Rural-Urban Migration and Vietnamese Agriculture

Donna Brennan, Elizabeth Petersen, Nguyen Ngoc Que and David Vanzetti[1]

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Abstract

Vietnam has achieved remarkable economic growth since it liberalised its markets, and further economic growth and opportunities are predicted both within and outside the agriculture sector. However, growth has not been evenly distributed across regions and significant structural adjustment pressures are expected in the medium to long term. A dynamic, eight region, 13 commodity, non-linear programming model of Vietnam's agricultural sector is used to analyse the likely impact of a change in rural-urban migration on agricultural production, prices, trade and regional incomes.

[1] Donna Brennan is now deceased. The other authors are respectively from The University of Western Australia, the Institute of Policy and Strategy for Agricultural and Rural Development, Hanoi and the Australian National University. Contact: Liz.Petersen@tpg.com.au. The authors thank ACIAR for funding this project.

Introduction

Vietnam has achieved remarkable economic growth since it liberalised its markets, and further economic growth and opportunities are predicted both within and outside the agriculture sector. However, significant structural adjustment pressures are expected in the short to medium term. One source of pressure is the movement of labour from rural to urban regions. At present, the Vietnamese government restricts the movement of people to the cities. One of the concerns of policy makers is the potential effect on agricultural output and household incomes of a movement of labour out of rural areas.

The pressure for people to move from urban regions derives from the low productivity in the rural sector. In Vietnam, 48 percent of the labour force employed in agriculture are producing only 22 per cent of the output (GSO 2011). Average productivity in the sector is low, although some crops, such as coffee and cashews, appear to be exceptions (Manning 2010), and significant improvements have been observed in some rice growing areas, according to estimates by Kompas et al. (2009). Moving a proportion of these workers into more productive activities could result in substantial gains. The policies restricting movement are aimed at various social objectives, such as reducing congestion and overcrowded living conditions. One effect is to keep labour in agriculture. The result is labour supply to agriculture is more abundant than otherwise, and this leads to an increase in agricultural output.

The purpose of this paper is to quantify the potential impacts of a movement of labour from rural to urban areas. We introduce a dynamic, eight region, 13 commodity non-linear programming model of Vietnam's agricultural sector, called VAST (**V**ietnam **A**gricultural **S**ec**T**or model). We use the model to show the output, trade and welfare effects by commodity and region.

Internal migration

The standard economist's approach to migration, for example Lewis (1954), is to explain it in terms of wage differentials. With surplus labour and low marginal productivity in the rural sectors, workers can better themselves by seeking opportunities in urban areas. Industrialisation tends to start in urban areas, and the shortage of labour increases wages and draws in labour from the agricultural sector. Eventually, the wage differential will diminish and may disappear altogether. This model is undoubtedly simplistic, and fails to explain some of the observed movements, but nonetheless it provides a useful framework.

Vietnam has a population of 88 million in which some 61 million live in rural areas (GSO 2011). Because of high population growth rates in the 1970s and 1980s, the share of the population of working age, over 15, is quite low, some 50 million, and thus this share will expand in the years ahead as birth rates fall and the population ages. Income per capita is 4.1 million VND in rural areas and 9.7 million VND in urban areas.[2] Thus, the differential is quite large, and increases with the level of skill. Skilled workers command a much higher wage in urban areas. Poverty rates reflect incomes. The poverty rate in 2010 was 17 per cent in rural areas compared with 7 per cent in urban areas (GSO 2011). Thus, there is an incentive for workers, particularly those with skills, to move to the cities.

Rural-urban migrants amounted to over 2 million in 2009, some 9 per cent of the urban population (GSO 2011). Cities such as Ho Chi Minh City, Hanoi, Hai Phong, Da Nang, Quang Ninh, Binh Duong, and Dong Nai have attracted large numbers (Loi 2005). The Vietnamese Government implements a household registration system which limits the movement of migrants to the cities. Most migrants, more than 90 per cent, are classified as temporary, and hence restricted in accessing public services such as education and health care.

The interest here is in the potential effect on the agricultural sector of a movement of labour out of the sector. Unemployment in the rural sector is estimated to be relatively low, at 2.3 per cent, but a further 4.3 per cent are considered to be underemployed. Population projections from GSO (2011) are for growth of 1.05 per cent per annum for the ten years to 2020, with almost all the growth occurring in urban areas.[3] With income per capita increasing at 7 per cent per annum (GSO 2011), this is expected to lead to a significant increase in demand for food products, particularly high protein livestock products such as beef, chicken, pork and fish. If this demand is satisfied internally, an increase in production or imports of

[2] One US$ is currently worth around 21,000 Vietnamese dong (VND).

[3] GSO's medium variant, which assumes birth rates falling to 1.85/woman, has urban population growing from 26.2 million in 2010 to 35.6 million in 2020, whereas the rural population remains steady at 60.5 million.

feed such as maize, cassava, sweet potato and soy meal will be necessary. The prices of these products should rise, with both positive and negative effects on rural households.

On the supply side, labour makes up about 23 per cent of the cost of production of primary agricultural products, although this increases to 30 per cent for fruit and vegetable products.[4] Almost all of this labour is unskilled. Labour is used in similar proportions to land, but the use of capital is minimal, around 6 per cent of the value of output.

For purposes of analysis the country is divided into eight regions, as shown in table 1. The 2006 baseline populations in these regions are shown in table 1. The most urbanised areas are in the South East, Red River Delta and Mekong River Delta regions. The delta areas are also the regions producing rice and livestock, particularly pigs (see table 2).

Table 1 Urban and rural population, 2006

		Base population	
		Urban	**Rural**
		million	million
Red River Delta	(RRD)	4.55	13.66
North East	(NEM)	1.79	7.67
Northwest Mountains	(NWM)	0.36	2.24
Northern and Central Coast	(NCC)	1.46	9.21
Southern and Central Coast	(SCC)	2.15	4.98
Central Highlands	(CH)	1.37	3.50
South East	(SE)	7.55	6.25
Mekong River Delta	(MRD)	3.60	13.82
Total		22.82	61.33

Source: GSO (2007a).

One aspect of interest in a regional model is the dispersion of prices across regions. These differences reflect transport costs between regions, and differences in supply and demand conditions. Figure 1 shows the example of rice. Prices are relatively similar across regions, although there may be greater disparity within a region. Data for other commodities are shown in the Appendix table A4. The greatest disparity is observed for cassava, which is expensive in the delta regions. There is also quite a range in seafood prices between the coast and the mountains.

