Transformation of pig markets in Vietnam:
Will small-scale pig farmers be squeezed out?

(A new version of 2010 report updated by CAP's team)

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Abbreviation

AFTA	ASEAN Free Trade Area
ASEAN	Association of Southeast Asian Nations
CAP	Center for Agricultural Policy
CAFTA	Central America Free Trade Agreement
CH	Central Highland
EURO	European Union
FAO	Food and Agriculture Organization
GSO	General Statistical Office of Vietnam
IPSARD	Institute of Policy and Strategy for Agriculture and Rural Development
IFPRI	International Food Policy Research Institute
ILLRI	International Livestock Research Institute
MRD	Mekong River Delta
NAFTA	North American Free Trade Agreement
NCC	North Central Coast
NU	Northerm Upland
RRD	Red River Delta
SCC	South Central Coast
SE	South East
USDA	U.S. Department of Agriculture
VND	Vietnam dong
VHLSS	Vietnam Household Living Standard Survey
VPM	Vietnam Pig-sector Model
WB	World Bank
WTO	World Trade Organization

Introduction

In the last 20 years, globalization and regionalization has become a common trend in the world with the establishment of EURO, AFTA, NAFTA, CAFTA ... and other regional free trade agreement such as APEC. Vietnam is also an active countries in participating in regional associations and free trade agreements, particularly WTO, ASEAN[1], ASEAN plus three[2] and most recently, Vietnam is in the final negotiation round for joining TPP[3]. All of these associations and free trade agreement have a common point of reducing import tariff for most products. In this context, Vietnam's livestock production, especially pig sector, will face enormous challenges. With obsolete technology, small scale farming and has to import most material for animal feed production... production cost of Vietnam's pig sector is much higher than many other countries in partner countries. Therefore, Vietnamese government concerns that Vietnamese pig sector, especially small and medium scale producer will be squeezed out of the market.

At the first section of the report, we will describes the most updated data about current situation of pig production and consumption in Vietnam as well Vietnamese government policies on livestock production in Vietnam.

In the following section, by updating and upgrading/refining the Vietnamese pig sector model (VPM) developed by IFPRI in 2010, we will make projections of the evolution of the pig sector in Vietnam over the next 10 years (2015-2025) under alternative assumptions, including assumption when Vietnam join TPP and import tax for pig products reduce to answer the above question.

More specifically, this study attempts to address the following research questions:

- How will pig products tax reduction affect pig demand, consumption, price and import/export of Vietnam?

- How will rising income & urbanization affect total pig demand and the composition of pig demand?

- How will shifts in pig demand influence pig producers, particularly small-scale producers? More specifically, will small-scale pig producers be squeezed out of the market?

- How will growth of pig production affect maize markets, specifically, will rising demand for feed lead to maize imports?

- How would alternative assumptions about income growth, productivity growth, and consumer behavior influence the evolution of pig sector?

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1 Including: Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, and Cambodia.
2 Including: ASEAN countries, China, Japan, and Korea.
3 Including: Brunei, Chile, New Land, Singapore, United States, Australia, Peru, Vietnam, Malaysia, Mexico, Canada, and Japan.

Current situation of pig production and pig consumption in Vietnam

Livestock sector in Vietnam

After more than 25 years since the Doi moi policy which aims at moving Vietnam from a centrally controlled economy towards a more market-oriented one was ratified, Vietnam has witnessed tremendous success in terms of its social and economic development. The success is demonstrated by rapid growth of the economy (7-8 percent per year on average), accompanied with impressive poverty reduction, with the poverty rate declining from 70 percent in 1986 to 12.4 percent in 2011 (Phan and Coxhead 2010). Improved living standards, along with growing populations, have increased demand for high-quality food and foodstuffs in general and animal products in particular. In order to meet that demand, the livestock sector in Vietnam has developed remarkably in both head size and volume of meat produced.

The gross output of livestock in Vietnam has increased annually, reaching approximately 145 thousand billion VND (~6.87 billion USD[4]) in 2013. In the period 2005-2012, the average annual growth rate of livestock production was 6 percent. Nearly 90 percent of total output was attributed to meat products including domestic animals and poultry, in which domestic animals accounted for 70-80 percent (see Table 1

Table 1: Gross output of livestock at constant 2010 prices by product (Billion VND)

Source: GSO (2014)

Year	Domestic animal	Poultry	Non-meat product	Total	Growth of Livestock Gross Output (%)
2005	74749.1	9820	10019.7	95252.9	11.4
2006	81117.3	10101.8	10314.3	101792.1	6.9
2007	84157.6	10440.8	11347	106454.8	4.6
2008	87962.9	13362.8	12095.2	114543.8	7.6
2009	96192.2	15972.4	13223.1	126614.4	10.5
2010	97685.4	19884.2	15280.1	135137.2	6.7
2011	99494.9	25760.7	13606.6	141204.2	4.5
2012	101377.7	26921.7	14141.1	144863.0	2.6
2013	102589.8	27596.5	15295.8	147979.5	2.2
2014	106313.9	28453.2	19247.9	154015.0	4.1

Total meat production in 2013 reached well over 4 million tons of all kinds of meat products, representing a doubling of the production in 2000 (see Figure 1). Pig dominates meat production at 3,217.9 thousand tons (74.2%), poultry meat ranks 2nd with 746.9 thousand tons (17.2%). Noteworthy,

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[4] Exchange rate in April, 2015

during the outbreak of bird flu epidemic from 2003-2009, production of poultry decreased remarkably and production of pig and beef increased as a substitute for poultry.

Figure 1: Meat production in period 2000-2013 (Thousand tons)

Source: GSO, 2014
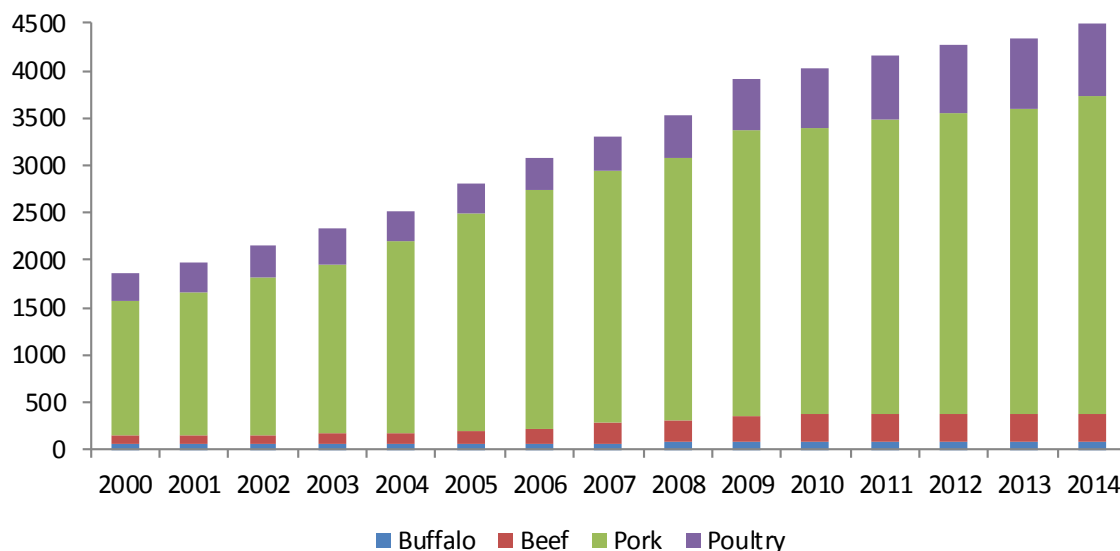
Pig production system in Vietnam

The number of pigs in Vietnam during the period 2000 to 2013 is shown in Figure 2. The number increased steadily between 2000 and 2004 with an annual growth rate of 6.3 percent. This number, however, has showed a declining tendency since 2005 due to the consequence of continuous animal disease outbreaks. For example, in the period 2005- 2006, foot and mouth disease (FMD) exploded in 40 provinces, with 12,571 infected cases causing 7,258 deaths. While disease outbreaks moderated afterwards, in 2010- 2013, Vietnam witnessed another explosion of both FMD and Porcine Reproductive and Respiratory Syndrome (PRRS) in a wide area causing 2,083 infected cases (Asian Pig Veterinary Society Congress 2013). As a result, in 2013, the total quantity of pigs in the whole country only reached 26.3 million head.

Figure 2: Number of pigs in Vietnam in the period 2000-2014 (thousand pig heads)

Source: GSO, 2014
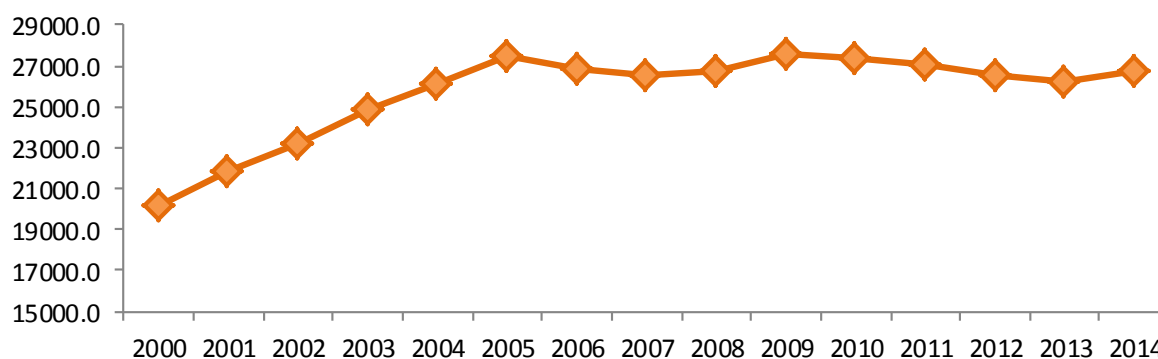
Figures 3 and 4 depict the distribution of pig population and the volume of pig supply in each of the 7 regions of Vietnam over three years (2006, 2011 and 2014). No major change occurred in the regional distribution of pig stocks. However, it can be seen that the relative pig numbers declined in the Central Coast and in the Red River Delta, and increased slightly in the North Uplands.

Only three regions: RRD, NU and SE have encountered some gradual improvement in relative pigmeat production. The rest of the country including MRD, the second largest pig production, is facing some relative decline in pigmeat supply.

Figure 3: Distribution of pig number by regions

Source: GSO, 2014
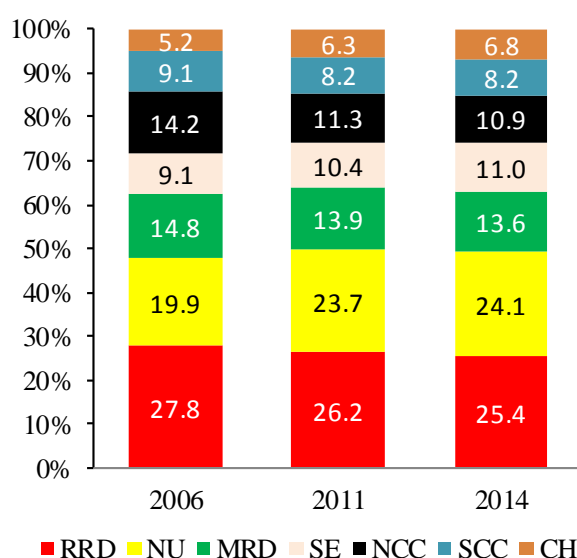
Figure 4: Distribution of pig supply by regions

Source: GSO, 2014
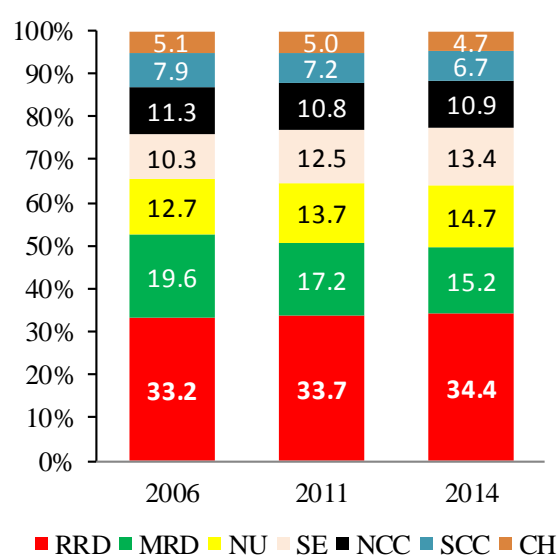
Note: NU: North Uplands, RRD: Red River Delta, NCC: North Central Coast, SCC: South Central Coast, CH: Central HighLands; SE: South East; MRD: Mekong River Delta

RRD is always found to be the largest area of pig production in Vietnam. It is observed a small reduction of its share in total pig herd, but its proportion in national pigmeat supply tends to slightly increase overtime indicating, perhaps, some improvement in pig productivity (off-take).

MRD appears to be the second largest region in pigmeat supply in Vietnam, although it is still lagged behind NU in terms of pig number. Unfortunately, MRD tends to lose its position overtime, both in pig population and pigmeat supply.

NU turns out to be the second largest region in terms of pig number, but it falls in the third rank with regard to pork supply. This kind of absurdity for the region might be explained by the predominance of small-scale backyard pig faming with majority of low-yield local pig species. However, unlike MRD with a downtrend in pig production scaling, the NU's position in national pig secor, both in terms of pig number and pigmeat production, tend to be increasing gradually.

SE seems to be merely the fourth largest pig producing area in Vietnam, in spite of large-scale pig production that prevailed here.

Vietnam's pig production is comprised mostly of backyard/household operations. Comparing the results from the Agricultural Censuses 2001 and 2011, we can observe the changing size-composition of the pig sector in Vietnam. During this period, the share in the national pig herd in small farms with less than 100 pigs fell from 98.2 percent to 84.1 percent while the share of large commercial farms

with 100 or more pigs increased from 1.8 percent to 15.9 percent[5]. As part of its livestock development policy, the Vietnamese Government plans to adopt measures to increase the size of pig producing units (Ministry of Agriculture and Rural Development, Vietnam, 2007). This trend probably favors the development of specialized registered pig farms engaged in commercial industrial-style farms. Production units vary from being of a subsistence-type, to being semi-commercial, to being completely commercial units. Household pig production is often a sideline activity and a part of farm diversification in Vietnam. Considerable heterogeneity exists in production units although most units have become more involved in market transactions in recent times.

Table 1. Distribution of pigs and farms by type of pig farm

Source: Calculated by based on Agro-Census 2001, 2006, 2011 and estimate for 2014

Year	Share	Type of Farm	NU	RRD	NCC	SCC	CH	SE	MRD	TOTAL
2001	% of farms	Small farm	99.997	99.992	99.999	99.998	99.986	99.883	99.992	**99.991**
		Large farm	0.003	0.008	0.001	0.002	0.014	0.117	0.008	**0.009**
	% of pigs	Small farm	99.75	99.18	99.76	99.73	98.85	82.38	98.24	**98.24**
		Large farm	0.25	0.82	0.24	0.27	1.15	17.62	1.76	**1.76**
2006	% of farms	Small farm	99.97	99.87	99.96	99.95	99.80	99.15	99.87	**99.88**
		Large farm	0.03	0.13	0.04	0.05	0.20	0.85	0.13	**0.12**
	% of pigs	Small farm	98.12	93.35	96.84	97.02	89.48	59.55	95.19	**92.14**
		Large farm	1.88	6.65	3.16	2.98	10.52	40.45	4.81	**7.86**
2011	% of farms	Small farm	99.94	99.71	99.94	99.91	99.70	95.34	99.68	**99.76**
		Large farm	0.06	0.29	0.06	0.09	0.30	4.66	0.32	**0.24**
	% of pigs	Small farm	95.49	80.75	94.92	92.74	82.54	42.71	88.42	**84.07**
		Large farm	4.51	19.25	5.08	7.26	17.46	57.29	11.58	**15.93**
2014	% of farms	Small farm	99.91	99.53	99.93	99.87	99.65	94.83	99.50	**99.67**
		Large farm	0.09	0.47	0.07	0.13	0.35	5.17	0.50	**0.33**
	% of pigs	Small farm	92.92	66.54	93.82	88.82	78.21	31.78	80.65	**76.57**
		Large farm	7.08	33.46	6.18	11.18	21.79	68.22	19.35	**23.43**

Pig price in Vietnam has increased sharply at the first haft of 2011 and reach its peak in July and August in most provinces. This is the period when China increases their pig purchase (live pig) and many Vietnamese trader has bought live pig from South East, Central Coast, Red River Delta and Northern Highland and sell them at the border gate, it is estimated that the price at border gate is about 20,000 VND higher than domestic price[6]. From August 2011 to the end of 2012, pig price has decreased gradually toward level of Jan, 2011, except for a slightly increase in January 2012 when demand for pig for Tet holiday increased.

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[5] Due to lack of information in the Agricultural Censuses, it is hardly to know that whether this is entry of commercialized production or whether this is a shift of small farms into large farms. A further study is needed to find out the answer.

