Rice Land Designation Policy in Vietnam and the Implications of Policy Reform for Food Security and Economic Welfare

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Abstract

With the aim of promoting national food security, the Vietnamese government enforces the designation of around 35 per cent of agricultural land strictly for paddy rice cultivation. We investigate the economic effects of adjusting this policy, using an economy-wide model of Vietnam with detailed modelling of region-specific land use, agricultural activity, poverty, and food security measures. Our results show that the removal of the rice land designation policy increases real private consumption by an average of 0.35 per cent per annum over 2011-2030, while also reducing poverty, improving food security, and contributing to more nutritionally balanced diets among Vietnamese households.

I. INTRODUCTION

Land reform has been an important contributor to Vietnam's experience of rapid economic growth and poverty alleviation in its transition from a command economy to a market economy. Through the land laws of 1987, 1993, their subsequent revisions in 1998 and 2001, and the new land law of 2003, farmers have been granted long term land use rights, and rights of land transfer, exchange, lease, inheritance, and mortgage. These reforms have raised incentives to use land more efficiently, while also promoting development of a land market. Agricultural production has expanded, turning Vietnam from a net food importer in the late 1970s and early 1980s to a net food exporter in the 1990s and 2000s.[1]

Nevertheless, the state still retains the right to decide on land use purposes through land use planning. Central and local governments regularly adopt five and ten year plans for land use at the national and provincial levels. These plans specify in detail the acreage of land to be devoted to annual crops, rice, perennial crops, forestry, aquaculture, salt making, and non-agricultural purposes. Proposed changes in land use must be approved by district or provincial level authorities (National Assembly, 2003).

Land use planning is most strictly enforced in rice cultivation.[2] Rice remains the most important food in the Vietnamese diet, accounting for more than half of the average energy intake (Bui, 2010). The Government's Resolution on National Food Security stipulates that by 2020 3.8 million ha must be reserved for rice cultivation (GOV, 2009a). Hereafter we refer to this land as 'designated' paddy land. This represents about 90 per cent of currently cultivated paddy land, or 35 per cent of land used for agricultural production. The policy's stated purpose is to promote food security in general, but with a particular emphasis on self-sufficiency in rice production and rice price stabilisation (GOV, 2009a).

In general, we expect agricultural land to generate its highest economic benefit when used in a manner that produces the highest land rental price. If paddy cultivation were to represent such a use for all of the 3.8 million hectares currently designated for paddy, then the designation policy would effectively not be binding, with the policy introducing no market distortions. However, while climate and soil conditions in many parts of Vietnam are well suited to growing rice, there is evidence that paddy farmers might shift to other crops in the absence of the designation policy (To, Nguyen, and Marsh, 2006; Markussen, Tarp, and Broeck, 2011)[3].

While the rice land designation policy may promote rice production, this comes at the cost of productive and allocative inefficiencies. To date there have been few studies on the economic effects of the policy. Existing studies of Vietnam's land policies focus on the evolution of the privatisation of agricultural land management, tenure security and transfer rights, and the development of the land market (for example, Ravallion and van de Walle, 2008; Do and Iyear, 2008; Deininger and Jin, 2008). Do and Iyear (2008) cite restrictions on crop choice as one reason why increased land titling has had limited impact on investment in perennial crops.

Three studies have explicitly examined crop choice restrictions in Vietnam. Two of these, To *et al*. (2006) and Markussen *et al*. (2011), considered the degree to which land designation policy affects crop choice. Both studies find that the paddy land designation policy has a substantial effect on the proportion of agricultural land allocated to paddy production. The third study, Nielsen (2004), is the only assessment of the economy-wide consequences of Vietnam's land designation policy.

Nielsen (2004) used a comparative static version of the GTAP model to simulate, among other things, the effects of exogenously shifting five per cent of Vietnam's rice land to other agriculture. This was found to reduce welfare. However Nielsen noted that, due to lack of data, her study could not model policy-generated land rental wedges between designated paddy land and other land uses. As we will argue later in this paper, the rental price of designated paddy land is lower than that available in other agricultural uses. Under these circumstances, a movement of designated land to an alternative use is likely to be welfare improving.

Our paper makes a number of contributions to the research on land designation policy. First, we model region-specific wedges between the land rental received on designated land and that possible if the same land was unencumbered. Second, we model detailed region-specific agricultural sectors, facilitating the modelling of demand and supply for land. Third, we undertake our analysis within a dynamic general equilibrium model with annual periodicity. Compared with comparative static analysis, the dynamic analysis allows us to build a more realistic business as usual baseline forecast, against which the policy shock can be evaluated. This is important for capturing long term changes in the structure of the economy. Fourth, we evaluate the policy's effects on the evolution of poverty head count by linking the CGE model with a micro-simulation (MS) model. Fifth, we propose three measures of food security and food diversity: the rice surplus index, the food cover index, and the rice share in total household calorie intake. We use these measures to explore the effects of paddy land designation on food security.

Vietnam is not unique in its paddy land designation policy. Myanmar also directly regulates paddy land cultivation, restricting conversion to non-paddy agriculture (Pingali and Siamwalla, 1993; Asian Human Rights Commissions, 2011). Other major rice producing countries influence paddy land area through either direct regulation or financial incentives (Yang and Blandford, 2011; IRRI, 1995; OECD, 2009). More generally, many countries have policies restricting the conversion of agricultural land to non-agricultural uses. The method that we outline in this paper could be used not only to analyse paddy land use restrictions outside of Vietnam, but could easily be generalised to examine agricultural land use restrictions more broadly.

The remainder of the paper is as follows. Section II describes our model, focusing on the modelling of the rice land designation policy and regional land allocation across alternative agricultural uses. Section III describes our assumptions underlying a simulation in which we explore the removal of the rice land designation policy. Section IV discusses the results of our model simulation, focussing on macroeconomic, distributional and food security outcomes. Section V concludes the paper.

II. THE MODEL

We undertake our analysis with a version of the MONASH-VN model tailored to include agricultural land use detail. MONASH-VN is an implementation for Vietnam of the large scale CGE model MONASH (Dixon and Rimmer, 2002). The model's database is in part based on input output data for the Vietnamese economy for the year 2005 (GSO, 2007), updated to 2010 using observed changes in the economy.[4] The standard version of MONASH-VN, based on the input output data of GSO (2007) contains 113 national industries. To suit the purposes of this study, we expand MONASH-VN to cover 195 industries, of which 91 are regional agricultural industries. By regional agricultural industry, we mean a particular agricultural industry cross classified with the region in which it operates. For example, we model the paddy industry in each of Vietnam's seven agro-ecological regions. In addition to paddy, each of the following industries is also distinguished by the region in which it operates: sugar cane, maize, cassava, vegetables, other annual crops, aquaculture, rubber, coffee, tea, fruits, other perennial crops, and rice processing. Of these 13 industries, the first 12 are land using primary producers, and the last, rice processing, uses no land as a direct input, but rather, sources a significant share of its inputs in the form of harvested paddy from rice cultivation. With 13 agricultural industries modeled in each of 7 regions, we have 91 regional agricultural industries. This is important for our modeling of land use at the regional level.

To elucidate the poverty impacts of policy interventions in the rice market, we link MONASH-VN with a micro-simulation (MS) module based on data from the Vietnam Household Living Standard Survey (VHLSS) for 2006 (GSO, 2008). The MS module uses results for commodity prices, factor employment and factor prices from the CGE core to update the income and expenditure details of the 9189 households in the VHLSS survey data.[5]

The equations of MONASH-VN assume that optimizing behaviour governs decision making by industries and households. Each industry minimizes unit costs subject to given input prices and a nested constant returns to scale production function. Three primary factors are identified: labour, capital and natural resources. The model distinguishes two types of natural resource. One, representing sub-soil assets, is specific to individual mining industries. The second, agricultural land, is specific to regions, but potentially mobile between alternative agricultural uses. We elaborate on this in the land use modelling section below.

Household commodity demands are modeled using a representative household, which is assumed to act as a budget-constrained utility maximiser. Imported and domestic commodities are modelled as imperfect substitutes with user-specific constant elasticity of substitution (CES) functions. The export demand for any given Vietnamese commodity is inversely related to its foreign currency price. The model recognizes consumption of commodities by government, and the details of direct and indirect taxation instruments. It is assumed that all sectors are competitive and all goods markets clear.

The model recognizes three types of dynamic adjustment: capital accumulation, net liability accumulation and lagged adjustments. Capital accumulation is industry specific, and linked to industry-specific net investment. Annual changes in the net liability positions of the private and public sectors are related to their annual investment/savings imbalances. In policy simulations, the labour market follows a lagged adjustment path. In the short run, real consumer wages respond sluggishly to policy shocks. Hence short-run labour market pressures mostly manifest as changes in employment. In the long run, employment returns to its baseline trend value, with labour market pressures reflected in movements in the real wage. The model is solved using GEMPACK (Harrison and Pearson, 1996).

Region-specific Land Use Modelling

Within each of the seven agro-ecological regions of our model, we distinguish modeling of the demand and supply sides of the land market. Beginning with the demand side, we assume that industries choose land inputs so as to minimize the cost of their composite primary factor input, subject to a CES production function and given prices of primary factor inputs. In percentage change form, this optimization problem generates equations describing demand for land, by agricultural industry *i* located in region *r*, of the following form:[6]

$$x^{(2)r}_{Land,i} = x^{r}_{Prim,i} - \sigma^{r}_{Prim,i}\left(p^{(2)r}_{Land,i} - p^{r}_{Prim,i}\right) \quad (i \in \text{AGRACT})\ (r \in \text{REG}) \tag{1}$$

where

REG	comprises the seven regions: Red River Delta; North Midland and mountainous region; North Central Coast; South Central Coast; Central Highlands; South East; and Mekong River Delta;
AGRACT	comprises twelve land using primary producers: paddy, sugar cane, maize, cassava, vegetables, other annual crops, aquaculture, rubber, coffee, tea, fruits, other perennial crops, and rice processing;

$x^{(2)r}_{Land,i}$ and $p^{(2)r}_{Land,i}$ are percentage changes in the quantity and price of land inputs used by agricultural industry *i* in region *r*;

$x^{r}_{Prim,i}$ and $p^{r}_{Prim,i}$ are percentage changes in the quantity and price of an effective primary factor composite, comprising land, labour and capital, used in by agricultural industry *i* in region *r*; and,

$\sigma^{r}_{Prim,i}$ is the elasticity of substitution between primary factors faced by agricultural industry *i* in region *r*. We set $\sigma^{r}_{prim,i}$ values for agricultural industries using values reported in Narayanan and Walmsley (2008).