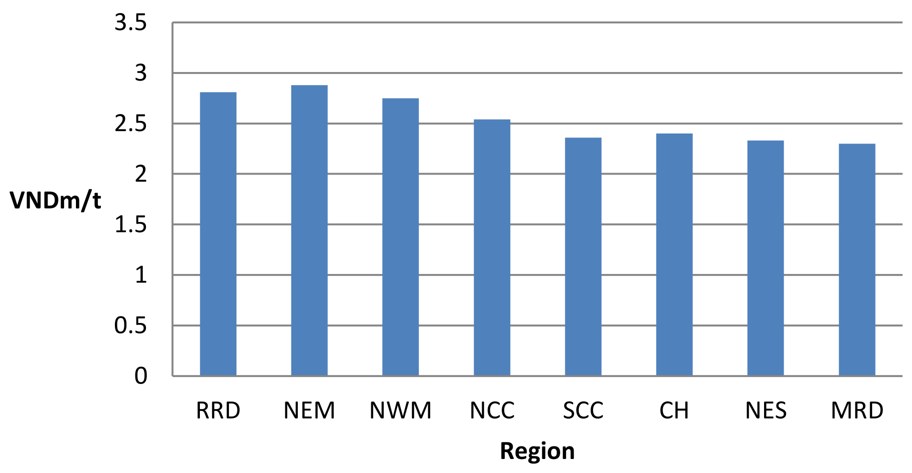
[4] GTAP database

Table 2 Regional production, 2006

	RRD kt	NEM kt	NWM kt	NCC kt	SCC kt	CH kt	SE kt	MRD kt	Total kt
Rice	3,681	1,431	316	1,880	1,058	450	940	10,583	20,339
Maize	245	492	332	397	116	677	388	140	2,788
Sweet potato	122	169	23	208	55	61	25	51	714
Cassava	28	150	85	148	161	435	303	48	1,358
Soy	99	42	25	7	0	34	4	28	239
Pigs	356	147	18	112	68	48	168	250	1,167
Chicken	83	46	11	28	8	10	38	33	256
Other poultry	35	16	3	12	7	3	9	44	128
Beef	11	7	2	14	11	8	6	6	66
Milk	13	3	2	4	2	5	147	26	202
Seafood	116	26	4	37	5	7	45	637	877
Fishmeal	1	1	0	1	2	0	42	65	112
Trashfish	16	6	0	21	1	0	286	521	851

Source: Derived from GSO (2007b)

Figure 1 Regional rice prices



The major exports are rice, cassava and seafood[5]. Rice and seafood are predominantly grown in the Mekong River Delta, whereas cassava is popular in the Central Highlands. The major imports are feedstuffs maize, soy and fishmeal. Milk is a major food import. Vietnam produces most of its own meat with local and imported feed. Maize demand is 3,499 kt with 2,789 kt supplied locally. Cassava, exclusively a feed for livestock, is the only significant feed export (table 3).

[5] Major exports coffee and cashew nuts are excluded from this analysis.

Table 3 National imports and exports, 2006

	Imports kt	Exports kt
Rice	0	5,257
Maize	847	-
Cassava	0	605
Soy	806	-
Pig	6	37
Chicken	34	-
Other Poultry	2	-
Beef	15	-
Milk	129	-
Seafood	0	417
Fishmeal	171	-
Trashfish	-	-

Source: Derived from GSO (2007b)

Scenarios

To assess the potential effects of migration, we simulate two scenarios over ten years. The first is a reference case where population growth in each region is the same in both urban and rural areas. There is no migration. In the alternative scenario the additional population in rural areas migrate to urban areas in each of the eight regions. Thus, there is no growth in rural population (natural growth is equal to net out-migration) and up to 7 per cent growth in urban areas depending on the initial number of people in each region (see table 4). The estimates are based on GSO projections to 2020. We have assumed here that rural migrants move to the cities in their respective regions. In reality some would move to urban areas in other regions, and some would move from one rural area to another. With respect to labour supply in rural areas, this assumption does not affect our analysis.

Table 4 Scenarios - urban and rural population growth

	Scenario 1 Even growth		Scenario 2 Migration	
	Urban	Rural	Urban	Rural
	%	%	%	%
Red River Delta	0.96	0.96	3.86	0
North East	1.01	1.01	5.36	0
Northwest Mountains	1.01	1.01	7.27	0
Northern and Central Coast	0.64	0.64	4.69	0
Southern and Central Coast	0.64	0.64	2.13	0
Central Highlands	1.53	1.53	5.46	0
South East	2.01	2.01	3.67	0
Mekong River Delta	0.66	0.66	3.24	0

Source: Derived from GSO data.

Methodology

The tool of analysis is a dynamic, 8 region, 13 commodity non-linear programming model of Vietnam's agricultural sector, VAST, developed within the General Algebraic Modeling System (GAMS) framework. The VAST model solves for the national consumer and producer prices by maximising producer and consumer surplus. Supply and demand are functions of price, all markets must clear (production plus imports equals consumption plus exports) and price relationships must hold. Price relationships are held through the following assumptions:

a) producer and consumer prices relate through margins;
b) consumer prices are a function of import costs;
c) imports are determined through Armington equations describing substitution between imports and domestic products; and
d) regional prices are linked to national prices. Transport and other costs are modelled as constant so that the relationship between regional and national prices is maintained.

The demand side of the model is represented by a log-log model where price elasticities are calculated from an underlying regional AIDS model for food expenditure calculated for budget shares in the base year. Over a ten year time horizon income and, to a lesser extent, population growth, determine demand for a product.

The model is dynamic in that it projects changes over time in response to demand growth driven by income and population growth. Productivity growth in terms of crop productivity, yield per animal and food conversion ratios drive growth in output over time. Aside from food demand, treatment of the interaction between the Vietnamese agriculture sector and the rest of the economy is dealt with by using exogenous, user determined, parameter assumptions that reflect economic growth paths, such as changes in urban and rural income, and world prices. The model is described in detail in Appendix Sections A1 to A3. The methodology used to ensure market equilibrium is presented in Appendix Section A4.

Results

In the ten years to 2006, Vietnam's population is expected to grow from 84 to 95 million. The urban and rural projections by region are shown in table 5 for the two scenarios. The difference in the rural population for the two scenarios is 7 million. In the major agricultural areas, there is a drop of 1.1 million in the Mekong River Delta and 1.5 million in the Red River Delta and South East.

Table 5 Population under alternative scenarios

	Baseline in 2006		**S1: Even Growth to 2016**		**S2: No Rural Growth to 2016**	
	Urban	Rural	Urban	Rural	Urban	Rural
	million	million	million	million	million	million
Red River Delta	4.6	13.7	5.0	15.0	6.8	13.5
North East	1.8	7.7	2.0	8.5	3.1	7.6
Northwest Mountains	0.4	2.2	0.4	2.5	0.8	2.2
Northern and Central Coast	1.5	9.2	1.6	9.8	2.4	9.1
Southern and Central Coast	2.2	5.0	2.3	5.3	2.7	5.0
Central Highlands	1.4	3.5	1.6	4.1	2.4	3.4
South East	7.6	6.3	9.2	7.6	11.0	6.1
Mekong River Delta	3.6	13.8	3.8	14.8	5.1	13.7
Total all regions	**22.8**	**61.3**	**25.9**	**67.6**	**34.3**	**60.7**
Total	**84.2**		**93.5**		**95.1**	

The major differences in production in 2016, shown in table 6, are moderate, especially in comparison with the growth over the ten year period. The greatest relative differences are in rice, maize and soy with growth decreasing by 7 – 9 per cent with no rural growth compared with the even growth scenario. Milk production increases by 6 per cent. Fishmeal and trashfish production does not expand through time as it assumed the most fisheries are fished to capacity (Edwards et al. 2004). All other differences are minimal at 1 – 3 per cent.

Table 6 Change in production

	Baseline Supply	S1: Even Growth	S2: No Rural Growth
	kt	%	%
Rice	20,338	31	24
Maize	2,787	43	35
Sweet potato	714	66	65
Cassava	1,358	20	18
Soy	239	25	16
Pig	1,167	110	112
Chicken	256	103	106
Other Poultry	128	95	97
Beef	66	105	108
Milk	202	119	125
Seafood	877	19	20
Fishmeal	112	0	0
Trashfish	851	0	0

National prices are consistent with changes in production (table 7). Feed prices are increased significantly (especially for sweet potato and maize) driven by the demand for pigs and poultry with rising incomes. Meat prices are in fact reduced because of the rapid rise in production. Rice, seafood and fishmeal prices are stabilised by world prices so there is little change. National consumer prices (not shown here) also move in line with producer prices.