[6] http://dantri.com.vn/kinh-doanh/o-at-ban-heo-sang-trung-quoc-806920.htm

Figure 4: Price of pig (over 80kg) in selected provinces in Vietnam in 2011 and 2012 (VND/kg)

Source: Agroinfo
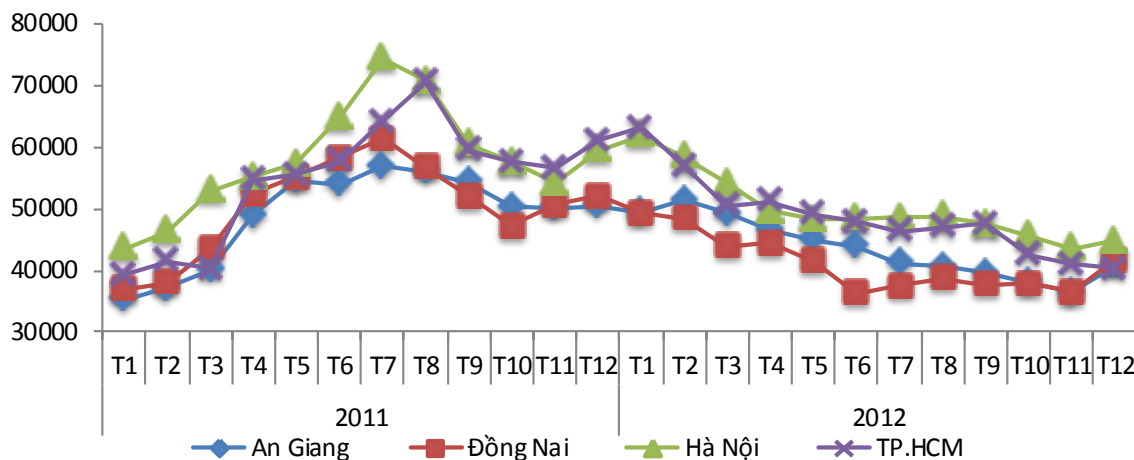
As a substitute of pig, price of chicken has increases slightly during July and August 2011 when pig price reach its peak. Chicken price also increase slightly during Tet holiday and fluctuated until the end of 2012. The price of local chicken is always around 60,000 VND higher than exotic chicken. Poultry production in Vietnam is also have to deal with imported chicken wing and chicken leg with very low price.

Figure 5 Price of chicken in 2011 and 2012 (VND/kg)

Source: Agroinfo
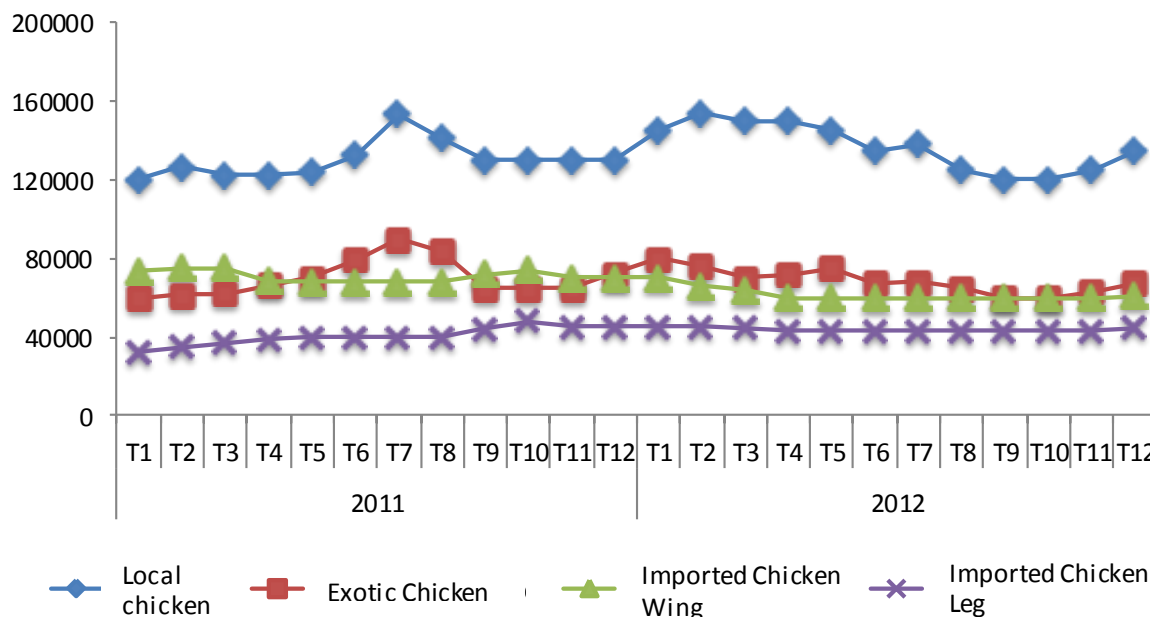
Pig meat consumption in Vietnam

With more than 90.5 million people in 2014, Vietnamese population ranks 14th in the world and is a large market for animal products. Besides, Vietnam is also one of the countries with highest urbanization rate, in 2014, Vietnamese urban population is 32.9% (29.8 million people), 13.2 percent

point higher than 1990 (GSO, 2014). The increasing population, especially in urban area has made consumption of livestock products, such as meat, egg and milk has risen dramatically in recent years.

According to Vietnam Household Living Standard Survey (VHLSS) from 2002 to 2012, most Vietnamese households consume meat products such as pig, beef, buffalo meat, poultry meat, and fish/shrimp, in which pig is the most important source of meat. More than 98 percent of households consume pig. Around 60 percent of total household expenditure on meat is allocated to pig, 20 percent went to poultry and the remaining 20 percent went to other meats. These shares are almost unchanged over the past several years. Urban consumers constitute 25 percent of the total population, but they consume almost 50 percent of total pig produced in the country. In urban areas, pig accounts for 58 percent of meat consumed while in rural areas, pig accounts up for to 65 percent.

Figure 6: Share of meat consumption in Vietnam's households

Source: Calculated based on VHLSS 2002, 2004, 2006, 2008 & 2012
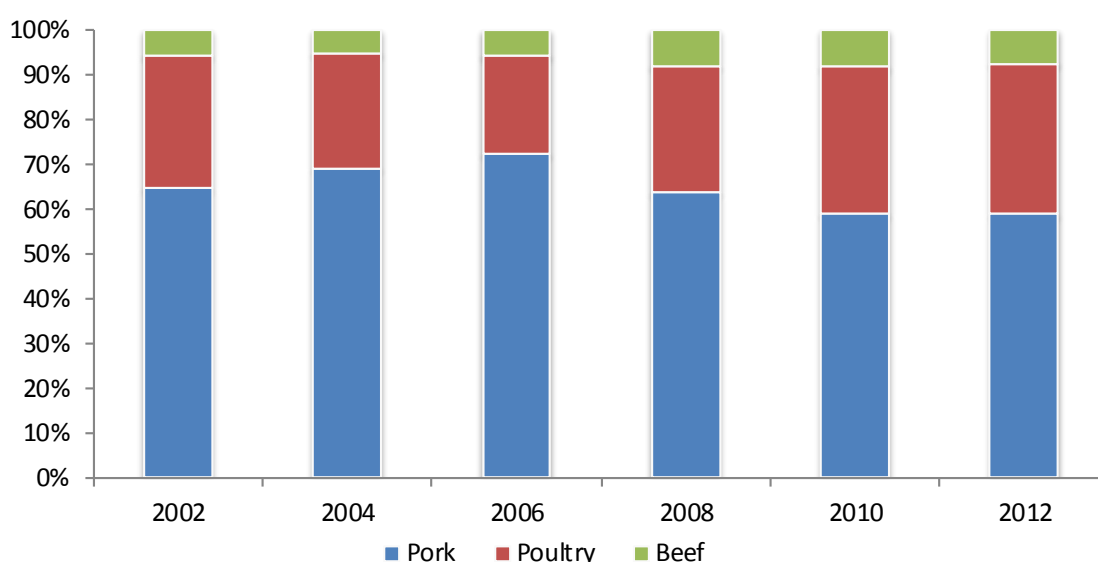
Vietnamese consumers prefer to buy fresh pig (and live or fresh poultry products) from daily markets. Thus, almost all pig produced in Viet Nam is sold as fresh meat to meet consumer preferences; processed meat accounts for less than 6 percent of meat sold, especially in rural areas. According to a study on "The supply and trend food in a number of provinces and cities of Vietnam" by the Information Centre for Agriculture and Rural Development (Agroinfo 2012), 93.3 percent of surveyed rural consumers bought meat in the temporary markets and only 13.2 percent of meat products have a quarantine stamp (included wet market). When purchasing meat, the most important criteria considered by rural consumer are cheap prices and the convenience of selling points.

In most developing countries in the world, proportion of pig in household total meat consumption decreases and proportion of chicken and beef increases noticeably when household income increases, however, this trend is not happening in Vietnam and China. Pig still accounts for a large share of household consumption when households get richer, and the volume of pig consumed in the richest income quintile is more than twice as much as in the poorest quintile. These results give a first indication that income growth is a major driver of increasing pig consumption in Vietnam[7]. Besides, Vietnamese pig consumption is only 23.1 kg (LW)/person/year in 2012, well below other countries like Hong Kong, China or European Union (FAOSTAT, 2013). Therefore, the domestic market will be a

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[7] Author calculation from VHLSS

potential market in the upcoming years and focusing on the domestic market is still a good strategy for producers.

Figure 7: Per capita pig consumption of several countries (kg LW[8]/capita/year)

Source: FAOSTAT, 2013
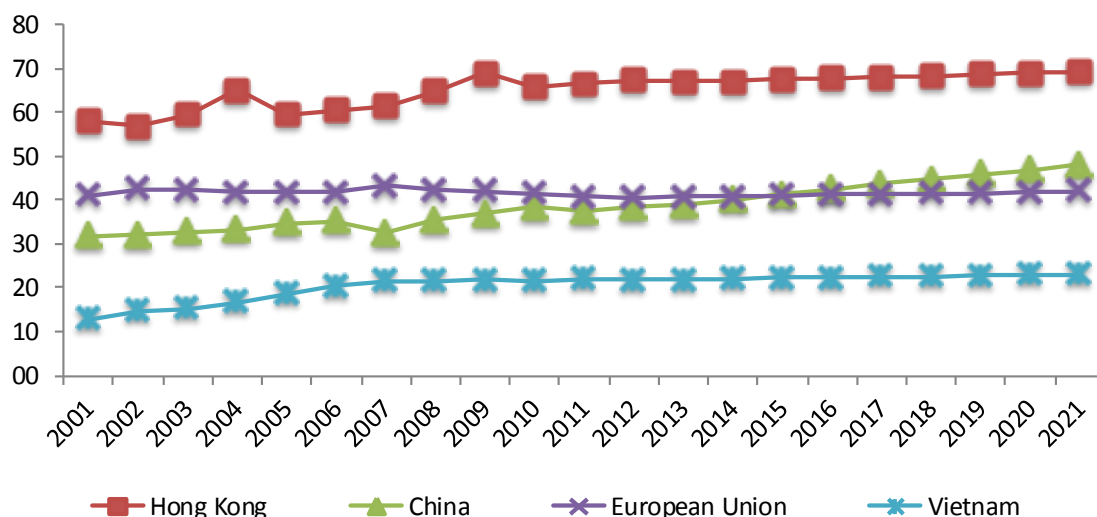
Considering pig consumption by 8 economic regions in period 2002-2012 (Table 2), residents of Red River Delta has the highest pig consumption meanwhile the lowest consumption is observed in the North West. This figure also shows the similar tendency of pig consumption in all regions; namely pig consumption increased in period 2002-2006 then declined in 2008, reached the highest level in 2010 and once again decreased in 2012[9].

Table 2: Annual per capita pork consumption in period of 1992-2014 by region in Vietnam (kg CW[10])

Source: VHLSS 1992, 1998, 2002, 2004, 2006, 2008, 2010, 2012 and estimate for 2014

Region	1992	1998	2002	2004	2006	2008	2010	2012	2014
North Uplands	3.8	6.3	9.2	10.2	11.1	9.3	13.4	11.1	11.7
Red River Delta	4.3	4.9	10.9	11.8	13.4	12.5	15.3	12.7	13.6
North Central Coast	3.0	5.9	6.5	7.8	8.4	7.0	10.3	8.2	8.9
South Central Coast	2.9	4.7	5.5	6.5	7.2	6.8	8.1	7.2	7.4
Central Highlands	2.8	4.9	6.3	7.2	8.4	7.5	9.4	8.2	8.5
South East	4.0	5.3	9.2	12.3	13.8	11.5	10.9	9.6	10.0
Mekong River Delta	3.4	4.8	6.9	8.8	11.1	7.7	9.6	8.4	8.7
Whole country	**3.6**	**5.2**	**8.2**	**9.8**	**11.2**	**9.4**	**11.5**	**9.8**	**10.3**

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[8] LW: Light Weight
[9] It seems due to the economic depression
[10] CW: Consumer Weight

Figure 8: Annual per capita pork consumption by region in Vietnam, 1992-2014 (kg)

Source: VHLSS
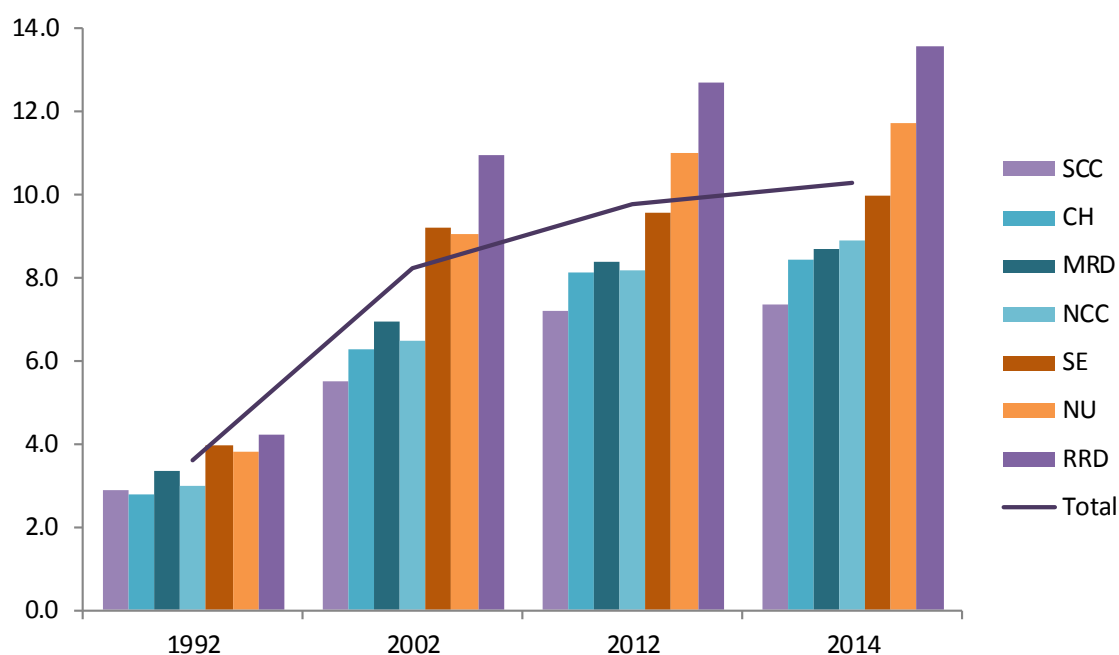
Policy Issues related to livestock and pig sector

During the period 2001 – 2012, Vietnam's livestock policies focused on three pillars including: (i) production (breeding, concentrated production planning...), ii) market (policy for pig export support) and iii) processing; specifically,

Policy on development for plant varieties, animal breeding and forestry varieties in the period 2000 – 2010 (Decision No. 225/1999/QĐ-TTg 10th December 1999 and Decision No. 17/2006/QĐ-TTg 20th January 2006) has brought many positive results in breeding sector, selecting and adding a large amount of new breeding, and greatly increasing the diversity of the gene pool in Vietnam. However, the dissemination of good breeding practices is quite limited. One of the main reasons is the large share of small scale production. Farmers do not have information about breeding, while the breeding system is underdeveloped, management efficiency is very low, and infrastructure is not compatible to practical needs.

Policies to develop pig farming for export (Decision No. 166/2001/QĐ-TTg 26th October 2001 of Prime Minister) encourage the development of zones for export of high quality pigs. However, pig industry in Viet Nam is fragmented and unplanned, low efficiency, high production cost and poor quality management. The supporting policies for pig production are not compatible, especially land, credit and market control policies. These are the reasons why Vietnamese pig products cannot compete in international market.

Policies to encourage new construction, expansion of slaughter and processing houses as well as poultry clusters production (Decision 394/QĐ-TTg 13rd March 2006 of Prime Minister) has obtained considerable achievements such as the establishment of some models of slaughtering and meat processing using industrial methodologies which ensure quality and food safety and hygiene.

In addition to livestock related policies applied for the whole country above, the government has established different plans for each economic zone.

Red River Delta

According to Decision 795/QĐ-TTg issued on 23rd May 2013 from the Prime Minister, pig and poultry will be the main commodities in livestock industry of Red River Delta in the period 2010 - 2020. These two commodities will be developed into large scale production. The processing industry is also encouraged through credit support policies. However, the development of these two commodities is mostly for local consumption from this economic zone instead of export. This is because it is very difficult for producers to compete in the international market in the upcoming period. Thus, focusing on the local market with the advantage of short distances is a wise selection.

Northern Mountainous and Midland (North East and North West)

According to Decision No.1064/QĐ-TTg issued on 8th July 2013 from the Prime Minister, pig and grass-eating animals such as goat, cow, and buffalo are designated as the main pillars for the livestock industry in the Northern Mountainous and Midland in the period 2010-2020. For the Northwest (including Hoa Binh, Son La, Dien Bien, Lai Chau), policy will support large-animal production, especially dairy cows and meat cows, and a focus in orientation towards high-quality processed products. For the Northeast, pig and large animals like cows and buffaloes will be the main pillars for livestock, almost of which targeting local consumption.

Central Highlands

At this moment, we have not found any documents in the overall plan for socio-economic development in the Central Highlands in the period 2010 – 2020. However, according to the Leadership Board on Central Highlands, the Central Highlands has invested in imported breeds like Debu, Brahman red, white... to crossbreed, creating the foundation for good quality, high yielding breeds to replace low productivity local breeds. There is also a focus on supply for households and ethnic minority group officials. Currently, in the Central Highlands livestock clusters totally replace small-scale production for subsistence.

South East

South East has great potential especially in industrial plants and aquaculture, fisheries, and livestock around the city. Pig, poultry, and dairy cows are the main products, especially in Dong Nai provinces. However, according to our current understanding, there is still not an overall policy for this region. Instead, each province has its own policy for livestock development. This may lead to incompatibility among regions as well as supply and demand in the upcoming period.