On the supply side of the land market, we model land owners as cognisant of differences in land rental prices across alternative land uses when allocating the region's agricultural land across alternative land-using industries. We allow for differences in the ease with which land moves between alternative agricultural uses by modelling the land allocation process as having two stages, as illustrated in Figure 1.

[Figure 1 here]

We assume that land owners within each region solve a two stage optimisation problem, first solving (2), and then taking as given the outcomes of (2) when solving (3).

maximise:

$$U^{(1)r}\left[X^{(1)r}_{Land,1}P^{(1)r}_{Land,1}T^{(1)r}_{Land,1},\ X^{(1)r}_{Land,2}P^{(1)r}_{Land,2}T^{(1)r}_{Land,2},\ \ldots,X^{(1)r}_{Land,|AGRGROUP|}P^{(1)r}_{Land,|AGRGROUP|}T^{(1)r}_{Land,|AGRGROUP|}\right] \tag{2}$$

subject to: $$X^{(0)r}_{Land} = \sum_{k\in AGRGROUP} X^{(1)r}_{Land,k} \qquad (r \in REG)$$

maximise:

$$U^{(2)r}_{g(i)}\left[\delta_{i,1}X^{(2)r}_{Land,\,1}P^{(2)r}_{Land,\,1},\ \delta_{i,2}X^{(2)r}_{Land,\,2}P^{(2)r}_{Land,\,2},\ \ldots,\ \delta_{i,12}X^{(2)r}_{Land,12}P^{(2)r}_{Land,12}\right]$$

$$\text{where } \delta_{i,j}=\begin{cases}1 \text{ if } g(i)=g(j)\\ 0 \quad \text{otherwise}\end{cases} \text{ and } (i,j\in \text{AGRACT})^{7} \qquad (3)$$

subject to: $$X^{(1)r}_{Land,g(i)}=\sum_{t:g(i)=g(t)}X^{(2)r}_{Land,t} \qquad (g(i)\in \text{AGRGROUP})\ (r\in \text{REG})$$

where

AGRGROUP is the set of broad agricultural groups: paddy, annual crops, aquaculture and perennial crops.

g(i) = *paddy* for *i* = *paddy*.

annual crops for *i* = *sugar cane*, *maize*, *cassava*, *vegetables*, and *other annual crops*.

aquaculture for *i* = *aquaculture*

perennial crops for *i* = *rubber*, *coffee*, *tea*, *fruits* and *other perennial crops*.

|AGRGROUP| denotes the size of set AGRGROUP

$X^{(0)(r)}_{Land}$ is the supply of agricultural land, undifferentiated by use, in region *r*.

$X^{(1)(r)}_{Land,k}$ is the supply of agricultural land to use *k* ($k\in$ AGRGROUP) in region *r*.

$X^{(2)(r)}_{Land,i}$ is the supply of agricultural land to use *i* ($k\in$ AGRACT) in region *r*.

$P^{(1)(r)}_{Land,k}$ is the rental price of land in use *k* ($k\in$ AGRGROUP) in region *r*.

$P^{(2)(r)}_{Land,i}$ is the rental price of land in use *i* ($k\in$ AGRACT) in region *r*.

$T^{(1)r}_{Land,k}$ is the power (1 minus the rate) of a phantom tax on returns from land type *k*.

$U^{(1)(r)}$ is the utility derived by agricultural land owners from allocating undifferentiated land across alternative uses within AGRGROUP.

$U_k^{(2)(r)}$ is the utility derived by agricultural land owners in *r* from allocating land k across alternative uses within AGRACT.

In implementing this problem in MONASH-VN, we use the CRESH functional form to describe $U^{(1)r}$ and $U_k^{(2)r}$. As Dixon and Rimmer (2006) explain, (2) and (3) describe problems in which resource owners view rents earned on different resource uses as imperfect substitutes. The land supply functions implicit in this problem have the attractive property that the total quantity of land at each decision stage remains unaffected by price-induced reallocations of land across alternative land uses.[8]

The solutions to problems (2) and (3), converted to percentage change form are

$$x_{Land,i}^{(2)r} = x_{Land,g(i)}^{(1)r} + \sigma_{Land,i}^{(2)r}[p_{Land,i}^{(2)r} - p_{Land,g(i)}^{(1)r}] \qquad (i \in \text{AGRACT})\ (r \in \text{REG}) \qquad (4)$$

$$x_{Land,k}^{(1)r} = x_{Land}^{(0)r} + \sigma_{Land,k}^{(1)r}[p_{Land,k}^{(1)r} + t_{Land,k}^{(1)r} - p_{Land}^{(0)r}] \qquad (k \in \text{AGRGROUP})\ (r \in \text{REG}) \qquad (5)$$

where

$x_{Land}^{(0)r}$, $x_{Land,k}^{(1)r}$, $x_{Land,i}^{(2)r}$, $p_{Land,k}^{(1)r}$ $p_{Land,i}^{(2)r}$ and $t_{Land,k}^{(1)r}$ are, respectively, the percentage changes in $X_{Land}^{(0)(r)}$, $X_{Land,k}^{(1)(r)}$, $X_{Land,i}^{(2)(r)}$, $P_{Land,k}^{(1)(r)}$, $P_{Land,i}^{(2)(r)}$ and $T_{Land,k}^{(1)(r)}$;

$p_{Land}^{(0)r}$ is the percentage change in the average rental price of agricultural land in region *r*;

$\sigma_{Land,i}^{(2)r}$ is an elasticity measuring the responsiveness of land supply to agricultural activity *i* in region *r* in response to changes in the ratio of the land rental price in agricultural activity *i* to the average land rental price in agricultural group *g(i)*.

$\sigma^{(1)r}_{Land,k}$ is an elasticity measuring the responsiveness of land supply to agricultural group *k* in region *r* in response to changes in the ratio of group *k*'s average land rental price to region *r*'s average land rental price.

$p^{(1)r}_{Land,k}$ and $p^{(0)r}_{Land}$ are weighted average (calculated using elasticity modified land area weights) percentage changes in average rental prices for agricultural land, defined as follows:

$$p^{(1)r}_{Land,k} = \sum_{i:g(i)=k} S^{*(2)r}_{Land,i} p^{(2)r}_{Land,i} \qquad (k \in \text{AGRGROUP}) \ (r \in \text{REG})$$

$$p^{(0)r}_{Land} = \sum_{k} S^{*(1)r}_{Land,k} (p^{(1)r}_{Land,k} + t^{(1)r}_{Land,k}) \qquad (r \in \text{REG}), \quad \text{where,}$$

$$S^{*(2)r}_{Land,i} = (\sigma^{(2)r}_{Land,i} S^{(2)r}_{Land,i} / \sum_{t:g(i)=g(t)} \sigma^{(2)r}_{Land,t} S^{(2)r}_{Land,t}) \qquad (i \in \text{AGRACT}) \ (r \in \text{REG})$$

$$S^{*(1)r}_{Land,k} = (\sigma^{(1)r}_{Land,k} S^{(1)r}_{Land,k} / \sum_{t} \sigma^{(1)r}_{Land,t} S^{(1)r}_{Land,t}) \qquad (k \in \text{AGRGROUP}) \ (r \in \text{REG}), \text{ where}$$

$$S^{(2)r}_{Land,i} = X^{(2)r}_{Land,i} / X^{(1)r}_{Land,g(i)} \qquad (i \in \text{AGRACT}) \ (r \in \text{REG})$$

$$S^{(1)r}_{Land,k} = X^{(1)r}_{Land,k} / X^{(0)r}_{Land} \qquad (k \in \text{AGRGROUP}) \ (r \in \text{REG})$$

Equations (4) and (5) describes land supply to alternative agricultural uses. The functions are constant returns to scale. In the absence of changes in relative land rental prices within any given land supply nest, a change in the supply of agricultural land to that nest leads to uniform expansion in land supply to all land uses within the nest. A change in relative land rental prices induces transformation in land supply, with the strength of this transformation governed by the elasticities $\sigma^{(1)r}_{Land,k}$ and $\sigma^{(2)r}_{Land,i}$.[9] We base the values of these elasticities on existing parameter value estimates (see Ahmed, Hertel, and Lubowski, 2008; Golub and Hertel, 2011) and discussions with agricultural experts in Vietnam.[10] In Stage 1 of Figure 1, the land transformation elasticities are 0.3 for paddy, 0.5 for other annual crops, 0.25 for aquaculture, and 0.15 for perennial crops. Transformation elasticities across crops in Stage 2 are higher than Stage 1 elasticities, reflecting easier transformation possibilities across alternative crop types once the major land use decisions described by Stage 1 have been made. The Stage 2 elasticities are 0.8 for annual crops, and 0.5 for perennial crops. As these parameters contain a degree of uncertainty, we conducted a sensitivity analysis using alternative values. This analysis suggested that the conclusions we draw in this paper, as discussed in Section IV, are quite robust with regard to variations in the land transformation parameters within a ±50 per cent range.[11]

