LAND TRANSACTIONS IN THE NORTH OF VIETNAM: A MODELLING APPROACH

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Abstract

The use of mathematical models to describe the interactions of variables is useful in modern management. In this paper, a 'mixed' model combining the knapsack problem, a household model and a form of spatial equilibrium model into a modelling framework is developed. The impacts of changes in off-farm wage rates, transaction costs in the rental market, the output prices of paddy crops, and land transactions were examined in the model. The simulation has led to the conclusion that the real benefits to farm households from land consolidation may not be apparent until the real opportunity cost of farm labour begins to rise. In addition, a reform policy in the administrative sector which encourages, not only the process of land accumulation and the rental market to be more active, but also farmers to involve themselves more actively in farming will improve their well-being. Moreover, a policy which allows farmers to freely cultivate other annual crops (cash crops) instead of rice and corn may be important and it should be considered in the future.

JEL: C6, Q15, Q24.

Key words: Land transactions, modelling, knapsack problem, Vietnam.

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1. INTRODUCTION

In Vietnam, it has been reported, both before and after the 1993 Land Law, that many land transfers occur legally and illegally (Kerkvliet, 2000; Do and Iyer, 2003; Ravallion and van de Walle, 2003; World Bank in Vietnam, 2003). Land transaction activities have been observed in many localities (Kerkvliet, 1995; Chung, 2000). However, the extent of these activities is different between the northern and southern regions. In the north, renting and borrowing of land use rights are apparently more common, while mortgaging, swapping, buying and selling land use rights are more common in the Mekong River Delta, the Central Highlands and the North South East region (Kerkvliet, 2000; Marsh and MacAulay, 2004).

One of the approaches used to assess the possible benefits and costs of a system of agriculture where a large number of small plots is held and managed by each household is to model the possibilities that may arise through re-organisation and exchange of the plots. Exchanging plots has become possible with the introduction of a more flexible land rights system in Vietnam. However, in general, there seems to be a very limited level of exchange (Marsh and MacAulay, 2004). This may be the case because agricultural labour in Vietnam, especially in the north and the Red River Delta, is in surplus and existing levels of technology applied in agriculture are low. There are also low opportunity costs for rural labour and difficulties in the transfer of labour from farm to non-farm employment.

The aim of the paper is to develop a model for land transactions which allows the significance of changes in off-farm wage rates, transaction costs in the land rental market and the output prices of paddy crops to be considered. The paper is organised as follows. In the next section, a theoretical framework is discussed. The empirical model is formulated in the next section. Simulation of different scenarios and empirical results are then reported. The final section

includes some conclusions.

2. THEORETICAL FRAMEWORK

Modelling a land market poses a number of difficulties in model formulation and mathematical representation. One approach to the problem of analysing the transfer and adjustment of land parcels is to recognise the parallels with the transfer of goods in a spatial equilibrium model and that of filling a knapsack (Hung and MacAulay, 2002). The classical knapsack problem is where a given volume for a knapsack is available to be filled so that the weight carried is maximised given the known weights of the individual items (Moore et al., 1993). In terms of plots, this is similar to filling a given requirement for land area with a number of plots of known area. The knapsack problem is a zero-one integer programming problem. Integer programming allows the variables to have a value of one implying that the item is included in the knapsack, or zero when it is not. In the case of land plots, a value of one implies the plot is included in the household's parcel of plots (overall area) while a value of zero implies it is not. This is combined with the possibility of transferring plots between households using the ideas of spatial equilibrium. The objective in relation to the plots is to exchange them (if required) at a minimum transaction cost.

Spatial equilibrium models are based on the idea of the transfer of goods between regions with each region having both a supply and demand for goods. There are transfer or transportation costs between the regions. The parallel for the case of the transfer of plots between households is that each household will have a supply of land in the form of a number of plots (or area of land) and a demand for that land based on cropping plots of land for production. If the transfer of plots between households is possible then this can be captured in a way similar to the transfer of goods between regions. However, in the case of plots, given areas will be transferred or not (zero or one) rather than a variable number of goods.