Mekong Delta

According to the Plan on Agriculture Structure Transformation to 2020, vision to 2030 for Mekong Delta, the main types of livestock that need to be encouraged to develop in Mekong Delta are pig, poultry, meat cows, and buffaloes. The above document also stated that concentrated clusters are to be encouraged to develop both industrialized models and half-industrialized models of production. The development of concentrated clusters comes alongside the development of a modern processing industry to meet the local market. The international market seems not to be the priority in the upcoming period.

An overall strategy for the whole region is necessary to use livestock resources effectively, especially when domestic producers have to compete with international exporters based on WTO and other free

trade agreements. For pig products in WTO, Viet Nam signed a commitment to reduce tariffs in which the rate for chilled pig and frozen pig decreased from 30 percent and 30 percent, respectively, in 2007 to 25 percent and 15 percent in 2012, respectively. However, the implementation of tariff reduction started from 2008, just one year after the commitment. These reductions in tariffs will cause a significant change in pig production while local producers have to compete with low-price importers. To overcome this problem, there must be a structural change toward large – scale and industrialized production. At this moment, the support policy for pig production seems to be inefficiency to increase competitiveness of local producers.

In the upcoming free trade agreement, TPP[11] for example, policy makers in Vietnam seem to be not well prepared for TPP especially in pig products. The TPP agreement has been postponed and unfinished in 2013. However, TPP can bring many opportunities for agriculture but not for pig products separately. When tariff and non-tariff barriers are removed, Vietnam local producers might face pressure from other countries in TPP. Support policy for this situation should be directed to improve competitiveness and large-scale production instead of through subsidies as now.

Objectives

The overall objective of this study was to explore the hypothesis that changes in the pig demand and the growth of modern retail outlets will squeeze small-scale pig producers out of the market in Vietnam. More specifically, this study attempts to address the following research questions:

- How will rising income & urbanization affect total pig demand and the composition of pig demand?

- How will shifts in pig demand influence pig producers, particularly small-scale producers? More specifically, will small-scale pig producers be squeezed out of the market?

- How will growth of pig production affect maize markets; specifically, will rising demand for feed lead to maize imports?

- How would alternative assumptions about income growth, productivity growth, and consumer behavior influence the evolution of pig sector?

These issues were addressed by updating and upgrading/refining the Vietnamese pig sector model (VPM) developed by IFPRI in 2010, and using it to make projections of the evolution of the pig sector in Vietnam over the next 10-20 years under alternative assumptions.

Section 2 describes the model and the data used to calibrate the model to represent the Vietnamese pig sector. Section 3 describes the results of the simulation exercises, starting with a base scenario using the most plausible assumptions and proceeding to test the sensitivity of the results to alternative assumptions. Section 4 summarizes the results of the study and draws some preliminary implications for policy.

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[11] Trans-Pacific Strategic Economic Partnership Agreement

Research methods

Methods

Vietnam Pig Model 2014 (VPM2014) is an upgraded version of VPM2010. The base-period input data of VPM2014 is consistent with the actual performance of Vietnam pig sector in 2014. Moreover, all price and income elasticities of demand for the selected commodities in the model are econometrically re-estimated using pooled data from the last 6 rounds of Vietnam Household Living Standard Survey (VHLSS) during period of 2002-2012, and they are at more detailed level of spatial coverage (i.e. these elasticities are estimated for urban and rural areas in each of seven regions in Vietnam).

In VPM2014 regional maize supply equations are split into area and yield functions.
In term of producer and consumer classification, VPM2014 has higher level of disaggregation as compared to VPM2010. Pig producer typology is re-defined to have three groups (traditional, commercial and modern) instead of two (traditional and modern) as in VPM2010:

- Traditional pig producers (TradPig) are small-scale pig farms (less than 100 pigs per farm) producing fresh/warm pork for rural traditional outlets mainly (i.e. 95% of TradPig is assumed for rural consumers);
- Commercial pig producers (CommPig) are large-scale pig farms producing fresh/warm pork for urban traditional outlets mainly (i.e. 95% of CommPig is assumed for urban consumers);
- Modern pig producers (ModPig) are industrial-based large-scale pig farms producing cold (chilled/frozen/canned) pork for urban modern outlets (supermarkets) mainly (only 2% of ModPig is assumed for rural consumers).

Instead of only one aggregate consumer category for each of seven regions as in VPM2010, there are two groups of consumers (i.e. rural and urban) in each of seven regions in the upgraded VPM2014. The substitution/complementary price effects are also considered in the upgraded model by adding cross-price elasticities to the behavorial functions. Thus, the new arrangement for model structure makes the size of VPM2014 triple as compared to that of VPM2010.

The big advantage of the VPM2014 with higher level of disaggregation as compared to the VPM2010 is that it can avoid the aggregation bias due to not accounting for differences between urban and rural areas in terms of consumption patterns, income and population growth. Thus, using VPM2014 we can assess the direct impact of fast growing urbanization on the evolution of Vietnamese pig sector over time.

Table 3: Comparison between initial and current upgraded version of Vietnam Pig Model

	Initial VPM2010	Upgraded VPM2014
1. Base period	2006 (not up-to-date)	2014 (up-to-date)
2. Model Structure:	Less disaggregated	More disaggregated
2.1. Regions	7 domestic regions (no urban & rural) plus rest of the world	7 domestic regions (each split into urban & rural area) plus rest of the world
2.2. Commodities	Maize food Maize feed	Maize food Maize feed
	Warm pork Cold pork	Warm pork Cold pork
2.3. Producers	Traditional Pig Farms	Traditional Pig Farms
	Modern Pig Farms	Commercial Pig Farms
		Modern Pig Farms
2.4. Consumers	Aggregate consumers	Rural consumers
		Urban consumers
2.5. Market Outlets	Traditional	Traditional Rural
	Modern	Traditional Urban
	Import & Export	Modern Urban
		Import & Export
2.6. Model Statistics:	10	13
Blocks of equations	286	778
Single equations	11	14
Blocks of variables	289	782
Single variables		
Periods	10	10
Scenarios	9	10
Total result variables	26,010	78,200

Because the model consists of a mix of equalities and inequalities, it is solved using mixed complementarity programming (MCP), which links each inequality to a complementary variable, which becomes positive when the inequality becomes binding. For example, the import parity restriction is an inequality, and it is linked to the import variable. When the import parity restriction becomes binding (the domestic price is constrained by the import parity price), imports become positive.

The model is programmed using the General Algebraic Modeling System (GAMS) software package with the PATH solver and run repeatedly for each of 10 selected time periods from 2015 to 2025.

The core of the VPM2014 model consists of thirteen sets of equations, as described in algebraic form below:

1. Crop area equation in normal mathematical form:

$$\log(AR_{f,r,u}) = \alpha^A_{f,r,u} + \sum_{f'} \left[\beta^A_{f,f',r,u} * \log(P^{SF}_{f',r,u}) \right]$$

        Where:

        AR: Feed crop area;

α^A: Intercept of crop area function;

β^A: Elasticity of feed crop area with respect to its own & cross-prices;

P^{SF}: Feed crop producer price;

f and f′: Feed crop index and its alias;

r: Region index;

u: Urban-rural index.

2. Crop yield equation in normal mathematical form:

$$\log(\text{YLD}_{f,r,u}) = \alpha^Y_{f,r,u} + \beta^Y_{f,r,u} * \log(P^{SF}_{f,r,u})$$

Where:

YLD: Crop yield;

α^Y: Intercept of feed crop yield function;

β^Y: Elasticity of feed crop yield with respect to its own price.

3. Crop supply equation in normal mathematical form:

$$S^F_{f,r,u} = (\text{AR}_{f,r,u} * \text{YLD}_{f,r,u}) * \text{CNV}_f$$

Where:

S^F: Feed crop supply;

CNV_f: Conversion ratio from producer weight to consumer weight for feed crops.

4. Livestock supply equation in normal mathematical form:

$$\log(S^L_{l,r,u}) = \alpha^L_{l,r,u} + \sum_{l'}\left[\beta^L_{l,l',r,u} * \log(P^{SL}_{l',r,u})\right] + \sum_f\left[\gamma^L_{l,f,r,u} * \log(P^{SF}_{f,r,u})\right]$$

Where:

S^L: Livestock supply;

α^L: Intercept of livestock supply;

β^L: Elasticity of livestock supply with respect to own and cross-price of livestock products;

γ^L: Elasticity of livestock supply with respect to feed crop producer price;

P^{SL}: Livestock producer price;

l and l′: Livestock index and its alias.

5. Food demand equation in normal mathematical form:

$$\log(D_{c,r,u}) = \alpha^D_{c,r,u} + \sum_{c'}\left[\beta^D_{c,c,r,u} * \log(P^D_{c',r,u})\right] + \gamma^D_{c,r,u} * \log(Y_{r,u}) + \log\text{POP}_{r,u} * 1000$$

Where:

D: Food demand;

α^D: Intercept of food demand;

β^D: Elasticity of food demand with respect to own and cross-price of food;

γ^D: Elasticity of food demand with respect to consumer income;

P^D: Food demand price;

Y: Consumer income;

c and c′: All commodity (all food) index and its alias;

POP: Population.

6. Feed demand equation in normal mathematical form:

$$\log(D_{f,r,u}^F) = \alpha_{f,r,u}^F + \sum_{f'}[\beta_{f,f',r,u}^F * \log(P_{f',r,u}^{DF})] + \sum_{l}[\gamma_{f,l,r,u}^F * \log(P_{l,r,u}^{SL})] + \log\left(\sum_l S_{l,r,u}^L\right)$$

Where:

D^F: Feed demand;

α^F: Intercept of feed demand;

β^F: Elasticity of feed demand with respect to own and cross-price of feed;

γ^F: Elasticity of feed demand with respect to livestock producer price;

P^{DF}: Feed demand price.

7. Commodity inflow inequality in normal mathematical form:

$$\sum_{r'} TQ_{c,r',r,u} + M_{c,r,u} \geq D_{c,r,u} + \sum_f[ID_{c,f}^1 * D_{f,r,u}^F]$$

Where:

TQ: Transport-in commodity quantity;

M: Commodity import;

ID^1: Identity matrix for proper dimension of feed demand/supply in inflows.

8. Commodity outflow inequality in normal mathematical form:

$$\sum_l[ID_{c,l}^2 * S_{l,r,u}^L] + \sum_f[ID_{c,f}^1 * S_{f,r,u}^F] \geq \sum_{r'} TQ_{c,r,r',u} + X_{c,r,u}$$

Where:

TQ: Transport-out commodity quantity;

X: Commodity export;

ID^2: Identity matrix for proper dimension of livestock supply in inflows.

9. Domestic trade inequality in normal mathematical form:

$$P_{c,r,u}^S/CNV_c + MARG_{c,r,r',u}^D \geq P_{c,r',u}^D$$

Where:

P^S: Commodity producer price;

P^D: Commodity consumer price;

CNV_c Commodity conversion ratio from producer to consumer weight;

$MARG^D$: Marketing price margin for internal trade.

10. Import inequality in normal mathematical form:

$$(P_c^W + MARG_c^W) * NER * (1 + TAX_c^M) + IMT_c + MARG_{c,r,u}^M \geq P_{c,r,u}^D$$

Where:

P^W: World commodity (FOB) price;

$MARG^W$: World commodity price margin (CIF-FOB);

TAX^M: Import tax in fraction;

IMT: Implicit import tax;

$MARG^M$: Commodity import price margin.

11. Export inequality in normal mathematical form:

$$P_{c,r,u}^S/CNV_c + MARG_{c,r,u}^X + IXT_c \geq P_c^W * NER * (1 - TAX_c^X)$$

Where:

TAX^X: Export tax in fraction;

IXT: Implicit export tax;

MARG^X: Commodity export price margin.

12. Import quota limit inequality in normal mathematical form:

$$QT_c^M \geq \Sigma_r \Sigma_u M_{c,r,u}$$

Where:

QT^M: Import quota limits.

13. Export quota limit inequality in normal mathematical form:

$$QT_c^X \geq \Sigma_r \Sigma_u X_{c,r,u}$$

Where:

QT^X: Export quota limits.

Data

The Vietnam Pig-sector Model is calibrated to represent the situation in 2014 using data and estimates from a variety of sources. Pig production in each region is based on estimate of live-weight production by the General Statistical Office. In 2014, there were 26.8 million pigs in Vietnam, yielding 3.4 million tons of live weight production. The regions with the largest production were the Red River Delta with 1170 thousand tons and the Mekong River Delta with 516 thousand tons. The split between modern, commercial and traditional pig production is carried out by seven-step procedure: 1) Calibrate the GSO-estimated total regional pig production to match the VHLSS-based estimate of total regional pig demand 2) Based on regional data from the 2011 Agricultural Census on the size distribution of pig farms to define the share and the production of large-scale and small-scale pig farms in each region; 3) Define the traditional pig sector production equal to small-scale pig farm production in each region; 4) Define the total national modern pig sector production equal to 4% of total national pig demand plus export. Then distribute the total national modern pig production by regions, proportional to urban population and number of modern outlets. 5) Define regional production of commercial pig sector as residuals (total pig production less traditional and modern production). 6) Define regional urban consumption for Cold pig equal to 98% of regional modern pig production and define regional urban consumption for Fresh pig as residuals (total pig consumption les Cold pig consumption); 7) Define regional rural consumption for Cold pig equal to 2% of regional modern pig production and define regional rural consumption for Fresh pig as residuals (total pig consumption les Cold pig consumption);

Per capita pig consumption in each region in 2014 is an estimate based on the 2012 VHLSS and the growth pattern of pig consumption derived from 8 rounds of VHLSS 1992, 1998, 2002, 2004, 2006, 2008, 2010, 2012. According to this estimation result, per capita consumption is about 11.7 kg, though it is higher in urban areas (13.2 kg) than in rural areas (11.0 kg). The split between modern and traditional pig products is initially based on the ILRI Pig Consumer Survey carried out as part of this project. As described above, chilled, frozen, and processed pig were considered to be "modern pig products", while fresh pig was classified as "traditional pig products." According to the survey, modern pig products, as defined here, accounted for about 2 percent of the volume of pig consumption in 2006. The modern pig consumption in 2014 is derived from the 2% share found in 2006 and the estimated change over 2006-2014. As documented in the statistical year book of 2013, number of supermarkets increases by 1.7 times from 385 units in 2005 to 659 units in 2012. Taking account of this quantity improvement of modern retail outlets we assume that the modern pig consumption in term of its proportion in the total pig demand over period of 2006-2014 would be 2 times more, on the average accounting for about 4% in 2014. However, this proportion was applied differently by regions and proportional to their current level of production and consumption.

Prices of pig and maize in 2014 for each region were derived from VHLSS 2012 taking into account of the price changes between two years, 2012 and 2014. This change was obtained from the national aggregate prices in 2012 and 2014 collected by IPSARD's Information Center. Consumer prices for pig ranged from 111000 VND/kg to 134000 VND/kg, and for maize from 6900 VND/kg to 8700 VND/kg. Producer prices for pig ranged from 42000 VND/kg to 51000 VND/kg, and for maize from 5600 VND/kg to 7000 VND/kg. The margins between consumer and producer prices were calculated based on the price levels as mentioned above and the conversion rate from producer weight to consumer weight, e.g. 0.9 for maize and 0.4 for pig.

World prices of pig and maize and volumes of international trade were based various online information such as FAO, USDA, WB, and GSO. According to the USDA, Vietnam exported annually about 20 thousand tons of pig in the last three year 2011-2013. According to GSO in 2014 the volume of maize import is 4.6 million tons. Import tariffs for pig products and maize were based on published rates by the Ministry of Finance. The tariffs on imported pig and maize are 25% and 5%, respectively.

The own, cross price and income elasticities of demand for pig and maize by urban and rural consumer groups in each of 7 agro-economic regions in Vietnam are based on CAP's demand analysis using pooled data from six rounds of VHLSS 2002, 2004, 2006, 2008, 2010 and 2012.

In the absence of supply elasticity estimated for Vietnam, the VPM uses supply elasticity based on earlier estimates by CAPSim, a database of supply elasticity generated by Chinese Center for Agricultural Policy (CCAP) for China.

The per capita income for each region is based on per capita consumption expenditure estimated by CAP using the 2012 VHLSS. The 2014 population in each region is derived from the GSO's online database for 1990-2013 and preliminary estimate of the total population by GSO for 2014.

The projections require estimates of the growth in per capita income, population, and technology over time.

- Population: According to the historical data provided by the GSO, the annual population growth rate of Vietnam is 1.63 percent in 1990-2000 period, 1.14 percent in 2000-2010 period and 1.053 percent for the last three years. We assume population growth will remain 1.05% per year over the period of the projections.

- Income: According to the estimates based on data of several rounds of VHLSS, real per capita income in Vietnam grows at 8.6% per year over period of 2002-2010, however the growth slows down to 6% per year during the last three year period. For the model, we assume a 5 percent growth rate in per capita income. As described in the next section, we test the sensitivity of the projections to changes in the income growth rate assumption.

- Technology: Between 2002 and 2010, maize yields in Vietnam rose from 3.1 to 4.1 tons/hectare, equivalent to a 3.7 percent annual growth rate, but for the last three years maize yield growth rate reduces to 2.3% per year. For the VPM, we assume that the rate of productivity growth in the maize sector is 2% per year throughout the projection period. There are no comparable data to measure productivity growth in the pig sector, but we use the off-take figures measured by total pig slaughtered weights divided by total pig population as a rough proxy for productivity growth in the pig sector. The annual growth rate of pig off-take is 5.7% during the period of 2002-2010, but it reduces to 3.5% in the last three years. Thus, we assume that in the next decade traditional pig sector follow a 2% annual growth in technology, commercial and modern pig sector have higher growth in production technology,

at 2.5 and 3% per year, respectively. We also test the sensitivity of the results to changes in productivity growth in the three sectors of the model[12].

