature that there is a one-to-one relationship between their fixed factor endowments and their enterprise mix. The goal was to understand and explain this relationship, over and beyond the role of these factors.

For the "avecindados" of group 1, the difference between the reference solution and the fitted solution is significant, given their very constrained condition: they grow subsistence maize only on one hectare of steep soils with hand tools. The difference lies in their using their hectare only for maize, whereas the economically optimal solution suggests cropping only part of it and leaving the other part for one cow to graze. The increase in farm profit would be by 15%. This solution is possible because the one cow is allowed to graze the stubble in the dry season. The suboptimality of the fitted solution lies in these farmers not making use of this stubble. Sociological knowledge of the local situation informs that this is so because the bigger, more powerful farmers take hold of these stubble areas in the dry season to graze their own cattle. Because they are also employers of the avecindados who work as labourers on their farms.

nothing is said or done about this custom. The non-use of the stubble is equivalent to a sort of levy, tax or rent, based on shear force. The relevance of this information was checked by introducing a constraint on the accessibility of dry season stubble into the reference solution. When this was done, it became identical to the fitted solution.

For the "extensive farmers" of group 3, the difference between the reference solution and the fitted solution lies in the use of mountainside land (desmonte or agostadero), as shown in Figure 7a. The optimal solution suggests that it should be wholly used to graze cattle and increase their numbers, rather than devoting part of it to maize. Also, a greater part of the maize grown on "temporal" land should be fed to cattle rather than sold. The optimal solution thus points towards a farming system more heavily oriented towards cattle production, with numbers being greater by 30 % compared to the fitted solution. Analysis of model results indicates that the discrepancy lies totally with the different uses of maize, as animal feed in one case and as a cash crop in the other. In reality, farmers do not use it as animal feed. Why is that so?

Figure 7a

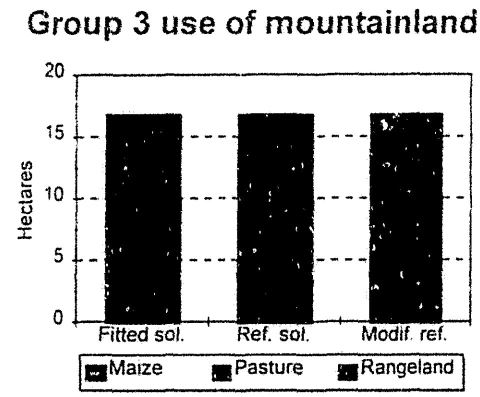
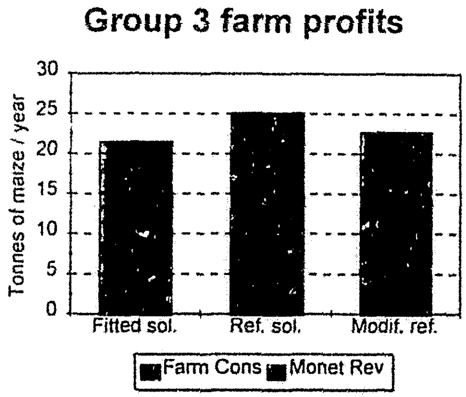


Figure 7b



(Farm Consumption & Monetary Revenue)

Further investigation of model results revealed that if the optimal solution does increase farm profit by about 20% (Figure 7b, reference solution), it also reduces direct monetary inflow by 10% and increases cash-flow constraints accordingly. The farmer sells his grain as quickly as possible for want of fresh cash. The model directly suggests constraints tied to short-term credit repayments. This could be checked with a further survey. A constraint on the level of seasonal income was introduced on the reference model by imposing a level at least equal to that of the fitted solution. The result was quite spectacular and indicated the hypothesis was right: by imposing this cash-flow constraint, the reference solution became very similar to the fitted solution (Figure 7b, modified reference). This group of farmers was thus shown to be constrained by their access to short-term credit. Further local investigations confirmed this result.

Though qualitatively identical, the solutions still differed slightly quantitatively, as the profit level in the fitted solution was only 90% that of the constrained optimum. Further analysis of the solution showed that this was due to mismanagement of pastures early and late in the dry-season. This suggested improved pasture management was needed.

The analysis of group 3's behaviour is exemplary of the heuristic approach. Group 5 is even more instructive.

