THE WELFARE OF SMALL LIVESTOCK PRODUCERS IN VIETNAM UNDER TRADE LIBERALISATION - INTEGRATION OF TRADE AND HOUSEHOLD MODELS

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Abstract

Vietnam has negotiated a series of bilateral and multilateral trade agreements and has made significant steps in integrating into the world economy. This integration is likely to have both positive and negative effects on different stakeholders in the economy. This paper seeks to measure the effects on the welfare of Vietnam's small livestock producers' by linking a household model and the GTAP trade model. A GTAP utility SplitCom is used to separate out pig and poultry prior to several trade liberalisation scenarios being run. A recursive household model with a two-stage LES-AIDS model on consumption side and Cobb-Douglas functions on production side are used. Impacts of likely changes in the prices of inputs and outputs arising from different trade scenarios on behavior and welfare of the farm household are presented.

I. Introduction

WTO accession by Vietnam on 11 January 2007 as the 150th member of this organization culminated a long process of efforts to integrate of the Vietnamese economy into international markets. The integration started in 1986, when the Doi Moi restructuring process began. In the integration process, Vietnam negotiated and signed with more than 100 trade partners. Among them, a bilateral agreement with the European Union (EU) was signed in 1992, an agreement to become an official member of ASEAN in 1995 and joint ASEAN Free Trade Area (AFTA) in 1996 was implemented, and in 2000 Vietnam entered into a bilateral trade agreement (BTA) with the USA.

Each time such a major agreement was reached, Vietnam's trade with that region expanded, and these trade agreements were clearly an impetus to ongoing domestic economic reforms in Vietnam to become a more open economy in the process of integration into the global economy. Implementation of multilateral and bilateral trade agreements is likely to provide benefits for the economy and increase welfare for society. In case of the livestock sector, trade liberalisation may bring both opportunities and threats, and have effects on both supply side and demand side. For example, income growth may increase demand for meat, but the domestic industry may also have to compete with imported products. Reducing tax on imported maize/or soybean may make feed prices decrease, but the opportunity cost of labour in livestock production may increase.

Livestock in Vietnam are predominantly raised in small-scale household production units. At present, small holder producers supply the majority of the meat in the market,

with most households operating individually in the production and marketing of livestock and livestock products. For most of those households, raising livestock is an important source of cash income, providing at least 50 percent of cash income in small households (Lapar, Vu & Ehui 2003). The small household's livestock production is constrained by poor access to markets, a very low scale of operation, poor access to improved genetics and to high-quality forage and concentrates, and poor animal husbandry and animal nutrition. In that context, it is not clear whether the small livestock households will be worse off or better off from the effects of trade liberalisation.

Objective of the Study and Paper's Structure

The objective of the study is to analyze implications of trade liberalisation on Vietnam's small scale livestock producers. The paper will examine how welfare of the households is affected when prices change due to trade liberalisation, and also seeks how household's production and consumption actions change when trade scenarios happen.

The paper is organized as follows: in the next section, methodology is presented that tries to link the international trade model with the household model to quantify welfare impacts on the small households as a consequence of trade liberalisation. The following part presents the trade model and household model, and the results of linking the 2 models together. The results of changes in welfare and production and consumption behaviors of the household are presented, with some conclusions drawn at the end of the paper.

II. Methodology and the models

To model trade liberalisation, both bilateral as well as multilateral trade agreements between Vietnam and the others countries, a multi-country general equilibrium model is used. The Global Trade Analysis Model (GTAP), with its focus on worldwide trade policy, is suitable for this purpose. Since the latest version and the most recent database of GTAP includes data for Vietnam, the Vietnamese economy with all its factor and activity flows is represented in the model.

Given the aim of investigating welfare changes of the household, and the reaction of the household production and consumption behaviors, price changes for consumption commodities, as well as production factors, including labour in the agricultural sector shall be incorporated. This information can be derived from the results of the GTAP simulation. The research only examines one-way effects of trade liberalisation on

households, but not their influencing the international arena. Therefore, an approach that incorporates feedback from the households to the international system is not required. In this study, an approach of combining the GTAP general equilibrium model with a micro level of a household model is chosen. By linking to a household model, response of the household to price signals in term of substitution between commodities in consumption and production, and also in labour allocation will be captured.

Since the target of the study is small households in the livestock sector, especially the households raising pigs and chickens, how trade liberalisation affects individual sub-sectors is especially considered. That the reason why software SplitCom is used to separate pig and poultry out of the aggregate group of livestock in the standard GTAP framework.

1. Trade Model – GTAP and SplitCom

GTAP was initially developed in 1992 at Purdue University in the USA. It is a standard CGE model based on the neoclassical theory of firm and household behavior assuming perfect competition, rational and utility optimizing behavior. It is designed to be a multi-region, general equilibrium model with bilateral trade flows between all regions and linkages between economies and between sectors within economies. The model uses the Armington approach by which products are differentiated by origin and are assumed to substitute imperfectly for one another forming a composite import aggregate that substitutes imperfectly for domestically produced goods. Primary factors (land, unskilled labour, skilled labour, capital and natural resources) are substitutable but as a composite are used in fixed proportions to intermediate inputs. The standard model is a comparative static model which means that after introducing an exogenous shock like a policy change the model works out a new equilibrium in all markets and determines new values for the endogenous variables.

Simulations are undertaken using the GTAP version 6.2 database. The database has 96 countries and regions and 57 sectors that are initially aggregated up to 18 commodity groups, and 20 countries and regions. The database includes tariffs, export subsidies and taxes, subsidies on output and on inputs such as capital, labour and land, and applies to 2001. The regional aggregation aims to split out the ASEAN countries as much as possible while grouping together African and Latin American countries with which Vietnam's trade is limited. The sector aggregation attempts to split out sectors with significant protection, such as textiles and apparel, manufactures, and electronics.

Since the study is interested in the impacts of trade liberalisation on the households who raise pig and chicken as one main source of income, price changes of these two commodities are especially considered. That is the reason of implementation of SplitCom, which is the program developed by Centre of Policy Studies (Monash University) in 2005 to provide the tool that is necessary for splitting GTAP commodities into homogeneous and differentiated sub-groups. Pig and poultry were taken separately from the group of OAP, which includes live pig, live poultry and other animals, creating 2 more commodities LivePig and LivePoultry, and then the rest of the group is called LiveOther. Therefore the database now is disaggregated to a total of 20 commodity groups and 20 regions and countries for simulation (detail in Annex A1 and A2). In order to use these new commodities, GTAP requires a TAB file which updates the *userwgt.har* file of the SplitCom. This includes weights in bilateral trade flows, in production and consumption of new commodities/or sector both as final and intermediate inputs. Data from UN Comtrade, International Statistics, WITS, FAOStat, and SAMs of countries were explored for this purpose. The table below presents outputs and trade data of sectors of Vietnam year 2001.

Table 1: Vietnam's Output and Trade Flows, 2001 (mil. USD)

Sector	Output	Export	Import
Paddy and processed rice	6467	374	17
Vegetable and fruit	1902	257	71
Other crops	1541	810	225
Live Pig	881	2	5
LivePoultry	434	0	7
LiveOther	545	62	29
Pork, poultry, and other meats	168	33	20
Beef and sheep meats	22	0	7
Fishing	1541	49	6
Oilseed and vegetable oil	93	45	90
Processed food	2895	1365	374
Beverages and tobacco	1222	22	395
Milk and dairy products	241	2	239
Natural res, petroleum product	3703	2346	1692
Chemical, rubber, plastic	2938	495	2796
Textile and apparel	7994	4746	1848

Manufactures	10203	2313	6780
Electronic	528	446	1002
Transport, communication	2143	534	2546
Services	26763	1552	6997
Total	72223	15453	25145

Source: GTAP v.6.2

The default solution method for the GTAP model is Gragg's method where the model is solved several times with an increasingly fine grid. The resulting price changes for commodities as well as for production factors are used in simulation analysis of the household model. The standard GTAP closure, in which prices, quantities of all non-endowment commodities, and regional incomes are endogenous variables, conversely, policy variables, technical change variables, and population are exogenous to the model, is used in simulations of this study.

Trade Scenarios of Trade Liberalisation Simulation

In this study, several scenarios are explored using the GTAP model. The first one is Vietnam unilateral trade liberalisation; it means Vietnam complete removals all of its trade taxes. This voluntary makes Vietnam obtain some benefit itself without negotiating with others. However, the market access benefits are limited because other countries do not open their markets.

The second scenario is when Vietnam and all other ASEAN countries fully eliminate all tariff and subsidies, and apply a free trade area in ASEAN. The trade barriers among the other countries still stay the same.