In this study, once the combined knapsack and spatial equilibrium model has been established, other elements of the farming systems for the households may be added. For example, crops may be produced using inputs of labour and land. Households that have less land may rent-in land while households who have large amounts of land may rent out. Moreover, households can hire-in labour or employ their labour off-farm. Another element in the model can be incorporation of some of the costs of land fragmentation. If the distances between the plots are known then for each plot the labour time for working the land and the travel time between plots can be included. As a result, households can choose a combination of plots which can reduce labour and transportation costs. Therefore, in a 'mixed' model, land and other resources can be transferred to or from the households and will tend to move to those that can use them more efficiently. This can be represented as a programming problem:

(1) Max $Z = - T'X + P'Q - P_d D - C_t X$

subject to

$$A_x X \leq a_x$$
$$- A_y X \leq -a_y$$
$$Q = f(a_y, D)$$
$$p_d d - p_q q \leq 0$$
$$C_t X \leq c_t$$
$$X \text{ is } \{0, 1\} \text{ and } Q, D \geq 0$$

Where: Z is the total profit obtained from all households in a village;

X is a vector of zero-one variables indicating the transfer of plots;

T is a vector of transaction costs;

Q and P are vectors of outputs and the output prices;

D and P_d are vectors of the level of inputs used by all households and the input prices;

C_t is a vector of transfer costs from farmers houses to plots;

c_t is the total transfer costs of each household before land transactions take place;

a_x and a_y are the total supply of and demand for land of each of m households (area); and

A_x and A_y are matrices of m x n order representing the area of plots (n is the total number of plots of m households).

The level of output can be a function of the resulting land area a_y (after any transfers have taken place) and other inputs. Thus, problem (1) is a non-linear programming problem. It is assumed that each farm household has a plot with a given area (a_i) and there are m households. The matrices A_x and A_y, represent the area structure of the plots and are of the following form:[1]

$$A_x = \begin{bmatrix} a_1 & a_1 & \cdots & a_1 & & & & & & & & \\ & & & & a_2 & a_2 & \cdots & a_2 & & & & \\ & & & & & & & & \ddots & & & \\ & & & & & & & & a_m & a_m & \cdots & a_m \end{bmatrix} \quad (m \text{ x } m)$$

$$A_y = \begin{bmatrix} a_1 & & & & a_2 & & & & a_m & & & \\ & a_1 & & & & a_2 & & \cdots & & a_m & & \\ & & \ddots & & & & \ddots & & & & \ddots & \\ & & & a_1 & & & & a_2 & & & & a_m \end{bmatrix} \quad (m \text{ x } m)$$

3. FORMULATION OF THE EMPIRICAL MODEL

When modelling the possible exchange of land parcels there are a number of modelling issues involved. Essentially, land transfer between households requires an effective market in land, or in the case of Vietnam, the ability to transfer land-use rights. In setting up a land transaction model at the household and village levels, the existence of a labour market is also assumed, indicating that farmers can hire-in labour for farm activities and/or be employed. The objective of the model is to maximise the total profit of all households in a village. The activities of the model are the land area of each household, the planted area of each crop, the sale and consumption of

[1] If a household has n plots, the matrixes A_x and A_y are of m x $(m$ x $n)$ order.

crop outputs, family and off-farm labour used, variable costs, rents in and out, and transportation costs.

Based on the above assumptions, let household i ($i=1, ..., m$) have N_i plots and A_i units of land that are located in l_i locations. The household also has $\overline{L}_i$ units of labour which include L_i^f units used for farm activities and L_i^o units for off-farm work. The household cultivates s crops ($s = 1, ..., S$) in t periods ($t = 1, ..., T$). The empirical model can be mathematically represented as follows:

(2) Max Z = $$\sum_{i=1}^{m}\sum_{s=1}^{S}\sum_{t=1}^{T} p_{ist}Q_{ist}^{s} + \sum_{i=1}^{m} w_i L_i^o - \sum_{i=1}^{m}\sum_{t=1}^{T} C_{it}$$

Subject to

Supply of land $$\sum_{j=1}^{ni}\sum_{l}^{li}\sum_{i'=1}^{m} a_{jlii'}X_{jlii'} \le A_i \text{ for all } i=1, ..., m$$

Demand for land $$\sum_{j=1}^{ni}\sum_{l}^{li}\sum_{i'=1}^{m} -a_{jli'i}X_{jli'i} + A_i^* \le 0 \text{ for all } i=1, ..., m$$

Total land $$\sum_{i=1}^{m} A_i^* \le \sum_{i=1}^{m} A_i$$

Constraints on plots $$\sum_{i'=1}^{m} X_{jlii'} \le 1 \text{ for all } i=1, ..., m, j = 1, ..., n_i, \text{ and } l_i = b, non\text{-}b,$$

and *other*

Production outputs $$Q_{ist}^c + Q_{ist}^s \le a_{ist}^* F_{ist}(A_i^*, l_{ist}^{f*}, N_i) \text{ for all } i = 1, ..., m, \ s = 1, ...,S,$$

and $t=1, ..., T$

Total labour $$L_i^f + L_i^o \le \overline{L}_i \text{ for all } i = 1, ..., m$$

Family labour $$\sum_{s=1}^{S}\sum_{t=1}^{T} l_{ist}^f a_{ist}^* - L_i^f \le 0 \text{ for all } i = 1, ..., m$$