The bottom line story for the "big farmers" of group 5 is that all endeavours to bridge the gap between their behaviour as captured by the fitted solution and an economic optimum ultimately failed. By comparing the fitted solution to the first (unconstrained) reference solution, a strong discrepancy appeared. The use of mountainside and irrigated land (Figures 8a & 8b), corresponded to an actual farm profit some 35% lower than the optimum (figure 8c). Basically, these farmers should not be using mountainside land to grow maize and should be replacing

Figure 8a

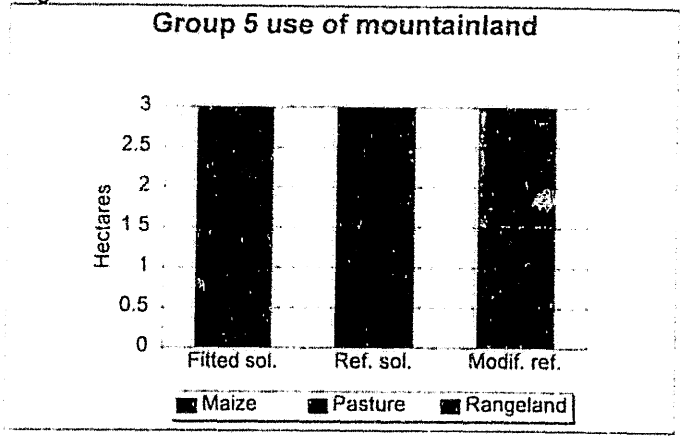
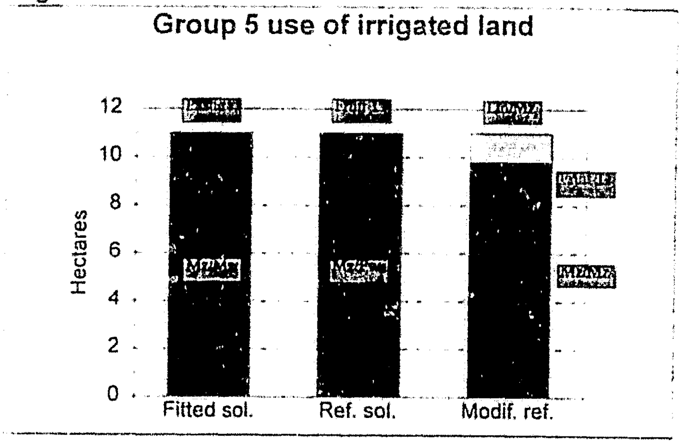


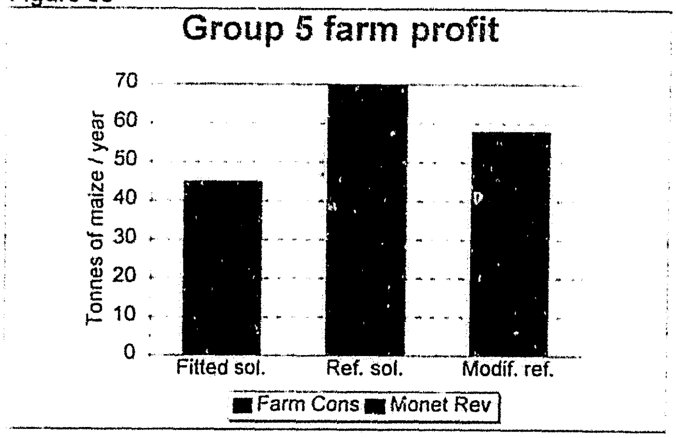
Figure 8b



Rotations (X/Y) :

Mz = Maize
Fw = Fallow (grazed)
Fruit T = Fruit Trees
Lm = Lime trees

Figure 8c



LEGEND: Fitted sol. = Fitted solution
Ref. sol. = Reference solution
Modif. ref. = Modified reference
Farm Cons = Farm Consumption (or expenses)
Monet Rev = Monetary Revenue

pastures by fruit trees on irrigated land if they want to be economically efficient However, this reference solution relies heavily on the use of maize as animal feed. For reasons similar to the previous case, farmers do not allow themselves to use maize in this way.