These represent the main assumptions behind the VPM. However, these assumptions are not fully compatible with each other, especially between regions. The fact is that we do not have actual data on trade between regions. As mentioned somewhere above, the interregional trade will be defined endogenously by the model following the rules of spatial arbitrage (i.e. the price differences and the cost of transportation and marketing between regions determine the trade flows). To get the supply-demand balance for all regions in the base year, we need to run the model once to reconcile these discrepancies and this initial solution becomes the base scenario.

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[12] Productivity growth refers to changes in technology that allow an increase in output for the same amount of inputs. For modeling purposes, we simulate productivity growth by a rightward shift in the supply curve.

Results

Under the base scenario with the combination of most likely assumptions about per capita income growth, population growth, production technology growth as well as world price growth, the Vietnam Pig Model could be used to predict some key features of Vietnam's pig market including demand, supply, price and export/import at national and regional level. In addition, we design several scenarios with different assumptions to see how the supply, consumption and trade will change over the next decade in response to changes in growth of per capita income, pig and feed production technology and so on. The detail information of the base scenario and other simulations are shown in Table 4. Summary of alternative simulations

Table 4. Summary of alternative simulations

Scenario	Assumptions
1. Base scenario	Per capita income growth: 5%
	Population growth: 1.05%
	Nominal exchange rate growth: 2%;
	Maize technology growth: 2%
	Traditional pig technology growth: 2%
	Commercial pig technology growth: 2.5%
	Modern pig technology growth: 3.0%
	World price growth for maize: 0.23%
	World price growth for pig: -1.2%
	(WB Price Forecast 2013-2025, version Jan 2015)
	Income elasticity of maize: 0.393
	Income elasticity of traditional pig products: 1.247
	Income elasticity of commercial pig products: 1.375
	Income elasticity of modern pig products: 1.513
	Own price elasticity of supply for traditional pig: 0.60
	Own price elasticity of supply for commercial pig: 0.65
	Own price elasticity of supply for modern pig: 0.75.
2. Higher income growth	Same as base scenario except that per capita income growth is increased to 10%
3. No productivity growth in	Same as base scenario except that productivity growth in

	traditional pig sector	traditional pig sector is reduced to 0%
4.	Higher productivity growth in traditional pig sector	Same as base scenario except that productivity growth in traditional pig sector is increased to 10%
5.	Higher productivity growth in commercial & modern pig sector	Same as base scenario except that productivity growth in commercial & modern pig sector is increased to 10%
6.	No productivity growth in maize sector	Same as base scenario except that productivity growth in maize sector is reduced to 0%
7.	Higher income elasticity in commercial & modern pig products	Same as base scenario except that income elasticity for commercial & modern pig products is increased to 2.7
8.	Higher income elasticity and higher productivity growth in commercial & modern pig sector	Same as base scenario except that income elasticity for commercial & modern pig products is increased to 2.7 and productivity growth in commercial & modern pig sector is increased to 10%
9.	Worst-case scenario for traditional pig sector	Same as in base scenario except that • Per capita income growth increased to 10% • Income elasticity of traditional pig reduced to 0.5 • Tech growth in traditional pig sector reduced to 0% • Income elasticity of commercial & modern pig increased to 2.7 • Tech growth in commercial & modern pig sector increased to 10%
10.	No tariff for pig products between ASEAB+ and TPP countries	World price of pig by 1%.

1. Base scenario

The base scenario is the combination of the most plausible assumptions, namely:

- Per capita income growth will be 5.0 percent per year (the annual growth rate of per capita income in Vietnam is decreasing from more than 8 percent during 2000-2010 to about 6 percent in the last three years. Thus it is expected to be 5 percent for the next period of 2013-2025).
- Population growth will be 1.05 percent per year (as the average population growth rate in recent years).
- Maize technology will be improved at 2 percent per year (this was estimated based on growth patterns of maize yields over the last decade (3.7 percent during 200-2010 period and 2.3 percent in the last three years).
- Traditional pig production technology will increase at 3 percent per year (this was estimated based on growth patterns of pig off-take during the last decade. For the growth rate of modern pig production technology, we assumed this was one percentage point higher than for traditional pigs.

- The assumptions about the income elasticity of fresh pig and modern pig products are the same as in original VPM 2010, i.e. 0.9 and 1.8 respectively.
- Furthermore, we assume that world price growth rate of maize and pig will be -0.13 and 1.75 percent per year, respectively (this is derived from the projection by FAO reported in the Outlook 2013).

Table 5 shows national demand and supply under the base scenario. In the model, there are four categories of supplies, including: traditional pig meat, commercial pig meat, modern pig meat and maize. For the demand side, demand for pig is broken into demand for traditional pig, commercial pig and modern pork. Maize demand is divided into maize for food and maize for animal feed. As shown in this table, in 2014, national demand for traditional pig meat is 845 thousand tons (62.5%), demand for commercial pig is 453 thousand tons (33.5%) and demand for modern pig meat is 54 thousand tons (4.0%). Frozen pig has become more and more popular and demand for modern pig increases 10.6% annualy from 2014 to 2025, however, consumer in Vietnam still prefer fresh pig, therefore, proportion of modern pig remain at 4.0% from 2014 to 2025. Consumer will aslo switch from traditional pig to commercial pig, which is more safety and traceable.

In 2014, total demand for maize is 9,377 thousand tons, of which 9,190 thousand tons (98 percent) goes into animal feed industry, and only 187 thousand tons were used as human food. Annual growth of maize as food is 0.7% and maize as feed is 9.5 percent. After 10 years, total demand rises to 25,036 thousand tons and the picture is basically the same with 99.2% demand is for maize as feed (an increase of 1.2 percentage points compared to 2014).

Table 5. National supply and demand under the base scenario (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditio- nal pig	Commer- cial pig	Modern pig	Maize as food	Maize as feed	Traditio- nal Pig	Commer -cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	881	473	57	181	9440	881	473	57	4785
2016	932	503	61	193	10254	932	503	61	4962
2017	994	539	66	194	10950	994	539	66	5268
2018	1072	586	72	190	11720	1072	586	72	5711
2019	1169	645	81	186	12652	1169	645	81	6315
2020	1289	719	91	182	13786	1289	719	91	7120
2021	1436	811	105	179	15134	1436	811	105	8192
2022	1617	926	123	177	16753	1617	926	123	9613
2023	1840	1072	143	180	18723	1840	1072	147	11506
2024	2117	1256	154	189	21432	2117	1256	199	14026
2025	2463	1490	163	201	24835	2463	1490	279	17450
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	59.8	36.2	4.0	0.8	99.2	58.2	35.2	6.6	

Looking at the supply side, we can see that the supply of pig is predicted to increase sharply during 2014-2025 periods (10.9% annually), among which, growth rate of traditional pig and commercial pig is namely 10.2% and 11.4% while growth rate of modern pig is 16.1%. Total supply of modern pig increase from 54 thousand tons in 2014 to 279 thousand tons in 2025 (5.2 times higher) and supply of

fresh pig (traditional pig and commercial pig) increases from 1,298 thousand tons to 3,953 thousand tons (3.1 times). With the higher living standard, urbanization, development of supermarket system and changes in consumer preferences, modern pig (frozen pig) will become more and more popular, in 2025, modern pig will account for 6.6% of total pig production in Vietnam while traditional pig reduces from 62.5% to 58.2% and commercial pig increases from 33.5% to 35.2%. We can see that the supply of traditional pig and commercial pig are equal to the demand because fresh pig is a non-tradable commodity. Frozen pig is a tradeable commodity and as we can see in Table 5, since 2023, production of modern pig in Vietnam will outnumber demand, therefore, Vietnam will be able to export modern pig. The amount of export pig increase rapidly during 2023-2025 (from 3.8 thousand tons to 116.2 thousand tons in 3 years), in 2023, only 2.58 % of modern pig production is exported, but in 2025, nearly half of modern pig production (41.56 %) is exported.

Maize production for food and animal feed is difficult to seperate, thus, we only have the supply for maize in general. Nowaday, Vietnam's maize production does not meet domestic demand, especially for the animal feed industry and Vietnam has to import million tons of maize every year. Limited resources (land, labor...) and competition from other sectors (crops with higher profit, livestock production, aquaculture...) makes the growth rate of maize production lower than the growth rate of the pig production sector. Hence, maize import quantities are increasing over time, as shown in Table 6. In 2014, Vietnam imported 4,704 tons of maize from five main markets, including: India, Cambodia, Thailand, Argentina and United State of America. In 2025, the predicted amount is 7,585 thousand tons.

Table 6: Exports and imports under the base scenario (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0	0	0	4704
2015	0	0	0	4836
2016	0	0	0	5486
2017	0	0	0	5876
2018	0	0	0	6199
2019	0	0	0	6522
2020	0	0	0	6848
2021	0	0	0	7121
2022	0	0	0	7317
2023	0	0	3.8	7397
2024	0	0	45.2	7596
2025	0	0	116.2	7585

The amount of imported maize is predicted to increase in the coming years. However, maize prices in 2013 were much lower than 2012 and 2011 (as shown in Figure 9), and many feed producers have stockpiled maize. In 2014 these producers might use their stocks, thus the amount of imported maize would be much different from the predicted number.

Figure 9: World maize price (US$/ton)
Source: FAO 2013
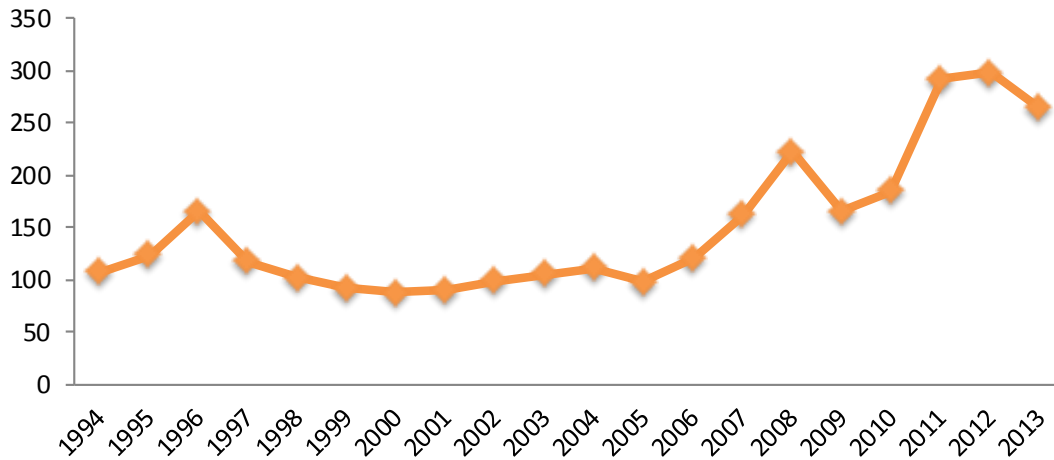
Figure 10 shows the retail prices and farm-gate prices of pig and maize. Average price of pig is 119,370 VND/kg, of which, commercial pig have the highest price (130,540 VND/kg), and following by modern pig (126,960 VND/kg) and price of traditional pig is the lowest (112,891 VND/kg). Pig price increase slightly during 2014-2017 period and decrease gradually since 2017 to 2025. Price of commercial pig decreases faster than traditional pig, therefore, since 2020, price of commercial pig is smaller than trational pig. Price of modern pig follow the same pattern of traditional pig and commercial pig until 2022, since 2023, modern pig can be exported and thus, price of this commodity increase steady until 2025.

Figure 10: National average consumer price under the base scenario (VND/kg)

Source: Simulation results 2015
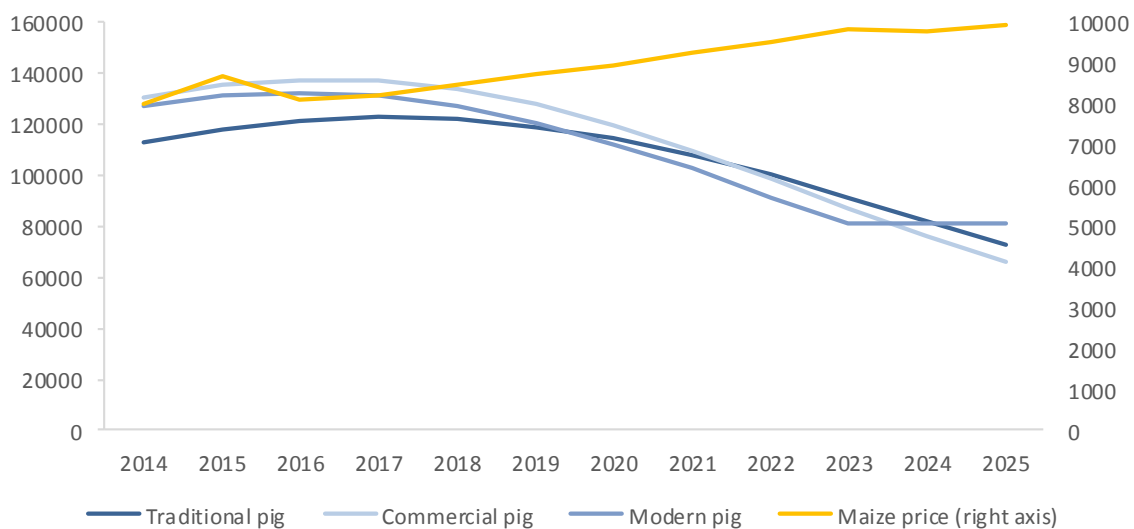
Maize price starts at 8,024 VND/kg in 2014, rise steadily until 2023 when it reaches the peak price of 9,840 VND/kg. Since 2023, maize price fluctuated around 9,800.

In general, with this business as usual scenario, modern pig sector is still very small over next decade. Large scale farm producer still only account for 4% of total production and 6.6% consumption of frozen, chilled or canned pork. Growth of pig production remain at more than 10%/year and higher than demand, therefore, Vietnamese modern pig is able to export in about 8 years.

2. Higher income growth

In this scenario, we assume that per capita income growth over the ten year period is 10% instead of 5% per year. In that situation, we expected that people will consume more modern pig instead of traditional pig.

It can be seen from Table 8 that changes in income per capita growth leads to changes in supply and demand for all commodities. The demand for all three types of pig is higher under this scenario than in the base scenario. However, the increase in demand for modern pig is higher than in the base scenario due to a shift in consumption, while the increase in traditional pig and commercial pig demand derives mainly from population growth. Demand for modern pig increases by 13.5% per year (2.9 percentage points higher than the base scenario), while total demand for modern pig in 2025 is 218 thousand tons, which is 4.04 times higher than 2014 and 1.34 times higher than the base scenario. Demand for traditional pig steadily rise by 12.1% (1.9 percentage points higher than base scenario) and demand for commercial pig rises 12.7% annually (1.3 percentage points higher than base scenario). Due to the higher growth rate, the share of modern pig products in total consumption in 2025 rises from 4.0% in the base scenario to 4.5% under this scenario.

Table 7. National supply and demand with Scenario 2 (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Comme r-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	896	478	57	184	9599	896	478	57	4785
2016	963	513	62	199	10607	963	513	62	4962
2017	1045	556	68	203	11519	1045	556	68	5269
2018	1146	611	76	202	12538	1146	611	76	5713
2019	1271	679	85	201	13780	1271	679	85	6316
2020	1425	765	98	200	15281	1425	765	98	7124
2021	1616	873	114	198	17096	1616	873	114	8194
2022	1851	1009	135	197	19280	1851	1009	135	9616
2023	2145	1181	162	199	21952	2145	1181	162	11506
2024	2513	1400	196	205	25208	2513	1400	200	14048
2025	2976	1681	218	215	29483	2976	1681	276	17495
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	100.0
Share 2025	61.0	34.5	4.5	0.7	99.3	60.3	34.1	5.6	100.0

In this scenario, as mentioned above, the production of traditional pig is equal to consumption and goes up steadily by 12.1% per year. Commercial pig rise 12.7%/year and modern pig production annual growth rate is 16.0 %/year, which is lower than in the base scenario (16.1 %). Higher demand and lower supply results in later export of modern pig, in base scenario, Vietnam starts to export modern pig since 2023, however, in this scenario, Vietnam will not export modern pig until 2024.

Table 8. Export and import with Scenario 2 (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4997
2016	0.0	0.0	0.0	5844
2017	0.0	0.0	0.0	6452
2018	0.0	0.0	0.0	7028
2019	0.0	0.0	0.0	7665
2020	0.0	0.0	0.0	8357
2021	0.0	0.0	0.0	9100
2022	0.0	0.0	0.0	9861
2023	0.0	0.0	0.0	10644
2024	0.0	0.0	4.4	11364
2025	0.0	0.0	58.0	12204

The expansion of pig production leads to an increase in demand for maize as feed, while technological growth in maize remains constant. Consequently, Vietnam has to import more maize for the animal feed production. The annual growth rate of imported maize is 9.1 % in this scenario (4.7 percentage points higher than base scenario). By 2025, Vietnam imports 12.2 million tons of maize, more than 1.6 times higher than in the base scenario.

In base scenario, price of maize start decreasing since 2023, however, in this scenario, growing demand keeps maize price increasing steadily during the whole prediction period. Growth rate of maize price in this scenario is 2.5% per year, which is 0.6 percent point higher than base scenario. At the end of the prediction period, maize price reaches 10,518 VND/kg, which is 6.1 % higher than base scenario.

Price of traditional pig, commercial pig and modern pig changes in the same pattern – which is increase at first and then decrease. However, price of traditional pig reaches its peak in 2019 (139,164 VND/kg) while highest price of commercial pig is the price in 2017 (144,417 VND/kg) and price of modern pig start to fall since 2017. At the end of prediction period, price of pig will be lower than their price at the beginning.