Renting out land $$-\sum_{j=1}^{ni}\sum_{l}^{li}\sum_{i'=1}^{m}(r_{l2}-t_2)a_{jlii}X_{jlii'} + R_i^{out} \le 0 \text{ for all } i = 1, ..., m \text{ and } i \neq i'$$

Renting in land $$\sum_{j=1}^{ni}\sum_{l}^{li}\sum_{i'=1}^{m}(r_{l2}+t_2)a_{jli'i}X_{jli'i} - R_i^{in} \le 0 \text{ for all } i = 1, ..., m \text{ and } i \neq i'$$

Total costs $$\sum_{s=1}^{S}c_{ist}^{ac}a_{ist}^{*} - \frac{R_i^{out}}{T} + \frac{R_i^{in}}{T} + C_i^{tr} \le C_{it} \text{ for all } i = 1, ..., m \text{ and } t = 1, ..., T$$

Constraints on fragmentation and transportation costs are:

$$\sum_{j=1}^{ni}\sum_{l}^{li}c^{tr}d_{jli}a_{jlii}X_{jlii} + \sum_{j=1|l=b}^{ni}\sum_{i'=1}^{m}c^{tr}d_{jli'}^{b}a_{jli'i}X_{jli'i}$$

$$+ \sum_{j=1|l=bn}^{ni}\sum_{i'=1}^{m}c^{tr}(d_{jli'}^{non-b} + kMax(d_{jli'}))a_{jli'i}X_{jli'i}$$

$$+ \sum_{j=1|l=other}^{ni}\sum_{i'=1}^{m}c^{tr}(d_{jli'}^{other} + 2kMax(d_{jli'}))a_{jli'i}X_{jli'i} \le \sum_{j=1}^{ni}\sum_{l}^{li}c^{tr}d_{jli}A_i$$

for all $i = 1, ..., m$ and $i \neq i'$

$$X_{jlii'},\ A_i^{*},\ a_{ist}^{*},\ Q_{ist}^{s},\ Q_{ist}^{c},\ L_i^{f},\ L_i^{o},\ R_i^{in},\ R_i^{out},\ C_{it}, \text{ and } C_i^{tr} \ge 0$$

where: $X_{jlii'}$ is a zero/one variable indicating whether plot j in location l_i of household i transferred to household i' is chosen;

A_i^{*} (A_i) is the land area of household i after (before) land transactions have taken place;

a_{ist}^{*} is the planted area of crop s of household i at season t after land transactions have taken place;

$a_{jlii'}$ ($a_{jli'i}$) is the size of plot j in location l_i of household i (i') transferred to household i' (i);

Q_{ist}^{s} and Q_{ist}^{c} are the output amount of crops sold and consumed by household i at season t, respectively and p_{ist} is the market price of the product;

$F(A_i^{*}, l_{ist}^{f*}, N_i)$ is the yield function of farm size (A_i^{*}), family labour (l_{ist}^{f*}), and the number

of plots (N_i) for crop s at time t;

L_i^f and L_i^o are family labour used on and off-farm of household i and w_i is the wage rate;

l_{ist}^{f*} is the family labour used on crop s of household i at season t;

R_i^{in} and R_i^{out} are the total amount of money paid and received for renting in and out land of household i, respectively;

r_{l2} is the rental rate in location l_i and t_2 is the transaction cost for land rental;

C_{it} is the total cost (cash requirements) of household i at season t;

c_{ist}^{ac} is the total variable cost per unit of land needed for crop s at season t of household i;

d_{jli} is the distance from the house of household i to plot j in location l;

$d_{jli'}^{b}$, $d_{jli'}^{non-b}$, and $d_{ji'}^{other}$ are the distances from the house of household i' to plot j located in the 'basic', 'non-basic', and 'other' locations, respectively;

k is an increase in transportation costs resulting from land fragmentation; and

C_i^{tr} is the total transportation cost of household i for each season.