Table 7 Change in national producer prices

	Baseline	S1: Even Growth	S2: No Rural Growth
	(VND/kg)	%	%
Rice	2,339	-1	1
Maize	1,236	148	175
Sweet potato	1,424	450	672
Cassava	774	0	41
Soy	12,717	28	33
Pig	14,313	0	0
Chicken	38,069	-17	-16
Other Poultry	21,062	-20	-18
Beef	26,916	-8	-1
Milk	9,116	-23	-15
Seafood	18,000	0	0
Fishmeal	2,674	0	0
Trashfish	5,050	0	0

Rural-urban migration has a modest effect on food consumption (table 8). In the reference scenario there is a movement away from maize and sweet potato towards high protein foods, meat, milk and seafood. This trend is magnified slightly under the urban migration scenario. This reflects the higher income levels in urban areas. Migrants who move to the cities enjoy higher incomes and consume more of the income elastic protein foods.

Table 8 National consumption

	Baseline Food Demand	S1: Even Growth	S2: No Rural Growth
	kt	%	%
Rice	11,534	24	23
Maize	136	-30	-31
Sweet Potato	307	-59	-64
Soy	70	76	81
Pig	1,136	72	78
Chicken	290	95	98
Other Poultry	131	94	96
Beef	81	99	107
Milk	331	100	112
Seafood	1,327	64	69

The demand for livestock products drives the demand for feed (table 9). Rice and maize are the most significant feeds. Demand for all feeds are increased slightly.

Table 9 National feed demand

	Baseline Feed Demand	S1: Even Growth	S2: No Rural Growth
	kt	%	%
Rice	3,547	78	79
Maize	3,498	109	111
Sweet Potato	569	97	98
Cassava	753	110	112
Soy	975	94	96
Fishmeal	283	52	53
Trashfish	375	19	21

The increase in feed demand for livestock production is reflected in feed trade (table 10). Maize, soy and fishmeal imports are increased and rice and cassava exports are reduced (cassava exports are ceased in the no rural growth scenario). Meat imports are increased in line with increased demand. Pig exports are increased ten-fold from a low base over the 10 year period, but exports are decreased slightly with the no rural growth scenario compared with even growth, reflecting increased domestic demand. Seafood exports are also reduced as a result of increased domestic demand.

Table 10 Change in imports and exports

	Imports			Exports		
	Baseline	S1: Even Growth	S2: No Rural Growth	Baseline	S1: Even Growth	S2: No Rural Growth
	kt	%	%	kt	%	%
Rice	0			5,257	14	-12
Maize	847	304	341	0		
Cassava	0			605	-93	-100
Soy	806	113	118	0		
Pig	6	72	78	37	1,276	1,141
Chicken	34	35	39	0		
Other Poultry	2	20	26	0		
Beef	15	72	105	0		
Milk	129	70	92	0		
Seafood	0			417	-82	-77
Fishmeal	171	86	88	0		

Policy implications

The simulation results suggest the movement of labour from rural to urban areas may be beneficial for consumers and have only a limited impact on producers. The consumer impact derives from the increase in incomes that migrant workers can obtain in urban locations.

The impact of migration on agricultural output appears to be minimal with slight increases in meat production and slight decreases in feed output. Furthermore, producers who remain in the rural areas may be better off because any decrease in production is offset to some extent by an increase in prices, although this does not happen where the domestic price is determined by international prices, as is the case of rice, the major crop in Vietnam.

Simulated results suggest that migration is unlikely to have a significant adverse impact on prices. The Government policy of restricting migration seems difficult to justify on the grounds of food security.

The analysis presented here assumes full employment, which implies migration out of the rural area lessens production. GSO data suggests modest levels of unemployment and underemployment in rural areas. If these potential workers could find employment in the agricultural sector, the losses in production are likely to be minimal. The modelling assumes no substitution of capital and land for labour. Thus the negative effects are overestimated.

VAST could be refined by introducing other factors, capital and land, into the model. Kompas et al. (2009) in a study of total factor productivity in the rice market, have called for further land reform, and an analysis of potential reforms using VAST would be useful. A further refinement would be the development of a general equilibrium model. The limitation of a partial model such as this is that changes in employment of factors in the agricultural sector do not affect output in other sectors. In reality, an expansion of output in agriculture requires a fall in production in another sector.

Finally, VAST could be applied to a range of structural adjustment issues. This includes an assessment of the impact of negative production shocks in one region, such as a flood in the Mekong River Delta, on prices and consumption in other regions. The rate of land use change out of agriculture and the impacts of climate change could be examined if productivity shocks and land losses were fed into the model. Other government policies that could be examined include reduced marketing margin due to better transport infrastructure, changes in the rate of technical change (via extension), encouragement of crop production in a particular area (e.g. maize), limitations in production (cassava), and trade policy affecting border prices (cassava).

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Appendix: Detailed description of VAST

The VAST model is solved within GAMS using constrained optimisation. The objective function is to maximise surplus derived from three model sub-sectors; cropping producer surplus (*cropPS*), livestock producer surplus (*lvstkPS*) and food consumer surplus (f*oodCS*) (equation 1):

$$Max \quad cropPS + lvstkPS + foodCS \tag{1}$$

For each sub-sector, the model solves for the equilibrium of market demand and supply, for each year in a series of forward projection years. Demand growth over time is driven by changes in income and population and the model determines the response of the agriculture sector to these underlying changes in demand. The supply side includes short-term and longer-term responses as will be described below.

Each of the thirteen commodities may be included in seven sets within the model as shown in table A1. The seven sets include: food products, crops, livestock, feeds, Armington products (products that are imported and so Armington equations are used to determine substitution of domestic goods and imports. Non-Armington products are not imported so consumer prices is determined by domestic markets only), and exported products.

Each of the model sub-sectors will be described in more detail in Sections A1 to A3. The methodology used to ensure market equilibrium is presented in Appendix Section A4. Most of the data are provided within these Sections. They are taken from the following main sources:

1. The Vietnam Household Living Standards Survey conducted by the General Statistical Office of Vietnam (conducted in 2002, 2004 and 2006) (GSO 2007a). It covers approximately 45,000 households (World Bank 2004),
2. Agrocensus data (GSO 2007a),
3. Land use survey data (GSO 2006), and
4. Trade, price and tourism statistics (GSO 2007b).

A1 Cropping subsector

The cropping producer surplus is measured as the area below the producer price minus the area under a cropping supply curve, summed for all crops, *c*, in all regions, *r*, and for all years 0 to *t*. A Cobb Douglas supply curve is used, defining the quantity supplied, *S*, in year, *t*, (Q_{Scrt}) as follows:

$$Q_{Scrt} = k_{crt} \cdot \frac{Q_{Scr0}}{P_{Scr0}^{\ \varepsilon_{cr}}} . P_{Scrt}^{\ \varepsilon_{cr}} \quad (2)$$

where k_{crt} = the crop productivity scaling factor is defined as:

$$k_{crt} = (1 + \psi_{cr})^t \quad (3)$$

and where ψ_{cr} = the annual productivity growth. The scaling factor measures net productivity, and can be negative if yield growth doesn't compensate for land loss. Also, it is assumed that labour is used in fixed proportions to other input such that ψ_{cr} includes population growth (i.e. ψ_{cr} = the population growth rate (θ_{Ur} in equation 17) + annual productivity growth for non-labour inputs),

Q_{Scr0} = quantity supplied in the baseline year, *0*,

P_{Scr0} = the supply price in the baseline year, *0*,

P_{Scrt} = the supply price at time, *t*, and

ε_{cr} = the own-price elasticity of supply.

