F. GÉRARD, ERWIDODO AND I. MARTY*

Evaluation of the Impact of Trade Liberalization on Food Crop Production and Farm Income in Lowland Java, Indonesia

INTRODUCTION

Since the mid-1980s, the Indonesian economy has been progressively liberalized, following a self-adjustment process after the drop in oil prices. Despite these adverse circumstances the country managed to maintain rapid economic growth, as it had since the end of the 1960s. The agricultural sector has contributed to the dynamism of the economy. Both BULOG (the national foodcrop agency) and the Ministry of Agriculture have played a major role in that success, providing a stable environment for producers and consumers through use of various policy instruments, promoting adoption of new varieties and techniques for growing crops, and providing subsidized inputs. By maintaining rice price stability on domestic markets, BULOG, since 1967, has diminished some of the risk associated with agricultural activities and contributed to social stability by isolating consumers from sharp fluctuations in staple food prices. The importance of market regulation for the welfare of the poor is well known (Newberry, 1989; Timmer, 1992). With the intensification of international negotiations on trade liberalization, further deregulation of the agricultural sector is probable and there is an urgent need to assess the consequences both for national production and for farm income. These issues will be discussed using a micro–macro approach. The methodology is described first, the Indonesian context is then reviewed and the results of various simulations are described and analysed.

METHODOLOGY: A MICRO–MACRO APPROACH

The methodology[1] proposed in this paper is a micro–macro approach, based on a detailed representation of farming systems through opportunities and constraints relating to agricultural production as determined by agroclimatic and socioeconomic conditions for each type of system. There is then a switch to the regional level through scale parameters representing the share of each farming system. The model must reproduce farmers' behaviour, evaluate the

*ESCAP CGPRT Centre, Indonesia and CIRAD-URPA, Nogent Sur Marne, France (Gérard), Centre for Agro-Socio-Economic Research, Bogor, Indonesia (Erwidodo) and CIRAD-URPA (Marty).

response to policy and estimate the impact on economic indicators at the farm and aggregate levels.

Since production is represented by a set of farming systems, it is possible to adjust the set according to the type of policy issue to be explored (poverty alleviation, regional development and so on). A great deal of attention is devoted to the representation of market imperfections and risk is taken into account as an important factor in farmers' decision making. Agricultural production is clearly a risky activity since the production level is random and geographic correlation of risks and moral hazard make insurance difficult, while the simultaneity of borrowing and depositing lead to difficulties for the banking system. Farmers are thus very sensitive to financial risk. It is assumed that they base their decisions on expectations of gross margins and potential deviations for each activity (Hazell and Scandizzo, 1979). Some imperfections on factor markets are also considered.

To identify the main farm types (operating in a homogeneous environment and with similar production factor endowments) statistical analysis of a set of data crossing agroclimatic and socioeconomic variables was combined with interviewing experts and with bibliographical review. Each representative farm type could then be described by a non-linear mathematical programming model. It was assumed that each farmer makes choices from a set of activities and techniques, utilizing those which maximize the expected utility of wealth under simultaneous constraints.[2]

Wealth is defined as the total value of the assets at the end of the year. In order to consider risk attitudes, use was made of a mean-variance analysis (Markowitz, 1959), slightly modified to introduce endogenous risk aversion:

$$Max\ U(W_F) = E(W_F) - \frac{1}{2}\sigma^2 A_{WF}. \tag{1}$$

Here $E(W_F)$ represents the expected wealth for the farm F, σ^2_{WF} the associated expected possible deviation and A the risk aversion coefficient, which is endogenous and inversely proportional to wealth.

$$E(W_F) = \Sigma_a A_{F,a} * E(P_a). \tag{2}$$

$A_{F,a}$ represents the volume of assets (a) owned by the farm (F) and $E(P_a)$ the expected price associated with it. Thus wealth is defined as the sum of the value of assets (land, equipment, livestock, cash and savings).

The risk associated with a given wealth level depends on the portfolio of activities and assets for the period.

$$\sigma^2_{WF} = \Sigma_a(\sigma_a * E(P_a) * A_{F,a})^2 + \Sigma_{act}(\sigma_{act} * E(MB_{act}))^2 \tag{3}$$

All crop activities are covered (act) while $E(MB_{act})$ represents the expected gross margin for each activity, with σ as the associated expected deviation. Covariances between activities are assumed to be zero.