In the model, transportation costs were assumed to be directly proportional to distances from farmers' houses to land plots and plot sizes. There was no plot purchase in the sample used in this model and cash requirements for crop production in each season for each household were small. Therefore, a credit constraint was not included in the model. This was done because the farm size of households in the north of Vietnam are small such that cash requirements for crop production are not a large amount and households are not likely to be constrained by cash – land is much more significant.

It is assumed that land transactions in general, and plot exchanges in particular, occur within a village. In practice this is generally the case because commune organisation in Vietnam makes it difficult for households from one commune to cultivate land in another commune. Data from three farm households in Dai Dong commune, Ha Tay province collected for the ACIAR project

ADP 1/97/092 were used for the construction of the empirical model. There were four locations in the village and each household had plots located in three of these locations, a 'basic' and two 'non-basic' locations.[2] The fourth location for each household was known as 'other'. It was also assumed that land soil fertility was the same for each location so that the rental rate varied only in different locations but not within a location.

In the model, the output of rice was used for sale and family consumption by the household and was represented by the production function under the translog and transcendental forms. Corn and soybean were produced for sale. The total profit was calculated as the sum of the sale of crop outputs from all plots of the households and the income from off-farm work and renting-out land, less the total costs which included variable costs, costs of land rented-in, and transportation and transaction costs.

4. RESULTS AND DISCUSSION

The method used in solving the problem was with a branch and bound technique. The software used was What's Best version 7.0 (LINDO Systems Inc. 2003). In order to measure the impact of land transactions, each household was restricted to cultivate only their own land. This means that a constraint on the restriction of land transactions was included in the model. When the restriction on land transactions was removed, it was apparent that there could be significant change, especially within the village. Without restrictions, households B and C changed their activities to increase their profits. Household B concentrated on crop production while household C increased off-farm work and decreased farming activities. The crop production of household B was more efficient so this household rented in a large amount of land. Farming activities for household C were relatively less efficient and therefore this household rented out half of its land and produced

[2] A 'basic' location is where the farm household has the largest number of plots.

to meet family consumption requirements only (see Hung 2005). If the rental market were not restricted and farmers were free to exchange or rent land in and out, in this way they were better off. This leads to the conclusion that a market for land use rights in the north of Vietnam is now important and desirable. Therefore, policies which encourage the land market to be more active should be considered.

In the base case, the wage rate for off-farm work was estimated to be an average of about VND 20,000 per working day. It was assumed that the wage rate increased from this level to VND 80,000 which was equivalent to the daily wage rate of higher educated people (university level). The percentage change in land rented-out seemed to be directly proportional to the wage rate. It increased relatively rapidly when wage rates were in the range of VND 20,000 to 40,000 and then increased at slower rates up to the level of VND 80,000 (Figure 1). This implies that an increase in wage rates leads farmers to rent-out more land because crop production becomes relatively less profitable in comparison with working off-farm. In the future, if opportunities for off-farm work are available, farmers are likely to rent-out land and have stronger incentives to leave farming.

In order to examine the impacts of changes in transaction costs in the land market, a change of five percent in these costs was simulated. It is apparent that as transaction costs increased, the area of land rented-out by households also decreased (Figure 2). Thus, an increase in transaction costs leads to a decrease in the area of land transacted in the market. It is also observed that the area of land rented-in by households A and C decreased, while for household B the level varied with no clear trend. This leads to the conclusion that, when transaction costs in the rental market are high households who rent-in land will rent-in less land and households who rent-out will also rent-out less land. Therefore, a decrease in these costs is important and desirable. A policy which leads to a decrease in transaction costs in the rental market will encourage the land market to be more active.

Changes in the output prices of rice and corn were also examined to see the effect of these price changes on land transactions and crop production. A decrease of five percent in the price of these crops was simulated (Figure 3). The percentage change in the total land transactions was measured as a proportion of the total amount of land rented–in or -out and the total farm areas. Land rented-out in the figure is calculated as a percentage change in farm size. From the figure, it is apparent that a decrease in the output prices of paddy crops leads to a decrease in land transactions. In addition, it also leads to an increase in the percentage change of the total areas of land rented out. If the output prices of crops decrease, crop production becomes less profitable and farmers have less incentive to be involved in farming. As a result, they want to rent-out more land and leave farm production. On the other hand, there are not many farmers who want to participate in the rental market because they want to reduce farm production which is less profitable.