Modelling of Rice Land Designation Policy

As discussed above, land is modelled as a factor which, when unconstrained by policy, can move between alternative agricultural sectors within each region, subject to a given land supply specification. However, as discussed in Section I, Vietnamese authorities have declared that certain land be used for the purpose of paddy production only. If land designation in a region changes land use, then we can infer that the designated land earns, on average, a land rental lower than that which it would earn if it were not so encumbered. Indeed, the economic cost of the policy can be viewed in terms of the land rent foregone by constraining a given area's use to paddy, when more profitable land uses would otherwise be chosen. At the margin, the extent of this foregone land rent can be measured by the ratio of the land rental available from non-paddy land use in region *r* (P_N^r) relative to the rental available from paddy land use (P_P^r). We calculate this ratio using data from Dao (2010), Cheesman *et al.* (2007), Le *et al.* (2010), Sinh Thai Trung Viet (2010), Thanh Nam (2010) and SCAP (2010), reporting results in column (1) of Table 1.[12] We model the land designation policy within the MONASH-VN database by using 'phantom taxes', that is, taxes that have the effect of changing behaviour but collecting no net revenue. In calibrating the model, we assume that the initial phantom tax rates have been set so as to equalise the post-tax return from reallocating a unit of land away from paddy and toward non-paddy use, while simultaneously collecting no net revenue.[13] That is, for given values for P_N^r, P_P^r, V_P^r and V_N^r, set T_P^r and T_N^r such that:

$$(P_N^r T_N^r)/(P_P^r T_P^r) = 1 \tag{6}$$
$$V_P^r(1-T_P^r) + V_N^r(1-T_N^r) = 0 \tag{7}$$

where V_P^r and V_N^r are the values of gross land rental payments on land used in region *r* for paddy and non-paddy uses respectively. Solving (6) and (7) provides:

$$T_N^r = (S_p^r\{P_N^r / P_p^r\} + S_N^r)^{-1} \tag{8}$$
$$T_P^r = (P_N^r / P_p^r)(S_p^r\{P_N^r / P_p^r\} + S_N^r)^{-1} \tag{9}$$

where $S_N^r = V_N^r/(V_N^r + V_p^r)$ and $S_p^r = V_p^r/(V_N^r + V_p^r)$.

[Table 1 here]

The purpose of the phantom taxes is to give effect to both the government's policy of land designation, and the economic cost of this policy expressed in terms of the land rent foregone by the policy impediment to allocation of land to its most valued use. Table 1 describes our data for calculating the initial values for the phantom taxes by region and land use. The meaning of the phantom tax rates is perhaps made clearer with an example. In the first row of Table 1, we see that in the Red River Delta region the ratio of non-paddy to paddy land rentals is 4.21:1. We reconcile this ratio with our assumption that land owners receive the same per unit revenue, net of phantom taxes, across alternative land uses, via a revenue-neutral tax/subsidy package, consisting of an initial 39 per cent tax on land supplied to non-paddy use with the revenue raised from this tax used to finance a 156 per cent subsidy on land supplied to paddy. The initial values for the phantom tax factors in 2010 are reported in column D. We model the removal of the land designation policy as moving the values of the phantom tax factors from their initial values, to 1.

We note several advantages of the phantom tax approach to modelling the designation policy. First, by incorporating the initial levels of T_P^r and T_N^r in our database, we put in place the allocative efficiency losses produced by the land designation policy. Second, we do not need to model the removal of the designation policy by exogenously moving land out of paddy and into other agricultural uses. Rather, we model removal of the policy by driving the values of T_P^r and T_N^r to 1. This changes post-tax returns to land supplied across alternative uses. The model then endogenously finds the new land allocation pattern following removal of the designation policy.[14] Finally, the phantom tax approach allows us to adopt an implicit assumption of sensible government policy making in our baseline (no policy change) forecast. In the baseline, we assume the levels of the phantom tax factors remain unchanged from their initial (2010) values. Agricultural land remains free to move between alternative uses in response to changes in relative land rental prices. Keeping the phantom tax factors fixed in the baseline, rather than the quantity of land in paddy production, is equivalent to assuming that the Vietnam government calibrates its land designation policy, in either a de jure or de facto manner, to maintain a given allocative efficiency loss through time. The alternative assumption, maintenance of an exogenous supply of land to paddy agriculture, would require endogenous determination of the allocative efficiency loss, giving policy makers an implausibly passive role in the baseline scenario.

III. SIMULATION DESIGN

Policy analysis with a dynamic model like MONASH-VN requires two model runs: a business-as-usual baseline forecast, and a policy simulation. The baseline forecast is intended to be a plausible forecast of the economy, tracking available forecasts for macroeconomic variables, industry technologies, household preferences, trade and demographic variables. The policy simulation incorporates all features of the baseline forecast, but with the addition of policy-related shocks reflecting the details of the policy change under investigation. The economic implications of the policy change are reported as deviations in values for model variables between the policy and forecast simulations. This section describes our baseline forecast and the shocks and model closure for the policy simulation.

Baseline Forecast

Inputs into our baseline include independent forecasts from international organizations, government agencies and research institutions. We exogenously determine Vietnam's real GDP growth rate equal to values forecast by IMF/World Bank (2010) over the period 2010 2030, through endogenous determination of average primary-factor-saving technical change. We exogenously determine baseline population and employment growth rates at values forecast by ILO (2010). We exogenously determine the growth rate of aggregate agricultural land in the baseline at -0.34 per cent per annum, based on forecasts by NIAPP (2010) and Zhu (2010).[15]

We assume that aggregate consumption spending (private and public) is a fixed proportion of national income, and that this propensity to consume will be unchanged over the baseline forecast period. We also assume that as the economy grows, foreign demand for Vietnamese exports will expand at a rate sufficient to keep the country's terms of trade unchanged over the baseline forecast period.

For household rice consumption, we adopt the forecast of Nguyen *et al.* (2011) that per capita rice consumption will fall by 1 per cent per annum, from 135kg/person in 2010 to 110kg/person by 2030. We assume that as households reduce their rice consumption, they increase their consumption of other food items through budget-neutral changes in household taste parameters.

Policy Shocks

As described in Section II, in our baseline we model the land designation policy as a revenue neutral subsidy/tax combination between returns available from supplying land to paddy and non-paddy uses in each of the seven regions. In our policy simulation, we model the removal of the land designation policy by removing these subsidy/tax combinations over the five year period 2011 to 2015.

Model Closure in the Policy Simulation

In the policy simulation we assume that the ratio of nominal consumption spending (private and public) to nominal GNDI is endogenous, adjusting to ensure that real (investment price deflated) national savings remains on its baseline path. As discussed in Giesecke and Tran (2010), this assumption facilitates the interpretation of the economy-wide real consumption deviation as a welfare measure by ensuring that movements in real national income are expressed as movements in real consumption, and by minimising the impact on real consumption of movements in the price of investment relative to the price of consumption. In terms of the basic mechanics of macroeconomic causation, the main effect of this closure is to ensure that economy-wide consumption moves with national income. We also assume that real government consumption spending is held on its baseline path. Investment in each industry is a positive function of the rate of return on capital in the industry, and the balance of trade is endogenous. Note however that much of the scope for deviations from baseline in the balance of trade / GNDI ratio is constrained by our assumption that real private consumption adjusts in each year of the policy simulation so as to keep real national savings on its baseline path.

IV. SIMULATION RESULTS

Macroeconomic Results

By 2030, nation-wide, removal of the land designation policy causes a 10.7 per cent decline in paddy land acreage relative to baseline, as land owners move land into higher valued uses such as non-perennial annual crops, aquaculture, and perennial crops (Part A, Table 2).

[Table 2 here]

In terms of its contribution to the real GDP deviation, the reallocation of land towards high value uses is equivalent to an improvement in effective land supply. At the economy-wide level, determination of Vietnam's real GDP (Y) can be described by:

$$Y = A \cdot F(X_{Capital}, X_{Labor}, X_{Land}) \tag{10}$$

where F is a constant returns to scale function, $X_{Capital}$, X_{Labor} and X_{Land} are employment of capital, labour and land respectively, and *A* describes the efficiency with which primary factor employment produces output. Converting (10) to percentage change form:

$$y = a + S_{Capital}\ x_{Capital} + S_{Labor}\ x_{Labor} + S_{Land}\ x_{Land} \tag{11}$$

where S_i is the share of payments to factor *i* in GDP at factor cost, and lower case letters denote the percentage change in the corresponding upper case variables in (10).

We can describe the effective land input, X_{Land}, through the multi-input production function:

$$X_{Land} = g\left(X_{Land,1},\ldots,X_{Land,|\text{AGRGROUP})|}\right) \qquad (12)$$

where g is a positive function and $X_{Land,1},\ldots,X_{Land,|\text{AGRGROUP}|}$ are hectares of land supplied to the four broad agricultural groups. Converting (12) to percentage change form, and assuming that land-using firms are profit maximisers, we obtain:

$$x_{Land} = \sum\nolimits_{i=1}^{4} S_i^{(V)N} x_{Land,i} \qquad (13)$$

where $S_i^{(V)N}$ is a value share, measuring rents accruing to agricultural land employed in use *i* as a proportion of total economy-wide agricultural land rents; and $x_{Land,i}$ is the percentage change in the number of hectares of land supplied to agricultural use *i*.

In our simulations, given region-specific stocks of land are free to move between alternative agricultural uses. In percentage change form, this provides (14):

$$0 = \sum\nolimits_{i=1}^{4} S_i^{(Q)N} x_{Land,i} \qquad (14)$$

where $S_i^{(Q)N}$ is a quantity share, measuring the area of agricultural land employed in industry *i* as a proportion of the total nation-wide agricultural land area. The fact that the aggregate agricultural land area in the policy simulation is constrained to its baseline value appears in row 6 of Table 2 as a 0 per cent deviation in land area (quantity weights). Subtracting (14) from (13) provides:

$$x_{Land} = \sum\nolimits_{i=1}^{4} \left(S_i^{(V)N} - S_i^{(Q)N}\right) x_{Land,i} \qquad (15)$$

From (15) it is clear that a positive deviation in effective land supply (x_{Land}) occurs if land moves from uses that have low land rental rates to uses that have high land rental rates. The reallocation of land described in Part A of Table 2 is of this type. This accounts for the positive deviation in effective (rental weighted) land input described in row 7 of Table 2. By 2015, the removal of the land designation policy generates a positive deviation in effective land input of 1.75 per cent (row 7, Table 2). In 2015, we forecast land rental payments to represent 11.9 per cent of GDP. Hence, via equation (11), the 2015 deviation in effective land supply contributes 0.21 percentage points to the 2015 real GDP deviation of 0.3 per cent (row 5, Table 2). The remainder of the positive deviation in 2015 real GDP is due to the positive deviations in the capital stock and employment (rows 8 and 9, Table 2).