The third scenario involves the extension of AFTA by expanding the free trade area to include Japan, Korea and China. In this scenario, China is a competitor of many ASEAN economies, with its large, low-cost labour force, and it may have some impacts for adjustment in the economies of ASEAN in general and Vietnam in particular.

Bilateral trade agreements are relatively easy to negotiate but are of limited value if the two economies are similar. For developing countries, agreements with large developed countries are generally considered the most beneficial. An agreement between Vietnam and the USA and between Vietnam and EU are considered here. Reasons for choosing USA and EU is that both of them are big economies, the USA seems to be potentially an

exporter of maize and soybean to Vietnam and it may effect the livestock sector, and both USA and EU are big trade partners of Vietnam in apparel and textile trading.

Multilateral liberalisation refers to a potential WTO agreement. To simplify the analysis a 50 per cent reduction in tariffs, exports subsidies and domestic support for all regions is assumed.

The final simulation is globalization, without any trade barriers among countries over the world that indicate the potential gains from trade liberalisation and the opportunity cost of not liberalising fully.

Table 2: Alternative Trade Scenarios

Scenarios	Title	Change in tariffs
1 Uni	Vietnam unilateral trade liberalisation	- 100% import tax in VNM
2 AFTA	Free trade area in ASEAN	ASEAN countries exempt 100% import tax to each others
3AFTA+3	Free trade area in ASEAN plus China, Japan and Korea	ASEAN countries and JPN, KOR, CHN exempt 100% import tax to each others
4 VNM-USA	Bilateral trade between VNM and USA	VNM and USA exempt 100% on trade between 2 countries
5 VNM-EU25	Bilateral trade between VNM and EU	VNM and EU25 exempt 100% on trade between 2 regions
6 Multi	Multilateral trade liberalisation	- 50% import tax of all countries
7 Glob	Free trade over the world	- 100% tax all regions

2. The Household Model

The Theoretical Framework of a Household Model

This section will present the theoretical framework of a household model. The model of household behavior presented here is a semi-commercial family farm with a competitive labour market. As in other LDCs countries, this type of farm is common in Vietnam, and lies on a continuum between wholly commercialized farms employing only hired labour and marketing all output and a pure subsistence farm using family labour and producing

solely for home consumption.However the competitive labour market assumption may not hold: this is examined later.

In general, an agricultural household is assumed to maximize its utility function. This is specified as a function of market purchased goods, home produced goods, and leisure time, and is written succinctly as:

$$U = U(L, C, M, a_i) \qquad \text{i =1, ….,} \qquad (1)$$

where:

L = leisure,

C = own-consumption of agricultural output,

M = consumption of market purchased goods,

a_i = household characteristics (for example, number of dependents)

Clearly, L, C, and M can be vectors of commodities or leisure consumption for different members of the household. This optimization is subject to certain constraints. In the household model the objective function is constrained by the three restrictions on the household's actions.

The first one is the technology constraint(s):

$$F = F(D, d_{j,} A) \qquad \text{j=1,…..,} \qquad (2)$$

where:

F = total agricultural output,

D = total labour inputs (both family and hired) used in production of F,

d_j = other variable inputs,

A = area of land used in F production,

The production function of the household is assumed to be quasi-convex and increasing in inputs, but marginal product is decreasing in inputs. The household can produce more than one output, and hence can have more than one technology constraints. However, the total land for cultivation activity is (here) assumed to be fixed.

The household has the opportunity of utilizing its total endowment of time in either working on or outside its farm, or taking leisure:

$$T = L + H_f + H_{off} \qquad (3)$$

As mentioned above, the total working time for farm job, *D*, includes both family working labour, and labour hired from outside (if needed)

$$D = H_f + H_{hired} \quad (4)$$

So if combining (3) and (4) together, we can rewrite the time constraint of the household as follows:

$$T = L + D + H_{off} - H_{hired} \quad (5)$$

where

T = total household time available for labour,

L =leisure,

D = total labour inputs (both family and hired) used in production of F,

H_f = time working on its farm of family labour,

H_{off} = time working off- farm of family labour,

H_{hired} = working time of labour hired in for farm,

The household maximizes its utility subject to a budget constraint, which defines that total expenditure for physical commodities can not over the total money that household can get from work plus exogenous income. Assume that family labour and hired labour are perfect substitutes and face with the same wage rate.

$$qM + pC = w(H_{off} - H_{hired}) + R + pF - \sum w_j d_j \quad (6)$$

where

R = non-wage, non-farm net other income,

q = price of M,

p = price of C,

w = wage-rate,

H_{off} = time working off- farm of family labour,

H_{hired} = working time of labour hired in for farm,

w_j = prices of other variable factors.

In order to simplify the problem, those three constraints can be collapsed into a single constraint, namely the “full income” constraint as follows:

$$qM + pC + wL = \Pi + R + wT \quad (7)$$

where $\Pi = pF(D) - wD - \sum w_j d_j$ is net profit from the household's agricultural production. The left-hand side of equation (7) is total expenditure of the household, includes the "expenditure" on leisure and the right-hand side is an augmented version of Becker's concept of "full income", which is the sum of any non-wage, non-farm net other income (*R*), a measure of the farm's profits (∏), and the value of the household's stock of time (*wT*) (Becker, G. 1965). Since land is treated as a fixed factor, the rent payments or receipts, if any, are captured in the definition of *R*.

This "full income" constraint in particular distinguishes agricultural household models from other approaches and highlights the interdependency between consumption and production decisions made at the household level. Farm technology, quantities of fixed inputs, and prices of variable inputs and outputs affect household consumption decisions since they determine the size of the farm profit portion of the full income constraint. Thus, this approach permits the identification of the linkages between farm household production and consumption decisions.

By rearranging the full income constraint, now the problem of the household is maximizing its utility (1) with the constraint (7). The household can choose quantities of the consumption for commodities and labour input for agricultural production. Forming the Lagrangian, the household problem takes the following form:

$$\Re = U(L, C, M) + \lambda(Y^* - qM - pC - wL) \quad (8)$$

Where λ is the Lagrangian multiplier and Y^* is the value of the full income that results from profit maximizing behavior:

$$Y^* = wT + R + \Pi^* = wT + R + pF(D^*, d_j, \overline{A}) - \sum w_j d_j - wD^* \quad (9)$$

where D^* is labour input that household chose for farm's agricultural production to get maximum profit Π^* , with the land cultivation fixed $\overline{A}$. So the Kuhn-Tucker marginal conditions at the point of the optimum are:

$$\frac{\partial \Re}{\partial L} = \frac{\partial U}{\partial L} - \lambda w = 0 \quad (10a)$$

$$\frac{\partial \Re}{\partial M} = \frac{\partial U}{\partial M} - \lambda q = 0 \quad (10b)$$

$$\frac{\partial \Re}{\partial C} = \frac{\partial U}{\partial C} - \lambda p = 0 \qquad (10c)$$

$$\frac{\partial \Re}{\partial \lambda} = Y^* - qM - pC - wL = 0 \qquad (10d)$$

The marginal conditions of the equations (10) can be solved to yield demand equations for choice variables X_i, which can be *C, M, L* as follows:

$$X_i = X_i(q, p, w, Y^*, a_i) \qquad (11)$$

The demand system follows neoclassical theory, where demand depends upon prices, income, and possibly household characteristics. However, in the household model, full income, Y^*, is determined by technological production in the equation (9). Therefore changes in the factors that will influence production, profit, and hence change in Y^* will lead to changes in consumption behavior.

The model is also set up under some simplifying assumptions, which help consumer demand equations and output supply and variable input demand equations be derived by modeling the farm household decision making process recursively as two separate stages, despite their simultaneity in time. These assumptions briefly include: the household is price-taker in all markets and all markets exists; commodities are homogeneous, including the labour market; decisions relating to the total stock of land and labour are treated as given; intertemporal allocation and risk are omitted. (Barnum & Squire 1979).

Results of Econometric Models

This section presents results of econometric estimation for production and consumption aspects of the household model. The production segment is analysed employing a Cobb-Douglas (CD) production function. The consumption side is specified using 2 stages: the Linear Expenditure System (LES) for a broad grouping of goods and expenditures in the first stage, with the integration between demand for commodities and the allocation of time for leisure and labour supply. In the second stage, expenditure for each of individual commodities in the main food group is allocated using the Linear Approximation Almost Ideal Demand System (LA-AIDS).