Fixed factor utilization is subject to constraints defined by endowment and other transactions. For example, the land constraint requires that the sum of land allocated for each crop $j(AL_j)$ represents a smaller area than the total land available for cropping. This variable is defined by the sum of land owned (*Laown*), land purchased (*Lp*) and land rented in (*Lrin*) minus land sold (*Ls*) and land rented out (*Lrout*). Thus for each farm:

$$\Sigma_j AL_j \leq Laown + Lp - Ls + Lrin - Lrout \tag{4}$$

The same kind of equations hold for labour, animal traction and machine allocation.

For each period, the production cost of each activity (C_{act}) can be covered by cash flow availability coming from the last period (*Pcash*), current earning activities ($Earn_{act}$), or borrowing (*B*). If some surplus cash exists it is transferred to the next period. Family consumption (*Cons*) as well as investment and savings (*Sav*) are included in this equation.

$$\Sigma_{act} C_{act} + Cons + Inv + Sav = \Sigma_{act} Earn_{act} + Pcash + B + Tcash \tag{4}$$

A financial cost is associated with borrowing. Access to credit can be affected by caution, or globally constrained to a fixed amount for the village or region according to conditions in the capital market. Consumption is defined as a minimum level plus part of the expected profit which is determined by a consumption propensity. Investment and savings can be negative if some decapitalization is necessary. For the costs and returns of each activity, the time of paying for production costs and the point in time of earning money have to be carefully determined in order to take account of production lags which have very important effects on farmers' liquidity. For crops, the production costs have to be paid at the beginning of the season and the associated earnings come in only at its end. For outside labour from other farms, consideration must be given to the local rules; for example, when payment is in kind after the harvest, the lag has to be taken into account. Lags can be harmful for farmers, generating cash flow problems and non-linear responses to market incentives (Boussard, 1992). Some markets have a range of influence and balanced equations may be necessary at village level, for renting land, equipment or labour.

Within the model, time has to be treated according to the local nature of agriculture; in lowland Java, for example, three seasons have generally to be considered. In order to consider links between activities of the three seasons, the optimization is calculated on a yearly basis according to the expected results of quarterly activities.

The decision process leads to a land allocation to crops and techniques, livestock activity levels, investment and borrowing, and labour allocations between farm and off-farm activities. Decisions are based on expectations of prices and yields, subject to time lags between decisions and actual production, while expectations are affected by information imperfections.[3] At the end of each production period, real prices and yields are computed by applying a random coefficient to an average value. The production level and the end of period farm endowment are then calculated with 'real variables'. In this way the results of each year are used as exogenous parameters for the next period.

The model is recursive and dynamic, despite a static optimization, because each year is linked to the preceding year. It is thus possible to incorporate the importance of past results in current decisions without using a very big model. Farm-type models are linked together through markets, for labour and land at the village level and for agricultural products at national level. Because the objective is to identify the effects of policy on decisions, the 'farm types' module is linked with a set of economic variables defining the socioeconomic environment in which farmers' decisions take place.

This model addresses policy effects in an original way both at farm level and, after aggregation across all types of farms, at regional and national level. It also gives immediate impact and time lag effects and builds in risk. These features are important primarily because farm heterogeneity will lead first to different impacts on farm income for a given policy and it is useful to evaluate these variations in order to display spatial impacts. Secondly, because the reactions of the agents are not instant and their behaviour can have delayed impacts (on the environment, for example), it is important to evaluate both short and long-term effects. Thirdly, markets for products and factors are not assumed to be perfect and risk is operationalized so that stylized farm situations can be represented as accurately as practically possible. With all the features the dynamics of agricultural supply, as defined by Nerlove (1979), are more effectively represented.