Figure 11: National average consumer price (VND/kg)

Source: Simulation results 2015
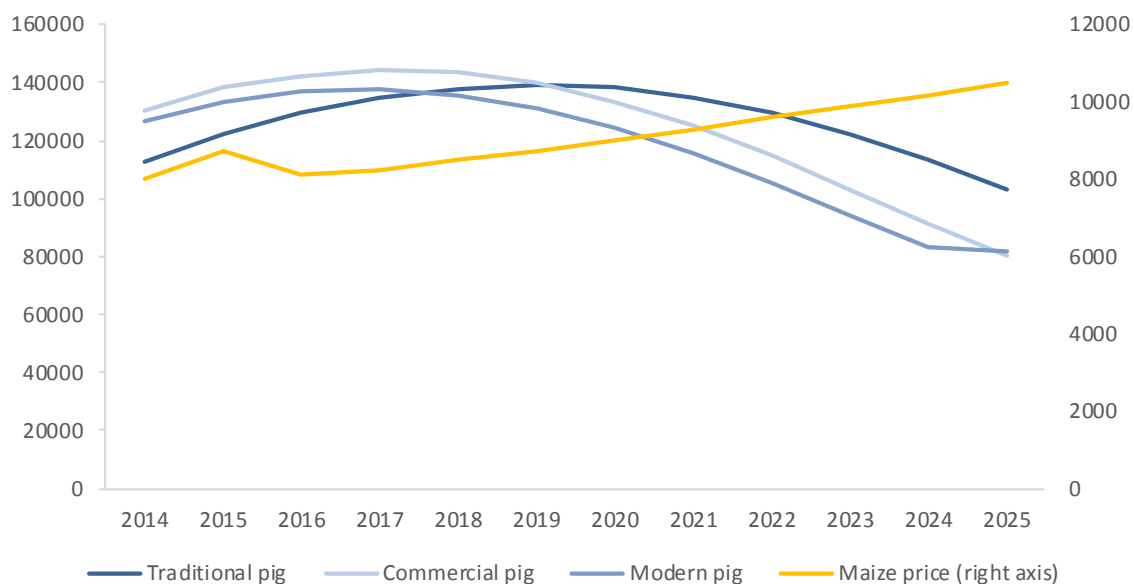
This scenario demonstrates an optimistic picture of modern pig production and a less favorable one for traditional pig producers. In this scenario, demand for modern pig rockets while demand for traditional pig climbs slowly, resulting in an increase in the market share for modern pig products. More maize is required to meet the higher demand for pig production. Despite the fast growing demand for modern pig, domestic production still produce enough pork for consumption and Vietnam is still able to export modern pork since 2024. However, to meet national demand for pig production, Vietnam also have to import much larger amount of maize.

3. No productivity growth in the traditional pig sector

Scenario 3 is a pessimistic option for traditional pig production where it is assumed there is no improvement in production technology. The reason for this assumption is that traditional pig producers are fragmented and technologically backward. Moreover, most traditional pig farmers feed their pigs with leftovers and from scavenging food. Applying new technologies in the traditional sector has many more constraints than in the commercial and modern pig sector.

Such technological stagnancy induces a reduction in the supply of traditional pig in 2025 by 1260 thousand tons compared to the base scenario. In corresponding with the constrained supply, the demand for traditional pig grows at only around 3.3% annually over the whole period of 2014-2025 (comparing to 10.2% in base scenario). The supply and demand of maize is only slightly different from the base scenario.

Table 9. National supply and demand with Scenario 3 (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Commer-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	871	474	57	182	9412	871	474	57	4784
2016	901	503	61	195	10151	901	503	61	4962
2017	931	540	66	198	10736	931	540	66	5268
2018	961	587	72	197	11358	961	587	72	5709
2019	991	646	81	195	12082	991	646	81	6313
2020	1023	720	92	192	12940	1023	720	92	7120
2021	1055	813	106	192	14026	1055	813	106	8179
2022	1089	929	123	192	15312	1089	929	123	9587
2023	1124	1076	146	192	16867	1124	1076	146	11467
2024	1164	1263	163	210	19261	1164	1263	190	13938
2025	1203	1500	176	218	22099	1203	1500	264	17332
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	41.8	52.1	6.1	1.0	99.0	40.5	50.6	8.9	

Changes in volume of exported pig is not significant, Vietnam starts to export pig since 2024 and exported amount increase sharply, however, still a little less than base scenario. Smaller pig production also leads to lower demand for maize, therefore amount of maize imported in 2025 is 34.3 % smaller than base scenario and difference in annual growth rate is 2.9 percent point.

Table 10. Export and import without productivity growth in the traditional pig sector with Scenario 3 ('000 tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4810
2016	0.0	0.0	0.0	5385
2017	0.0	0.0	0.0	5666
2018	0.0	0.0	0.0	5847
2019	0.0	0.0	0.0	5965
2020	0.0	0.0	0.0	6011
2021	0.0	0.0	0.0	6040
2022	0.0	0.0	0.0	5917
2023	0.0	0.0	0.0	5593
2024	0.0	0.0	26.4	5533
2025	0.0	0.0	88.0	4984

Compared to the base scenario, changes in the price of all types of pig and maize are significant. The lack of technological improvement in traditional pig production leads to a continuous increase of traditional pig price. In 2025, consumers will have to pay 182,700 VND for a kilogram of traditional pig meat, 2.5 times higher than in the base scenario. Price of maize and modern pig bottoms out in 2024. Price of commercial pig reaches a peak in 2016 and then starts to fall.

Figure 12: National average consumer price (VND/kg)
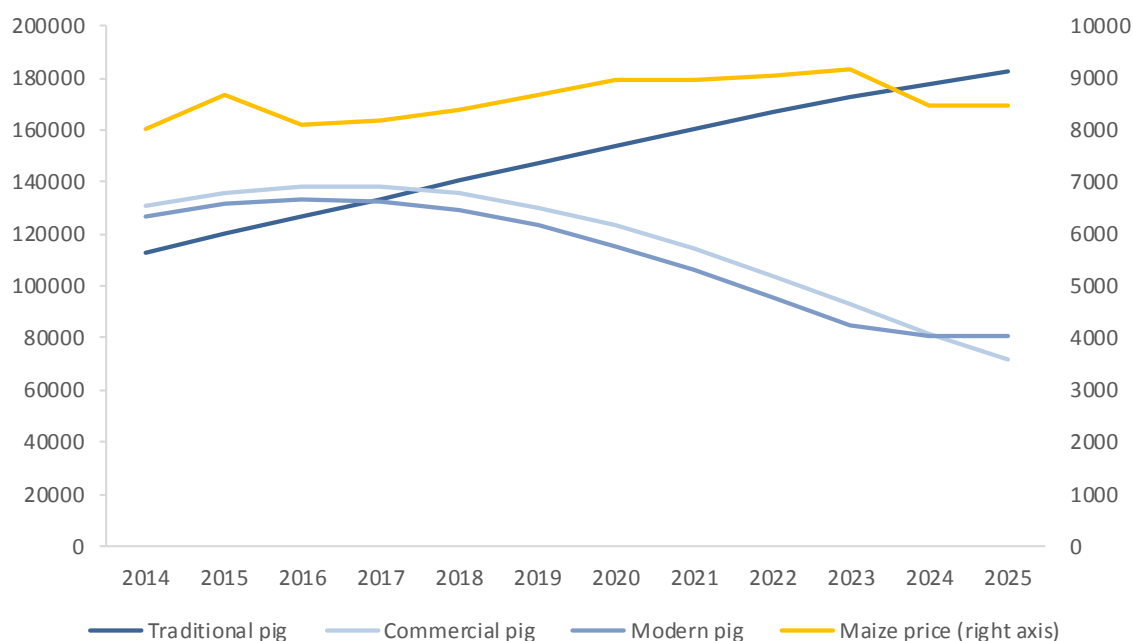
Source: Simulation results 2015

4. Higher productivity growth in the traditional pig sector

In the previous simulation, we assumed that there was no technological change in the traditional pig sector. However, in this scenario, we considered the impact of a much higher rate of technological change. More specifically, we examined the effects of assuming that productivity growth in the traditional pig sector rises at 10% per year instead of 3% in the base scenario.

Table 11 shows the national demand and supply of pig and maize products. The demand for traditional pig products rises from 845 thousand tons in 2014 to 6,674 thousand tons in 2025. The annual growth in demand for traditional pig products is 20.7% per year, higher than the 10.2% annual growth in the base simulation (10.5 percentage point higher). In this simulation, the demand for modern pig products has an annual growth rate of 9.5 % per year (1.1 % point less than base scenario), growth rate of commercial pig demand is 11.4%, similar to base scenario. The fast growth rate of traditional pig is the reason for its large proportion in pig demand. In 2025, proportion of modern pig and commercial pig are only 1.8 % and 17.9%, more than 80% of total pig demand is of traditional pig.

Table 11: National supply and demand with higher productivity growth in Scenario 4 (thousand tons)

Source: Simulation results 2015

Year		Demand					Supply		
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Commer-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	895	473	57	180	9485	895	473	57	4785
2016	978	502	61	191	10412	978	502	61	4962
2017	1095	539	66	189	11294	1095	539	66	5268
2018	1259	585	72	183	12349	1259	585	72	5712
2019	1487	644	80	178	13708	1487	644	80	6316
2020	1802	717	91	175	15451	1802	717	91	7124
2021	2240	808	105	176	17693	2240	808	105	8195
2022	2853	923	122	184	20553	2853	923	122	9623
2023	3717	1067	134	202	24348	3717	1067	155	11525
2024	4940	1251	141	229	29444	4940	1251	214	14072
2025	6674	1484	147	265	36174	6674	1484	306	17524
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	80.4	17.9	1.8	0.7	99.3	78.8	17.5	3.6	

Looking at the supply side, the annual growth in the traditional pig sector is at 20.7%, 10.5 percentage points higher than the base scenario. Annual growth of commercial pig sector is 11.4% (no changes comparing to base scenario) and growth rate the modern pig sector is 17.1%, which is 1.0 percentage point higher than the base simulation. Consequently, the share of the traditional pig sector in total national pig production increases from 62.5% to 78.8% in terms of volume.

Table 12. Export and import in Scenario 4 (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4879
2016	0.0	0.0	0.0	5641
2017	0.0	0.0	0.0	6215
2018	0.0	0.0	0.0	6821
2019	0.0	0.0	0.0	7570
2020	0.0	0.0	0.0	8503
2021	0.0	0.0	0.0	9674
2022	0.0	0.0	0.0	11114
2023	0.0	0.0	20.5	13025
2024	0.0	0.0	72.7	15601
2025	0.0	0.0	158.5	18915

Higher productivity growth of traditional pig leads to larger supply of this sector, which occupies market share of commercial pig and modern pig, that will lead to a surplus in modern pig production and Vietnam will export modern pig in 2023, one year earlier than base scenario. The development of the pig sector also leads to an increase in the quantity of imported maize from 4.7 million tons in 2014 to 18.9 million tons in 2025. Thus, the annual growth of maize imports is at 13.5%, higher than in the base simulation (4.4%).

Prices of sectors are un-stable in this scenario. Rapid growth in traditional pig production leads to surplus in this sector, meanwhile traditional pig is not able to export therefore price of traditional pig collapses during 2014-2025 period; in 2025, price of traditional pig is only 20,539 VND/kg. As a substitute commodity, decrease in traditional pig price also causes decrease in commercial pig price and modern pig price. However, price of modern pig only reduces until 2023, in 2023 Vietnam start export modern pig and price hold steady until 2025.

Figure 13: National average consumer price (VND/kg)

Source: Simulation results 2015
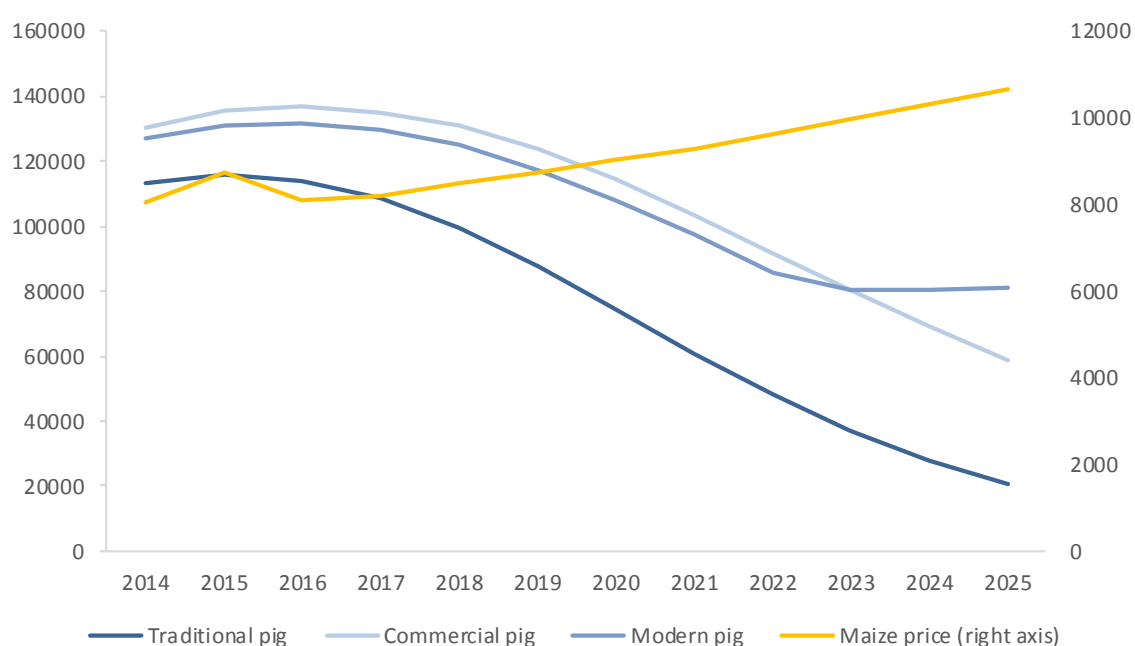
In conclusion, this is a positive scenario for traditional pig production where the technology index grows by 10% per year. We argue that this is more likely to happen than scenario 3 because of the government's extension programs and farmer awareness of new technology. In this scenario, prices of all types of pig decrease due to significant increase in the supply of traditional pig. As a result, demand and supply of modern pig and commercial pig also slightly decreases compared to the baseline. Export volumes of pig increase sharply since 2014 when the supply of pig is in excess of its demand.

5. Higher productivity growth in the modern sector

The Vietnamese government has put many efforts into promoting the expansion of large-scale pig production. Thus, in this simulation we assume that productivity growth in the modern pig sector rises at 10% per year instead of 4% in the base scenario.

Increase of productivity will results in the increase massively of modern pig supply, in this scenario, supply of modern pig increases 30.9 % per year (14.8 percentage point higher than base scenario), supply of commercial pig increases 19.5% annually (8.1 percentage point higher than base scenario) while growth rate of traditional pig remain at 10.1% (see Table 13). Supply of maize also rallies in order to meet the animal feed demand of pig market. In 2025, demand for maize is 25,036 thousand tons (about 1.7 times higher than base scenario) and supply of maize is 8,302 thousand tons.

Table 13. National supply and demand with higher productivity growth in the modern pig sector (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Comme r-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	881	479	57	180	9486	881	479	57	4785
2016	931	522	62	190	10401	931	522	62	4962
2017	993	581	70	187	11274	993	581	70	5269
2018	1070	663	79	181	12314	1070	663	79	5712
2019	1166	776	93	177	13653	1166	776	93	6315
2020	1283	931	111	175	15360	1283	931	111	7122
2021	1428	1144	124	178	17715	1428	1144	151	8194
2022	1608	1439	130	185	21018	1608	1439	228	9616
2023	1831	1851	137	197	25546	1831	1851	362	11510
2024	2107	2425	144	218	31958	2107	2425	605	14034
2025	2438	3204	151	209	37402	2438	3204	1046	17674
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	42.1	55.3	2.6	0.6	99.4	36.5	47.9	15.6	

We can also see that the demand for modern pig is not accordingly to the supply, while supply goes up sharply, demand for modern pig only increase 9.8 % per year, which is even slower than base scenario. As a result of that, Vietnam is able to export modern pig since 2021, which is 3 years earlier than base scenario. In 2025, Vietnam will export 896 thousand tons of modern pig, which accounts for 85.6% of total pig production in Vietnam.

The modern pig sector uses a large amount of maize for animal feed production. As the modern pig sector develops faster and maize production does not increase, Vietnam will have to import more maize. In 2025, Vietnam imports 19,938 thousand tons of maize; this is 10,879 thousand tons higher than in the base scenario and 12,353 thousand tons higher than in 2014.

Table 14. Export and import with higher productivity growth in the modern pig sector (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4881
2016	0.0	0.0	0.0	5628
2017	0.0	0.0	0.0	6192
2018	0.0	0.0	0.0	6783
2019	0.0	0.0	0.0	7514
2020	0.0	0.0	0.0	8413
2021	0.0	0.0	27.9	9699
2022	0.0	0.0	97.6	11588
2023	0.0	0.0	224.6	14234
2024	0.0	0.0	461.0	18143
2025	0.0	0.0	895.9	19938

The price of traditional pig, commercial pig and modern pig decrease during prediction period, of which, price of traditional pig decreases gradually from 2017, price of commercial pig decreases sharply from 2015 (from 130,540 VND/kg in 2014 to 23,657 VND/kg in 2025) and price of modern pig bottoms out in 2021, but remains stable from 2018 to 2025.