The data used in the econometric models are from primary data of the Vietnam Household Living Standard Survey (VHLSS) 2004, a multi-purpose household survey, and is focused on about 7000 households which represent for 8 ecological regions and 64

provinces. Four regions Red River Delta, the Northern upland (includes North East and North West), the Central region (includes North Central Coast, South Central Coast and Central Highland), and the South (includes Mekong River Delta and North East South) have been analyzed, but the current paper only considers a model for 1 region: Red River Delta (RRD), one of the two main important deltas of the country for agricultural production, with 1,533 households. The region accounts for 21.68 percent of the total VHLSS sample.

Production Functions

Assume that the household only takes part in three agricultural production activities: rice cultivation, pig and chicken raising. The production functions take the specific forms as follows:

$$F_{rice} = \alpha_{0r} A^{\alpha 1r} D^{\alpha 2r} V^{\alpha 3r} \quad (12a)$$

$$F_i = \alpha_{0i} G_i^{\alpha 1i} D_i^{\alpha 2i} V_i^{\alpha 3i} \qquad i = \text{pig, chicken} \quad (12b)$$

where A is land cultivation for rice production, D is labour requirement, V are variable inputs, and G is feed for pig or chicken. It is assumed that these production functions can be estimated independently. The result from ordinary least squares estimation of the CD production functions reported in Annex A7, in detail. Here, the estimated production functions for RRD can be summarised by:

$$F_{rice} = 751.48 A^{0.61} D_{rice}^{0.059} V_{seed}^{0.048} V_{fertilizer}^{0.223} V_{pesticide}^{0.058}$$

$$F_{pig} = 0.98 G_{pig}^{0.584} D_{pig}^{0.171} V_{pig}^{0.095}$$

$$F_{chicken} = 0.78 G_{chicken}^{0.46} D_{chicken}^{0.21} V_{chicken}^{0.137}$$

Consumption with Linear Expenditure System (LES) Model in the First Stage

The first stage of demand analysis operates at an aggregate level, and identifies demand functions for food commodities, other expenditure, and at the same time, the household labour supply function is also obtained.

An assertion of the classical theory of consumer demand is that the consumer-worker acts as if maximizing its own-utility function. In this section, a direct utility function is used, based on the Linear Expenditure System (LES) (Stone 1954), which is extremely useful

because it assumes consumption is a linear function of prices and disposable income. Since the intra-household distribution can not be considered in detail, it is assumed that the household maximizes its joint utility function, and the utility function for each individual member is identical and is additive over the number of household member. For an individual member of the family the utility function is written as:

$$u = \sum \beta_i \ln(x_i - \gamma_i) \qquad \text{i=1,….,n,} \qquad (15)$$

where x_i indicates per capita quantity consumption of the ith commodity, and γ_i are committed quantity of ith commodity for consumption, n is total member of the household, and i here includes leisure as a consumption good, with $\sum \beta_i = 1$, and $(x_i - \gamma_i) > 0$

It is assumed that the household in this research consumes three broad groups of purchased commodities: main food, other food and other expenditure (including the industrial commodity group and other daily expenditure), and leisure. Dependents are assumed to consume all their available time in the form of leisure and to consume the same quantities of other goods as do working family members. The household has n_1 working members and the n_2 dependents, and the total number of members is $n = n_1 + n_2$. For the present application, the following household utility is defined as:

$$U = n_1\beta_1 \ln(l - \gamma_1) + n_2\beta_1 \ln(t - \gamma_1) + n\beta_2 \ln(c_{fd} - \gamma_2) + n\beta_3 \ln(c_{ofd} - \gamma_3) + n\beta_4 \ln(m - \gamma_4) \qquad (16)$$

subject to

$$wL + p_{fd}C_{fd} + p_{ofd}C_{ofd} + qM = E \qquad (17)$$

where c_{fd} is per capita consumption of main food group of commodity C_{fd}, c_{ofd} is per capita consumption of commodity group of other foods $C_{ofd,}$ m is per capita consumption of industrial goods and other expenditure M, l is leisure for working member, and L is total leisure time; w, p_{fd}, p_{ofd}, and q are wage of labour, price indices of main food group, other food group, and industrial goods and other expenditure group, respectively. E is full income as defined previously.

By expanding equation (16) with constraint (17) we now have a demand system of equations for the main food group, other food group, and industrial goods and other

expenditure (18b-d), and a supply function of labour (18a). The detail of expansion can be found out in the Annex A8.

$$-ws = -\bar{\gamma}w + \beta_1(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (18a)$$

and

$$p_{fd}c_{fd} = \gamma_2 p_{fd} + \beta_2(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (18b)$$

$$p_{ofd}c_{ofd} = \gamma_3 p_{nfd} + \beta_3(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (18c)$$

$$qm = \gamma_4 q + \beta_4(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (18d)$$

In this system of equations, there is an intuitively appealing interpretation that each member of the household firstly sets aside subsistence expenditures on the commodities and leisure, then allocates the difference between full income (per capita) and the minimum subsistence expenditures, among leisure time and the various commodities in the fixed proportions β_i.

In estimation of the above system of equations, parameters of γ_i and β_i are needed to be estimated. The parameters $\bar{\gamma}, \gamma_2, \gamma_3, \gamma_4$ appear in each of the three expenditure, and labour supply equations, and thus the estimation procedure is chosen that constrains the estimates of the $\gamma's$ to be consistent across equations. This is achieved by noting that, for the marginal budget shares to sum to 1, $k\beta_1 + \beta_2 + \beta_3 + \beta_4$ must equal unity: that is an estimate of β_1 can be obtained from estimates of $\beta_2, \beta_3, \beta_4$. In order to estimate appropriate parameters, identifying prices of each commodity group and the opportunity cost for each day of labour is very important[3].

Estimation of the LES proceeds under the assumption that the disturbance terms in each equation are independent and have zero means and uniform variances. The equation of

[3] In the initial method of LES estimation, the wage of labour, or in other words, opportunity cost of each day of labour is based on the market wage. However, some households in the dataset do not take part in the labour market in either selling or buying labour, they only work on their farm. The main reasons may be those households face constraints in seeking off-farm jobs, due to seasonal features of the agricultural sector, or the households live in the isolated areas. For them, using the market wage as the opportunity cost of labour may overstate, or undervalue the cost of family labour, and lead to an inaccurate estimation of their reaction in demand. This raises the need of applying a technique of accounting implicit value of family labour, however, in the limitation of the paper, the technique can not be presented here in detail, but only the result of applying that technique.

labour supply was omitted from the system in estimation to avoid singularity of the variance-covariance matrix, hence its parameter, β_1, was obtained from the restriction that the marginal budget shares are add up to 1.

The estimation of the LES is difficult due to non linearity in the coefficients γ_i and β_i which enter in a multiplicative form. Therefore the technique of Seemingly Unrelated Regression, with an iterative approach is applied to overcome this difficulty. Given initial estimates of the β_i, the remaining parameters were estimated, and then the β_i, re-estimated given these results. This was continued, iteratively, until parameter estimates converged. The table below presents parameters of the linear expenditure system for households in RRD:

Table 3: Estimated Parameters of the LES of the Household in RRD

Commodity group	Coefficient	Estimate	T-statistic
Labour supply	β_1^*	0.223	
	$\bar{\gamma}$	206.35	67.70
Main foods	β_2	0.308	36.93
	γ_2	61.363	42.26
Other foods	β_3	0.334	34.09
	$\gamma 3$	-9.07E-14	-3.84
Industry and others	β_4	0.136	21.02
	γ_4	4.024	23.10

**: Derived from the restriction that $k\beta_1 + \beta_2+\beta_3+\beta_4=1$. In calculating β_1, k was set at mean value of 0.682*

Consumption with Linear Approximately-Almost Ideal Demand System (LA-AIDS) Model in the Second Stage

In the second step of estimating the demand function and assessing the effect of expenditure and price to demand for commodities in the main food group, the AIDS model, proposed by Deaton and Muelbauer (1980) is used.

In the AIDS model, demand is represented by the budget share of each commodity, while prices and income are expressed in logarithms.