Regional supply prices for all products, *p*, (of which crops, *c*, is a sub-set) in all regions, *r*, in year *t*, are determined by national supply prices multiplied by a supply price factor:

$$P_{Sprt} = P_{Spnt} * \Phi_{pr} \quad (4)$$

where: P_{Spnt} = national supply price, and

Φ = the supply price factor, defined as the producer prices by region divided by national domestic supply price. It is calculated using data from the baseline year and is used to calculate supply prices by region in successive years:

$$\Phi_{pr} = P_{Spr0} / P_{Spn0} \quad (5)$$

The model solves for national supply prices in subsequent years.

Data for ψ_{pr}, Q_{Scr0} and P_{Scr0} are provided in tables A2 to A4. ε_{cr} is assumed to be 0.2. Data for P_{Spn0} is provided in column 1 of table A5.

A2 Livestock subsector

The main responses in animal production in a single year include changes to feeding regimes in response to prices, and changes in annual yield (including changes in the number of cycles and animal slaughter weight). Producer surplus is calculated over two years for animals with slow stock adjustment (beef cattle and dairy cattle) and over one year for other animals (pigs, chickens, ducks, geese, other poultry and seafood).

The livestock producer surplus is measured as the area below the producer price minus the area under a livestock supply curve, summed for all livestock types, *l*, all regions, *r*, and for all years 0 to *t*. A Cobb Douglas supply (yield) curve is used, defining the yield per animal at time, *t*, (Y_{lrt}) as follows:

$$Y_{lrt} = k_{lrt} \cdot \frac{Y_{lr0}}{P_{Slr0}{}^{\varepsilon_{lr}} * C_{Flr0}{}^{\kappa_{lr}}} . P_{Slrt}{}^{\varepsilon_{lr}} * C_{F\,lrt}{}^{\kappa_{lr}} \tag{6}$$

where k_{lrt} = the livestock productivity scaling factor (measured in the same way the crop productivity scaling factor as defined in equation 3),

Y_{lr0} = livestock yield in the baseline year,

P_{Slr0} = the supply price in the baseline year,

ε_{lr} = the own-price elasticity of supply,

C_{Flr0} = the cost of feed in the baseline year,

κ_{lr} = the calculated elasticity of livestock supply with respect to feed cost (which is based on the cost share and the supply price elasticity),

P_{Slrt} = the supply price at time, and

$C_{F\,lrt}$ = the cost of feed.

Data for Y_{lr0} , P_{Slr0} and ε_{lr}, are provided in tables A6, A4 and A7, respectively. P_{Slrt} is a subset of P_{Sprt} as is calculated as per equation (4). More information on the feed components of the model is provided subsequently (starting equation 9).

Farm supply for animals of type, l, in region, r, (Q_{Slr}) is calculated by multiplying yield (Y_{lr}) by stock (T_{lr}):

$$Q_{Slr} = Y_{lr} * \frac{T_{lr}}{1{,}000} \tag{7}$$

Data for T_{lr} is presented in table A8.

The elasticity of livestock supply with respect to feed cost, κ_{lr},, is a function of the own-price elasticity of supply and the feed cost share as follows:

$$\kappa_{lr} = -\varepsilon_{lr} * \varsigma_{lr0} \tag{8}$$

where ς_{lr0} is the feed cost share which is used to work out the relevant supply response to feed price changes and is calculated by dividing feed cost by the regional supply price in the baseline year:

$$\varsigma_{lr0} = C_{Flr0} / P_{Slr0} \tag{9}$$

The cost of all feeds at farm level for livestock type, l, region, r, and time, t, (C_{Flrt}) is calculated as follows:

$$C_{Flrt} = \alpha_{lr} * FCR_{lr0} * \left(\sum_{l} (Q_{Blr0} * P_{Clrt}) + Q_{Ilr0} * P_{CIlrt} \right) \tag{10}$$

where: α_{lr} = a feed cost adjustment factor,

FCR_{lr0} = the feed conversion ratio of feed diets,

Q_{Blr0} = the quantity of raw feed purchased from the farm sector,

P_{Clrt} = the regional consumer price,

Q_{Ilr0} = the quantity of feed purchased from the industrial sector, and

P_{CIlrt} = the regional industrial price of feed.

Data for α_{lr}, FCR_{lr0}, Q_{Blr0} and Q_{Ilr0} are provided in tables A9 to A12. The model solves for P_{Clrt} as calculated by equation (12). C_{Flr0} is calculated from equation 10 using parameter data for P_{CIrt} and P_{CIIrt} in the baseline year. Data for P_{CIr0} and P_{CIIr0} are provided in tables A13 and A14 respectively.

Prices paid for industrial feed by consumers for each industry type, *I*, region, *r*, and year, *t*, (P_{CIrt}) is a function of consumer prices for feed ingredients, the demand for raw feed by feedmills and a price margin, as follows:

$$P_{CIrt} = i_{Ir} + \sum_{f} \left(q_{Ifr0} * P_{Cfrt} \right) \tag{11}$$

where: i_{Ir} = the industrial margin (the difference between the industrial price and the calculated recipe cost), calculated from the above equation using P_{Cfr} in the baseline year,

q_{Ifr0} = the demand for raw feed by feedmills for feed type, *f*, in the baseline year, and

P_{Cfrt} = consumer prices for feed type, *f*, calculated as per equation (12) below.

Data for q_{Ifr0} and P_{Cfr0}, are provided in tables A15 and A13, respectively.

Regional consumer prices for all products, *p*, all regions, *r*, in year *t*, (P_{Cprt}) are determined by national domestic prices multiplied by a consumer price factor as shown in equation (12):

$$P_{Cprt} = P_{Cpnt} * \Omega_{pr} \tag{12}$$

The consumer price factor for all products, *p*, in region, *r*, (Ω_{pr}), is defined as the consumer prices by region divided by national domestic consumer price, calculated for the baseline year (equation 13) and is used to calculate consumer prices by region in successive years.

$$\Omega_{pr} = P_{Cpr0} / P_{Cpn0} \tag{13}$$

Data for consumer prices (P_{Cpn0}) are provided column 2 in table A5.

The model solves for national consumer prices in subsequent years.

A3 Food demand subsector

The demand side of the model is represented by a log-log model where price elasticities are calculated from an underlying regional AIDS model for food expenditure calculated for budget shares in the base year:

$$w_{ir} = a_{ir} + \sum_j b_{ijr} \ln P_{Cjr} + c_{ir} \frac{\ln B_r}{\sum_j w_{jr} \ln P_{Cjr}} \tag{14}$$

where w_{ir} = budget share of consumer food, *i*, in region, *r*,

B_r = per capita food budget in region, *r*,

P_{Cjr} = a vector of consumer prices for food, *j*, in region *r*, and

a_{ir}, b_{ijr} and c_{ir} are coefficient estimates.