THE INDONESIAN CASE

Indonesia is the largest archipelago in the world, consisting of more than 13 600 islands, almost half of which are inhabited, stretching across some 5150 km of sea in the region of the equator and extending over 5000 km between its longitudinal extremes. The development level of various islands is quite different and explains the high diversity of agroclimatic and socioeconomic conditions faced by farmers throughout the country. Java represents 60 per cent of the total population and national foodcrop production, with only 7 per cent of the area. Within Java a highly diversified agriculture can still be found. Moreover, as the density of population is already 814 inhabitants per km^2, the policy impact on farm income and consequently on rural migration is an important concern for policy makers. For all these reasons, this paper will concentrate on the case of lowland Java.

Three broad zones were distinguished, two in irrigated areas, with one rainfed area. In the former there were divisions according to levels of water availability and the level of water management, which ranged from high and intermediate to low. On rainfed land there were two areas, one of them being drier than the other (Table 1). Three seasons were considered, one wet and two dry. The crops involved are rice, maize, soybean, mungbean, cassava and various kinds of vegetables.[4]

Irrigated land with a high level of water control obtains the highest yields. Concentrated mainly in the rich volcanic and alluvial soils of lowland Java, the characteristic pattern consists of two crops of rice, often followed during the second dry season by a secondary crop or by vegetables. A non-rice crop seems to be far more common than a third rice crop, owing to water availability, labour constraints and crop rotation to control pests. Farmers in irrigated areas use high-yielding varieties of rice, as well as large quantities of fertilizer. Yields reach more than 5.5 tonnes per hectare. Three types of farm (F1–3) were represented in this area (Table 1), mainly differing by type of land holding.

In the area with moderate water control, water availability often allows cultivation of two crops of rice, but with a lower yield level than in the sawah with high water control, especially during the first dry season. A third crop is also common. In areas with low water control, secondary crops are more developed. During the wet season, poor drainage makes the cultivation of non-rice crops almost impossible. In these areas, traditional varieties of rice can be found. The presence of small streams allows rice cultivation during the other seasons. Four types of farm were represented in this zone, of which two mainly grow soybean as a secondary crop (F4, F5) and two primarily grow maize (F6, F7).

Farmers in rainfed areas have to wait for the monsoon to grow rice, which entails considerably more risk than in irrigated areas. As the level of water control is low, the higher-yielding varieties of rice are less frequently used. Fertilizer use is also lower and the yields seldom reach more than 4.5 tonnes per hectare. Rice cannot be grown during the dry season, when soybeans is a common crop. The second dry season is usually fallow owing to drought.

TABLE 1 *Main lowland farming systems and their characteristics in Java*

Farming systems characteristics	Technical irrigated with high-level water control			Simple irrigated with moderate to low water control				Rainfed	
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Area controlled (ha)	2.4	1.05	0.95	1.2	0.7	1.2	0.7	0.35	0.35
Active persons	3.2	3.2	3.6	2.5	2.7	2.5	2.7	2.0	3
Type of land	irt	irt	irt	irt	irt–irs	irt	irt–irs	rai	rai–dry
Cultivated area (%)	95	96	94	44	60	56	70	47	30
Rice	2	1.5	1.3	36	36	8	6	3	2
Soybean	0	0	0	19	4	36	24	30	29
Maize	3	2.5	4.7	0	0	0	0	20	39
Mechanization	yes	yes	yes	yes	yes	yes	yes	no	no
Yearly net income per cap (million rp)	2.5	1	0.6	1.6	0.8	1.9	0.9	0.55	0.25
Off-farm income (%)	12	26	36	17	29	18	35	37	40
Animals in total wealth (%)	0.01	6.3	0.3	3.5	8.1	3.5	7	0.2	0.3

Notes: Land 'controlled' is land 'owned' + land 'rented in' – land 'rented out'; 'irt' is 'technical irrigated', 'irs' is 'simple irrigated', 'rai' is 'rainfed land' and 'dry' is 'dryland'.

TESTING THE IMPACT OF LIBERALIZATION

Since GATT and APEC negotiations are now under intensive discussion, the characteristically strong intervention of the government of Indonesia in the agricultural sector is increasingly criticized, both within and outside the country. Hence it is interesting to attempt an assessment of the consequence of a free trade environment for food crops and inputs at both regional and farm level.