Figure 14: National average consumer price (VND/kg)

Source: Simulation results 2015
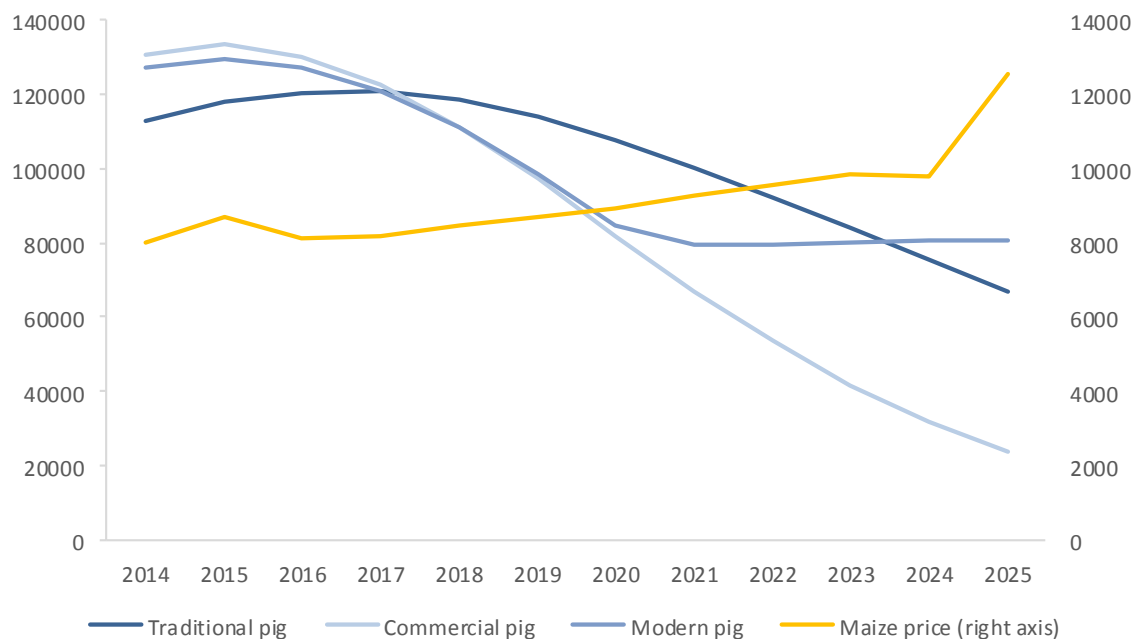
In conclusion, this scenario assumes higher productivity growth in the modern pig sector. This is successful in expanding production in the modern sector and export quantities. However, its effect in

generating foreign currency is significantly undercut because of the larger maize imports needed to sustain the growth in pig production.

6. No productivity growth in the maize sector

Maize is a very important crop in Vietnam. Maize area, production, and yields have been increasing dramatically in recent years. However, maize production and yields in 2012 are slightly lower than 2011. In the future, due to the negative impact of pollution, climate change and disease epidemics, maize productivity might not increase. In this scenario, we assume that growth in maize productivity is 0% instead of 2.0% to examine the impact of zero growth in maize productivity on the pig sector.

Figure 15: Maize area and yield in Vietnam

Source: GSO, 2013
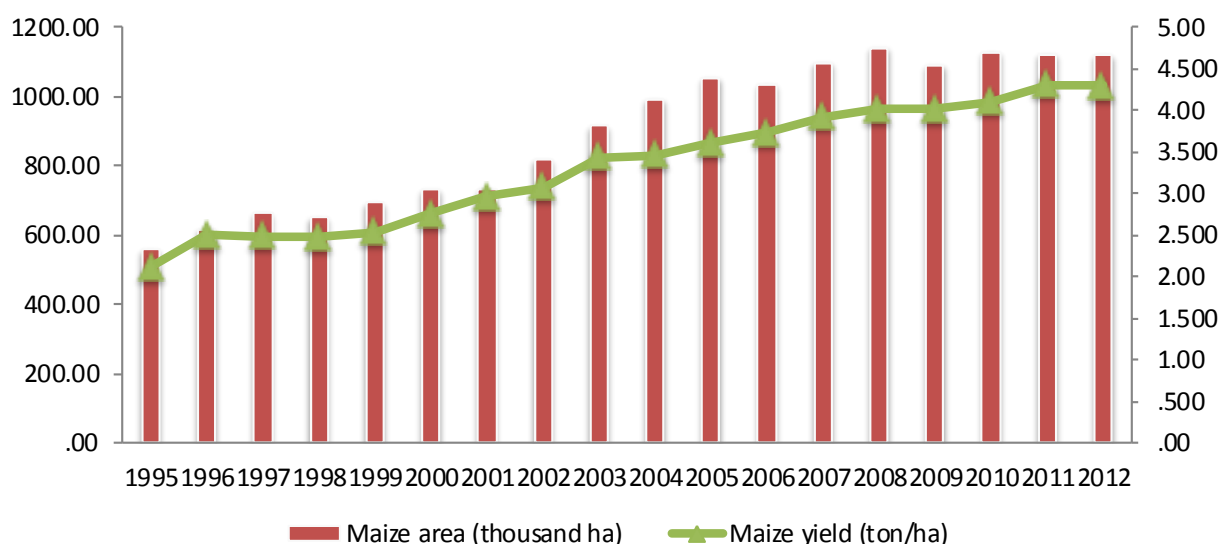
In this scenario, demand and supply of pig is mostly equal to base scenario. The assumption "No productivity growth in the maize sector" was the reason for a slow growth rate of maize production (only 0.1% comparing to 12.7% in base scenario). As productivity growth is 0%, the increase in maize supply may come from an increase in the cultivated area, although this is just a small amount due to limited land resources. However, in practice, the cultivation area of maize depends much on government policy. If the Vietnamese government removes or reduces its policy to keep 3.8 million ha of land under rice for food security, many rice growing farmers would switch to maize because of higher profits associated with it. Maize supply is almost flat during 2014-2025 period (4,673 thousand tons in 2014 and 4,749 thousand tons in 2025), while maize demand increases significantly (from 9.4 million tons to 24.7 million tons).

Table 15. National supply and demand under without productivity growth in maize sector (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditional pig	Commercial pig	Modern pig	Maize as food	Maize as feed	Traditional Pig	Commercial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	881	473	57	181	9437	881	473	57	4692
2016	932	503	61	193	10249	932	503	61	4676
2017	994	539	66	193	10941	994	539	66	4680
2018	1072	586	72	190	11706	1072	586	72	4687
2019	1169	645	81	183	12611	1169	645	81	4698
2020	1288	718	91	177	13705	1288	718	91	4709
2021	1435	811	105	174	15048	1435	811	105	4716
2022	1616	926	123	173	16643	1616	926	123	4726
2023	1839	1071	143	176	18604	1839	1071	147	4733
2024	2116	1255	154	183	21175	2116	1255	199	4742
2025	2461	1489	163	193	24457	2461	1489	279	4749
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	59.8	36.2	4.0	0.8	99.2	58.2	35.2	6.6	

If maize were a non-tradable commodity or if the Vietnamese maize market were closed, the maize price would increase rapidly due to rising demand. However, Vietnam has been annually importing a large amount of maize, with its domestic price affected by the international market. Therefore, in this scenario, demand price and supply price do not change, but the amount of imported maize surges from 4,704 thousand tons to 19,901 thousand tons, 2.6 times higher than in the base scenario (see Table 16).

Table 16. Export and import without productivity growth in the maize sector (thousand tons)

Source: Simulation result 2014

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4926
2016	0.0	0.0	0.0	5766
2017	0.0	0.0	0.0	6455
2018	0.0	0.0	0.0	7208
2019	0.0	0.0	0.0	8096
2020	0.0	0.0	0.0	9173
2021	0.0	0.0	0.0	10506
2022	0.0	0.0	0.0	12090
2023	0.0	0.0	3.7	14047
2024	0.0	0.0	45.0	16616
2025	0.0	0.0	115.8	19901

Our assumption is that the Vietnamese maize price is equal to the international maize price. Thus, the shortage of maize in the market will be sufficient by importing. If the imported amount of Vietnam is small, it will not affected world price, but if the imported amount of maize reach certain level, it will changes the international price of maize. In this scenario, since 2018, Vietnamese maize market will start to affect international maize market, in 2025, maize price is 10,803 VND/kg, which is 9.00% higher than base scenario.

Figure 16: National average consumer price (VND/kg)

Source: Simulation results 2015
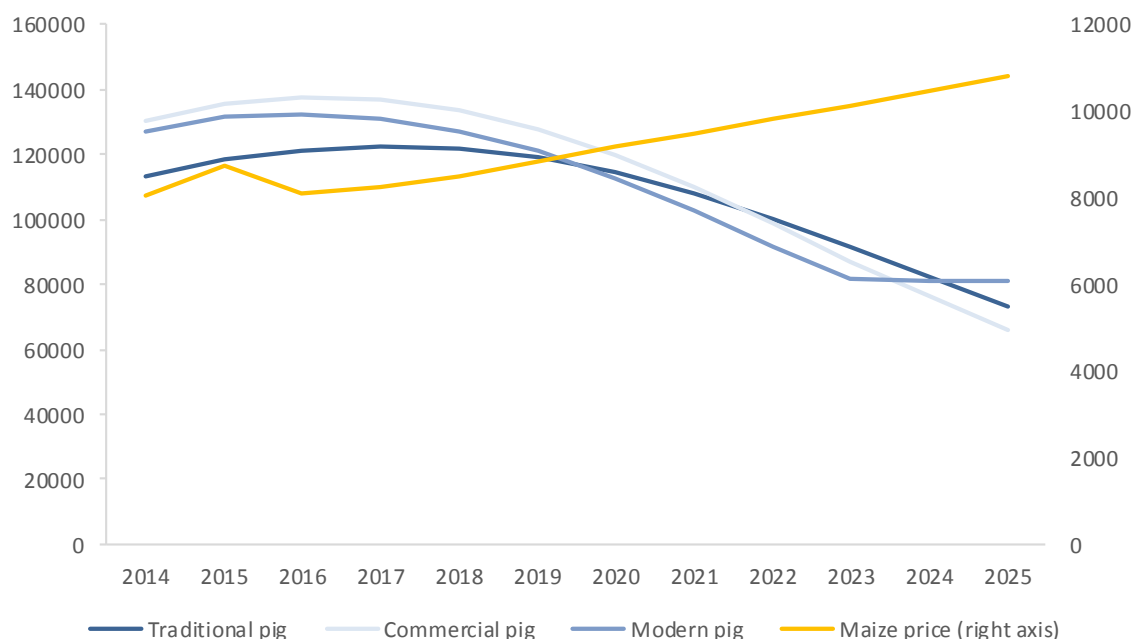
To conclude, this scenario gives a pessimistic picture of maize production in Vietnam. However, this is not likely to happen because Vietnam currently has quite low maize productivity compared to other countries in the world. In the future, with the development of gene-modified maize, new cultivation methods, and crop management systems, maize productivity in Vietnam might increase sharply. Even with low productivity growth, Vietnam can still satisfy its national demand by importing. However, this will worsen Vietnamese trade balance.

7. Higher income elasticity of modern pig products

In all of the above scenarios, we assumed the income elasticity for traditional pig was 0.9 and modern pig was 1.8, similar to figures in the previous version of VPM 2010 whereby the income elasticity for modern pig products was double the income elasticity for traditional pig products. However, despite the doubling of the income elasticity, simulations results reveal that modern pig still accounts for a minor share of the pig market, even in 2025. This is because the majority of Vietnamese population still live in rural areas where only traditional fresh pig is available, and most urban residents still buy their pig in small daily markets instead of supermarkets. In this scenario, we assume that the consumption habit change more rapidly, with more people switching to modern pig when they have higher income. Here, we thus assume that the income elasticity of modern pig is 2.7, three times higher than the income elasticity for traditional pig products and 1.5 times higher than in the base scenario.

With the higher income elasticity, demand for modern pig increases much faster than in the base scenario, with the annual growth rate of modern pig demand at 13.5% (this number is 10.6% in the base scenario). In 2025, demand for modern pig is 218 thousand tons, 55 thousand tons higher than in the base scenario. It accounts for 4.9 % of the total pig market, a relatively small number but still higher than in the base scenario (4.0%).

Higher income elasticity of modern pig demand also cause changes in maize demand. Demand for maize as food increases slightly from 187 tons to 189 tons from 2014 to 2025, while annual growth in the demand for maize as animal feed is 10.5%, only minor changes comparing to baseline.

Table 17. National supply and demand with higher income elasticity for modern pig products (thousand tons)

Source: Simulation results 2015

Year		Demand				Supply			
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Comme r-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	881	480	57	183	9529	881	480	57	4785
2016	932	516	62	198	10452	932	516	62	4962
2017	996	562	68	200	11269	996	562	68	5269
2018	1074	619	76	198	12181	1074	619	76	5712
2019	1172	690	86	195	13287	1172	690	85	6316
2020	1292	780	98	191	14630	1292	780	98	7124
2021	1441	894	114	187	16269	1441	894	114	8192
2022	1623	1036	135	183	18220	1623	1036	135	9613
2023	1849	1217	162	180	20587	1849	1217	162	11506
2024	2128	1449	195	181	23520	2128	1449	201	14044
2025	2475	1747	218	189	27514	2475	1747	278	17458
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	55.7	39.3	4.9	0.7	99.3	55.0	38.8	6.2	

In this scenario, the supply of modern pig is 278 thousand tons, barely different from base scenario. The annual growth of modern pig supply is 16.0%, only 0.1 percentage point different from the baseline rate. Supply of commercial pig increase 1.6 percentage point faster than base scenario and 2.7 percentage point higher than traditional pig sector, which means in 2025, commercial pig will account for approximately 38.8% of pig supply in Vietnam.

In

Table 18, we can see the projection of the export quantity of modern pig. Given higher income elasticity of modern pig demand, Vietnamese demand for modern pig increases more than domestic modern pig production. Therefore, exports of modern pig are later than in the baseline (2024 comparing to 2023 in baseline scenario).

Table 18. Net exports with higher income elasticity for modern pig products (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4926
2016	0.0	0.0	0.0	5688
2017	0.0	0.0	0.0	6200
2018	0.0	0.0	0.0	6667
2019	0.0	0.0	0.0	7165
2020	0.0	0.0	0.0	7697
2021	0.0	0.0	0.0	8264
2022	0.0	0.0	0.0	8790
2023	0.0	0.0	0.0	9261
2024	0.0	0.0	5.9	9657
2025	0.0	0.0	60.0	10245

Larger pig production will lead to larger maize demand, especially maize for feed. While domestic maize production remains the same, the amount of imported maize increases significantly. In this scenario, maize imports rise at a rate of 7.3% per year and will reach 10,245 thousand tons in 2025, slightly more than in the baseline.

Demand for modern pig increase leads to increase in price of modern pig. In this scenario, price of modern pig decrease slightly slower comparing to base scenario (3.9 %/year comparing to 4.0 %/year)

Figure 17: National average consumer price (VND/kg)

Source: Simulation results 2015
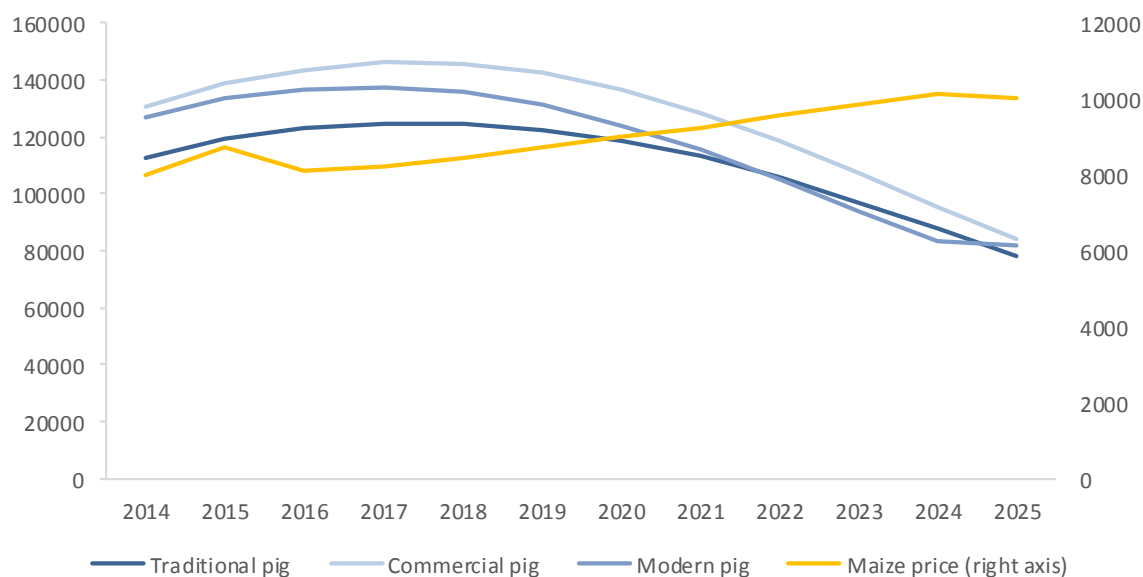
In conclusion, if the income elasticity of modern pig demand increases, the demand for both modern pig and traditional pig will increase. However, demand for modern pig grows at a higher rate. Compared to baseline, traditional pig supply and demand growth is almost the same, while demand of modern pig will increase at slightly higher rate (1.9 percentage points higher than the baseline). The same pattern of growth could be seen for domestic pig prices. In this scenario, exports of modern pig start one year later than base scenario.

8. Higher income elasticity and higher productivity growth in the modern pig sector

In the above-mentioned scenario 7, we found that the demand for modern pig increases significantly under higher income elasticity. However, we also assumed that productivity growth in the modern pig sector remained unchanged. In practice, pig producers could respond very quickly to these market signals. As demand increases, many investors including foreigner will invest in pig farms, especially in the context of further trade liberalization. These investors will bring new management and production technologies resulting in higher productivity growth. We thus test in this scenario the combined impact of higher income elasticity in the modern pig sector and annual growth in the production technology in the modern pig sector of 10% (it is 4% in the base scenario).

Such a combined scenario will lead to an annual increase in the supply of modern pig of 12.8% (2.2 percentage points higher than in the base scenario). In 2025, Vietnam will produce 1,013 thousand tons of modern pig, which is 18.7 times higher than in 2014, and nearly equal to the scenario 5 (only modern pig productivity growth - see Table 19). The growth rate of traditional pig supply is now 10.1% per year, which is only 0.1 percentage point lower than base scenario.