The function form of the AIDS model can be expressed as follows:

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_i \ln(\frac{M}{P}) + \mu_i \quad (19)$$

Where:

w_i is the budget share of a given food commodity

p_i is the price of commodity i

i = rice, pork, chicken, fish and prawn, vegetable, and other meats

M is a measure of household welfare, typically per capita income or per capita expenditure for main food group

μ_i is random disturbances assumed with zero mean and constant variance

P is a translog price index, and defined by

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2} \sum_k \sum_l \gamma^*_{kl} \ln p_k \ln p_l \quad (20)$$

Where k is = 1, …6, l=1,…,6, and the γ_{ij} parameters are defined under symmetry as follows:

$$\gamma_{ij} = \frac{1}{2}(\gamma^*_{ij} + \gamma^*_{ji}) = \gamma_{ji} \quad (21)$$

However, the AIDS model may be difficult to estimate because the price index is not linear in the parameters. In addition, the theory of the household does not provide any empirically plausible value for α_0. Therefore, due to its simplicity, the Linear Approximate Almost Ideal Demand System (LA/AIDS) with the Stone index is widely used (Asche & Wessells 1997). The Stone's price index (P^*) is calculated as follows:

$$\ln(P^*) = \sum_i w_i \ln(p_i) \quad (22)$$

Where w_i is the budget share among the commodities, and p_i is price of each individual commodity. But since prices will never be perfectly collinear, it is widely cited that applying the Stone index will introduce some measurement error (Moschini, 1995). The Stone index does not satisfy the fundamental property of index numbers because it is variant to changes in the units of measurement for prices. One solution is to ensure that prices are scaled by their sample mean. Following Moschini's suggestion, a Laspeyres price index can be used to overcome the measurement error. Specifically, the log-linear analogue of the Laspeyres price index is obtained by replacing w_i with $\overline{w_i}$, which is a

mean budget share. Hence the Laspeyres price index becomes a geometrically weighted average of prices:

$$\ln(P^L) = \sum_i \overline{\omega_i} \ln(P_i)$$

An LA/AIDS model with the Laspeyers price index is applied for this study.

$$\omega_i = \alpha_i^{**} + \sum_j \gamma_{ij} \ln(p_j) + \beta_i (\ln(M) - \sum \overline{w}_j \ln(p_j)) + \mu_i^{**} \qquad (23)$$

where $\alpha_i^{**} = \alpha_i - \beta_i (\alpha_0 - \sum_j \overline{w}_j \ln(\overline{p}_j))$

In estimation of the LA-AIDS model, one equation has to be dropped (here other meats), and the Seemingly Unrelated Regression technique was used. The other demand equations are estimated with homogeneity and symmetry restrictions imposed. Estimated parameters of the LA/AIDS and demand elasticities for 6 commodities in the main food group can be found in Annex A9. The results show that all goods in the main food group are inelastic in demand, and also are indicated as necessary goods. The other meat is the most sensitive to expenditure change, followed by pork, fish, and chicken, meanwhile the least sensitive to income are rice and vegetable, which are consistent with prior expectations.

III. Results of Implementation of Trade Liberalisation in the GTAP Model and Linkage between GTAP and Household Model

The results of the GTAP simulations are presented in some broad categories. The table below gives an overview of the output effects of the various scenarios.

Table 4: Initial values and percentage changes in Vietnamese outputs under the alternative GTAP scenarios

Sector	Initial output (US$m)	Unila-teral	AFTA	AFTA +3	VNM-USA	VNM-EU	Multi-lateral	Global
Paddy and processed rice	6467	-2	6	6	0	0	1	4
Vegetable and fruit	1902	-3	-2	-3	-1	-1	-1	-3
Other crops	1541	-5	-6	-14	-1	-6	-9	-18
Live Pig	881	0	-1	1	0	2	2	3
Live Poultry	434	0	-1	0	0	2	1	2
Live Other	545	-3	-3	-6	0	-2	-3	-6

Pork, poultry, other meats	168	-13	-10	-21	-1	-9	-10	-27
Beef and sheep meats	22	-6	-1	-6	-2	0	-3	-10
Fishing	1541	-2	-1	-2	0	-1	-1	-4
Oilseed and vegetable oil	93	-17	37	27	-2	-9	-7	-6
Processed food	2895	-6	-1	-10	-1	-5	-8	-18
Beverages and tobacco	1222	-22	-18	-20	0	0	-9	-21
Milk and dairy products	241	-26	-5	-6	-1	-4	-12	-24
Natural res, petrol product	3703	-5	-1	-8	-1	-4	-4	-10
Chemical, rubber, plastic	2938	-10	-4	28	-1	-7	0	14
Textile and apparel	7994	32	1	12	6	27	19	42
Manufactures	10203	-17	0	-18	-2	-8	-10	-24
Electronic	528	41	19	22	0	-6	11	19
Transport, communication	2143	-1	-1	-5	-1	-5	-2	-6
Services	26763	4	1	3	0	1	2	3

Source: GTAP simulations

Significant adjustments in the production can be observed following trade liberalisation. In most scenarios, rice, pig and poultry output increases or at least stays the same. Textile, electronic, and service sectors experience very positive production effects. Meanwhile manufacturing, meats and processed food sectors reduce their production. Of interest is the difference in Unilateral and regional or multilateral production. In the Unilateral scenario there is no expansion in export markets, as countries other than Vietnam do not reduce their tariffs. Most sectors contract. With liberalisation in AFTA there is an increase in Vietnamese production of oilseeds (OSO), whereas EU liberalisation leads to an increase in Vietnamese production of livestock. This limits the flow of labour into electronics and services.

A more obvious effect on Vietnam of trade liberalisation is the change in trade flows. Table 5 presents changes in exports across the scenarios. Two sectors with a positive change in production, textiles and electronics, also show an increase in exports in all scenarios. These sectors are export oriented. Textile exports are 60 per cent of production and electronics 85 per cent. As with output, the increase in trade is greatest with Unilateral liberalisation. The trade increases are driven by domestic reforms rather than improved market access. In the livestock sector, the initial trade in pigs and poultry is minimal. Unilateral liberalisation generates an increase in exports of livestock but the other scenarios do not, even though livestock production increases in all scenarios. This implies that other countries are sourcing their supplies from elsewhere as a result of lower costs of production in response to tariff changes.

Table 5: Initial value and percentage changes in Vietnamese exports from alternative scenarios

Sector	Initial exports (US$m)	Unila-teral	AFTA	AFTA +3	VNM-USA	VNM-EU	Multi-lateral	Global
Paddy and processed rice	374	-8	57	65	-2	-4	12	42
Vegetable and fruit	257	-1	-7	7	-1	-10	4	10
Other crops	810	-2	-5	-18	-2	-10	-13	-24
Live Pig	2	1	-8	-2	-1	-13	-5	-13
LivePoultry	0	15	1	-17	0	-11	-4	-10
LiveOther	62	-2	-5	-17	0	-10	-3	-7
Pork, poultry, other meats	33	-9	-12	-45	0	-22	-20	-45
Beef and sheep meats	0	22	-6	-28	4	-22	2	15
Fishing	49	3	1	2	0	-5	2	7
Oilseed and vegetable oil	45	2	115	102	-2	-13	7	34
Processed food	1365	1	2	-12	-1	-7	-8	-19
Beverages and tobacco	22	6	12	19	0	6	8	19
Milk and dairy products	2	29	-1	278	73	-16	37	222
Natural res, petrol product	2346	3	-1	-1	-1	-4	0	-3
Chemical, rubber, plastic	495	-8	-1	194	-3	-16	28	140
Textile and apparel	4746	63	4	33	10	38	35	81
Manufactures	2313	11	20	10	-3	-12	2	0
Electronic	446	49	23	28	0	-5	14	26
Transport, communication	534	-2	-2	-7	-1	-8	-3	-8
Services	1552	-8	-4	-17	-3	-13	-11	-24

Source: GTAP simulations

In the model closure used here there is no requirement in an individual country that import value must equate to export value. Any increase in the trade deficit will be accommodated by capital inflows. The removal of tariff leads, as expected, to a significant increase in imports as shown in the table 6. The most notable exception is livestock, where the initial tariffs are quite low, five per cent for pigs and poultry. In this sector, imports exceed exports. There is a big increase in processed meat consumption, but much of this includes the 'LiveOther' category. There is significant variation across the scenarios, with the AFTA+3 and the globalisation scenario being most important. This shows the importance of China, on Vietnam's doorstep.