This constraint was introduced into the optimal model and the model was run again. The result did come closer to the fitted solution. Maize on *desmonte* land and in rotation on *riego* reappeared as part of the farm plan. However, this was at the expense of a severe fall in the number of cattle, which reduced from about 30 to 10. The freed labour was used for fruit trees. The most significant difference however lies with the level of immobilised capital (not shown on graphs), lower by 30% compared to the fitted solution. This suggests that income maximisation is not the only goal of these farmers, but that they are in a process of forced capitalisation. However, changing the objective function (hypothesis H2), by maximising long term capital rather than annual income, did not solve the problem.

A third modification to the reference model was made by maximising both annual income and long term capital, thus representing a mixed profitability and capitalisation strategy of the farmers. The result was indeed a level of profit, capitalisation and cattle more similar to those observed in the survey (Figure 8c, fitted solution and modified reference). The irrigated system was also more similar, in that the double maize/maize rotation recovered its initial importance. However, fruit trees were still a discrepancy and desmonte land should have been devoted partly to pastures.

In conclusion, these farmers did appear to pursue a mixed strategy of profitability and capitalisation, but the model was unable to explain their insistence on growing maize in some conditions and not producing fruit. The criterion of capitalisation suggested however that these farmers were not in a situation of equilibrium. In accordance with the general trend in the region, they were rather in a phase of developing their herd of cattle. The next phase, that of rational management, was only starting as was shown by the partial role of maximum profit. The insistence on growing maize apparently uneconomically can thus appear to be an inheritance from a previous state, where cattle were not yet an important part of the farming system. This led to an assumption that the model could not check: the economics of developing activities, whether cattle or fruit trees, cannot be captured by a static steady-state annual production model. This gives force to frequent criticisms about this method, as summarised in Malcolm (1990, sections 4.2 and 4.3). Furthermore, though the study only aimed at broad strategic aspects, risk was not explicitly considered.

Other cases of interest

The study of these three groups illustrates the heuristic approach to modelling. The method was applied to the ten other subgroups too, the goal being to determine the factors which, for the same set of fixed factor endowments, resulted in different enterprise mixes. Since the procedure was mostly the same, only the most interesting cases, those that add something new to the preceding examples, will be rapidly reviewed.

The "intensive farmers" of group 6 are subdivided into 4 subgroups according to enterprise mix (6A to 6D). Subgroup 6C, defined (Table 1) by six farmers oriented towards maize and fruit production, was unique in that it appeared to be at its economic optimum. There was no difference between the reference solution and the fitted solution. Of all the 13 groups, this was the only such case. Further on-site investigation showed that they were indeed technically well informed (through the fruit business technicians). That they made the most efficient use of their resources was consistent with this information.

The relatively large subgroup 4D included middle farmers with a diversified enterprise mix: maize, fruit trees and cattle. Its analysis led to another conclusion. Even after allowing for external constraints and objective function reformulations, it appeared impossible to reduce the discrepancies between the reference solution and the fitted solution. This pointed to an aggregation bias (hypothesis H3). The group, consisting of 12 farms, appeared to be too heterogenous, and should have been further subdivided. The study showed globally that the size of the group sample could neither be too large nor too small: too small, unstable "personal" factors were at work; too large, too many factors were at work. The meaning of small and large varies of course with global heterogeneity. However, no attempt was made to define the optimal group size in this perspective.

Several cases showed that the model could not adequately reproduce the rationale underlying the fruit tree enterprise. This confirmed the fact it could not capture the dynamics and the risks over time linked to fruit trees, but only the annual programs of crops and livestock. It also brought criticism to an initial assumption, which was only partly true: farmers did have access to the same technology (LP technical coefficients equal for all groups), except as regarded the fruit growing enterprise.

Finally, the two farmers classified 6D appeared to be highly suboptimal in terms of farm annual profit: the fitted solution was lower by 40% compared to the reference solution. This difference lay with an abnormally uneconomical number of cattle held. The outcome of the analysis was that these farmers did not have as their objective function a short term profit function. Instead, they seemed to be maximising the number of cattle that could be fed on their land. By changing the objective function accordingly (hypothesis H2), the reference solution became similar to the fitted solution. Sociological understanding meant these farmers had a prestige function, rather than an economic function. Further investigation revealed these farmers were "*caciques*", with strong local political power, and derived part of their prestige through the size of their herd, a traditional criterion in rural Mexico. This in turn translated into economic benefits, such as preferential long term loans from banks. The model was useful in highlighting the importance of such socioeconomic aspects.