Table 19. National supply and demand with higher income elasticity and higher productivity growth in the modern pig sector (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Commer-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	881	486	58	182	9575	881	486	58	4785
2016	932	536	64	194	10606	932	536	64	4963
2017	994	605	72	193	11618	994	605	72	5269
2018	1072	701	83	188	12829	1072	701	83	5712
2019	1168	832	99	181	14382	1168	832	99	6317
2020	1287	1012	120	177	16396	1287	1012	120	7123
2021	1433	1262	146	176	19025	1433	1262	152	8194
2022	1612	1614	160	180	22794	1612	1614	226	9616
2023	1833	2112	174	189	28018	1833	2112	358	11510
2024	2105	2814	188	188	33943	2105	2814	593	14131
2025	2426	3792	204	157	37796	2426	3792	1013	17954
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	37.8	59.0	3.2	0.4	99.6	33.6	52.4	14.0	

Commercial pig is the sector with highest demand growth (21.3%/year, 9.9 percent point higher than base scenario). Since 2022, supply of commercial pig will outnumber traditional pig and at the end of projection period, commercial pig account for 52.4% of pig market.

In base scenario, Vietnam starts to export pig since 2023. In this scenario, both supply and demand of modern pig increase significantly, however, supply growth rate is much higher than demand growth rate (30.5% comparing to 12.8%), therefore, in 2021, supply outnumbers demand and Vietnam starts to export modern pig. In 2025, 80.0% of modern pig production is exported, equal to 11.2% of total pig production.

Table 20. Net exports with higher income elasticity and higher productivity growth in the modern pig secto r (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	4971
2016	0.0	0.0	0.0	5838
2017	0.0	0.0	0.0	6542
2018	0.0	0.0	0.0	7304
2019	0.0	0.0	0.0	8246
2020	0.0	0.0	0.0	9450
2021	0.0	0.0	6.1	11006
2022	0.0	0.0	66.9	13358
2023	0.0	0.0	184.3	16697
2024	0.0	0.0	404.9	20000
2025	0.0	0.0	809.4	20000

Not surprisingly, the expansion of the pig sector also results in higher maize imports. In 2014 and 2025, Vietnam has to import 20,000 thousand tons of maize[13] (12,415 thousand tons higher than in the baseline scenario) and the annual growth rate of maize import was found to be 14.1%.

The trend in prices for traditional, commercial and modern pig is very close to what was observed in the base scenario. The price of modern pig in 2025 is 109,947 VND/kg (decrease 4.0%/year). Price of maize in this scenario is similar to scenario 5, when Vietnam has to import large amount of maize to meet the domestic demand, leads to a sudden rise in maize price. Price of commercial pig decrease faster (12.9%/year) and consumer only have to pay 29,690 VND for a kilogram of commercial pig in 2025.

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[13] In this model, we truncated the amount of imported maize at 20 million tons.

Figure 18: National average consumer price (VND/kg)

Source: Simulation results 2015
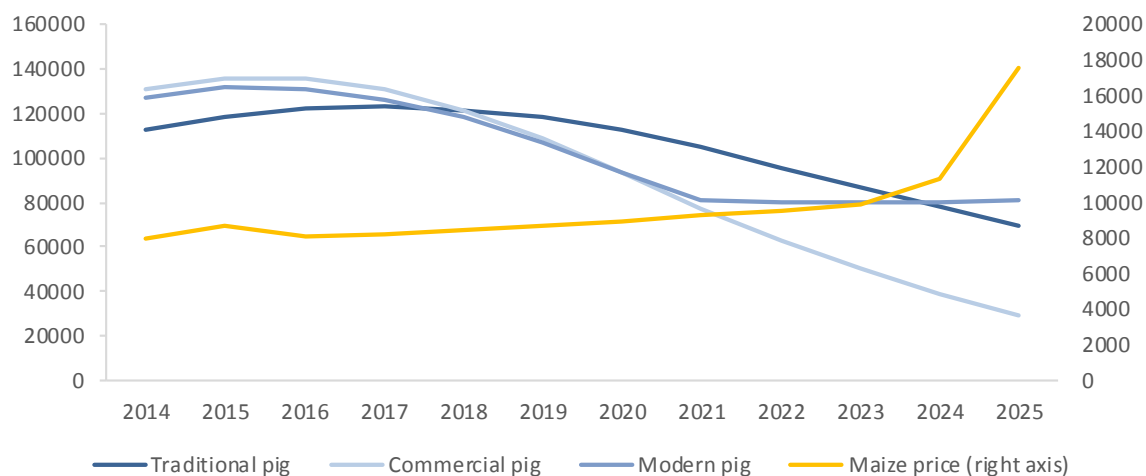
To summarize, in the scenario with high-income elasticity and high technology growth of modern pig, both demand and supply of modern pig increase significantly compared to the baseline. However, the increase in the supply of modern pig is higher than the increase in its demand, leading to sharp growth in pig exports. Prices of traditional and modern pig increase at almost the same rate as in the base scenario.

9. Worst-case scenario for traditional pig sector

In this scenario, we come up with assumptions that would be most favourable for the modern pig sector and least favourable for the traditional pig sector, including:

- Per capita income growth is 10% rather than 5%;
- Income elasticity of traditional pig is 0.5 rather than 0.9;
- Income elasticity of modern pig is 2.7 rather than 1.8;
- Productivity growth in the traditional pig sector is 0% instead of 3%;
- Productivity growth in the modern pig sector is 10% instead of 4%;

As a result, modern pig production rises massively from 54 thousand tons in 2014 to 907 thousand tons in 2025 (annual growth rate is 29.2%, 13.1 percentage point higher than base scenario). Demand for modern pig and commercial pig increase rapidly but still slower than supply (18.5% and 23.8% per year). As a result of rapid growth of modern pig, proportion of this sector climbs from 4.0% in 2014 to 13.4% in 2025 in term of supply. In term of demand, demand for commercial pig accounts for 76.8% of total, demand for modern pig rises from 4.0% in 2014 to 5.6% in 2025 and demand for traditional pig collapse to only 17.6%.

Demand for maize as human food maintains its 0.7% growth rate while demand for maize as feed increases 13.6% per year (4.1 percentage point higher than base scenario). In this scenario, total demand for maize as feed in 2025 is 37,250 thousand tons. This is almost 12.4 million tons higher than the base scenario.

Table 21. Long-term national supply and demand under the worst-case scenario for the traditional pig sector (thousand tons)

Source: Simulation results 2015

Year	Demand					Supply			
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Comme-r-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	864	494	59	185	9620	864	494	59	4784
2016	887	555	66	201	10671	887	555	66	4963
2017	908	638	76	204	11700	908	638	76	5270
2018	929	752	89	204	12964	929	752	89	5711
2019	950	910	108	202	14615	950	910	108	6315
2020	972	1131	134	200	16820	972	1131	133	7123
2021	994	1441	170	199	19817	994	1441	170	8192
2022	1016	1882	220	204	24009	1016	1882	223	9592
2023	1038	2522	257	205	30221	1038	2522	344	11487
2024	1060	3427	299	190	33737	1060	3427	547	14206
2025	1088	4752	350	201	37250	1088	4752	907	17930
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	17.6	76.8	5.6	0.5	99.5	16.1	70.4	13.4	

Looking at import and export performance (Table 22), Vietnam start to export modern pig since 2022, one years earlier than base scenario and one year later than scenario 8. In 2025, amount of modern pig export accounts for 61.5% of modern pig production and 8.3% of pig production in general.

Table 22. Long-term net exports under the worst-case scenario for the traditional pig sector (thousand tons)

Source: Simulation results 2015

	Traditional Pig export	Commercial Pig export	Modern Pig export	Maize import
2014	0.0	0.0	0.0	4704
2015	0.0	0.0	0.0	5021
2016	0.0	0.0	0.0	5909
2017	0.0	0.0	0.0	6634
2018	0.0	0.0	0.0	7457
2019	0.0	0.0	0.0	8503
2020	0.0	0.0	0.0	9897
2021	0.0	0.0	0.0	11824
2022	0.0	0.0	2.8	14620
2023	0.0	0.0	87.0	18939
2024	0.0	0.0	248.5	19721
2025	0.0	0.0	557.5	19522

Maize import rises rapidly at an annual rate of 13.8% (9.4 percentage points higher than base scenario) and reach 19,522 million tons by 2025.

Price of traditional pig, commercial pig and modern pig follow three different patterns. Traditional pig sector is the only sector with increasing price (3.0% annually), price of modern pig and commercial pig increase from 2014 to 2016 and start falling ever since, however, modern pig is an exportable product, hence, since 2022 when modern pig is exported, its price stop falling and almost flatten out at about 82,000 VND/kg. Commercial pig is not exportable, therefore price of this sector declines until the end of simulation period.

Figure 19: National average consumer price (VND/kg)

Source: Simulation results 2015
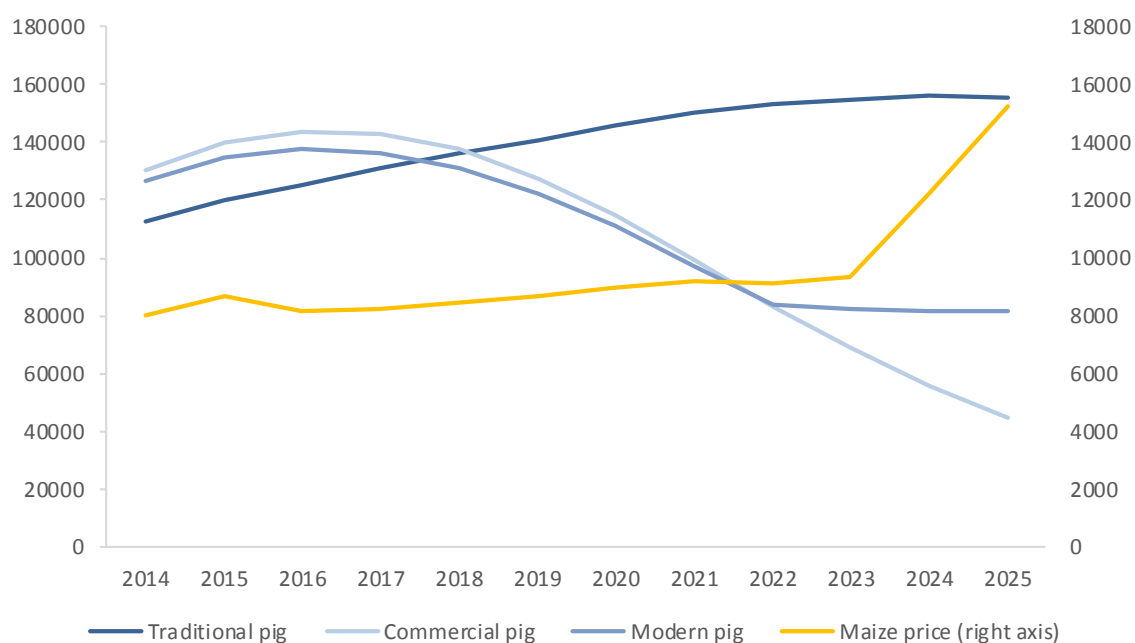
This simulation uses a set of five extreme assumptions designed to suppress the traditional pig sector and boost the modern sector. As a result, demand and supply of modern pig increases faster than in other scenarios. The market share of modern pig also reaches 36.3% in 2025 while in the base scenario, modern pig only accounts for 3.8% of the market. In this scenario, the development of the pig sector can be divided into two small periods: First, from 2014 to 2019, Vietnamese pig production is higher or equal to demand, and Vietnam still exports pig at the very beginning of the period. However, the price of modern pig increases significantly such that from 2020 to 2025, demand for modern pig is much higher than supply, Vietnam starts to import pig and import quantities increase significantly, with the price growth of modern pig slowing down to 4-6%.

10. No tariff for pig products between ASEAN Plus & TPP countries

According to Trans-Pacific Strategic Economic Partnership Agreement (TPP) and ASEAN plus three, Vietnam and other member countries will have to reduce import and export tax of certain commodities, including pig products. New tax rates and tariff reduction schedules depend on specific country and agreement, in this scenario, we assume Vietnam's import tax for pig products from TPP and ASEAN countries is equal to 0 since 2014. Using another model called GTAP, we get the result that reducing tax in TPP and ASEAN plus countries will reduce world price of pig by 1%. And we will

use this result in GEMPACK model to see the impact of free trade agreements on Vietnamese pig sector.

Table 23. Long-term national supply and demand under Scenario 10 (thousand tons)

| Year | | Demand | | | | | Supply | | |
	Traditio-nal pig	Commer-cial pig	Modern pig	Maize as food	Maize as feed	Traditio-nal Pig	Commer-cial pig	Modern Pig	Maize
2014	845	453	54	187	9190	845	453	54	4673
2015	881	474	65	188	9601	881	474	50	4762
2016	931	502	67	191	10212	931	502	55	4957
2017	993	539	72	191	10893	993	539	60	5265
2018	1072	586	77	190	11725	1072	586	68	5704
2019	1169	645	83	189	12751	1169	645	79	6303
2020	1289	719	92	187	13989	1289	719	91	7103
2021	1437	812	105	186	15432	1437	812	105	8167
2022	1619	928	123	186	17154	1619	928	123	9578
2023	1843	1073	146	190	19225	1843	1073	146	11457
2024	2121	1257	167	201	21873	2121	1257	183	13969
2025	2466	1492	181	220	25380	2466	1492	253	17359
Share 2014	62.5	33.5	4.0	2.0	98.0	62.5	33.5	4.0	
Share 2025	59.6	36.0	4.4	0.9	99.1	58.6	35.4	6.0	

Looking at Table 23 and Table 24, we can barely see the different of traditional pig and commercial pig comparing to base scenario. A possible explanation for this is imported pig is mostly chilled or frozen, while most Vietnamese people consume fresh meat, therefore, reducing import tax doesn't affect much Vietnamese pig market. Modern pig is the only sector affected by globalization and integration. Demand for modern pig is a little higher and supply is a little smaller, and the gap will be sufficient by import, however, the maximum amount of imported pig is only 15 thousand tons and happens from 2015 to 2019.

Table 24. Long-term net exports under scenario 10 (thousand tons)

	Traditional Pig export	Commercial Pig export	Modern Pig export	Modern Pig import	Maize import
2014	0.0	0.0	0.0	0	4704
2015	0.0	0.0	0.0	15	5026
2016	0.0	0.0	0.0	12	5446
2017	0.0	0.0	0.0	11	5819
2018	0.0	0.0	0.0	9	6210
2019	0.0	0.0	0.0	4	6636
2020	0.0	0.0	0.0	0	7074

2021	0.0	0.0	0.0	0	7451
2022	0.0	0.0	0.0	0	7763
2023	0.0	0.0	0.0	0	7958
2024	0.0	0.0	15.7	0	8105
2025	0.0	0.0	72.8	0	8241

The development of pig price in this scenario is identical to base scenario, except for a small change in modern pig price.

Figure 20: National average consumer price (VND/kg)
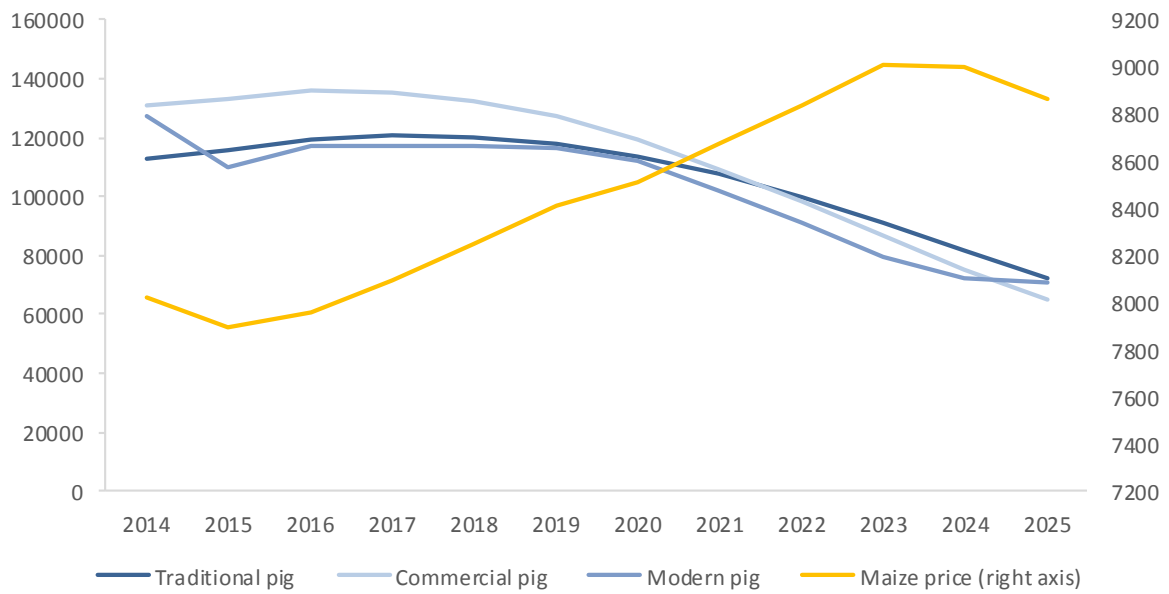
Summary and conclusions

Summary

The 2010 report written by Nicholas Minot et al. on the transformation of pig market in Vietnam was an attempt to design a dynamic partial equilibrium model to investigate the structural changes in the pig market in Vietnam over the next decades under different scenario options. In this report, we reviewed the current situation of Vietnamese livestock production, focusing on the pig sector and current government policies on livestock production up to 2014. Our key contributions to the development of the Vietnam Pig-Sector Model (VPM) are in updating with newer data and upgrading the model structure to avoid the aggregation bias and to account for impact of fast growing urbanization on evolution of the pig sector in Vietnam. Moreover we added some different macro-indicator assumptions to re-check the research questions raised in the former report but under a new context i.e., when the WTO commitment on tariff reduction has been fully satisfied and when Vietnam is further integrated into regional/world markets. However we maintained the model specification of Minot's research team, and largely kept the same scenarios.