Demand shifts over time as income grows. This shift in the demand curve is determined from the income elasticity, which is the product of the food expenditure elasticity and the food expenditure elasticity with respect to income growth (determined by Engel curves). The income elasticity is updated each year to allow for a gradually declining income elasticity as incomes grow. Each region has two consumer groups, urban and rural.

A detailed description of this aspect of the model is provided in Brennan (2010). Engel curves were estimated using on a semi-log form to allow for declining marginal allocation to the food budget as income grows:

$$B_{rUt} = d_{rU} + g_{rU} \ln I_{rUt} \tag{12}$$

where B_{rUt} = the budget allocation for food in region, *r*, for the urban/rural group, *U*, at time, *t*,

I_{rUt} = per capita income for the urban/rural group, *U*, in region, *r*, at time, *t*, and

d_{rU} and g_{rU} are coefficient estimates.

Income per capita (I_{rUt}) and population growth in region, *r*, for urban/rural group, *U*, at time, *t*, is described in the following two equations:

$$I_{rUt} = I_{rU0} * (1 + \varpi_{Ur})^t \tag{13}$$

$$L_{rUt} = L_{rU0} * (1+\theta_{Ur})^t \quad (14)$$

where: I_{rU0} = income per capita in the baseline year,

ω_{Ur} = annual income growth,

L_{rU0} = population in the baseline year, and

θ_{Ur} = annual population growth.

Data for I_{rU0} and L_{rU0} are provided in rows 1 to 4 of table A16. ω_{Ur} is held constant at 7% for all regions and for both the urban and rural groups. Standard data for θ_{Ur} is shown in scenario 1 of table 4 (Scenario 1).

The per capita consumer surplus for food is measured through the area under an inverse demand curve, summed for all food types, *i*, in all regions, *r*, for each urban/rural group, *U*, for all years 0 to *t*. The inverse demand curve at time, *t*, (q_{irUt}) is defined as:

$$q_{irUt} = \frac{L_{rU0}}{q_{irU0}^{\frac{1}{\varepsilon_{iirU}}}} . q_{irUt}^{1/\varepsilon_{iirU}} . \left(h_{irUt}\right)^{-1/\varepsilon_{iirU}} \quad (15)$$

where: q_{irU0} = per capita consumer demand in the baseline year,

ε_{iirU} = the own-price elasticity of demand for consumer food, *i*, (from equation 21 below), and

h_{irUt} = demand shift parameter associated with income growth (initially set to 1)

Data for q_{irU0} is provided in table A17. Equations for ε_{iirU} and h_{irUt} are provided below.

The food demand equation that describe per capita consumption (q_{irUt}) is:

$$q_{irUt} = h_{irUt} * n_{irU} * \prod_j P_{Cirt}^{\varepsilon_{ijrU}} \quad (19)$$

where: n_{irU} = the food demand constant (this is not used in the surplus calculations which subsumes cross-price effects into the constant), and

P_{Cirt} = consumer prices (determined by Equation (12))

The food demand constant, n_{irU}, sets the equation to observed quantities at observed prices in the baseline year and is calculated as follows:

$$n_{irU} = \frac{q_{irU0}}{\prod_j \left(P_{Cjr0}\right)^{\varepsilon_{ijrU}}} \tag{16}$$

Price elasticities, ε, are based on the budget share in the baseline period, defined as:

$$\varepsilon_{iirU} = -1 + \frac{b_{iirU}}{w_{iirU}} - c_{irU} \tag{171}$$

$$\varepsilon_{ijrU} = \frac{b_{ijrU}}{w_{irU}} - \frac{c_{irU}}{w_{irU}}.w_{jrU} \tag{18}$$

where subscripts *i, j, r*, and *U* refer to consumer foods, *i* and *j*, in region, *r*, for each demographic group, *U*. All AIDS demand equation parameters are taken from Brennan (2010).

The initial budget share of consumer food, *i*, in region, *r*, and urban/rural group, *U*, (w_{irU0}) is calculated as follows:

$$w_{irU0} = P_{Cir0} * q_{irU0} / B_{rUt} \tag{19}$$

where B_{rUt} = the budget allocation for food at time, *t* (calculated from equation (12), with data for B_{rU0} presented in row 5 and 6 of table A16). w_{irU0} is used in the elasticity equations (equations (171) and (18)), with subscripts *i* and *j* are interchanged in the equation above.

The term, h_{irUt}, is the demand shift parameter for consumer good, *i*, associated with income growth in region, *r*, for urban/rural group, *U*, in year, *t*, defined as:

$$h_{irUt} = h_{irU(t-1)}(1+\omega_{Ur})^{\eta_{irt}} \tag{20}$$

where: ω_{Ur} = annual income growth , and

η_{irUt} , = the income elasticity.

h_{irU} is set to 1 in the baseline year.

The income elasticity, η_{irUt}, is defined as:

$$\eta_{irUt} = (1 + \frac{c_{irU}}{w_{irU(t-1)}}).\frac{g_{rU}}{d_{rU} + g_{rU} \ln I_{rUt}} \tag{21}$$

where: g_{rU} and d_{rU} are the coefficient estimates from the Engel curve (see equation (12), and

I_{rUt} = per capita income in the current time period, which increases yearly by the annual income growth rate, ω_{rU}, as shown in equation (20).

Table A16 holds the data for g_{rU}, (rows 7 and 8), and d_{rU} (rows 9 and 10).

A4 Market equilibrium

It is assumed that internationally traded products are differentiated by country of origin, hence the Armington Approach is used to account for substitution between imported and domestically produced goods (Armington 1969). This approach is applied to all imported produces, M, (which initially includes all livestock products and maize) as follows:

$$\frac{M_M}{D_M - M_M} = \lambda_M * \left(\frac{P_{CMnt}}{P_M}\right)^{\varepsilon_M} \tag{26}$$

where M_M = quantity of imports,

D_M = quantity of imports consumed by domestic sources (this will be described further below starting at equation 31),

λ_M = the scaling parameter in the Armington equations (calculated from the above equation for the baseline year),

P_{CMnt} = the national consumer price (the cost of supply from domestic sources),

P_M = import price, and

ε_M = Armington elasticity of substitution between products of different countries.

For the standard version of the model, ε_M is set to 2.2 for all products. Export and import prices (held constant over time) and initial quantities are provided in table A5.

The price of imports price, P_M, is a function of the CIF price and a marketing margin:

$$P_M = CIF_M + m_M \tag{27}$$

where: CIF_M = the price of imports including insurance and freight, and

m_M = the import margin.

Data for CIF_M and m_M are provided in column 5 of table A5 and column 1 of table A18, respectively.

The national consumer price for imported products, *M*, at time, *t*, (P_{CMnt}) is a function of the national supply price:

$$P_{CMnt} = \frac{\left(P_{SMnt} / r_M + z_M\right) * \left(D_M - M_M\right) + \left(P_M * M_M\right)}{D_M} \qquad (28)$$

where: P_{SMnt} = the national supply price,

r_M = a conversion ratio used to convert wet weight to dry weight, and

z_M = domestic supply marketing margin.

The national consumer price for non-imported products, *Z*, at time, t, (P_{CZnt}) is the simpler:

$$P_{CZnt} = P_{Sznt} / r_Z + z_Z \qquad (29)$$

National consumer and supply prices for imported and non-imported products in the baseline year are provided in table A5. Baseline values for *r* and *z* are fixed according to columns 3 and 4 of table A18.