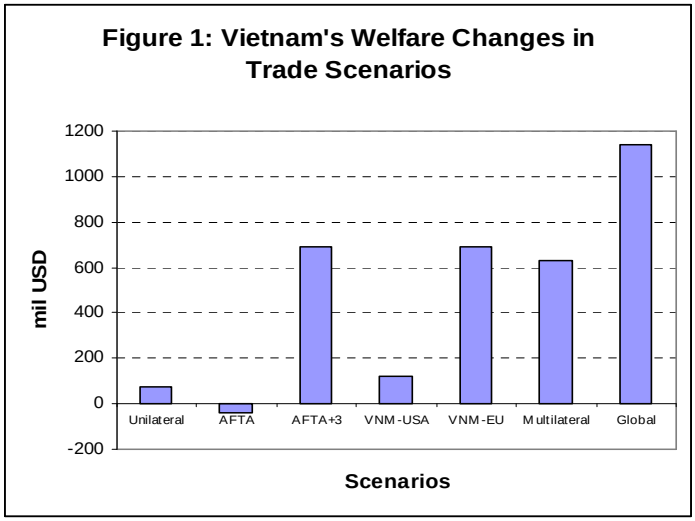
Table 6: Initial values and percentage changes in Vietnamese imports from alternative scenarios

Sector	Initial imports (US$m)	Unila-teral	AFTA	AFTA +3	VNM-USA	VNM-EU	Multi-lateral	Global
Paddy and processed rice	17	70	26	118	2	13	44	130
Vegetable and fruit	71	48	13	47	15	7	25	62
Other crops	225	17	6	16	2	6	8	21
Live Pig	5	2	1	11	1	5	6	13
LivePoultry	7	-2	3	3	0	5	3	4
LiveOther	29	3	2	12	1	6	6	16
Pork, poultry, other meats	20	69	47	66	9	27	33	104
Beef and sheep meats	7	9	2	4	4	-7	-1	5
Fishing	6	9	1	2	7	3	4	7
Oilseed and vegetable oil	90	14	23	28	1	3	10	25
Processed food	374	39	13	25	5	13	21	49
Beverages and tobacco	395	51	47	55	1	7	22	59
Milk and dairy products	239	19	4	11	3	7	12	26
Natural res, petrol product	1692	7	2	8	0	0	4	8
Chemical, rubber, plastic	2796	10	3	19	1	7	9	24
Textile and apparel	1848	78	11	57	11	37	41	101
Manufactures	6780	25	10	26	2	7	13	30
Electronic	1002	11	7	7	0	0	3	6
Transport, communication	2546	1	0	2	1	4	2	5
Services	6997	5	2	10	1	7	6	15

Source: GTAP simulations

Welfare indicators can be seen as a summary of policy changes. They incorporate changes in consumption, production, price and trade flows. The GTAP model uses the concept of equivalent variation[4] (EV) in income to measure welfare effects. The figure below presents the changes in welfare of Vietnam in the trade liberalisation scenarios. Scenarios of AFTA+3, bilateral trade with EU and multilateral give similar welfare changes for Vietnam. However, as expected the biggest welfare gain occurs following full trade liberalisation where the benefits of improved markets access are coupled with improved resource allocation. Also of interest are the low gains from unilateral liberalisation and the negative effects of the AFTA scenario.

[4] EV represents the money-metric equivalent to the utility change brought about by a change in prices. It measures the amount of money that would need to be taken away from the consumer before the price change to leave her as well off as she would be after the change in prices.



Source: GTAP simulations

In order to examine the welfare effects of the household from trade liberalisation scenarios, the price changes from the GTAP model are linked with the household model. Certain assumptions are made to match the different sectors or commodities of GTAP with those in household model. The sectors available in the GTAP database and the aggregation and/or splitting sector/commodities chosen for the liberalisation simulation have to be matched with those of the household model. (Refer Annex A6 for more detail.)

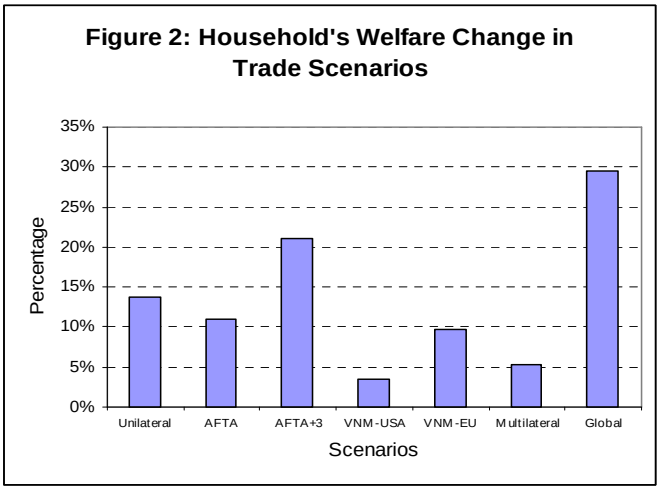
In calculating the welfare impacts on the livestock producing households using the household model, we apply the measure of compensating variation in income, which is the amount of money which, when taken away from the household after price and income change, leaves the household with the same utility as before the change (Varian 1996)[5]. The compensating variation (CV) is calculated as follows:

$$CV = Y^1 - Y^0 - \left[e\left(p^1, u^0\right) - e\left(p^0, u^0\right)\right]$$

where: Y^1 is income after the price change from p^0 to p^1, Y^0 is income in the baseline period, and the expenditure function e(p,u) is the minimum income which is necessary to reach the level utility u at given price p.

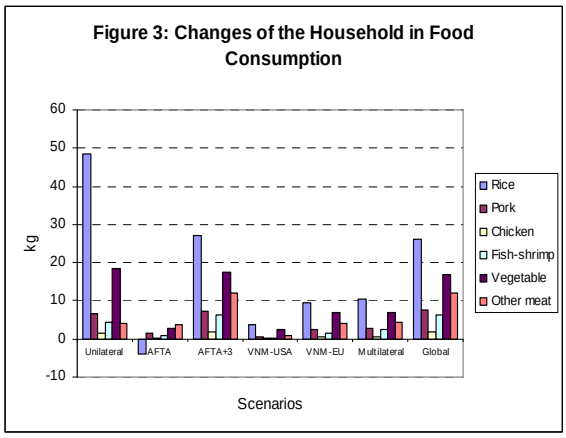
The compensating variation of the household measured as the change in utility for each scenario is presented in figure 2 below:

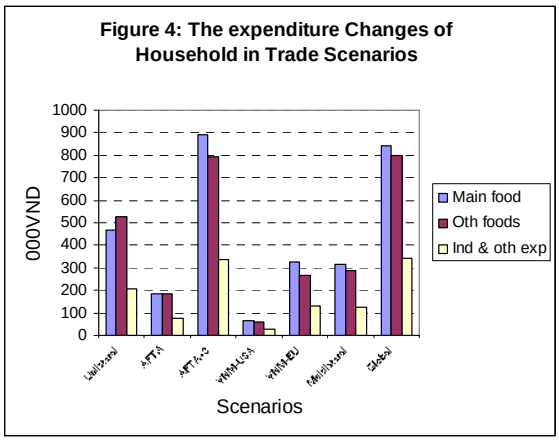
[5] This differs from equivalent variation used in the GTAP model to measure welfare.



Source: Household model simulation

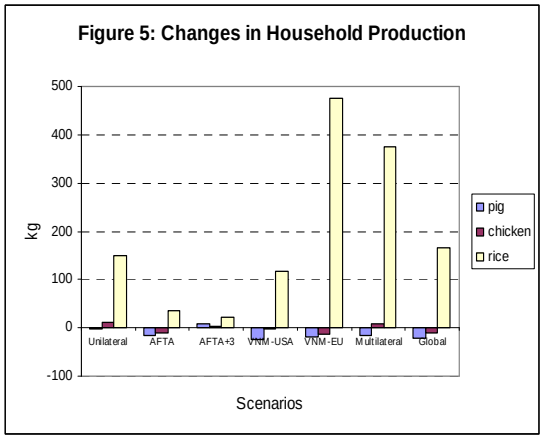
Total welfare gain for livestock households is relatively small in the scenarios of bilateral liberalisation with USA and EU, increasing about 5 per cent in comparison with the baseline. The most significant gain is obtained with full liberalisation over the world, with the value of welfare increased by nearly 4.5 million VND. In the unilateral liberalisation scenario, it is quite surprising that households get quite high welfare change, while total welfare as measured by GTAP of the whole country is negligible. The welfare gain of the household in trade scenarios is also explained by an increase in consumption of the household. In all simulations, due to a more open economy and decreased tax, the domestic consumers get more benefit from consuming cheaper commodities (See Annex A5), and the result is an improvement of household's utility from consumption of more food as well as industrial goods. (See figure 3 and 4 below)

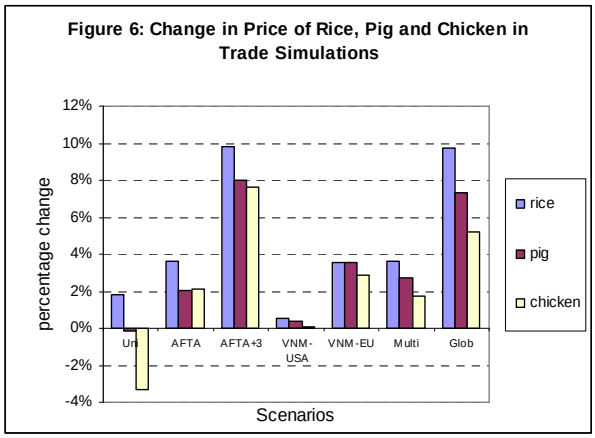




Source: Household model simulation

In all simulations, the household has a tendency to reduce its livestock production, meanwhile keeping or even increasing the output of rice (This can be seen in the figure 5 below). The price changes of output, rice, pig and chicken, can partly explain the differences in the household's production reaction. Figure 6 shows the differences between price changes of pig and chicken, the reason for splitting pig and chicken separately from the group of live livestock in GTAP database.