The increase in effective land supply raises the marginal product of labour for any given level of employment. In our simulation, we assume real wages are sticky in the short run, but fully flexible in the long run, with long-run employment in the policy simulation returning to its baseline level. By 2015, the real wage has begun the process of adjustment to return employment to baseline, but the process is not complete, allowing employment to rise relative to baseline by 0.12 per cent (row 9, Table 2). In the long run, wage adjustment ensures that employment returns to its baseline level. Hence, by 2030, the increase in the marginal product of labour is expressed entirely as an increase in the real wage (row 15, Table 2).

Two notable features of the trade accounts (rows 13 and 14, Table 2) are the short-run positive deviation in import volumes relative to export volumes and the steady long-run decline in the import volume deviation. The first effect is attributable to the short-run positive deviation in real investment. As is clear from Table 2, the short-run real investment deviation and the short run real consumption deviation both exceed the short-run deviation in real GDP. This causes the short-run deviation in real GNE to exceed the short-run deviation in real GDP. This accounts for the short-run movement towards deficit in the real balance of trade. Over the remainder of the simulation period, investment returns to close to its baseline level, and the weighted average of the private and public consumption deviations closely matches the deviation in real GDP. As a result, the initial movement towards deficit in the balance of trade is attenuated over the remainder of the simulation period.

The growing negative deviation in import volumes in Table 2 is due mainly to negative deviations in imports of agricultural products, foods and manufactured goods. Agricultural and food imports fall because the removal of the land designation policy lowers the average supply cost of domestic agricultural production, thus lowering prices of domestically produced food, and reducing demand for imported food. An important contributor to the fall in manufactured imports is a decline in fertiliser imports. Imported fertilisers represent more than half of all fertiliser used in Vietnam (GSO, 2007). The decline in fertiliser demand reflects the change in the composition of agricultural production, away from paddy. Paddy is more intensive in fertiliser use than most other crops in Vietnam (FAO, 2010).

Poverty Results

Figure 2 reports poverty head count rates for both the baseline and policy simulations. In discussing macroeconomic effects, we noted that removal of land designation lifts real GDP and real consumption relative to baseline. The MS model indicates that the poorest households are likely to participate in the general gains implied by these macroeconomic outcomes. In particular, the MS model shows households living under the poverty threshold benefiting in two ways. First, they experience income gains through a rise in the wage rate.

Second, they experience real income gains due to a fall in the average price of food (see Effects on Food Security section below). Together, these two effects result in the poverty head count rates in the policy scenario lying below their baseline values throughout the simulation period (see Figure 2).

[Figure 2 here]

Effects on Food Security

The concept of food security has many dimensions, and as such, has attracted a number of definitions and measures.[16] Two commonly used measures of national food security are the food gap index[17] and the food import capacity index[18]. However, these measures have been designed mainly to measure food security in food shortage countries (USDA, 2010, p. 1; FAO, 2003, p.5). As such, they are not particularly relevant to Vietnam, a country which, for the last two decades, has experienced a surplus of rice and many other food products. Nevertheless, since Vietnam's land designation policy is aimed at enhancing food security, in investigating the wider economic effects of the policy's removal, we think it important to also examine food security impacts. In MONASH-VN we calculate three food security measures: the rice surplus index, the food cover index, and the rice share in household food calorie intake. The *rice surplus index* is the ratio of the quantity of rice production to the quantity of total domestic rice demand. This measures the extent to which domestic rice production exceeds domestic uses. The *food cover index* is the ratio of total household expenditure to the value of household spending on all food and drink items. It measures the ability of households to cover their food bill. The *rice share in household food calorie intake* is an indicator of food diversity.[19] Approximately 70 per cent of rice is carbohydrates (FAO, 1993, Table 14). Hence, a move away from rice, and towards foods that are richer in protein, minerals and vitamins, such as vegetables, meat and dairy products, may improve the overall nutritional content of household food consumption.[20] In Table 3 we report the percentage deviations in the policy simulation values for these indexes away from their baseline values. To aid in the interpretation of these deviations, we also report the levels of the indexes in both the baseline and policy scenarios. Policy-induced deviations in food prices are reported in rows 10 through 12.

[Table 3 here]

We begin by noting that in the baseline simulation, the values of the rice surplus index (row 1) and the food cover index (row 4) increase over time, while the value of the rice calorie share (row 7) declines. We note that our baseline forecast carries an assumption of declining household rice consumption. At the same time, baseline rice production is forecast to increase due to rising productivity in paddy production and rice processing, together with general growth in the size of the baseline Vietnamese labour force. Jointly, the rise in baseline rice production and the decline in baseline rice consumption accounts for the increase in the baseline value of the rice surplus index (row 1). Removal of the land designation policy reduces the rice surplus index relative to baseline (row 3). However, in understanding the implications for food security of this change, we note that the level of the rice surplus index remains above its initial (that is, 2010) value in every year of the policy scenario (row 2).

Like the rice surplus index, the value of the food cover index is also forecast to increase in the baseline scenario (row 4). On average, expenditure elasticities for the commodities comprising the food bundle are less than unitary. Hence, the food budget share declines in the baseline scenario. The removal of the land designation policy causes real household consumption to increase relative to baseline (row 10, Table 2) while reducing the average price of the food bundle (row 12, Table 3). This accounts for the positive deviation in the food cover index (row 6, Table 3).

In the baseline scenario, the contribution of rice to the average household calorie intake is forecast to decline from 61 per cent to 29 per cent by 2030 (row 7, Table 3). As noted in our discussion of macroeconomic results, removal of the land designation policy causes a decline in paddy land acreage relative to baseline. This causes rice prices to rise relative to baseline (row 10, Table 3). However, the decline in paddy land acreage is matched by a rise in acreage allocated to other food production. This causes the average price of non-rice foods to fall relative to baseline (row 11, Table 3). This rise in the price of rice relative to other foods induces substitution away from rice consumption, which explains the negative deviation in the rice calorie share in row 9 of Table 3.

V. CONCLUDING REMARKS

Vietnam's rice land designation policy was initially developed in a setting in which rice accounted for a dominant share of food energy intake and the country faced a shortfall in rice production. Yet, over the past two decades, the country has achieved high success in raising the productivity and land use intensity of its irrigated rice areas. It is now a large surplus rice producer, exporting nearly one third of its production and accounting for more than 20 per cent of the world's volume of traded rice. With rising income and urbanization, food consumption patterns have begun to shift to greater consumption of fish, meat, fruits and vegetables and other products. These changes will accelerate in the years to come. The country's food security challenges now relate more to nutritional balance, household income vulnerability, and consumer price volatility, rather than to national rice availability.

While policy makers remain concerned about the prospect of widespread conversion of agricultural land for urban, industrial and other (permanent) non-agricultural uses, such conversions can be effectively managed or limited without needing to retain the national policy of rice land designations. Provided that the underlying conditions and incentives are favourable, most Vietnamese farmers will continue to grow rice, at least part time and on part of their land, long into the future. But to remain viable farmers, they will need to be supported to adopt more flexible patterns of land and other resource use, and to respond effectively to evolving patterns of demand for food and agricultural materials. These aims are not promoted by the restrictions built into the current rice land designation policy.

In this paper, we have assessed the effects of removing the paddy land designation policy in Vietnam, using a dynamic CGE model of the Vietnamese economy. The results show that the removal of the land designation policy will lead to certain shifts which will benefit the economy, including increases in real GDP and consumption, accelerated growth in agriculture and a decline in poverty. Removing restrictions on agricultural land uses would facilitate either more diversified land uses or some shift over to higher return crops and/or aquaculture for which domestic demand is growing rapidly. This process would occur without compromising food security in Vietnam. With the expected shifts, national rice output would remain in surplus of domestic consumption.

Naturally, our findings are conditioned by the inputs to our modelling, and must be qualified on that basis. We see our results as being sensitive to two sets of assumptions in particular: those governing the ease with which land can move between alternative uses, and those governing the magnitude of the rental rate differences between paddy and non-paddy agriculture. Future work would benefit from independent studies into these assumptions. Lower estimates for either would reduce the gains from land use liberalisation reported in this paper. Vietnam-specific estimates of land transformation elasticities would be helpful, as would estimates of land conversion costs. Future work could also look to improve estimates of land rental relativities between non-paddy and paddy agriculture, either through a comprehensive survey specifically designed to measure them, or by supplementing existing regular surveys with questions related to input costs for important Vietnamese crops.[21]

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[1] For an extensive discussion on land issues and the process of land reforms in Vietnam since independence in 1945, see Ravallion and de Walle (2008), and MacAulay *et al*. (2006).

[2] Officially, the Land Law 2003 only restricts the conversion of rice land to perennial crops, aquaculture, forestry or non-agricultural uses. It does not explicitly restrict the conversion of rice land to other annual crops. However, the law also stipulates the formulation and enforcement of regular land use plans by various government levels. These plans explicitly specify areas for rice land and for other crops (National Assembly, 2006). This introduces effective restrictions on rice land conversion to other uses, although the degree of enforcement varies from locale to locale (see, for example Markussen *et al*., 2011).

In recent years, the restrictions have become more explicit. The Decree 69/2009/ND-CP (GOV, 2009b) states that land use plans must clearly identify areas for wet rice cultivation, and provincial People's Committees are responsible for the protection of land areas for wet rice cultivation. The draft "Decree on rice land protection" (GOV, 2011) stipulates strict enforcement of rice land plans down to the commune level. The conversion of rice land to other uses, even to other annual crops, requires permissions from provincial authorities.

[3] The Vietnam Access to Resources Household Survey collected in 2008 (DERG, 2011) suggests that over 80% of surveyed paddy areas were used for paddy because farmers were obliged to do so by commune authorities.

[4] Our update simulation to 2010, using observed economic outcomes as reported by the General Statistical Office, uses the forecasting method described in Dixon and Rimmer (2002: 15-17).