Liberalizing the food crops sub-sector will lead to changes in the level of prices and in the variability of returns.[5] According to economic theory, domestic prices will adjust to international prices unless transaction costs are significant, or if domestic production is high enough in comparison with total world production to influence prices. In the first scenario (S1) domestic prices are assumed to adjust towards international prices in the second year of simulation (Y2). For rice during 1972–89, the coefficient of variation of prices was 0.59 on the international market and 0.16 for the domestic market (Gérard and Marty, 1995). Moreover, domestic prices were somewhat higher than international prices. The same may be said for soybean and maize in terms of price variability, while the price of maize was similar to the international level and that of soybean was around 50 per cent higher than on the international market (Gonzales *et al.*, 1993).

The main result in the projections is that rice output remains stable after the assumed liberalization (S1 compared with S0 in Figure 1). By contrast, soybean production decreases sharply in the liberalization scenario (S1, Figure 2), while maize production shows a strong increase (Figure 3). The changes underline the land competition between these crops. Since rice market stabilization is so important in Indonesia, the second scenario (S2) excluded this crop from the liberalization process. The impact is important in terms of income, as shown later, but not in production (Figures 1, 2, 3).

In view of the adverse impact on soybean output in the liberalization scenario, the effects of two technical improvements were included in the third

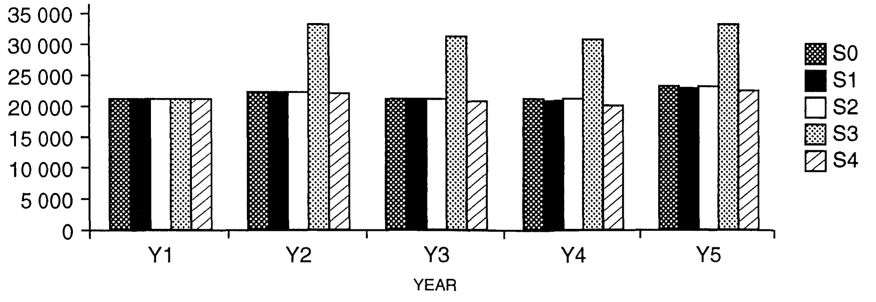

FIGURE 1 *Impact of liberalization on regional rice production*

scenario (S3) for rice and soybean (increased yield of 50 per cent for both crops, with improvement in practices and material). Resources are still being devoted to research on new varieties, which could generate further increase in yields of rice, especially in the rainfed area, while for soybean (where yields are around 800 kg/ha on average for lowland Java) the simulated increase will take yields to a medium level in comparison with international performance. Supply response is important for the two products. The increase in soybean production is higher than the yield increase because more land is allocated to the crop. In fact, the technological improvement overcompensates the loss of profitability induced by trade liberalization. In some areas, the crop becomes more profitable than maize, production of which decreases.