The quantity of domestic supply for all products, *p*, in region, *p*, (S_{pr}), is calculated as follows:

$$S_{pr} = Q_{pr} * r_p * (1 - p_p) * (1 - y_R) \qquad (22)$$

where: Q_{pr} = regional supply of products at farm level,

p_p = post-harvest losses, and

y_R = is the quantity of harvest retained for seed (assumed to be 3%).

Data for p_p is provided in column 5 of table A18.

The quantity of imported products consumed by domestic sources, D_M, is the sum of food and feed demand as follows:

$$D_M = \sum_{rU} G_{Mru} + \sum_{r} F_{Mr} \qquad (23)$$

where: G_{irU} = National food demand for all consumer foods, *i*, in all regions, *r*, and the urban/rural groups, *U*, and

F_{pr} = National feed demand in region, *r*, (including raw food demand from the farm sector as well as industrial feed inputs).

National food demand for all consumer foods, *i*, in all regions, *r*, and the urban/rural groups, *U*, (G_{irU}) is calculated as per capita demand multiplied by population, as follows:

$$G_{irU} = \sum_{rU} \frac{(q_{irU} * L_{rU})}{1000} \quad (24)$$

where: q_{irU} = per capita demand for consumer food, and

L_{rU} = current population.

National feed demand for product, *p*, in region, *r*, which includes raw food demand from the farm sector as well as industrial feed inputs (F_{pr}), is calculated as follow:

$$F_{pr} = \sum_{l} (Q_{Bpr0} * Q_{Slr} * FCR_{lr0}) + \sum_{l} (Q_{Ilr} * q_{Ilpr0}) \quad (25)$$

where: Q_{Bpr0} = the quantity of raw feed purchased from the farm sector (data in table A11),

Q_{Slr} = Farm supply for animals of type, *l*,

FCR_{lr0} = the feed conversion ratio of feed diets,

Q_{Ilr} = the quantity of feed purchased from the industrial feedmill sector, and

q_{Illpr0} = Industry demand for feeding livestock, *l*, feed type, *f*, in the baseline year.

Industry supply of feedmill feeds, for industry, *I*, region, *r*, and time, *t*, (Q_{Ilrt}) is calculated as

$$Q_{Ilrt} = Q_{Ilr0} * f_I \quad (26)$$

where: Q_{Ilr0} = Industry supply of feedmill feeds in the baseline year,

f_I = a variable that makes supply increase in proportion to demand increase at the regional level.

Data for Q_{Ilr0} is provided in table A12, and f_I is initially set to 1.

The general market clearance equation determines export quantity of product, p, (X_p) as:

$$X_p = S_{pr} - D_{pr} + M_p \tag{35}$$

This equation requires specific attention for seafood, E, and fishmeal, H, as shown in the following two equations.

The market clearance equation for seafood, E, specifies that the supply of seafood from aquaculture as well as capture fisheries, minus food demand and exports, must be greater than or equal to the quantity of caught fish used for fish meal, fish sauce and trashfish:

$$\sum_r S_{Er} + \sum_r e_r * (1 - p_E) - G_{Er} - X_E \geq \sum_r (e_r * R_r) \tag{36}$$

where S_{Er} = Quantity of domestic supply of seafood, E, in region, r,

e_r = Fish catch in region, r,

p_E = post-harvest losses of seafood, E,

G_{Er} = Food demand for seafood, E, in region, r,

R_r = Proportion of fish catch used for fishmeal, fish sauce and low-value feed (trash fish).

The market clearance equation for fishmeal, H, is:

$$\sum_r (e_r * A_r * r_H) - \sum_r F_{Hr} + M_H = 0 \tag{37}$$

where A_r = Proportion of fish catch used to make fishmeal,

F_{Hr} = National feed demand for fishmeal in region, r, and

M_H = Imports of fishmeal.

Data for e_r, R_r and A_r are provided in table A19.

Lastly, exports of non-rice products must satisfy Kuhn Tucker conditions A (that local price must be greater than or equal to exports prices after margins are taken into account) and B (if the local price is greater than export prices, then exports must be zero).

Kuhn Tucker Condition A: $$\frac{P_{SnN}}{r_N} \geq P_{XN0} - x_N \tag{38}$$

Kuhn Tucker Condition B: $$\left(\frac{\mathrm{P_{SnN}}}{r_N} - P_{XN0} + x_N\right) * X_N = 0 \qquad (27)$$

where: P_{SnN} = national supply price for non-rice products,

r_N = a conversion ratio used to convert wet weight to dry weight, for non-rice products,

P_{XN0} = price of exports for non-rice products in the baseline year,

x_N = an export margin for non-rice products, and

X_N = the quantity of national exports of non-rice products.

Initial values of P_{SnN} are provided in column 1 of table A5. Data for r_N and x_N are provided in table A18. P_{XN0} and initial values of X_N are provided in table A5.

Table A1 Products and sets used within the model

All products	Sets					
	Food products	Crops	Livestock	Feeds	Armington (imported) products	Exported products
Rice	x	x		x	x	x
Maize	x	x		x	x	
Sweet potato	x	x		x		
Cassava		x		x		x
Soybean	x	x		x	x	
Pigs	x		x		x	x
Chicken	x		x		x	
Other poultry (ducks, geese and others)	x		x		x	
Beef cattle	x		x		x	
Dairy cattle	x		x		x	
Seafood	x		x			x
Fishmeal				x		
Trashfish				x		

Table A2 Annual productivity growth (ψ_{pr}) (proportional increase in yield per hectare or per animal)

	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Rice	0.022	0.013	0.013	0.013	0.013	0.013	0.013	0.044
Maize	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Sweet Pot	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Cassava	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Soybean	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Pigs	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Chicken	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Oth Poultry	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Beef cattle	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Dairy cattle	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Seafood	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020

Table A3 Supply of each crop by region for the baseline year (Q_{Scr0}) (‘000 tonnes)

Crop	Region							
	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Rice	3,680	1,431	316	1,880	1,058	450	940	10,582
Maize	245	491	332	397	116	677	388	140
Sweet Pot	122	169	23	208	55	61	25	51
Cassava	28	150	85	148	161	435	303	48
Soybean	99	42	25	7	0	34	4	28

Table A4 Producer prices for all products (excluding fishmeal and trashfish) by region for the baseline year (P_{Spr0}) ('000 VND/kg)

Product	Region							
	RRD	**NEM**	**NWM**	**NCC**	**SCC**	**CH**	**SE**	**MRD**
Rice	2.9	2.9	2.8	2.6	2.4	2.4	2.4	2.3
Maize	1.4	1.3	1.1	1.4	1.2	1.0	1.1	1.9
Sweet Pot	1.5	1.5	1.9	1.2	1.2	1.9	1.4	1.5
Cassava	1.4	0.7	0.6	0.7	0.6	0.7	0.9	1.9
Soybean	13.2	13.9	10.2	14.5	12.5	11.0	11.8	13.3
Pigs	13.9	13.4	15.3	13.4	13.2	13.6	15.8	15.2
Chicken	35.6	34.5	38.6	36.1	36.5	36.7	38.2	30.9
Oth Poultry	19.6	22.7	26.1	20.5	20.3	22.9	20.8	21.5
Beef cattle	29.0	23.4	15.9	25.9	27.2	26.4	27.5	33.1
Dairy cattle	9.9	9.9	9.9	9.9	9.4	9.4	8.9	9.4
Seafood	12.9	18.0	23.0	14.9	14.9	14.9	21.4	18.0

Table A5 Miscellaneous national market parameters for all products for the baseline year