Source: Household model simulation

One feature which may explain the improvement in welfare due to trade liberalisation is the choice of the household in supplying labour or taking leisure. With the assumption of the household model that labourers can easily find work outside their farms, the household allocates only a small number of working hours to their farm, and spends the rest of their time working off-farm for more income as well as increased leisure. The leisure allocation is especially important in determining the welfare of the household. The results of simulations show that about 60 per cent of the increase in total welfare in the household is due to the changes in leisure (see Annex A10).

IV. Conclusions

The current paper develops a link between GTAP results and a household model to examine welfare changes of small livestock producers in Vietnam following trade liberalisation. Although GTAP has been used since 1992, and household models have been developed for around 30 years and applied to many countries, this is almost the first application of a household model for livestock households in Vietnam.

By linking GTAP with a household model, in this paper we examine how small livestock households react to changes in economic policies, especially in the context of trade

liberalisation. This is especially important, given that livestock plays a very important role in the agricultural sector and small households are dominant in livestock production in Vietnam. Analytical results from the household model also allow one to see how the household behaviors change when they are both consumers and producers. Taking into account how income effects from production, via profit, influences consumption, will give a more accurate assessment. Using SplitCom helps to examine different changes in pig and chicken sectors. Hence a more accurate measure of the change in household production to different price signals is captured.

Regarding the impacts of trade liberalisation on the household, the results from different liberalisation scenarios show that Vietnam's small households in the livestock sector would benefit from trade liberalisation. The largest benefit that households can have is if full trade liberalisation occurs over the world. In this case, the welfare of the household is dominated by the effect of household's labour allocation between off-farm and on-farm job, rather than the increase in production profit and consumption on commodities only.

ANNEX

A1 : GTAP sectoral concordance

No	New sector	Old sectors
1	RIC Paddy and processed rice	Paddy rice; Processed rice
2	VF Vegetable and fruit	Vegetables, fruit, nuts
3	OCR Other crops	Wheat; Cereal grains nec; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Sugar
4	Live Pig	Live pig
5	LivePoultry	Live poultry
6	LiveOther	Cattle, sheep, goats, horses; Animal products nec; Wool, silk-worm cocoons
7	OMT Pork, poultry, and other meats	Meat products nec
8	CMT Beef and sheep meats	Meat: cattle, sheep, goats, horses.
9	FSH Fishing	Fishing
10	OSO Oilseed and vegetable oil	Oil seeds; Vegetable oils and fats
11	OFD Processed food	Food products nec
12	B_T Beverages and tobacco	Beverages and tobacco products
13	MLK Milk and dairy products	Raw milk; Dairy products
14	RES Natural res, petroleum product	Forestry; Coal; Oil; Gas; Minerals nec; Petroleum, coal products
15	CRP Chemicals, rubber and plastic	Chemicals, rubber and plastic products
16	TXT Textile and apparel	Textiles; Wearing apparel; Leather products
17	MAN Manufactures	Wood products; Paper products, publishing; Mineral products nec; Ferrous metals; Metals nec; Metal products; Motor vehicles and parts; Transport equipment nec; Machinery and equipment nec; Manufactures nec
18	ELE Electronic	Electronic equipment
19	TCN Transport, communication	Transport nec; Sea transport; Air transport; Communication.
20	SVC Services	Electricity; Gas manufacture, distribution; Water; Construction; Trade; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings.

A2 : GTAP regional concordance

No	New region	Old countries/regions
1	USA	United States of America
2	EU25 European Union 25	Austria, Belgium, Denmark, Finland, France, Germany, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Cyprus, Czech Republic, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania.

3	JPN Japan	Japan
4	CHN China, Hong Kong	China, Hong Kong
5	VNM Viet Nam	Viet Nam
6	IDN Indonesia	Indonesia
7	MYS Malaysia	Malaysia
8	PHL Philippines	Philippines
9	THA Thailand	Thailand
10	KOR Korea	Korea
11	IND India	India
12	XEA Rest of East Asia	Taiwan, Rest of East Asia
13	XSE Rest of South East Asia	Cambodia, Singapore, Rest of Southeast Asia
14	XSA Rest of South Asia	Bangladesh, Pakistan, Sri Lanka, Rest of South Asia.
15	AUS Australia	Australia
16	ODV Other developed countries	New Zealand, Canada, Rest of North America, Switzerland, Rest of EFTA
17	LAM Latin America	Mexico, Bolivia, Colombia, Ecuador, Peru, Venezuela, Argentina, Brazil, Chile, Paraguay, Uruguay, Rest of South America, Central America, Rest of Free Trade Area of Americas, Rest of the Caribbean
18	AFR Africa	Egypt, Morocco, Tunisia, Rest of North Africa, Botswana, South Africa, Rest of South African Customs , Malawi, Mauritius, Mozambique, Tanzania, Zambia, Zimbabwe, Rest of Southern African Development Community, Madagascar, Nigeria, Senegal, Uganda, Rest of Sub-Saharan Africa
19	CEE Central and East Europe	Rest of Europe, Albania, Bulgaria, Croatia, Romania
20	ROW Rest of the world	Rest of Oceania, Russian Federation, Rest of Former Soviet Union, Turkey, Iran, Islamic Republic of, Rest of Middle East

A3: Changes of welfares from alternative scenarios (mil USD)

Regions	Unilateral	AFTA	AFTA+3	VNM-USA	VNM-EU	Multilateral	Global
USA	-88	-525	-4477	88	-87	-3029	-7493
EU25	231	-529	-2940	-33	-98	8785	13908
JPN	101	-565	25949	-29	-119	14018	33403
CHN	196	-247	-723	-35	-117	5611	9177
VNM	**72**	**-37**	**690**	**122**	**689**	**630**	**1141**
IDN	-5	233	401	-2	-10	422	920
MYS	12	565	1462	-3	-9	1296	2553
PHL	9	337	279	-3	-12	139	294
THA	15	422	2612	-7	-18	1271	2677
KOR	155	-119	9043	-11	-19	5725	11517
IND	-20	-91	-480	-6	-26	1930	1735
XEA	100	-124	-1268	-10	-17	1191	2568
XSE	72	1086	1615	-5	-11	794	2092
XSA	-23	-29	-239	-5	-20	325	218
AUS	3	-119	-783	-3	-8	701	2069
ODV	30	-44	-334	-10	-12	1663	3414
LAM	-7	-52	-912	-18	-33	1808	2662

AFR	-42	-80	-710	0	-25	2796	3661
CEE	-23	-7	-53	-1	-23	104	-8
ROW	-28	10	-917	-1	-17	1302	2016

Source: GTAP simulation

A4: Change on supply price of commodities and endowments in Vietnam under alternative scenarios (percentage)

	Unilateral	AFTA	AFTA+3	VNM-USA	VNM-EU	Multilateral	Global
Land	-5.59	5.23	11.48	-0.39	1.26	1.6	6.67
UnSkLab	9.15	3.21	13.56	1.3	6.52	7.17	17.66
SkLab	11.73	3.49	15.29	1.45	7.14	8.44	20.17
Capital	9.64	3.03	13	1.38	6.75	7.25	17.67
NatRes	-14.1	-3.7	-18.95	-1.9	-9.07	-11.21	-26.88
RIC	1.78	3.65	9.82	0.54	3.58	3.71	9.99
VF	0.41	2.4	9.39	0.22	3.22	3.37	9.18
OCR	0.44	1.01	4.82	0.28	2.19	1.12	4.23
LivePig	-0.17	2.03	7.97	0.36	3.64	2.89	7.63
LivePoultry	-3.31	2.09	7.64	0.04	2.98	2.01	5.73
LiveOther	0.5	0.92	5.61	0.26	3.36	2.08	5.71
OMT	1.1	1.52	6.59	0.45	3.41	2.77	7.09
CMT	-2.62	0.85	3.78	-0.51	3.32	1.07	2.39
FSH	-1.71	0.01	0.79	0.53	2.65	0.03	-0.43
OSO	-0.32	6.78	12.56	0.44	2.77	2.55	8.52
OFD	-0.36	0.66	4.11	0.42	2.95	1.47	3.81
B_T	-2.72	-2	0.74	0.49	2.86	0.37	1.57
MLK	-3.56	-0.16	2.36	0.23	2.49	-0.11	0.56
RES	-0.34	0.25	-0.04	0.06	0.42	0.03	0.41
CRP	1.29	0.65	4.09	0.58	2.99	1.97	5.18
TXT	-6.77	-0.38	-3.15	-0.11	1.45	-2.12	-4.2
MAN	-1.61	-0.05	0.67	0.48	2.52	0.6	1.8
ELE	-4.61	-2.39	-2.31	0.02	0.71	-1.45	-2.56
TCN	0.61	0.63	2.79	0.55	3.18	1.64	4.66
SVC	2.19	0.97	4.91	0.74	3.78	2.78	7
CGDS	-1.64	-0.12	0.71	0.49	2.55	0.57	1.86