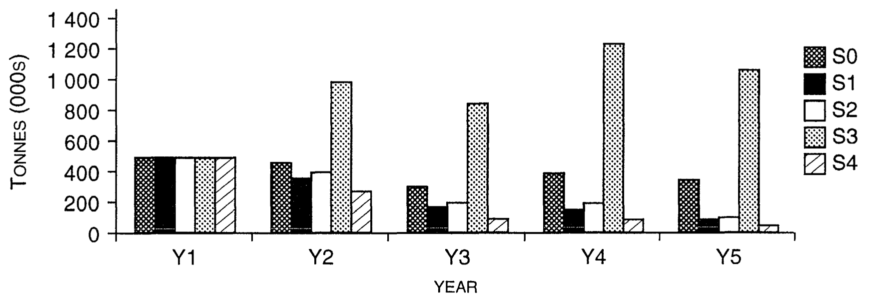

FIGURE 2 *Impact of liberalization on regional soybean production*

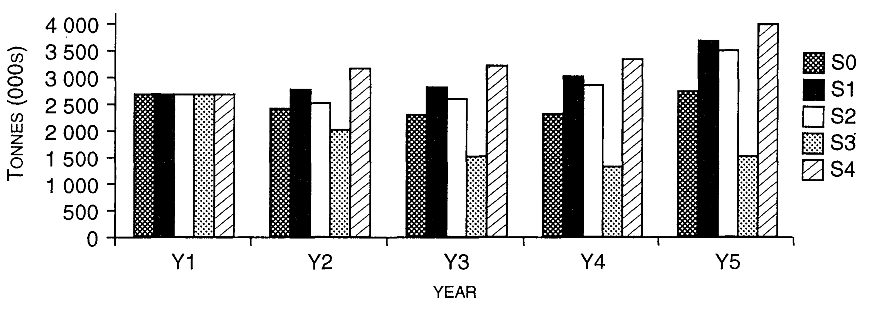

FIGURE 3 *Impact of liberalization on regional maize production*

Because the Indonesian economy experiences continuous rapid development, the last simulation (S4) assumes a quicker increase of off-farm activities in comparison with the base run (10 per cent instead of 5 per cent in the base run). There is a slightly unfavourable impact on rice production (Figure 1), a more serious negative impact on soybean (Figure 2), but a positive effect on maize output (Figure 3), underlining its low labour requirement.

One interesting feature of the MATA model is that it allows deeper analysis of income and crop allocation impacts at the farm level (Table 2). The decrease in agricultural income after liberalization of the whole food crops sub-sector is sharp for each farm type (S1), but the situation is much better if rice is excluded from the liberalization process (S2). The technical innovation scenario (S3) has different impacts from one farm type to another. For those with the high level of water control, agricultural incomes become larger than in the base run (S0), because they are highly specialized in rice and in a position to take advantage of innovation. For the farms in the rainfed area, the situation is hardly better than in the liberalized scenario (S1), since the small farm sizes do not allow much advantage to be gained from technical change. The simulation with the higher increase in off-farm activities (S4) has the worst impact on agricultural income. However, for total income this scenario is the most favourable, except on the biggest farms in the 'high level of water control' area. For this type of farm, competition on the labour market is very damaging, because there is heavy reliance on hired labour for cultivation. This analysis is confirmed by the results of the land allocation exercise, which shows that the difficulty of finding hired labour results in movement from soybean and rice to maize.

For all the other farms it is clear that the best way to increase rural income is to promote the development of off-farm activities such as processing and packaging of agricultural products or other small-scale rural industry. The farms which fared worst in the liberalization scenario (S1) were the small farmers (F3) and those in the rainfed area (F8 and F9). However, the importance of off-farm activities allowed them to maintain and not to decrease total income

TABLE 2 *Agricultural income in various scenarios after four years' simulations (000s rp)*

Farm type scenarios	Technical irrigated with high-level water control			Simple irrigated with moderate to low water control				Rainfed	
	F1	F2	F3	F4	F5	F6	F7	F8	F9
S0	1 979	664	353	1 279	541	1 586	575	183	61
S1	1 335	441	191	853	336	1 186	428	112	35
S2	1 726	606	274	1 022	434	1 370	534	146	45
S3	2 018	901	354	945	385	1 451	503	143	52
S4	1 135	384	245	705	358	1 032	408	101	33