[5] The top-down non-behavioural micro-simulation model allows us to obtain a first-order approximation of poverty and inequality impacts in Vietnam during the simulation period. The MS module neither imposes an assumed distribution nor employs the representative approach. Instead, the income source of each household (land, capital, labour, and transfers) in the micro data is updated using changes in factor prices and quantities from MONASH-VN model simulations. Similarly, the price of each household's commodity basket is likewise computed in the MS by using detailed changes in consumer prices from MONASH-VN.

[6] In MONASH-VN, input demand equations also include full treatment of technology variables. To avoid clutter, we omit these from (1). See Dixon *et al*. (1992: 124-126) for the derivation of (1).

[7] The δ's play no functional role in our theory. They facilitate notational compactness by allowing (3) to describe the optimisation problems of all four nests in Stage 2 of Figure 1.

[8] This property is not shared by CET or CRETH functions, also popular in modelling land supply response functions. That is, the total area of land across alternative uses i ($\Sigma_i L_i$) is not held constant when the optimization problem takes the form: choose $L_i ,\ldots L_m$, to maximize $\Sigma P_i L_i$, subject to $N = CRETH_i(L_i)$ and given values for P_i and N.

[9] Land conversion costs are not directly modelled. This is not unconventional in CGE land use modelling. While the role of transformation elasticities might best be confined to reflecting physical properties of agricultural land, describing only the marginal productivity gradient across alternative agricultural uses, it is not unconventional in CGE land use modelling to view these elasticities as embodying a wider set of impediments to land mobility, including "costs of conversion, managerial inertia, and unmeasured benefits from crop rotation" (Golub *et al.* 2010). In a review of twelve CGE studies on land use, Kretschmer *et al.* (2010) notes only one study (Gurgel *et al.* 2007) that directly models land conversion costs in addition to the CET approach. Gurgel *et al.* (2007) finds no clear advantage of the conversion cost approach over the CET approach. In our model, conversion costs are treated implicitly, since they appear in the input-output table as industry-specific inputs to capital formation.

[10] In particular, we are grateful for helpful discussions with researchers from the Rural Development Section of the World Bank Hanoi office, the Centre for Agrarian Systems Research and Development, the Centre for Agricultural Policy, and the Institute of Policy and Strategy for Agriculture and Rural Development. Our discussions of appropriate transformation elasticities commenced with a value of 0.3 for paddy land, which we based on two sources, Ahmed *et al.* (2008) and Golub and Hertel (2011). A 0.3 value for paddy agriculture is consistent with Ahmed *et al.* (2008)'s elasticity for crops over a 10 year period. It is also consistent with Golub and Hertel (2011) average crop land transformation elasticities for China and Japan. Starting with the value of 0.3 for paddy, we asked the agricultural experts to recommend transformation elasticities for the other land uses identified in the model, based on their understanding of the relative ease of converting land to these uses compared with paddy land conversion. We then calculated the output elasticities implicit in these transformation elasticities, and compared them with independent estimates (see Appendix 2 of supplementary material available from the authors or online at http://www.xyz) The transformation elasticities used in our core simulation are the outcome of these discussions and consistency checks.

[11] Specifically, we test the sensitivity of our results to changes in the Stage 1 land transformation elasticities by running a systematic sensitivity analysis using the method described in Horridge and Pearson

(2011). Results are reported in Appendix 1 of supplementary material available from the authors or online at http://www.xyz.

[12] Appendix 3 of supplementary material available from the authors or online at http://www.xyz explains how we developed our estimates of relative land rental rates from these sources.

[13] Equivalently, the phantom tax scheme could be implemented as either a tax on non-paddy use only, or a subsidy on paddy use only, with net revenue returned to households via a lump-sum grant.

[14] As we shall find in Section IV, the proportion of land that moves out of paddy and into other crops proves less than the proportion of paddy area reported by respondents in DERG (2011) as allocated to paddy because of the designation policy.

[15] Acording to the Government of Vietnam's plan, total agricultural land will decline by 11 per cent by 2030 due to the conversion of land to non-agricultural uses. There will be an additional loss of around 0.24 per cent of land if the sea level rises 17cm by 2030 due to climate change (NIAPP, 2010). However, the planned expansion of irrigation services as a climate change adaptation measure is expected to increase land available for cultivation by about 4.7 per cent (Zhu, 2010). In total, over 2009 – 2030, agricultural land in the baseline is projected to decline by 7 per cent, or 0.34 per cent per annum.

[16] See FAO (2003, p.29) for a widely used definition.

[17] This measure is used by the U.S. Department of Agriculture to measure food deficits in about 70 developing countries. Broadly, it measures the difference between available food and food needed to achieve a given nutritional standard (USDA, 2010).

[18] This measure is defined as the ratio of the value of food imports to the value of merchandise exports (Valdes and McCalla, 1999).

[19] The initial value for this share is calculated using household consumption data from the VHLSS 2004 and FAO calorie conversion factors, as used in Mishra and Ray (2009).

[20] FAO (1993, Ch.2) discusses malnutrition problems in 34 rice consuming countries. This is an important consideration in Vietnam. Vitamin and other nutritional deficiencies remain widespread, despite growing food surpluses and exports. For example, the 2009-2010 Nutrition Situation survey conducted by the National Institute of Nutrition and United Nations Children's fund (2011) found that among children

under five, the incidence of iron deficiency anaemia was 29% and vitamin A deficiency was 14%. Relatively high rates of child underweight and stunting conditions exist in Vietnam, even among those regions exhibiting high food surplus measures (such as the Mekong Delta).

[21] Regular surveys that are good candidates for adding such questions are the VHLSS and the VARHS (Vietnam Access to Resources Household Survey).

Table 1. Calculation of phantom tax factors

Region	A. Ratio of non-paddy rental rates & paddy rental rates (a)	B. Share in total agricultural land rentals of(b)		C. Phantom tax rates for(c)		D. Phantom tax factor for(d)	
		Paddy	Non-paddy	Paddy	Non-paddy	Paddy	Non-paddy
	P_N^r / P_P^r	S_P	S_N	R_P	R_N	T_P	T_N
Red River Delta	4.21	0.2	0.8	-1.56	0.39	2.56	0.61
Northern Mountainous Region	2.22	0.24	0.76	-0.72	0.23	1.72	0.77
North Central Coast	2.88	0.25	0.75	-0.96	0.32	1.96	0.68
South Central Coast	2.89	0.25	0.75	-0.96	0.32	1.96	0.68
Central Highlands	3.9	0.04	0.96	-2.49	0.10	3.49	0.90
South East	4.03	0.04	0.96	-2.59	0.11	3.59	0.89
Mekong River Delta	3.06	0.29	0.71	-0.92	0.37	1.92	0.63

Source: (a) Details are provided in Appendix 3 of an online document available at http://www.xyz or from the authors on request; (b) from the input output database of MONASH-VN; (d) calculated from columns (A) and (B) based on equations 8-9and (c) calculated from column (D) using the definition T=1-R.

Table 2. Land use and macroeconomic impacts *(% deviation from baseline)*

	2010	2015	2020	2025	2030
A. Land supply (acreage)					
1. Paddy	0.00	-9.45	-10.12	-10.44	-10.66
2. Other annual crops	0.00	8.32	8.14	7.75	7.39
3. Aquaculture	0.00	7.10	7.33	7.36	7.35
4. Perennial crops	0.00	2.78	2.78	2.68	2.58
B. Macro variables					
5. Real GDP at market prices	0.00	0.30	0.31	0.28	0.27
6. Land area (quantity weights)	0.00	0.00	0.00	0.00	0.00
7. Land area (rental weights)	0.00	1.75	1.84	1.85	1.84
8. Capital stock	0.00	0.08	0.13	0.08	0.03
9. Employment	0.00	0.12	0.05	0.01	0.00
10. Real private consumption	0.00	0.44	0.40	0.35	0.34
11. Real investment	0.00	0.31	0.10	0.00	-0.02
12. Real public consumption	0.00	0.00	0.00	0.00	0.00
13. Export volumes	0.00	-0.03	0.04	0.02	0.01
14. Import volumes	0.00	0.05	-0.01	-0.06	-0.08
15. Real wage	0.00	0.20	0.45	0.55	0.58

Table 3. Food security measures

	2010	2015	2020	2025	2030
Rice surplus index					
1. Level in the baseline scenario	1.705	1.905	2.086	2.244	2.375
2. Level in the policy scenario	1.705	1.828	1.967	2.107	2.223
3. Percentage deviation (policy vs. baseline)	0.00%	-4.01%	-5.71%	-6.10%	-6.40%
Food cover index					
4. Level in the baseline scenario	2.330	2.376	2.418	2.456	2.490
5. Level in the policy scenario	2.330	2.381	2.424	2.462	2.495
6. Percentage deviation (policy vs. baseline)	0.00%	0.19%	0.23%	0.22%	0.20%
Rice share in household calorie intake					
7. Level in the baseline scenario	0.610	0.530	0.445	0.364	0.292
8. Level in the policy scenario	0.610	0.526	0.439	0.357	0.286
9. Percentage deviation (policy vs. baseline)	0.00%	-0.76%	-1.38%	-1.84%	-2.25%
Percentage deviations in food prices (policy vs. baseline)					
10. Household price of rice	0.00	4.46	4.64	4.47	4.33
11. Weighted average price of the non-rice component of the household food bundle	0.00	-1.10	-1.21	-1.25	-1.28
12. Weighted average price of the household food bundle as a whole	0.00	-0.42	-0.52	-0.58	-0.62