5. CONCLUSIONS

The value to be gained from the use of this model is that the issue of land use and the market for land use rights can be solved by using a 'mixed' model with a knapsack problem, a household model and a spatial equilibrium model combined into a single modelling framework. From the results of the analyses, total profits increased if restrictions on land transactions were removed. In another simulation, as the wage rate increases farmers will rent-out more land. However, some households who produce relatively more efficiently increase their farm size. This leads to the conclusion that as Vietnam appears to have surplus agricultural labour, at least for much of the production year, the real benefits to farm households from land consolidation may not be apparent until the real opportunity cost of farm labour begins to rise. As the prices of rice and corn decrease, farmers tend to rent-out more land and the total area of land transacted in the

rental market decreases. As a result, farm profits decrease significantly and farmers want to leave farming. This result illustrates the problem facing agricultural development in the north of Vietnam where farmers depend heavily on the cultivation of paddy crops. In the other simulation, households who rent-in land will rent-in less land and households who rent-out land will also rent-out less land as transaction costs increase. Although, the impacts of changes in transaction costs on individual households are different, in general, an increase in these transaction costs leads to a decrease in farm size, the total planted area, and the total profits, especially farm profits. Therefore, a reform policy which leads to a reduction in transaction costs may encourage not only the process of land accumulation and a more active rental market, but also encourage farmers to be more actively involved in farming and enable them to increase their incomes.

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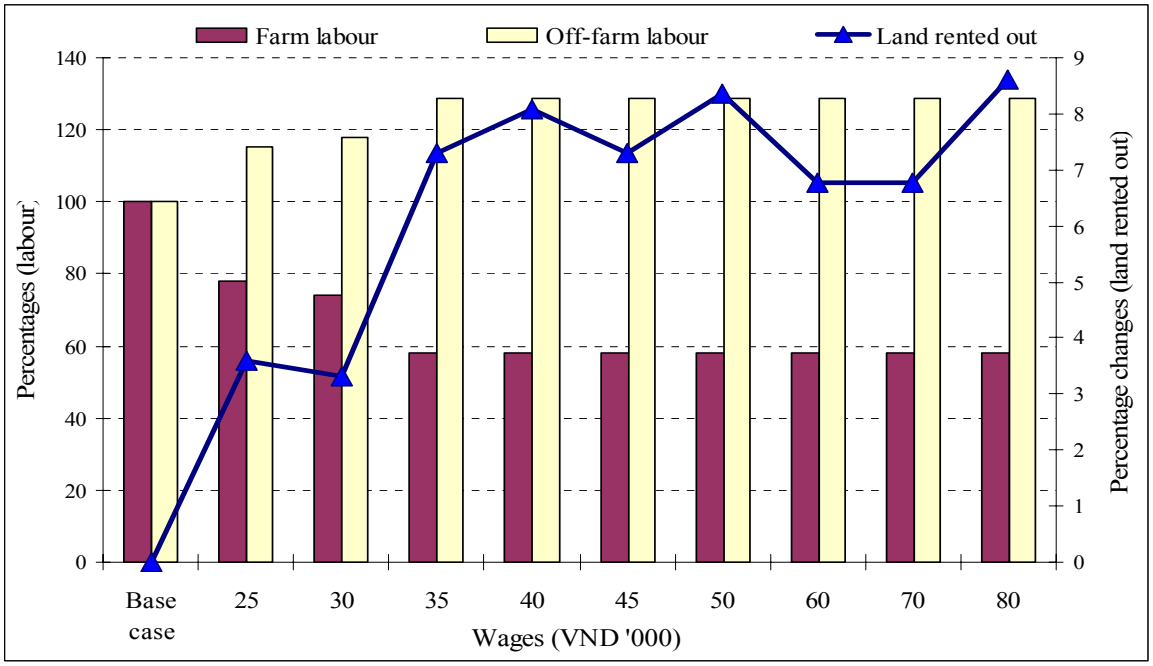