	1	2	3	4	5	6
Product	**National domestic supply price**	**National domestic consumer price**	**Export price**	**Export quantity**	**Import price**	**Import quantity**
	P_{Spn0}	P_{Cpn0}	P_X	X_X	CIF_M	M_M
	(‘000 VND/kg)	(‘000 VND/kg)	(‘000 VND/kg)	(‘000 tonnes)	(‘000 VND/kg)	(‘000 tonnes)
Rice	2.3	4.9	3.5	5,257	-	-
Maize	1.2	3.3	-	-	3.6	847
Sweet Pot	1.4	3.3	-	-	-	-
Cassava	0.8	2.6	2.3	605	5.6	806
Soybean	12.7	8.6		-	6.50	6
Pigs	14.3	29.3	26.0	37	30.0	34
Chicken	38.0	44.5	-	-	39.3	2
Oth Poultry	21.0	24.8	-	-	22.8	15
Beef cattle	26.9	67.2	-	-	64.1	129
Dairy cattle	9.1	17.2	-	-	11.9	-
Seafood	18.0	20.6	19.8	417	-	171
Fishmeal	2.7	10.7	-	-	10.7	-
Trashfish	5.1	5.1	-	-	-	-

Table A6 Livestock yield by animal type and region for the baseline year (Y_{lr0}) (kg/animal except seafood which is in kg/ha)

Product	**RRD**	**NEM**	**NWM**	**NCC**	**SCC**	**CH**	**SE**	**MRD**
Pigs	83.94	55.80	26.88	51.78	57.66	59.93	97.62	107.27
Chicken	2.23	1.69	1.85	1.37	1.07	1.78	4.04	1.61
Oth Poultry	2.33	2.30	1.97	1.88	2.25	3.41	4.67	2.23
Beef cattle	32.94	23.77	20.79	27.66	23.31	28.65	20.78	23.38
Dairy cattle	1,343.77	1,248.31	542.89	1,361.17	1,231.13	2,093.31	2,504.96	2,928.81
Seafood	2,091.82	894.59	688.51	1,258.70	586.17	1,581.04	2,920.74	1,016.83

Table A7 Own-price elasticities of supply for livestock yield by animal type and region (ε_{lr})

Product	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chicken	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Oth Poultry	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Beef cattle	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Dairy cattle	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Seafood	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Note: Elasticities of supply for livestock stocking rates are assumed to be 1 for all livestock types and all regions

Table A8 Stock numbers by animal type and region (T_{lr}) (‘000 animals except seafood which is ‘000 ha)

Product	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	6,987	4,343	1,094	3,600	1,964	1,315	2,863	3,891
Chicken	42,878	31,122	6,634	23,520	9,108	6,772	10,876	23,445
Oth Poultry	17,733	7,889	1,527	7,589	3,758	1,166	2,153	23,101
Beef cattle	806	774	265	1,252	1,208	740	776	670
Dairy cattle	10	3	3	3	2	3	62	9
Seafood	63	33	6	33	9	5	17	701

Table A9 Feed cost adjustment factors by animal type and region (α_{lr})

Product	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Chicken	1	1	1	1	1	1	1	0.5
Oth Poultry	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Beef cattle	1	1	0.7	1	1	1	1	1
Dairy cattle	1	1	1	1	1	1	0.7	0.7
Seafood	1	1	1	1	1	1	1	1

Table A10 Feed conversion ratios by animal type and region for the baseline year (FCR_{lr0})

Product	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	4.69	5.93	10.88	6.54	7.31	6.00	4.49	4.08
Chicken	4.57	4.42	2.31	5.42	8.56	2.41	3.07	10.20
Oth Poultry	7.31	5.72	5.98	7.85	9.10	4.80	4.27	9.22
Beef cattle	2.08	8.91	10.77	3.99	2.28	2.13	2.16	1.95
Dairy cattle	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Seafood	2.56	2.08	1.92	2.30	2.53	2.52	2.13	1.72

Table A11 Quantity of raw feed purchased from the farm sector by animal type and region for the baseline year (Q_{Blr0}) ('000 tonnes)

Animal type	Feed	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	Maize	0.28	0.32	0.35	0.04	0.03	0.36	0.02	0.00
Chicken	Maize	0.03	0.04	0.05	0.05	0.10	0.08	0.00	0.00
Other poultry	Maize	0.07	0.18	0.29	0.14	0.06	0.12	0.07	0.04
Beef cattle	Maize	0.14	0.00	0.00	0.02	0.06	0.02	0.11	0.07
Dairy cattle	Maize	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Pigs	Rice	0.09	0.03	0.04	0.19	0.14	0.02	0.03	0.13
Chicken	Rice	0.25	0.35	0.36	0.43	0.36	0.35	0.23	0.27
Oth poultry	Rice	0.13	0.28	0.41	0.20	0.08	0.18	0.23	0.24
Beef cattle	Rice	0.26	0.08	0.06	0.16	0.28	0.32	0.26	0.32
Dairy cattle	Rice	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Seafood	Rice	0.35	0.35	0.35	0.34	0.35	0.35	0.34	0.34
Pigs	Sweet Pot	0.01	0.04	0.03	0.03	0.14	0.06	0.00	0.00
Beef cattle	Pot	0.25	0.71	0.73	0.55	0.33	0.31	0.28	0.24
Seafood	Soybean	0.06	0.05	0.06	0.05	0.06	0.06	0.04	0.04
Seafood	Fishmeal	0.00	0.01	0.00	0.03	0.01	0.00	0.03	0.03
Seafood	Trash Fish	0.21	0.21	0.22	0.20	0.21	0.22	0.20	0.20

Table A12 Quantity of feed purchased from the industrial sector by animal type and region for the baseline year (Q_{Ilr0}) ('000 tonnes)

Anima type	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	0.43	0.19	0.37	0.10	0.08	0.14	0.80	0.53
Chicken	0.59	0.49	0.47	0.42	0.32	0.38	0.66	0.40
Othepoultry	0.66	0.53	0.42	0.59	0.45	0.40	0.46	0.35
Beef cattle	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Dairy cattle	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Seafood	0.37	0.38	0.37	0.38	0.41	0.38	0.50	0.49

Table A13 Consumer prices for all products by region for the baseline year (P_{Cpr0}) ('000 VND/kg)

Product	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Rice	4.9	4.9	5.4	4.6	4.6	4.9	5.6	4.7
Maize	3.5	3.5	4.3	3.7	3.3	3.4	5.7	5.1
Sweet Pot	2.9	2.9	2.7	2.3	3	2.7	4.5	3
Cassava	4.6	2.5	2	2.3	2	2.2	3.1	6.2
Soybean	7	6.9	6.6	8.3	9.7	9.8	11.4	11.9
Pigs	28.4	25.5	28.5	26.9	30.8	28.4	34.8	29.1
Chicken	32.2	35	37.1	32.1	36.6	34.8	39.5	29.6
Oth Poultry	19.1	22.2	26.1	19.2	24	24.8	31.7	20.5
Beef cattle	64.9	61.9	56.7	59.5	63.9	65.6	78.1	69.1
Dairy cattle	20.7	12.9	10.8	12.9	16.8	14.6	18.8	13.3
Seafood	19.9	20.3	24.8	18.1	19.7	19.4	26.6	18.5
Fishmeal	11.2	11.2	11.2	11.2	10.7	10.7	10.7	10.7

Table A14 Prices paid for industrial feed by consumers by region for the baseline year (P_{CIlr0}) ('000 VND/kg)