Concluding comments

In the Mexican study reported here, it was important to understand what were the various rationales underlying production decisions and farming systems, before embarking on any set of recommendations based on a priori criteria. These could have been the maximisation of short term farm profit, or a set of predefined constraints assumed not to vary significantly across the population considered. Indeed, the heuristic study reported here yielded results that proved useful for a later prospective analysis. The development of better husbandry techniques for cattle, and of better agronomic techniques for pasture management, were investigated (Schilizzi et al., 1994, section 6.3). The heuristic study would allow the results of technological research to be differentially adapted to different farm types, defined less by their structural resource endowments than by the rationale driving them.

The study showed that the three hypotheses initially formulated were not sufficient to ensure complete understanding of the available data. This was a consequence of the inherent restrictions of the model used: no representation of dynamics or risk. The model also appeared weak with respect to farmers' variable skills in the fruit tree enterprise.

The procedure showed the importance of an iterative, and possibly interactive, process between modelling and on-site verification by searching for new information. It demanded specific increments of information, and appeared as a tool for defining what new information was required at each new step. Ideally, decision makers (farmers in this case) become an essential ingredient of the validation procedure, by directly participating in the process. Whereas most models just represent the researcher's understanding of reality, the heuristic approach leads to a model that controls this understanding.

Heuristic models are a special combination of descriptive and normative models. They can be used to modify our assumptions and to improve our understanding of the system being modelled. They are useful as prerequisites to predictive, prospective or normative models.

The heuristic approach has been illustrated with very simple examples based on a linear programming model of farming systems. It is by no means limited to this type of tool or this type of application. Virtually any model can be used heuristically. It would probably enhance the credibility of economics as a science by increasing the opportunities in which it can confront models to reality, and modify models and assumptions accordingly. In the more standard predictive and normative approaches, it is reality, rather than the models or the assumptions underlying them, which too often must yield. This is especially true when applying western modes of thought directly to other societies with values different from ours. It is hoped that the simple technique advocated here may reestablish some balance between modelling and understanding of economic realities.

References

Alvarez Macias A., 1987: Analisis regional de la ganaderia bovina en el Estado de Colima. INIFAP, Mexico D.F. mimeo. 124 p.

Beaumond A. & Vergara Sanatana M., 1983: Analyse du fonctionnement d'un *ejido* a Coquimatlan. DAA Economie Rurale, ENSAM Montpellier. 65 p + Annexes.

Benzecri P., 1974 L'analyse des donnees. (2 vol.). Dunod, Paris.

Boulier F., 1986: Occupation de l'espace et gestion des ressources. Une etude de systeme agraire dans la vallee du Rio Alquisala. ESAT-CNEARC, Montpellier; Universidad de Colima, 55 p.

Boulier F., 1987: Gestion de l'espace et utilisation des ressources: modelisation d'un systeme agraire mexicain. LECSA & PIRSEM-CNRS, Montpellier, 72 p.

CEPAL, 1982: Economia Campesina y Agricultura Empresarial. Tipologigia de Productores del Agro Mexicano. Ed. Siglo XXI, Mexico. 280 p.

Cochet H., 1984: Histoire agraire du municipio de Coquimatlan (Colima, Mexique). DAA INA-PG, Paris. 154 p.

CONAFRUT, 1982: Programa de desarollo fruticola del Estado de Colima. Parte I, SARH Colima, Mexico.

Dent, J.B., 1975: The application of systems theory in agriculture. Chap. 3 in Dalton, G.E. (ed): *Study of Agricultural Systems*. Applied Science Publishers Ltd., London.

Dillon, J.L., 1978: An evaluation of the state of affairs in farm management. Paper to the Annual Conference of the Agricultural Economics Society of South Africa, Stellenbosch.

ICRA, 1987: Farming systems of the Colima plains, Colima, Mexico. ICRA Series no.26, Wageningen, NL.

IMMECAFE, 1985: Delegacion regional Colima-Jalisco: censo de productores. Colima, Mexico.

Kutcher, G.P., 1983: A regional agricultural programming modelfor Mexico's Pacific Northwest. In: Norton R.D., and Solís, L.M.(ed.), 1983: *The Book of CHAC. Programming Studies for Mexican Agriculture*. World Bank, Johns Hopkins Univ. Press, p. 317-51.