Figure 1: Impacts of wage rates on labour and land rented out

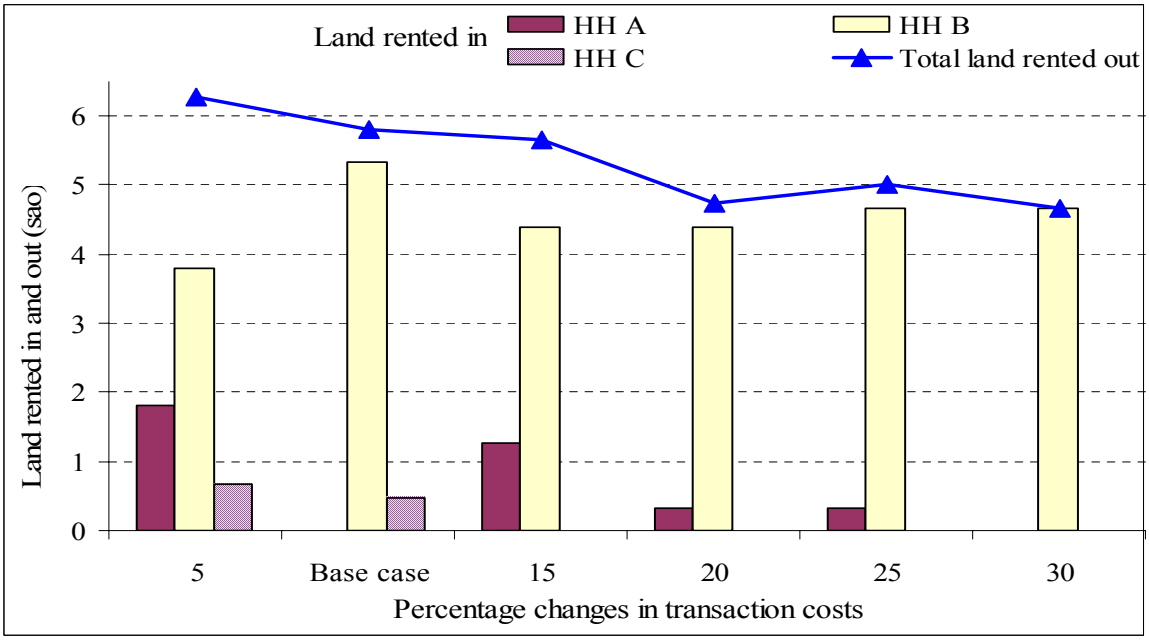

Figure 2: Simulation of changes in transaction costs in the rental market

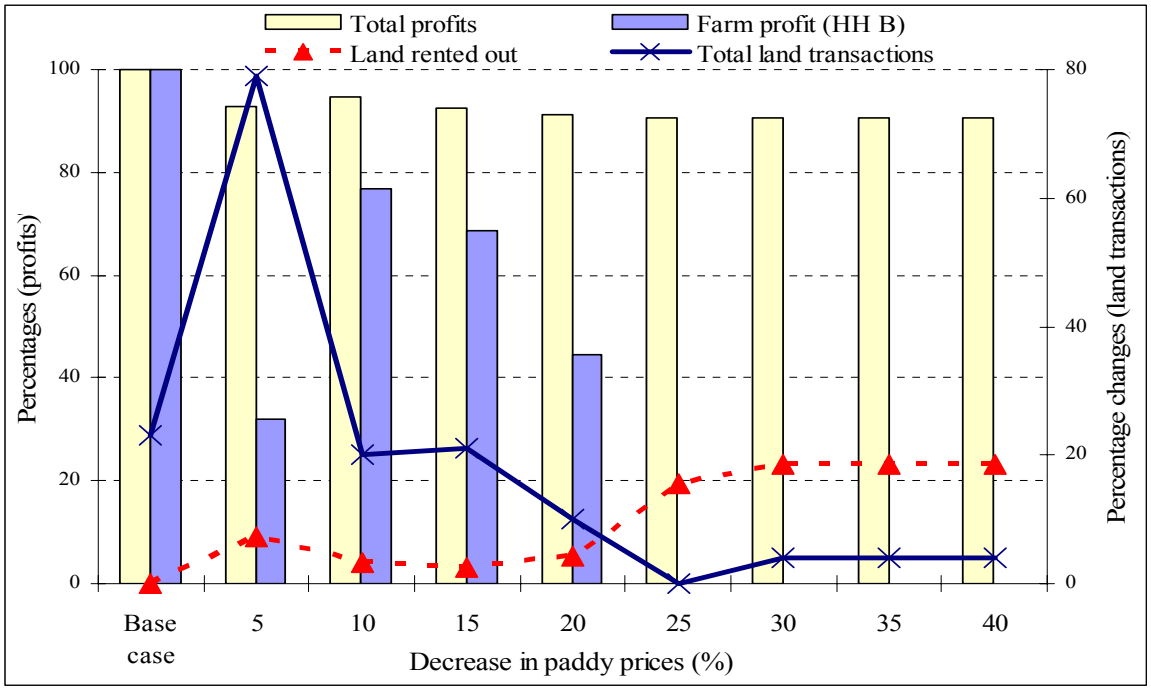

Figure 3: Simulation of changes in paddy prices