Product	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	5.09	4.53	5.82	5.21	5.18	4.46	6.16	6.43
Chicken	4.54	4.17	4.49	4.37	4.24	4.36	5.80	6.07
Beef cattle	4.75	4.16	4.42	4.40	4.35	4.47	5.94	6.38
Seafood	6.02	6.15	6.26	6.23	6.24	6.38	7.23	6.68

Table A15 Demand for raw feed by feedmills by region for the baseline year (q_{Ifr0}) ('000 tonnes)

Product	Feed	RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Pigs	Maize	0.40	0.40	0.40	0.40	0.30	0.30	0.30	0.30
Pigs	Rice	0.10	0.10	0.10	0.10	0.20	0.20	0.20	0.20
Pigs	Cassava	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Pigs	Soybean	0.20	0.18	0.30	0.22	0.21	0.13	0.14	0.15
Pigs	Fishmeal	0.02	0.02	0.03	0.02	0.02	0.01	0.02	0.02
Chicken	Maize	0.36	0.36	0.36	0.36	0.30	0.30	0.30	0.30
Chicken	Rice	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Chicken	Cassava	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Chicken	Soybean	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13
Chicken	Fishmeal	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.04
Beef cattle	Maize	0.39	0.39	0.39	0.39	0.29	0.29	0.29	0.29
Beef cattle	Rice	0.04	0.04	0.04	0.04	0.10	0.10	0.10	0.10
Beef cattle	Cassava	0.23	0.23	0.23	0.23	0.19	0.19	0.19	0.19
Beef cattle	Soybean	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14
Beef cattle	Fishmeal	0.02	0.02	0.02	0.02	0.05	0.05	0.05	0.05
Seafood	Rice	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Seafood	Soybean	0.16	0.15	0.17	0.13	0.14	0.16	0.09	0.10
Seafood	Fishmeal	0.11	0.12	0.10	0.14	0.13	0.11	0.18	0.17

Table A16 Demand side data for the urban and rural demographic groups by region

			RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
1	Income in the baseline year (I_{rU0}) ('000 VND/capita)	Urban	11,227	7,548	6,470	6,604	8,272	6,615	12,019	7,311
2		Rural	4,227	3,482	2,650	3,461	4,025	3,386	5,355	4,575
3	Population in the baseline year (L_{rU0}) ('000 people)	Urban	4,547	1,788	363	1,463	2,148	1,368	7,550	3,598
4		Rural	13,661	7,671	2,244	9,206	4,984	3,501	6,249	13,817
5	Budget allocation for food in the baseline year (B_{rU0}) ('000 VND/capita)	Urban	2,968	2,635	2,572	2,226	2,591	2,253	3,191	2,649
6		Rural	1,853	1,890	1,661	1,611	1,685	1,715	2,212	2,122
7	The slope of the Engel Curve (g_{rU})	Urban	1,588	1,103	1,103	1,259	1,259	1,678	1,678	1,515
8		Rural	990	1,075	1,075	848	848	1,148	1,148	1,225
9	Constant in the Engel curve (d_{rU})	Urban	-11,839	-7,210	-7,103	-8,850	-8,769	-12,509	-12,573	-10,829
10		Rural	-6,411	-6,878	-6,813	-5,297	-5,351	-7,619	-7,647	-8,205

Table A17 Per capita consumption of consumer foods for the urban and rural demographic groups by region for the baseline year (q_{irU0}) (kg/capita)

Product		RRD	NEM	NWM	NCC	SCC	CH	SE	MRD
Rice	Urban	116.53	126.61	131.63	130.64	118.61	132.50	104.60	127.36
Maize	Urban	1.32	2.20	5.60	1.12	1.31	2.35	0.60	0.86
Sweet Pot	Urban	3.04	3.07	2.52	2.49	1.87	2.46	2.12	3.01
Soybean	Urban	1.71	1.56	1.87	0.89	0.69	0.70	0.89	0.39
Pigs	Urban	20.19	21.42	17.74	13.56	12.87	12.72	18.91	17.08
Chicken	Urban	6.38	5.63	6.01	3.15	1.80	3.41	3.30	2.43
Oth Poultry	Urban	2.42	1.44	1.11	1.41	1.02	0.88	0.76	2.11
Beef cattle	Urban	3.01	1.12	1.69	2.52	2.66	2.09	2.50	0.70
Dairy cattle	Urban	7.23	2.90	3.16	3.34	6.64	6.09	14.48	5.45
Seafood	Urban	14.87	10.78	6.47	15.82	23.31	13.70	22.30	28.67
Rice	Rural	154.27	156.31	138.19	142.01	134.70	144.67	135.35	146.63
Maize	Rural	1.09	4.41	3.76	1.45	1.38	2.44	1.49	1.08
Sweet Pot	Rural	3.92	3.94	12.11	4.34	3.16	3.79	2.37	4.17
Soybean	Rural	1.21	1.16	0.93	0.60	0.44	0.61	0.80	0.35
Pigs	Rural	15.01	14.23	8.63	9.27	8.05	9.15	13.95	11.89
Chicken	Rural	4.21	4.91	3.98	2.62	1.75	3.07	3.40	2.64
Oth Poultry	Rural	1.86	1.59	0.90	1.10	1.01	0.66	0.84	2.67
Beef cattle	Rural	0.53	0.28	0.47	0.52	0.98	0.65	0.81	0.33
Dairy cattle	Rural	1.49	1.14	0.51	1.34	2.05	2.09	6.44	2.86
Seafood	Rural	8.77	7.15	4.98	11.07	16.17	11.50	19.63	25.82

Table A18 Margins and conversion ratios for all products

Product	1	4	2	3	5
	Import margin	**Export marketing margin**	**Conversion ratio, converting wet weight to dry weight**	**Domestic supply marketing margin**	**Post-harvest losses**
	m	***x***	***r***	***z***	***p***
Rice		0.23	0.70	1.58	0.14
Maize	0.41		1.00	1.80	0.10
Sweet pot			0.47	0.23	0.28
Cassava		0.68	0.47	0.95	0.07
Soybean	0.40		0.88	0.09	0.10
Pigs	2.89	2.19	0.60	5.42	0.00
Chicken	3.31		0.85	0.00	0.00
Oth Poultry	2.20		0.85	0.00	0.00
Beef	2.86		0.40	0.00	0.00
Dairy cattle	2.00		1.00	10.17	0.05
Seafood		1.80	1.00	2.58	0.10
Fishmeal	0.00	0.00	0.25	0.00	0.00
Trash fish	0.00	0.00	1.00	0.00	0.00

Table A19 Fish marketing data, including fish catch (e_r), and the proportion of catch used for fish meal, fish sauce and trash fish (R_r) by region

	RRD	**NEM**	**NWM**	**NCC**	**SCC**	**CH**	**SE**	**MRD**
Fish catch (e_r)	242.62	76.63	3.94	322.68	669.82	9.96	489.59	1,155.30
Proportion of fish catch used for:								
(a) Fish meal (A_r)	0.01	0.04	0.04	0.02	0.01	0.00	0.34	0.22
(b) Fish sauce	0.03	0.01	0.00	0.06	0.03	0.00	0.05	0.02
(c) Trash fish	0.07	0.08	0.05	0.07	0.00	0.03	0.58	0.45
Total (a + b + c) (R_r)	0.11	0.13	0.09	0.14	0.04	0.03	0.97	0.69