Source: GTAP simulation

A5: Change on consumer price of commodities in Vietnam under alternative scenarios (percentage)

	Unilateral	AFTA	AFTA+3	VNM-USA	VNM-EU	Multilateral	Global
RIC	1.77	3.64	9.79	0.54	3.55	3.58	9.71
VF	-0.58	2.15	8.38	-0.05	3.06	2.67	7.51
OCR	-2.6	-0.47	2.19	0.08	1.3	-0.46	0.18
LivePig	-0.18	2.02	7.93	0.36	3.54	2.72	7.25
LivePoultry	-3.3	2.05	7.59	0.03	2.8	1.74	5.17
LiveOther	0.17	0.71	4.73	0.23	2.92	1.56	4.38
OMT	-1.83	-0.38	3.67	0.11	1.86	1.08	1.77
CMT	-2.64	0.84	3.77	-0.52	1.97	0.32	1.54

FSH	-1.75	0.01	0.78	0.51	2.63	-0.11	-0.69
OSO	-14.74	-13.31	-12.49	-0.02	0.64	-6.17	-13.82
OFD	-6.37	-1.05	0.46	-0.17	0.95	-2.02	-4.38
B_T	-22.46	-18	-19.47	0.12	1.03	-9.16	-20.24
MLK	-10.77	-1.45	-0.39	-0.34	-2.71	-4.83	-9.79
RES	-7.2	-1.16	-6.92	-0.24	-0.16	-3.5	-7.26
CRP	-2.35	-0.56	0.12	0.19	0.98	-0.59	-0.87
TXT	-14.59	-1.54	-10.21	-0.78	-0.32	-6.24	-13.74
MAN	-7.88	-1.64	-5.95	0.2	1.07	-2.66	-6.08
ELE	-8.47	-4.56	-6.42	-0.47	-1.27	-3.94	-8.25
TCN	0.18	0.21	0.73	0.17	0.94	0.37	1.11
SVC	1.58	0.71	3.47	0.54	2.7	1.94	4.83

Source: GTAP simulation

A6: Matching between GTAP sectors and endowments in this study and their concordance with commodities and goods in Vietnam's household models

In household model	Matched GTAP sectors and endowments
Rice, Paddy, and Seeding	RIC: Paddy and processed rice
Live pig	Live Pig
Live chicken	LivePoultry
Chemical fertilizer and Pesticide	CRP: Chemical, rubber, plastic
Pork and chicken meat	OMT: Pork and poultry meats
Fish	FSH: Fishing
Vegetable and fruit	VF: Vegetable and fruit
Other meats	CMT: Beef, sheep, and other meats
Other foods	OSO: Oilseed & vegetable oil, OFD: Processed food, B_T: Beverages and tobacco, MLK: Milk and dairy products
Industrial commodities and other expenditures	TXT: Textile and apparel, MAN: Manufactures, ELE: Electronic, TCN: Transport, communication, SVC:Services
Agricultural Labour	UnSkLab: Unskilled Labour

A7: OLS estimation of production functions

Rice production function

Source	SS	df.	MS	Number of obs. = 3995
Model	2529.5133	8	316.189163	F(8, 3986) = 2736.94
Residual	460.487984	3986	.115526338	Prob > F = 0.0000
Total	2990.00129	3994	.748623257	R-squared = 0.8460
				Adj R-squared = 0.8457
				Root MSE = .33989

Rice output	Coefficient	Std. error	t	P> | t |	[95% Conf.	Interval]
Area	0.609834	0.014437	42.24	0.000	0.58153	0.638138
Seed	0.047518	0.007981	5.95	0.000	0.031871	0.063166
Chemical fertilizer	0.22347	0.009149	24.42	0.000	0.205532	0.241408
Pesticide	0.054194	0.00603	8.99	0.000	0.042373	0.066016
Labour	0.058637	0.005828	10.06	0.000	0.047211	0.070064
NE + NW	-0.11952	0.015533	-7.69	0.000	-0.14998	-0.08907
Central + CH	-0.29136	0.014538	-20.04	0.000	-0.31986	-0.26285
NES +MRD	-0.2865	0.024463	-11.71	0.000	-0.33447	-0.23854
Constant	6.62204	0.072516	91.32	0.000	6.479869	6.764211

Rice output = total output of rice cultivation raising/year (kg)

Area= total areas of rice cultivation/yea (ha)
Seed = total rice used as seeding/year (kg)
Chemical fertilizer = total chemical fertilizer used/year (kg)
Pesticide = total pesticide and herbicide used/year (bottle)
Labour = Total day working for chicken raising/year (man-days)
Other costs = total other cost for production (thousand VND)

Pig production function

Region RRD, NE, NW is omitted

Source	SS	df.	MS			Number of obs. =3191
Model	2197.96921	5	439.593841			F(5, 3185) = 2218.69
Residual	631.051269	3185	.198132266			Prob. > F = 0.0000
Total	2829.02048	3190	.886840275			R-squared = 0.7769
						Adj. R-squared = 0.7766
						Root MSE = .44512

Pig output	Coefficient	Std. error	t	P> | t |	[95% Conf.	Interval]
Feed	.5844212	.0106976	54.63	0.000	.5634462	.6053961
Labour	.1714647	.010323	16.61	0.000	.1512243	.1917052
Veterinary+ others	.0946292	.0106225	8.91	0.000	.0738016	.1154568
Central +CH	.0967256	.0172795	5.60	0.000	.0628455	.1306057
NES + MRD	.246214	.0326408	7.54	0.000	.1822149	.3102131
Constant	-.0242914	.0545676	-0.45	0.656	-.1312825	.0826997

Pig output = total output of pig raising/year (kg)
Feed = total cost of feeding pig/year (thousand VND)
Labour = Total day working for pig raising/year (man-days)
Other costs = total other cost for production (thousand VND)

Chicken production function

Region RRD is omitted

Source	SS	df.	MS			Number of obs. =1959
Model	837.416308	6	139.569385			F(6, 1952) = 924.45
Residual	294.705857	1952	.150976361			Prob. > F = 0.0000
Total	1132.12217	1958	.578203353			R-squared = 0.7397
						Adj. R-squared = 0.7389
						Root MSE = .38856

Chicken output	Coefficient	Std. error	t	P> | t |	[95% Conf.	Interval]
Feed	0.460	0.012	38.700	0.000	0.436	0.483
Labour	0.210	0.010	20.820	0.000	0.190	0.229
Veterinary+ others	0.137	0.011	12.560	0.000	0.116	0.159
NE+NW	0.048	0.024	2.030	0.043	0.002	0.094
Central +CH	0.158	0.024	6.460	0.000	0.110	0.206
NES + MRD	0.440	0.049	8.930	0.000	0.344	0.537
Constant	-0.251	0.055	-4.560	0.000	-0.359	-0.143

Chicken output = total output of chicken raising/year (kg)
Feed = total cost of feeding chicken/year (thousand VND)
Labour = Total day working for chicken raising/year (man-days)
Other costs = total other cost for production (thousand VND)