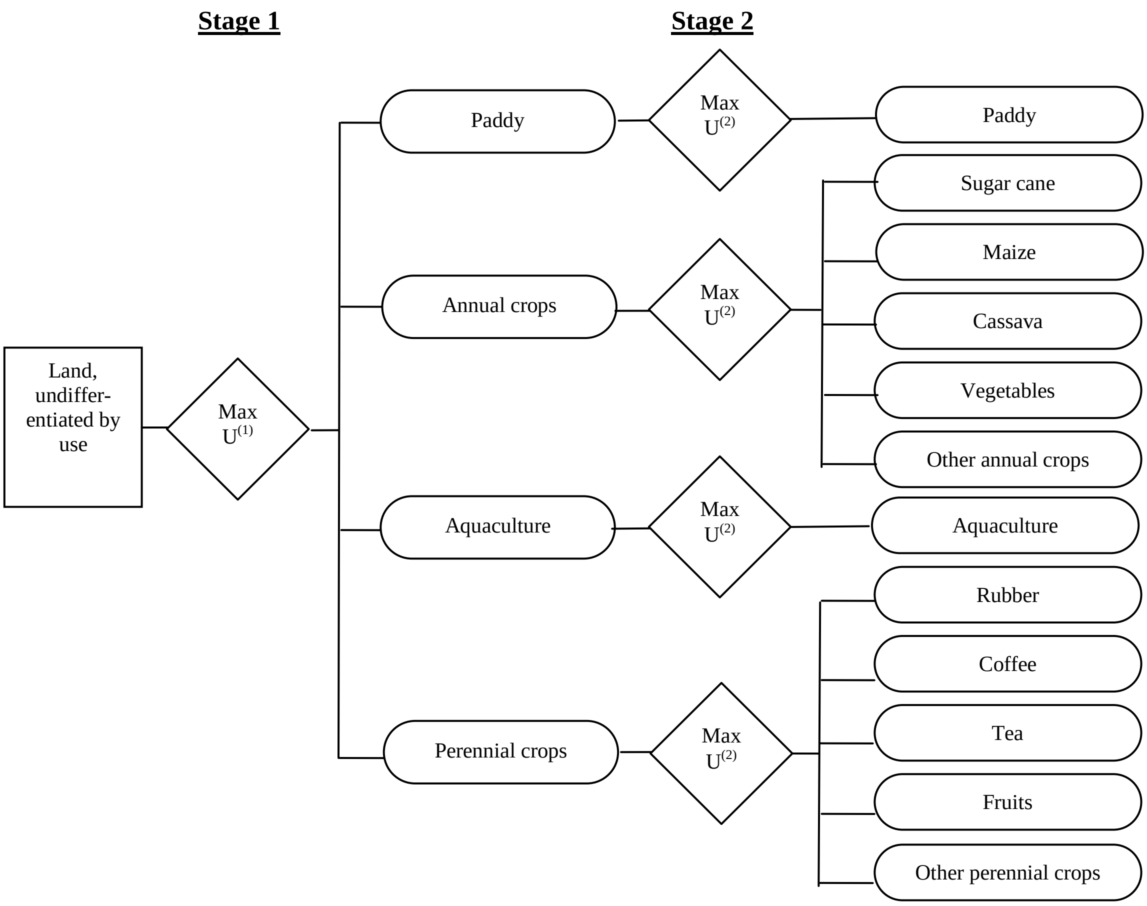


Figure 1. Structure of land supply within each region

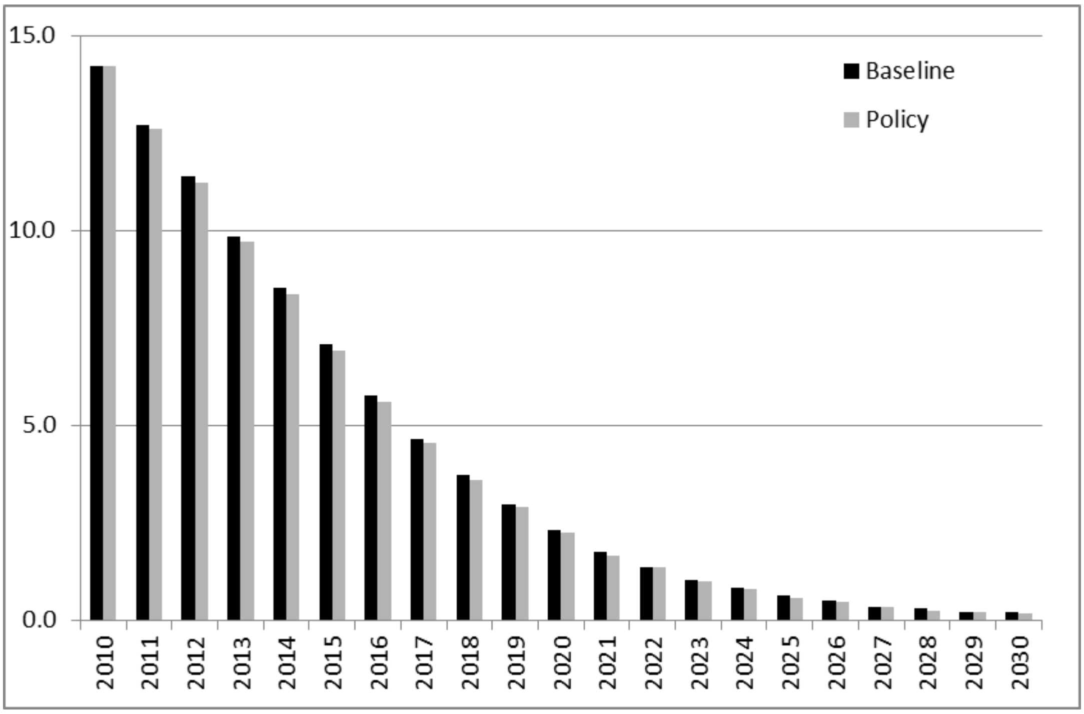


Figure 2. Poverty head count rates, baseline and policy.

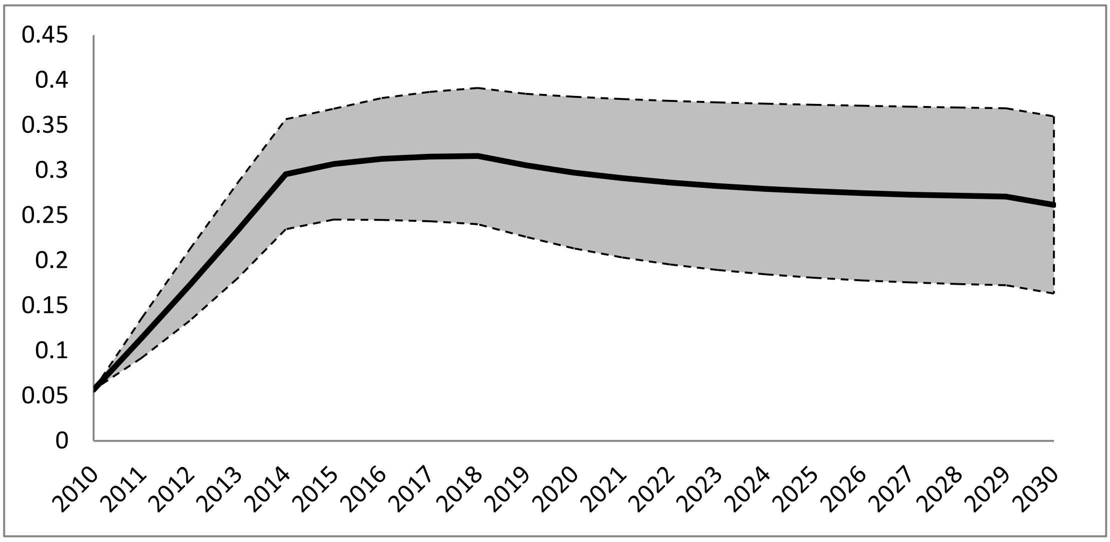
Supplementary material for "Rice land designation policy in Vietnam and the implications of policy reform for food security and economic welfare"

Appendix 1: Sensitivity analysis

Our policy simulation results derive mainly from land use changes in the first stage of the two-stage land allocation structure (see Figure 1 in the paper). We test the sensitivity of our results to changes in the Stage 1 land transformation elasticities by running a systematic sensitivity analysis (SSA) using the method described in Horridge and Pearson (2011). In the SSA, we vary the land transformation elasticities independently within a ± 50 per cent range according to a triangular distribution. Figure A1 reports the mean and the 95% confidence intervals for the percentage deviation in real GDP. The 95% confidence intervals are calculated using Chebyshev's inequality, the most conservative method for estimating a confidence interval where the distribution of the variable of interest is not known.

The sensitivity analysis suggests that the results of the core simulation reported in the paper are quite robust with regard to land transformation elasticities. The mean value of the GDP deviations under the sensitivity runs is almost identical to the real GDP deviation of the core simulation. Furthermore, we can be 95% confident that the average gain in real GDP over the period 2011-2030 will be within the range 0.19 to 0.36 per cent.

Figure A1. Real GDP and its 95% confidence intervals in the SSA
(Percentage change from baseline)



In investigating the results of the sensitivity simulations, we find that the higher real GDP deviations are associated with higher values for land transformation elasticities, and vice versa. This follows from the fact that, the higher are land transformation elasticities, the easier it is for land to move out of paddy (which has a relatively low rental rate) and into other uses (which have higher rental rates), when the land designation policy is removed.

In the paper we examined results for a number of food security indicators. Table A1 reports the mean and 95% confidence intervals for these indicators for both 2015 (the year in which the unwinding of the land designation policy is complete), and mean averages and confidence intervals for the period 2011-2030. In widening the potential range of the food security impacts through our sensitivity analysis, we find little in Table A1 that alters the main finding of the core simulation, namely, that removal of the designation policy is unlikely to have major impacts on food security.

Table A1. Mean and 95% confidence intervals for food security indicators in the SSA
(Percentage deviations from baseline)

Indicator	2015			Annual average 2011-2030		
	Mean	Min	Max	Mean	Min	Max
Rice surplus index	-4.01	-6.01	-2.02	-4.91	-7.42	-2.41
Food cover index	0.19	0.19	0.19	0.19	0.17	0.21
Rice share in household calorie intake	-0.76	-1.21	-0.31	-1.32	-2.10	-0.55
Household price of rice	3.20	1.95	6.96	4.33	1.56	6.38
Weighted average price of the non-rice component of the household food bundle	-0.85	-1.49	-0.70	-1.28	-1.46	-0.70
Weighted average price of the household food bundle as a whole	-0.33	-0.47	-0.38	-0.62	-0.52	-0.42

REFERENCE

Horridge, J.M., Pearson, R.K. (2011), ‘Systematic sensitivity analysis with respect to correlated variations in parameters and shocks’, GTAP Technical Paper No. 30, Center for Global Trade Analysis, Purdue University, West Lafayette.