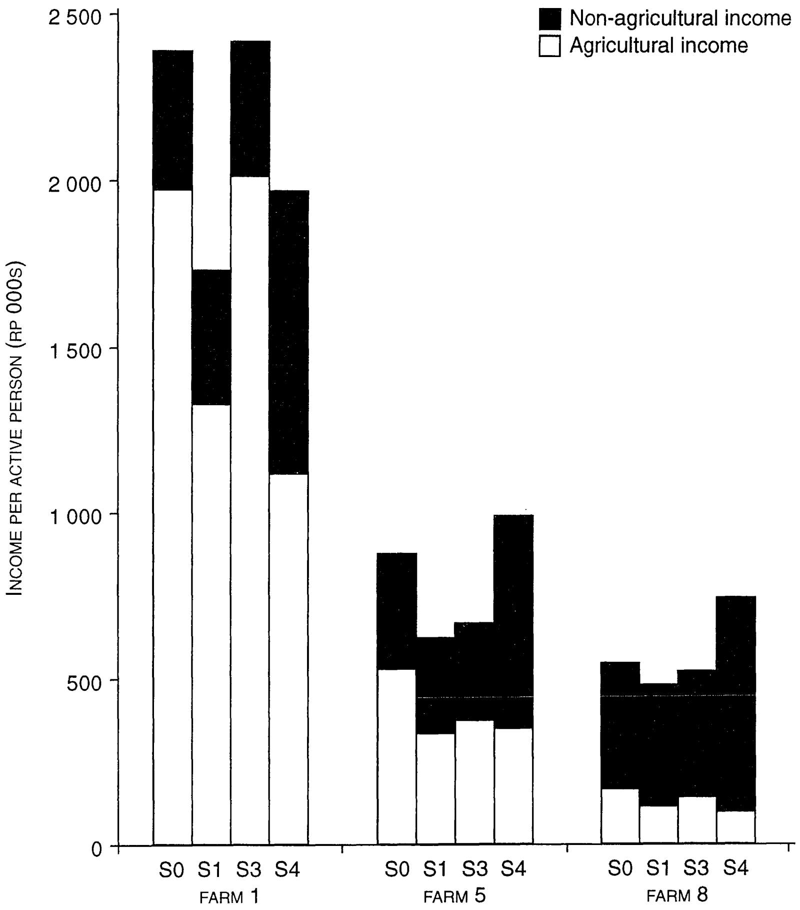

FIGURE 4 *Distribution of income after four-year simulations for three farms and three scenarios*

(Figure 4), which is significant since these three farm types represent roughly one and half million households (around four million active persons) and would have very little incentive to stay in agricultural production in the liberalization scenario.

CONCLUSION

Various scenarios concerning the liberalization of the food crop sub-sector were tested and analysed in this study. In contrast with previous analysis (Trewin *et al.*, 1993; Thorbecke, 1992), the use of a micro–macro approach enables evaluation of the impact to be made at various levels. Rice production is very stable with liberalization, while soybean production decreases sharply and maize production increases. At the farm level, the effects on agricultural income tend to be adverse, though the decrease is less pronounced if rice is excluded from the trade liberalization. Technological improvement for rice and soybean would be able to compensate partially for the impact of liberalization on income. Farms in the irrigated area could obtain higher income than in the base-run situation. Increased off-farm jobs opportunities have a strong positive effect on household income, except in the case of the largest farm type in the study.

Finally, the study highlights the importance of technical innovations, as induced by agronomic research, to maintain rural income during a trade liberalization process. It shows that claims about any favourable effects of liberalization for farmers, stemming from efficiency gains, have to be reconsidered in an imperfect market context, at least in the short term. The liquidity constraint and the existence of risk aversion would prevent farmers from specializing in the more profitable crops. The study also points out that the development of off-farm activities is necessary to increase rural income. The liberalization of agricultural trade will induce a sharp decrease in income, and for around 4 million active farm participants very few incentives will remain to keep them in agricultural production. Hence, even though liberalization could lead to a more efficient factor allocation, it could be worth considering the introduction of accompanying policies to minimize adverse effects.

NOTES

[1]This study uses the agricultural production module of the MATA model. For further details on methodology, see Gérard *et al.* (1994) and Deybe (1994).

[3]Various objective functions can be used in the MATA model. Farming system models usually use profit maximization in market economies and self-sufficiency objectives for subsistence economies. Here wealth is used as a proxy for the total value of the farm, because the model is dynamic but the optimization is static. Because we wanted to allow the level of assets to appear in the model, as well as to account for risk (it is less risky to own gold than to own buffaloes), it was better to consider the expected stock of wealth rather than flows of income. However, tests were made with expected profit (still taking risk into account) for the Indonesian case, leading to the same results. The constraints, in the Javanese case, defined a small set of activity combinations as optimum and the model is not sensitive to the formulation of the objective function.

[3]To approach the concept of rational expectations (Muth, 1961), given the fact that prices and yields are determined randomly around an average, farmers expect to obtain the average level of gross margins.

[4]For a number of reasons, sugarcane was not included in our study. The political regulation for this crop is complicated, with some forced crop allocation. Profitability is highly reliant on the proximity of sugar mill factories (Collier *et al.*, 1993) and this information was not included in the typology. In addition, the production lag is longer than the yearly optimization process used in the study.

[5]As pointed out by Koester (1993), the impact of liberalization of trade will be different according to the number of countries involved, but there is still great uncertainty about the impact on the world prices level and on instability.

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