A8: Expansion of demand system LES

The household utility is defined as:

$$U = n_1\beta_1 \ln(l-\gamma_1) + n_2\beta_1 \ln(t-\gamma_1) + n\beta_2 \ln(c_{fd}-\gamma_2) + n\beta_3 \ln(c_{ofd}-\gamma_3) + n\beta_4 \ln(m-\gamma_4) \quad (16)$$

subject to

$$wL + p_{fd}C_{fd} + p_{ofd}C_{ofd} + qM = E \quad (17)$$

Substituting *l=t-s* to the equation (16), where *t* is the total time available per individual, *s* is the quantity of time supplied to work activities, and dividing equally the household utility function for *n*, the problem now is maximizing individual member's utility function:

$$u = k\beta_1 \ln(t - s - \gamma_1) + (1-k)\beta_1 \ln(t - \gamma_1) + \beta_2 \ln(c_{fd} - \gamma_2) + \beta_3 \ln(c_{ofd} - \gamma_3) + \beta_4 \ln(m - \gamma_4) \quad (16a)$$

subject to $$kw(t - s) + p_{fd}c_{fd} + p_{ofd}c_{ofd} + qm = E/n \quad (17a)$$

where $k = n_1 / n$. Let $\beta_1' = k\beta_1$ and $w' = kw$, then it is apparent that the problem is that of the standard linear expenditure system, for which the expenditure equations are

$$w(t - s) = \gamma_1 w + \beta_1(E/n - w'\gamma_1 - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (a1)$$

$$p_{fd}c_{fd} = \gamma_2 p_{fd} + \beta_2(E/n - w'\gamma_1 - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (b1)$$

$$p_{nfd}c_{nfd} = \gamma_3 p_{nfd} + \beta_3(E/n - w'\gamma_1 - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (c1)$$

$$qm = \gamma_4 q + \beta_4(E/n - w'\gamma_1 - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (d1)$$

However, one of the problems in estimating the model is that the measurement of leisure as a residual after deducting working time from total available time may introduce a specification error (Abbott & Ashenfelter 1976). Following their approach, we modify the system of equations by substituting $(t - \bar{\gamma})$ for γ_1 in the equation (a1). This yield:

$$-ws = -\bar{\gamma}w + \beta_1(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (a2)$$

and

$$p_{fd}c_{fd} = \gamma_2 p_{fd} + \beta_2(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (b2)$$

$$p_{ofd}c_{ofd} = \gamma_3 p_{nfd} + \beta_3(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (c2)$$

$$qm = \gamma_4 q + \beta_4(b + w'\bar{\gamma} - p_{fd}\gamma_2 - p_{ofd}\gamma_3 - q\gamma_4) \quad (d2)$$

where $b = w's + p_{fd}c_{fd} + p_{ofd}c_{ofd} + qm = -kws + p_{fd}c_{fd} + p_{ofd}c_{ofd} + qm$

A9: Result of L A - AIDS regression for RRD

Iteration 1: tolerance = 0.00616148
Iteration 2: tolerance = 0.00009929
Iteration 3: tolerance = 1.644e-06
Iteration 4: tolerance = 2.675e-08
Seemingly unrelated regression, iterated

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
Rice	913	6	0.119509	0.149	162.12	0
Pork	913	6	0.08901	0.106	122.09	0
Chicken	913	6	0.047949	0.0272	28.15	0.0001
Fish	913	6	0.063733	0.0192	29.09	0.0001
Vegetable	913	6	0.033437	0.0683	73.8	0

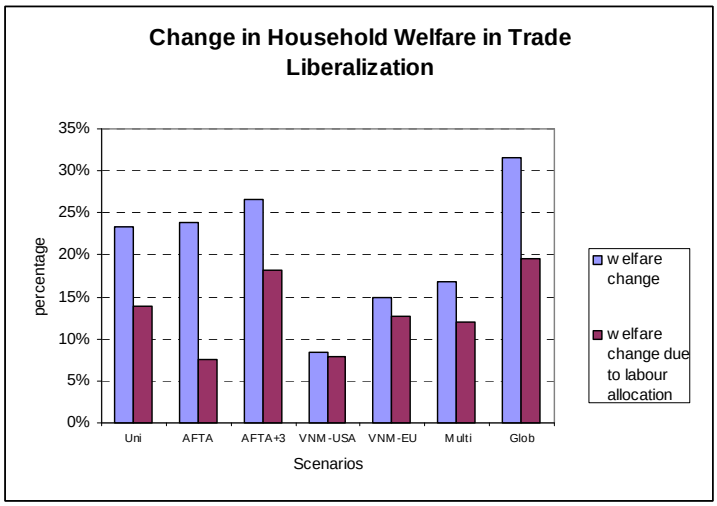
	Coefficient	Std. error	z	P> z	[95% Conf.	Interval]
Rice qty						
Rice price	0.185345	0.023026	8.05	0.000	0.140214	0.230475
Pork price	-0.07996	0.014382	-5.56	0.000	-0.10815	-0.05177
Chic price	-0.02951	0.009122	-3.24	0.001	-0.04739	-0.01163
Fish price	-0.04475	0.009314	-4.8	0.000	-0.063	-0.02649

Vege price	-0.01593	0.005687	-2.8	0.005	-0.02708	-0.00479
Othmeat price	-0.01519	0.007147	-2.13	0.034	-0.0292	-0.00119
Real income	-0.09708	0.010781	-9	0.000	-0.11821	-0.07595
Constant	1.404675	0.07929	17.72	0.000	1.249271	1.56008
Pork qty						
Rice price	-0.07996	0.014382	-5.56	0.000	-0.10815	-0.05177
Pork price	0.052484	0.013692	3.83	0.000	0.025649	0.079319
Chic price	0.000453	0.006735	0.07	0.946	-0.01275	0.013652
Fish price	0.026245	0.006913	3.8	0.000	0.012695	0.039794
Vege price	0.002591	0.004448	0.58	0.560	-0.00613	0.01131
Othmeat price	-0.00181	0.005315	-0.34	0.733	-0.01223	0.008606
Real income	0.069049	0.008026	8.6	0.000	0.053319	0.084779
Constant	-0.36941	0.059246	-6.24	0.000	-0.48553	-0.25329
Chic qty						
Rice price	-0.02951	0.009122	-3.24	0.001	-0.04739	-0.01163
Pork price	0.000453	0.006735	0.07	0.946	-0.01275	0.013652
Chic price	0.033656	0.008017	4.2	0.000	0.017942	0.049369
Fish price	0.005932	0.004649	1.28	0.202	-0.00318	0.015044
Vege price	-0.00896	0.003501	-2.56	0.011	-0.01582	-0.0021
Othmeat price	-0.00157	0.004192	-0.37	0.708	-0.00979	0.006646
Real income	0.004358	0.004334	1.01	0.315	-0.00414	0.012852
Constant	-0.03448	0.033142	-1.04	0.298	-0.09944	0.030477
Fish qty						
Rice price	-0.04475	0.009314	-4.8	0.000	-0.063	-0.02649
Pork price	0.026245	0.006913	3.8	0.000	0.012695	0.039794
Chic price	0.005932	0.004649	1.28	0.202	-0.00318	0.015044
Fish price	0.012005	0.006779	1.77	0.077	-0.00128	0.025292
Vege price	-0.00109	0.003079	-0.35	0.724	-0.00712	0.004946
Othmeat price	0.001656	0.003693	0.45	0.654	-0.00558	0.008895
Real income	0.006473	0.005757	1.12	0.261	-0.00481	0.017757
Constant	-0.0254	0.040694	-0.62	0.532	-0.10516	0.054357
Vege qty						
Rice price	-0.01593	0.005687	-2.8	0.005	-0.02708	-0.00479
Pork price	0.002591	0.004448	0.58	0.560	-0.00613	0.01131
Chic price	-0.00896	0.003501	-2.56	0.011	-0.01582	-0.0021
Fish price	-0.00109	0.003079	-0.35	0.724	-0.00712	0.004946
Vege price	0.021349	0.003117	6.85	0.000	0.015239	0.027459
Othmeat price	0.002041	0.002623	0.78	0.436	-0.0031	0.007182
Real income	-0.01321	0.003019	-4.38	0.000	-0.01912	-0.00729
Constant	0.184329	0.022606	8.15	0.000	0.140022	0.228635

** Uncompensated elasticities*

	Rice price	Pork price	Chic price	Fish price	Vege price	Othmeat price	Real income
Rice qty	-0.53934	-0.11804	-0.04378	-0.06989	-0.0186	-0.01992	0.809563
Pork qty	-0.56494	-0.81158	-0.02287	0.09693	-0.00981	-0.02647	1.338731
Chic qty	-0.42839	-0.00588	-0.54998	0.074559	-0.12486	-0.02427	1.05883
Fish qty	-0.51154	0.265362	0.058049	-0.87866	-0.01617	0.014048	1.068919
Vege qty	-0.13841	0.079482	-0.12007	0.00228	-0.6656	0.041025	0.801302
Othmeat qty	-0.59122	-0.15427	-0.07365	-0.02312	0.000388	-0.74381	1.585686

A10: Welfare Changes of Household and Effect of Labour Allocation to Welfare



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