Appendix 2. Relationship between land transformation elasticities and output supply elasticities: a check on MONASH-VN's land transformation elasticities

As discussed in Section II of the paper, in setting values for the model's agricultural land transformation elasticities, we relied on existing published estimates and advice from local agricultural experts, while also checking that the output supply elasticities implied by our transformation elasticities were consistent with elasticity estimates available from the published literature. This appendix documents these checks. We begin by outlining the relationship between output supply elasticities and land transformation elasticities. We then apply this theory to MONASH-VN data. We show that the MONASH-VN output supply elasticities implied by the MONASH-VN transformation elasticities lie within ranges established by independent published estimates.

We begin by defining the own-price elasticity of output supply (η_i^r) for industry *i* in region *r* as:

$$\eta_i^r = x_i^r / p_i^r \tag{A2.1}$$

where x_i^r and p_i^r are percentage changes in the quantity and price of output of regional industry (*i*,*r*).

Our task now is to express x_i^r and p_i^r as a function of the elasticity of substitution between labour, capital and land; the elasticity of land transformation across alternative land uses; and various shares relating to input costs and land use allocations.

We assume that cost-minimising producers combine units of capital, land, and composite labour in a CES production function to produce a composite primary factor input. The linearised cost-minimising input demand functions and unit cost function that arise from this problem are:[1]

$$x_{(K),i}^r = x_i^r - \sigma_i^r \times \left(p_{(K),i}^r - p_{(V),i}^r \right) \tag{A2.2}$$

$$x_{(L),i}^r = x_i^r - \sigma_i^r \times \left(p_{(L),i}^r - p_{(V),i}^r \right) \tag{A2.3}$$

$$x_{(N),i}^r = x_i^r - \sigma_i^r \times \left(p_{(N),i}^r - p_{(V),i}^r \right) \tag{A2.4}$$

$$p_{(V),i}^r = S_{K,i}^{(V)r} \times p_{K,i}^r + S_{L,i}^{(V)r} \times p_{L,i}^r + S_{N,i}^{(V)r} \times p_{N,i}^r \tag{A2.5}$$

where

σ_i^r is elasticity of substitution between primary factors faced by industry (*i*,*r*);

[1] See the derivation of these linearised equations in Dixon *et al* (1992).

$x^r_{(K),i}$, $x^r_{(L),i}$ and $x^r_{(N),i}$ are respectively the percentage changes in capital, labour and land employed in regional industry (*i*,*r*);

$p^r_{(K),i}$, $p^r_{(L),i}$ and $p^r_{(N),i}$ are respectively the percentage changes in the rental price of capital, nominal wage rate, and the rental price of land employed in regional industry (*i*,*r*);

$p^r_{(V),i}$ is the percentage change in the average price of primary factors used by industry (*i*,*r*); and

$S^{(V)r}_{(K),i}$, $S^{(V)r}_{(L),i}$ and $S^{(V)r}_{(N),i}$ are the shares of payments to capital, labour and land in industry (*i*,*r*)'s total primary factor costs.

The percentage changes in each industry's output price is a cost-share weighted average of the percentage changes in the prices of the industry's input costs, as follows:

$$p^r_i = S^r_{(V),i} \times p^r_{(V),i} + S^r_{(Int),i} \times p^r_{(Int),i} \tag{A2.6}$$

where:

$p^r_{(Int),i}$ is the percentage change in the average per-unit price of intermediate inputs; and

$S^r_{(V),i}$ and $S^r_{(Int),i}$ are, respectively, the shares of payments to primary factors and intermediate inputs in industry (*i*,*r*)'s total production costs.

We assume land supply functions which, when represented in percentage change terms, are of the following form:[2]

$$x^r_{(N),i} = x^r_{(N)} + \varepsilon^r_{(N),i} \times \left(p^r_{(N),i} - p^r_{(N)} \right) \tag{A2.7}$$

$$p^r_{(N)} = \sum_{i \in \{land\ users\}} \theta^r_{(N),i} \times p^r_{(N),i} \tag{A2.8}$$

where:

$x^r_{(N)}$ is the percentage change in the total quantity of agricultural land in region *r*.

$p^r_{(N)}$ is the weighted average (using land area weights) percentage change in the average rental price of land in region *r*;

$\theta^r_{(N),i}$ is the area of land used by industry (*i*) in region (*r*) expressed as a share of the total agricultural land area in region (*r*);

$\varepsilon^r_{(N),i}$ is an elasticity measuring the responsiveness of land supply to industry (*i*,*r*) to changes in the ratio of the land rental price in industry (*i*,*r*) to the average land rental price in region (*r*).

[2] See Section II of the main paper for the derivation of these land supply functions from an explicit optimization framework.

We now use the system of equations (A2.2) – (A2.8) to determine the short-run output elasticity (η_i^r) as defined by (A2.1). In the short run, we assume that: (i) capital stocks are unchanged (hence $x_{(K),i}^r$ = 0); (ii) total regional agricultural land is given (hence $x_{(N)}^r$ =0); (iii) the wage rate is determined independently of agricultural activity (hence $p_{(L),i}^r$ =0); and, (iv) the price of intermediate inputs is determined independently of agricultural activity (hence $p_{(Int),i}^r$ =0). Assuming also that the land rental rates in all agricultural industries *j≠i* are given, equations (A2.2) – (A2.7) become:

$$0 = x_i^r - \sigma_i^r \times \left(p_{(K),i}^r - p_{(V),i}^r \right) \qquad \text{(A2.9)}$$

$$p_{(V),i}^r = S_{(K),i}^{(V)r} \times p_{(K),i}^r + S_{(N),i}^{(V)r} \times p_{(N),i}^r \qquad \text{(A2.10)}$$

$$x_{(N),i}^r = x_i^r - \sigma_i^r \times \left(p_{(N),i}^r - p_{(V),i}^r \right) \qquad \text{(A2.11)}$$

$$x_{(N),i}^r = \varepsilon_{(N),i}^r \times \left(p_{(N),i}^r - p_{(N)}^r \right) \qquad \text{(A2.12)}$$

$$p_{(N)}^r = \theta_{(N),i}^r \times p_{(N),i}^r \qquad \text{(A2.13)}$$

$$p_i^r = S_{(V),i}^r \times p_{(V),i}^r \qquad \text{(A2.14)}$$

We begin by using (A2.9) and (A2.10) to solve for $p_{(K),i}^r$:

$$p_{(K),i}^r = \frac{x_i^r + \sigma_i^r S_{(N),i}^{(V)r} p_{(N),i}^r}{\sigma_i^r (1 - S_{(K),i}^{(V)r})} \qquad \text{(A2.15)}$$

Equating (A2.11) and (A2.12):

$$\varepsilon_{(N),i}^r \times \left(p_{(N),i}^r - p_{(N)}^r \right) = x_i^r - \sigma_i^r \times \left(p_{(N),i}^r - p_{(V),i}^r \right) \qquad \text{(A2.16)}$$

Substituting (A2.13) into (A2.16) gives:

$$p_{(N),i}^r = \frac{x_i^r + \sigma_i^r p_{(V),i}^r}{\varepsilon_{(N),i}^r (1 - \theta_{(N),i}^r) + \sigma_i^r} \qquad \textbf{(}\text{A2.17}\textbf{)}$$

Using (A2.17), (A2.15), (A2.10), (A2.14) and (A2.1), the output supply elasticity can be calculated as:

$$\eta_i^r = \frac{\sigma_i^r}{S_i^{(V)r}} \times \frac{\varepsilon_{(N),i}^r (1 - \theta_{(N),i}^r)(1 - S_{(K),i}^{(V)r}) + \sigma_i^r S_{(L),i}^{(V)r}}{\varepsilon_{(N),i}^r (1 - \theta_{(N),i}^r) S_{(K),i}^{(V)r} + \sigma_i^r (1 - S_{(L),i}^{(V)r})} \qquad \text{(A2.18)}$$

(A2.18) relates the output elasticity for commodity *i* to data and parameter values that can be evaluated from a CGE model database. We evaluate (A2.18) using data from the MONASH-VN database. Table A2.1 reports our estimation of η_i^r. Columns (1) – (7) report economy-wide values evaluated from the MONASH-VN database. Using (A2.18), Column (8) reports implicit output elasticities. Column (9) reports the range of commodity-specific output elasticities available from the literature. A summary of this literature is reported in Table A2.2. Comparing columns (8) and (9) of Table A2.1, we find that the implicit MONASH-VN output elasticities lie within published estimates.

Table A2.1 Data for the estimation of output supply elasticities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sector	Elasticity of substitution between primary factors[(a)]	Land transformation elasticity[(b)]	Land area share in total agriculture land[(c)]	Labour share in factor costs[(c)]	Capital share in factor costs[(c)]	Land share in factor costs[(c)]	Share of value added in total costs[(c)]	Output supply elasticity[(d)]	Available estimates for short-run supply elasticity[(e)]
	σ_i	$\varepsilon_{(N),i}$	$\theta_{(N),i}$	$S_{(L),i}^{(V)}$	$S_{(K),i}^{(V)}$	$S_{(N),i}^{(V)}$	$S_{(V)i}$	η_i	
1.Paddy	0.2	0.3	0.40	0.55	0.06	0.39	0.69	0.81	0.02 – 0.95
2.Other annual crops	0.2	0.5	0.27	0.54	0.20	0.25	0.84	0.57	0.02 – 2.85
3.Perennual crops	0.2	0.15	0.23	0.40	0.36	0.23	0.72	0.27	0.04 – 1.10
4.Aquaculture	0.2	0.25	0.09	0.38	0.20	0.42	0.64	0.47	0.06– 1.33

Note: (a) Taken from the GTAP database (Narayanan and Walmsley, 2008) and employed in MONASH-VN. (b) Taken from the MONASH-VN model database. (c) The share of value added in total costs is based on the Vietnamese IO table for 2005. Because the IO table does not distinguish sector-specific agricultural land rentals, we use factor shares from the 2003 Vietnamese SAM of Jensen and Tarp (2007) and the GTAP database to reallocate agricultural value added in the IO table. SAM 2003 was used for paddy, other annual crops and perennial crops. The GTAP database was used for aquaculture. (d) Calculated using equation (A2.18). (e) See Table A2.2 for the sources of these estimates. For a general discussion of the reasons for wide dispersion in published output supply elasticity estimates, see Sadoulet and de Janvry (1995: 85-111), Yu and Fan (2011).