Leger F., 1985: Utilisations agricoles et pastorales des espaces montagneux dans l'Etat de Colima. Mexique. DAA, ENSAM Montpellier, 108 p.

Leger F., Lemus S., & Jaubert R., 1987: Typologie et evolution des exploitations ejidales de l'Etat de Colima, Mexique. CUIDA, Univ. de Colima.

Leger, 1991: Diagnostic agroecologique prealable a la definition d'amenagements sylvo-pastoraux dans les zones montagneuses seches de l'Etat de Colima (Mexiaue). PhD, Univ. Paris VI, 198 p. + Ann.

Lemus S., 1989: Ejido, systeme agraire et communautes rurales au Mexique: le cas du municipio de Coquimatlan (Colima). PhD thesis, Univ. Montpellier III, 152 p.

Levenson A., 1988: Etude du systeme de credit rural mexicain et de son fonctionnement dans l'Etat de Colima. DEA dissertation, Univ. Montpellier III, 76 p.

Malcolm L.R., 1990: Fifty years of farm mamagement in Australia: survey and review. *Review of Marketing and Agricultural Economics*, 58 (1), 24-55.

Norton R.D., and Solis, L.M.(ed.), 1983. *The Book of CHAC. Programming Studies for Mexican Agriculture*. World Bank, Johns Hopkins Univ. Press, 602 p.

Nugent J.B., 1970: Linear programming models for national planning: demonstration of a testing procedure. *Econometrica*, Vol. 38 (6), Nov.

SARH, 1983a: Estudio del area pecuria del Estado de Colima. Representacion Estadal. Programa ganadero.

SARH, 1983b: Guia de riegos. Direccion General de Distritos de Riego, Distrito de Riego no.53, Colima.

SARH, 1983-86: Paquetes technologicas el Distrito de esarollo Rural no.106, Colima. SARH, Representacion en el estado de Colima.

SARH, 1985: Estudio de los distritos de temporal del estado de Colima. Repesentacion Estadal.

SARH, 1985-87: Informes de Distribucion de Aguas, Unidad Penitas. Direccion General de distritos de riego, Distrito de Riego no.53, Colima.

SARH-INIFAP, 1986: Guia para producir mas de temporal en el Estado de Colima. *Boleto para Producciones*, 9, 15 p.

Schilizzi S., Rey B., Galina-Hidalgo M-A., 1994: Fonctionement des systemes agraires. Etat de Colima, Mexique. INRA Publications, 359 p.

SPP, 1986: Anuario estadistico de Colima 1984. Tomo 11, Instituto Nacional de Estadistica, Geografia y Informatica. Mexico.

Tello-Reus C., 1984: Essai d'elaboration d'une typologie des exploitations dans une petite region au Mexique (Coquimatlan, Colima). ISPA Rennes & LECSA (INRA) Montpellier, 65 p.

Meaning of abbreviations in references

CEPAL:	Centro de Estudios Para la America Latina.
CNEARC:	Centre National d'Etudes Agronomiques des Regions Chaudes, Montpelier, France.
CONAFRUT:	Consejo Nacional de Frutas, Mexico.
CUIDA:	Centro Universitario de Investigacion de Desarollo Agropecuario, Univ. de Colima, Mexico.
DEA:	Diplome d'Etudes Approfondies (equivalent of a Masters Degree)
DAA:	Diplome d'Agronomie Approfondie (same as above, but in Agric. Science)
ENSAM:	Ecole Nationale Superieure d'Agronomie de Montpellier, France
ESAT:	Ecole Superieure d'Agronomie Tropicale, Montpellier, France
ICRA:	International Course for development oriented Research in Agriculture, Wageningen, The Netherlands
INA-PG:	Institut National Agronomique de Paris-Grignon, France.
INIFAP:	Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias, Mexico.
IMMECAFE:	Instituto Mexicano del Cafe, Veracruz, Mexico.
INRA:	Institut National de la Recerche Agronomique, France.
ISPA:	Institut Superieur des Productions Animales, Rennes, France.
LECSA:	Laboratoire d'Etudes Comparees des Systemes Agraires, Montpellier, France.
SARH:	Secretaria de Agricultura y de Recursos Hidraulicos, Mexico.
SPP:	Secretaria de Programacion y Presupuesto, Mexico.