Table A2.2 Estimates of output supply elasticities relevant to Vietnam

Crops, Survey/Study	Country	Period	Average[(a)]	Min[(b)]	Max[(c)]
1. RICE					
Scandizzo and Bruce (1980), cited in Sadoulet and de Janvry (1995)	Thailand, India, Pakistan, Bangladesh, Philippines, Indonesia, Malaysia, Taiwan, South Korea, Sri Lanka, Egyp, Iraq	1949-1974	0.286	0.080	0.700
Khiem and Pingali (1995), Danh (2007), cited in Yu and Fan (2011)	Vietnam	1975-2003	0.264	0.1	0.37
USDA (2000), cited in Yu *et al.* (2011)	China	1970-1987			
USDA (2000), cited in Yu *et al.* (2011)	China	1986-1997			
Mythili (2006)	India	1970-1990	0.155		
Mythili (2006)	India	1990-2000	0.161		
Review by Yu and Fan (2009)	Thailand	1951-1990s	0.362	**0.020**	0.650
Review by Yu and Fan (2009)	Indonesia	1969-2000	0.312	**0.020**	0.680
Review by Yu and Fan (2009)	Philippines	1949-1978	0.484	0.070	**0.950**
Review by Yu and Fan (2009)	Sri Lanka	1952-2000	0.247	0.090	0.609
Review by Yu and Fan (2009)	Asia	1966-2005	0.239	0.170	0.280
Yu and Fan (2009)	Cambodia	2004 and 2007	0.240	0.110	0.330
Kumar *et al.* (2010)	India	1981-2005	0.236		
2. ANNUAL CROPS					
2.1 Wheat					
Scandizzo and Bruce (1980), cited in Sadoulet and de Janvry (1995)	India, Pakistan, Egypt, Syria, Iraq, Jorden, Lebanon, Kenya	1950-1972	0.548	0.070	1.590
Kumar *et al.* (2010)	India	1981-2005	0.216		
Seeborg and Krzyzanowski (1990)	Poland	1971-1985	0.971		
Mythili (2006)	India, by state	1970-1990	0.333		
Mythili (2006)	India, by state	1990-2000	0.352		
2.2. Barley					
Scandizzo and Bruce (1980), cited in Sadoulet and de Janvry (1995)	India, Parkistan, Brazik, Syria, Iraq, Jordan, Lebanon, India	1951-1972	0.544	0.030	**2.850**
Lu 2002, cited in Yu *et al.* (2011)	China	1985-1997			
Huang and Rozelle 1998, cited in Yu *et al.* (2011)	China	1975-1992	0.366		
2.3. Maize					
Scandizzo and Bruce (1980), cited in Sadoulet and de Janvry (1995)	Kenya, Egypt, Syria, Fordan, Lebanon, sudan	1950-1972	0.372	0.040	0.950
USDA 2000, cited in Yu *et al.* (2011)	China	1970-1987	1.030		
USDA 2000, cited in Yu *et al.* (2011)	China	1986-1997	1.170		
Arnade and Kelch (2007)	Iowa	1960-1999	0.201		
2.4. Cassava					
Scandizzo and Bruce (1980), cited in Sadoulet and de Janvry (1995)	Thailand	1951-1965	1.090		
2.5. Soybean					
USDA 2000, cited in Yu *et al.* (2011)	China	1970-1987			
USDA 2000, cited in Yu *et al.* (2011)	China	1986-1997			
Wang 2000, cited in Yu *et al.* (2011)	China	1952-1997	0.324		
Arnade and Kelch (2007)	Iowa	1960-1999	0.314		
2.6. Potatoes					
Scandizzo and Bruce (1980), cited in Sadoulet and de Janvry (1995)	Syria, Lebanon	1950-1972	0.595	0.540	0.650
Huq and Arshad (2010)	Bangladesh	1980-2006	0.445		
2.7. Beet					
Seeborg and Krzyzanowski (1990)	Poland	1971-1985	0.434		
2.8. Pulse					
Huang and Rozelle 1998, cited in Yu *et al.* (2011)	China	1975-1992	0.039		
Kumar *et al.* (2010)	India	1981-2005	0.170		

Table A2.2 Estimates of output supply elasticities relevant to Vietnam (continued)

Crops, Survey/Study	Country	Period	Average[(a)]	Min[(b)]	Max[(c)]
2.9. Oil seeds					
Kumar *et al.* (2010)	India	1981-2005	0.508		
2.10. Cotton					
Mythili (2006)	India, by state	1970-1990	0.302		
Mythili (2006)	India, by state	1990-2000	0.304		
Many studies, cited in Rudaheranwa (2003)	Nigeria, Sudan, Uganda	1922-1967	0.394	**0.020**	0.730
2.11. Sugarcane					
Kumar *et al.* (2010)	India	1981-2005	0.122		
Mythili (2006)	India, by state	1970-1990	0.382		
Mythili (2006)	India, by state	1990-2000	0.369		
2.12. Groundnut					
Mythili (2006)	India, by state	1970-1990	0.247		
Mythili (2006)	India, by state	1990-2000	0.238		
2.13. Bean					
Vanegas 1992, cited in Rudaheranwa 2003	Uganda	1970 - 1988	0.260	0.110	0.540
Sserunkuma et al 1993, cited in Rudaheranwa *et al.* 2003	Uganda	1970 - 1991	0.440		
Arnade and Kelch (2007)	Iowa	1960-1999	0.890		
2.14. Vegetables					
Onyango and Bhuyan, (c. 2000)	New Jersey	1980-1997	0.563		
Onyango and Bhuyan, (c. 2000)	New Jersey	1980-1997	0.847		
3. PERENNIAL CROPS					
3.1. Fruits					
Onyango and Bhuyan, (c. 2000), for apples	New Jersey	1980-1997	0.630		
Onyango and Bhuyan, (c. 2000), for apples	New Jersey	1980-1997	0.852		
Laajimi *et al.*, (2008), for peach	Tunisia	1980-2004	0.070		
Clearsby *et al.*, (1991), for deciduous	South Africa		0.070		
3.2. Coffee					
McLaren and Fleming (1999)	Papua New Guinea	1977-1995	0.230		
Kumar and Sharma (2006)	India	1974-1999	0.255	0.190	0.320
Mwesigye (1989), Jolly *et al.* 1990, Temu (1991), Overfield (1991), cited in McLaren and Fleming (1999)	Papua New Guinea		0.203	0.160	0.270
Many studies, cited in Rudaheranwa (2003)	Uganda, Kenya, Africa	1926-1973	0.518	0.120	0.660
3.3. Tea					
Rahman (2007), cited in Imai *et al.* (2011)	Bangladesh		**1.100**		
Chowdhury and Ram (1978), cited in Kumar and sharma (2006)			0.320		
Kumar and Sharma (2006)	India	1974-1999	0.125	0.100	0.150
3.4. Rubber					
Kumar and Sharma (2006)	India	1974-1999	0.085	0.070	0.100
Uma Devi (1977), cited in Kumar and Sharma (2006)	India		0.190		
Viju and Prabhakaran (1988), cited in Kumar and Sharma (2006)	India		**0.040**		
3.5. Banana					
Sserunkuma *et al.*, (1992), cited in Rudaheranwa *et al.*, (2003)	Uganda	1970 - 1991	0.350		
4. AQUACULTURE					
Kumar *et al.* (2006), for fish	India, state data	1991-1999	0.315		
Kumar *et al.* (2006), for shrimp	India, state data	1991-2000	0.494		
Kumar *et al.* (2006), for mulluses	India, state data	1991-2001	0.278		
World Fish Centre model (2004)	Bangladesh, China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Vietnam		0.748	0.270	**1.330**
Traesupap *et al.* (1999)	Japan		**0.060**		

Note: (a) This column reports either the elasticity estimate where the study reports only one value, or an average of all estimates where the study reports many estimates for the same crop (for example, where the paper covers many regions within a country, or many countries within a study). (b) Minimum value of many estimates within a study. (c) Maximum value of many estimates within a study.

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Appendix 3: Sources and methods for estimating relative land rental rates

To our knowledge, there have been no Vietnamese studies specifically related to relative land rental rates (hereafter RLRR) between different crops within different regions. We developed our RLRR estimates from a number of sources, the two most important being Dao (2010) and Le *et al.* (2010). Dao (2010) provides RLRR estimates for maize, cassava, vegetables, sugar cane, tea, coffee and fruits in the Red River Delta, North Mountainous Area, and North Central Coast regions. We calculated RLRR for vegetables, fruits and aquaculture in Mekong River Delta using data on land rental rates per hectare from Le *et al.* (2010). Dao (2010) and Le *et al.* (2010) cover the major crops in the most important agricultural regions. However, we still require RLRR estimates for a number of other crops and regions, the two most important being Central Highlands coffee and South East rubber. Cheesman *et al.* (2007) and SCAP (2010) provide data allowing estimation of profit per hectare for coffee in the Central Highlands region. Sinh Thai Trung Viet (2010) and Thanh Nam (2010) provide insights into the profitability of rubber relative to paddy in the South East region. RLRRs between tea and paddy for the North Mountainous Area and Central Highland regions were obtained from SCAP (2010). The above sources provide RLRR estimates for all crops in most regions, covering 70 per cent of crop production. However, the model requires RLRRs for all crops in all regions. For those regional crops for which independent RLRR estimates could not be made, we adopted a weighted average of those regional RLRRs for which the above sources provided estimates. Finally, we presented our RLRR matrix for review and feedback by a panel of agricultural experts from CASRD (Centre for Agrarian System Research and Development), IPSARD (Institute of Policy and Strategy for Agricultural and Rural Development), MDI (Mekong Development Institute), and the Rural Development Sector of the World Bank Hanoi Office.

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