The basic hypothesis of the report is that the income elasticity of modern pig demand is much higher than that of traditional pig, and as a result of industrialisation, modernisation, and urbanization, people will shift to pig supplied by modern farms and in modern forms (i.e., pig that is chilled, frozen, or processed and sold in supermarkets). Consequently, under this hypothesis, small and medium farms will be gradually squeezed out of the market. There is a huge chance that this will happen because of high per capita income growth rates in Vietnam and the importance of pig in diets. Furthermore, the market share of large-scale (commercial and modern) pig farms has increased from 0.01 percent in 2001 to 16% in 2011 and is estimated to be more than 23% in 2014. However, only a small part of these large-scale pig farms could be considered as modern farms that are directly involved in the modern supermarket system in Vietnam.

Using VPM2014, a dynamic partial equilibrium model, with eight regions and four sectors, we simulated the development of the Vietnamese pig sector over a 10-year time scale. The model was calibrated using data on production, consumption, trade, and prices from Vietnam, as well as behavioural parameters estimated in Vietnam and elsewhere. We come up with several plausible scenarios with different assumptions about changes in income, population, production technology, exchange rates, world prices, and income elasticity. We used VPM2014 to examine the impact of those individual or combined changes on the pig market in Vietnam for both traditional and modern pig sectors as well as the maize sector, an important input for pig production.

Our simulation results revealed the following:

- The modern pig sector in Vietnam is small but increasing. Large-scale farms (over 100 pig heads) account for 37.5 per cent of the market, though only 13.2 per cent of meat products in Vietnam have any sort of quarantine stamp. Most pig products are sold as fresh meat in the daily market;

- In most scenarios with VPM2014, modern pig production increases slightly but remains relatively small as a share of consumption in the next decades, except for scenario 5 and 9. The traditional pig sector has a lower income elasticity and growth rate, because of its convenience and cheap prices, it is still popular in most parts of Vietnam, especially in rural areas;

- In the future, the traditional pig sector will likely be replaced by commercial pig sector, if income elasticity of modern pig changes and becomes higher than what is currently observed.

- Scenario 9 was the scenario with the least favorable outlook for traditional pig production. In this scenario, the market share of modern pig rises dramatically to 13.4% in term of supply, significantly higher than the 4.0% share in the base scenario. However, even with all the assumptions stacked against traditional pig production, fresh pig production (including traditional pig and commercial pig) still account for about 85.0 % of pig production.;

- Technology is the biggest motivation to improve the production of modern pig sector. Increasing demand without technology development will lead to imports instead of developing domestic production. Vietnam currently exports pig in relatively small quantities. In scenarios where the technology of the sector improves, the production of modern pig exceeds domestic demand and Vietnam will export more pig. In other scenarios, modern pig demand is higher than production, resulting in a decline in the amount of exported pig. In some cases, Vietnam will have to import pig;

- In all scenarios, Vietnam has to import maize for the animal feed industry. The imported amount depends on the production of pig and maize productivity. However, an increase in maize demand does not affect its domestic price given that supplies come from the international market at world prices.

Our conclusions do not support the hypothesis that small-scale pig producers will be squeezed when per capita income increases and consumption habits changes. Pig consumption per capita in Vietnam is relatively small compared to other countries in the world, while the income elasticity of both modern pig and traditional pig are still high. Therefore, in the next decade, demand for traditional pig should remain high and not necessarily squeeze small and medium-sized pig producers.

Policy implications

- Traditional pig production will still account for the majority of the pig market in Vietnam in the coming decades. Thus, the Vietnamese government will have to address food safety and pig quality issues in a broader view, taking into account both large farms and small and medium farms.

- Productivity and efficiency are two different concepts. The Vietnamese pig sector has high productivity but low cost efficiency due to high feed costs. In order to increase the amount of exported pig, Vietnam will have to pay more attention on increasing the cost efficiency of the sector through policies to reduce animal feed price (increase planned area of maize, prompt to spread GMO maize species) and applying new technology in pig production.

- It is not necessary to issue policies to protect small-scale pig farmers. Despite the slower growth rate of the traditional sector relative to the modern pig sector, the traditional pig sector is not likely to disappear for some decades.

- Technology changes in the modern pig sector will help to increase production, meeting national demand and allowing surpluses for export. Technological changes in the traditional pig sector will help to reduce prices, maintain market shares, and have pro-poor impacts. In the maize sector, improving technology help reduce the amount of imports.

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Annex

TP: Traditional Pig; CP: Commercial Pig; MP: Modern Pig; PG: Total Pig

MZ: Maize; MZH: Maize for humand food; MZL: Maize for Livestock feed; CW: Consumer Weight

Table 25 Detailed simulation result: 1. Base scenario (1)

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	881	473	57	**1411**	4785	881	473	57	**1411**	181	9440	**9621**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4836
2016	932	503	61	**1495**	4962	932	503	61	**1495**	193	10254	**10448**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5486
2017	994	539	66	**1599**	5268	994	539	66	**1599**	194	10950	**11144**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5876
2018	1072	586	72	**1731**	5711	1072	586	72	**1731**	190	11720	**11911**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6199
2019	1169	645	81	**1895**	6315	1169	645	81	**1895**	186	12652	**12837**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6522
2020	1289	719	91	**2099**	7120	1289	719	91	**2099**	182	13786	**13968**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6848
2021	1436	811	105	**2351**	8192	1436	811	105	**2351**	179	15134	**15312**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7121
2022	1617	926	123	**2666**	9613	1617	926	123	**2666**	177	16753	**16930**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7317
2023	1840	1072	147	**3059**	11506	1840	1072	143	**3055**	180	18723	**18903**	0.0	0.0	3.8	**3.8**	0.0	0	0	0	**0**	7397
2024	2117	1256	199	**3571**	14026	2117	1256	154	**3526**	189	21432	**21622**	0.0	0.0	45.2	**45.2**	0.0	0	0	0	**0**	7596
2025	2463	1490	279	**4232**	17450	2463	1490	163	**4116**	201	24835	**25036**	0.0	0.0	116.2	**116.2**	0.0	0	0	0	**0**	7585

Table 26 Detailed simulation result: 2. Higher income growth

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	896	478	57	**1431**	4785	896	478	57	**1431**	184	9599	**9783**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4997
2016	963	513	62	**1538**	4962	963	513	62	**1538**	199	10607	**10806**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5844
2017	1045	556	68	**1669**	5269	1045	556	68	**1669**	203	11519	**11722**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6452
2018	1146	611	76	**1832**	5713	1146	611	76	**1832**	202	12538	**12741**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7028
2019	1271	679	85	**2035**	6316	1271	679	85	**2036**	201	13780	**13981**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7665
2020	1425	765	98	**2288**	7124	1425	765	98	**2288**	200	15281	**15480**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8357
2021	1616	873	114	**2603**	8194	1616	873	114	**2603**	198	17096	**17294**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9100
2022	1851	1009	135	**2996**	9616	1851	1009	135	**2996**	197	19280	**19477**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9861
2023	2145	1181	162	**3489**	11506	2145	1181	162	**3489**	199	21952	**22151**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	10644
2024	2513	1400	200	**4113**	14048	2513	1400	196	**4109**	205	25208	**25412**	0.0	0.0	4.4	**4.4**	0.0	0	0	0	**0**	11364
2025	2976	1681	276	**4933**	17495	2976	1681	218	**4875**	215	29483	**29699**	0.0	0.0	58.0	**58.0**	0.0	0	0	0	**0**	12204

Table 27 Detail silmulation result: 3. No productivity growth in the traditional pig sector

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	871	474	57	**1402**	4784	871	474	57	**1402**	182	9412	**9594**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4810
2016	901	503	61	**1465**	4962	901	503	61	**1465**	195	10151	**10346**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5385
2017	931	540	66	**1536**	5268	931	540	66	**1536**	198	10736	**10934**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5666
2018	961	587	72	**1620**	5709	961	587	72	**1620**	197	11358	**11556**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5847
2019	991	646	81	**1718**	6313	991	646	81	**1718**	195	12082	**12277**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5965
2020	1023	720	92	**1834**	7120	1023	720	92	**1834**	192	12940	**13131**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6011
2021	1055	813	106	**1974**	8179	1055	813	106	**1974**	192	14026	**14219**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6040
2022	1089	929	123	**2141**	9587	1089	929	123	**2141**	192	15312	**15504**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5917
2023	1124	1076	146	**2346**	11467	1124	1076	146	**2346**	192	16867	**17059**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5593
2024	1164	1263	190	**2617**	13938	1164	1263	163	**2591**	210	19261	**19471**	0.0	0.0	26.4	**26.4**	0.0	0	0	0	**0**	5533
2025	1203	1500	264	**2967**	17332	1203	1500	176	**2879**	218	22099	**22317**	0.0	0.0	88.0	**88.0**	0.0	0	0	0	**0**	4984

Table 28 Detailed simulation result: 4. Higher productivity growth in the traditional pig sector

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	895	473	57	**1425**	4785	895	473	57	**1425**	180	9485	**9665**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4879
2016	978	502	61	**1541**	4962	978	502	61	**1541**	191	10412	**10603**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5641
2017	1095	539	66	**1700**	5268	1095	539	66	**1700**	189	11294	**11483**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6215
2018	1259	585	72	**1917**	5712	1259	585	72	**1917**	183	12349	**12532**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6821
2019	1487	644	80	**2211**	6316	1487	644	80	**2211**	178	13708	**13886**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7570
2020	1802	717	91	**2610**	7124	1802	717	91	**2610**	175	15451	**15626**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8503
2021	2240	808	105	**3153**	8195	2240	808	105	**3153**	176	17693	**17870**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9674
2022	2853	923	122	**3898**	9623	2853	923	122	**3898**	184	20553	**20737**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	11114
2023	3717	1067	155	**4939**	11525	3717	1067	134	**4918**	202	24348	**24550**	0.0	0.0	20.5	**20.6**	0.0	0	0	0	**0**	13025
2024	4940	1251	214	**6404**	14072	4940	1251	141	**6331**	229	29444	**29673**	0.0	0.0	72.7	**72.7**	0.0	0	0	0	**0**	15601
2025	6674	1484	306	**8464**	17524	6674	1484	147	**8305**	265	36174	**36439**	0.0	0.0	158.5	**158.5**	0.0	0	0	0	**0**	18915

Table 29 Detailed simulation result: 5. Higher productivity growth in the modern sector

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	PIG	MZ	TP	CP	MP	PIG	MZH	MZL	MZ	TP	CP	MP	PIG	MZ	TP	CP	MP	PIG	MZ
2014	845	453	54	1352	4673	845	453	54	1352	187	9190	9377	0.0	0.0	0.0	0.0	0.0	0	0	0	0	4704
2015	881	479	57	1418	4785	881	479	57	1418	180	9486	9666	0.0	0.0	0.0	0.0	0.0	0	0	0	0	4881
2016	931	522	62	1515	4962	931	522	62	1515	190	10401	10590	0.0	0.0	0.0	0.0	0.0	0	0	0	0	5628
2017	993	581	70	1644	5269	993	581	70	1644	187	11274	11461	0.0	0.0	0.0	0.0	0.0	0	0	0	0	6192
2018	1070	663	79	1813	5712	1070	663	79	1813	181	12314	12495	0.0	0.0	0.0	0.0	0.0	0	0	0	0	6783
2019	1166	776	93	2035	6315	1166	776	93	2035	177	13653	13830	0.0	0.0	0.0	0.0	0.0	0	0	0	0	7514
2020	1283	931	111	2326	7122	1283	931	111	2326	175	15360	15535	0.0	0.0	0.0	0.0	0.0	0	0	0	0	8413
2021	1428	1144	151	2724	8194	1428	1144	124	2696	178	17715	17893	0.0	0.0	27.9	27.9	0.0	0	0	0	0	9699
2022	1608	1439	228	3275	9616	1608	1439	130	3178	185	21018	21204	0.0	0.0	97.6	97.6	0.0	0	0	0	0	11588
2023	1831	1851	362	4043	11510	1831	1851	137	3818	197	25546	25744	0.0	0.0	224.6	224.6	0.0	0	0	0	0	14234
2024	2107	2425	605	5136	14034	2107	2425	144	4675	218	31958	32176	0.0	0.0	461.0	461.0	0.0	0	0	0	0	18143
2025	2438	3204	1046	6689	17674	2438	3204	151	5793	209	37402	37612	0.0	0.0	895.9	896.0	0.0	0	0	0	0	19938

Table 30 Detailed simulation result: 6. No productivity growth in the maize sector

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	881	473	57	**1411**	4692	881	473	57	**1411**	181	9437	**9618**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4926
2016	932	503	61	**1495**	4676	932	503	61	**1495**	193	10249	**10442**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5766
2017	994	539	66	**1599**	4680	994	539	66	**1599**	193	10941	**11134**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6455
2018	1072	586	72	**1731**	4687	1072	586	72	**1731**	190	11706	**11895**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7208
2019	1169	645	81	**1894**	4698	1169	645	81	**1894**	183	12611	**12794**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8096
2020	1288	718	91	**2098**	4709	1288	718	91	**2098**	177	13705	**13882**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9173
2021	1435	811	105	**2350**	4716	1435	811	105	**2350**	174	15048	**15222**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	10506
2022	1616	926	123	**2664**	4726	1616	926	123	**2664**	173	16643	**16816**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	12090
2023	1839	1071	147	**3057**	4733	1839	1071	143	**3054**	176	18604	**18780**	0.0	0.0	3.7	**3.7**	0.0	0	0	0	**0**	14047
2024	2116	1255	199	**3570**	4742	2116	1255	154	**3525**	183	21175	**21358**	0.0	0.0	45.0	**45.0**	0.0	0	0	0	**0**	16616
2025	2461	1489	279	**4229**	4749	2461	1489	163	**4113**	193	24457	**24650**	0.0	0.0	115.8	**115.8**	0.0	0	0	0	**0**	19901

Table 31 Detailed simulation result: 7. Higher income elasticity of modern pig products

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	881	480	57	**1419**	4785	881	480	57	**1419**	183	9529	**9712**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4926
2016	932	516	62	**1511**	4962	932	516	62	**1511**	198	10452	**10650**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5688
2017	996	562	68	**1625**	5269	996	562	68	**1625**	200	11269	**11470**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6200
2018	1074	619	76	**1768**	5712	1074	619	76	**1768**	198	12181	**12379**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6667
2019	1172	690	85	**1947**	6316	1172	690	86	**1947**	195	13287	**13482**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7165
2020	1292	780	98	**2170**	7124	1292	780	98	**2171**	191	14630	**14821**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7697
2021	1441	894	114	**2449**	8192	1441	894	114	**2449**	187	16269	**16456**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8264
2022	1623	1036	135	**2795**	9613	1623	1036	135	**2795**	183	18220	**18403**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8790
2023	1849	1217	162	**3229**	11506	1849	1217	162	**3229**	180	20587	**20767**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9261
2024	2128	1449	201	**3778**	14044	2128	1449	195	**3772**	181	23520	**23701**	0.0	0.0	5.9	**5.9**	0.0	0	0	0	**0**	9657
2025	2475	1747	278	**4500**	17458	2475	1747	218	**4440**	189	27514	**27703**	0.0	0.0	60.0	**60.0**	0.0	0	0	0	**0**	10245

Table 32 Detailed simulation result: 8. Higher income elasticity and higher productivity growth in the modern pig sector

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	881	486	58	**1425**	4785	881	486	58	**1425**	182	9575	**9757**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4971
2016	932	536	64	**1532**	4963	932	536	64	**1532**	194	10606	**10800**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5838
2017	994	605	72	**1672**	5269	994	605	72	**1672**	193	11618	**11811**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6542
2018	1072	701	83	**1856**	5712	1072	701	83	**1856**	188	12829	**13017**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7304
2019	1168	832	99	**2099**	6317	1168	832	99	**2099**	181	14382	**14563**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8246
2020	1287	1012	120	**2419**	7123	1287	1012	120	**2419**	177	16396	**16573**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9450
2021	1433	1262	152	**2847**	8194	1433	1262	146	**2841**	176	19025	**19201**	0.0	0.0	6.1	**6.1**	0.0	0	0	0	**0**	11006
2022	1612	1614	226	**3452**	9616	1612	1614	160	**3385**	180	22794	**22974**	0.0	0.0	66.9	**66.9**	0.0	0	0	0	**0**	13358
2023	1833	2112	358	**4303**	11510	1833	2112	174	**4119**	189	28018	**28207**	0.0	0.0	184.3	**184.3**	0.0	0	0	0	**0**	16697
2024	2105	2814	593	**5511**	14131	2105	2814	188	**5106**	188	33943	**34131**	0.0	0.0	404.9	**404.9**	0.0	0	0	0	**0**	20000
2025	2426	3792	1013	**7231**	17954	2426	3792	204	**6422**	157	37796	**37954**	0.0	0.0	809.4	**809.4**	0.0	0	0	0	**0**	20000

Table 33 Detailed simulation result: 9. Worst-case scenario for traditional pig sector

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	4704
2015	864	494	59	**1417**	4784	864	494	59	**1417**	185	9620	**9805**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5021
2016	887	555	66	**1507**	4963	887	555	66	**1507**	201	10671	**10872**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	5909
2017	908	638	76	**1621**	5270	908	638	76	**1621**	204	11700	**11904**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	6634
2018	929	752	89	**1770**	5711	929	752	89	**1770**	204	12964	**13168**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	7457
2019	950	910	108	**1968**	6315	950	910	108	**1968**	202	14615	**14817**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	8503
2020	972	1131	133	**2236**	7123	972	1131	134	**2236**	200	16820	**17020**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	9897
2021	994	1441	170	**2604**	8192	994	1441	170	**2604**	199	19817	**20016**	0.0	0.0	0.0	**0.0**	0.0	0	0	0	**0**	11824
2022	1016	1882	223	**3121**	9592	1016	1882	220	**3118**	204	24009	**24212**	0.0	0.0	2.8	**2.8**	0.0	0	0	0	**0**	14620
2023	1038	2522	344	**3905**	11487	1038	2522	257	**3818**	205	30221	**30426**	0.0	0.0	87.0	**87.0**	0.0	0	0	0	**0**	18939
2024	1060	3427	547	**5034**	14206	1060	3427	299	**4786**	190	33737	**33927**	0.0	0.0	248.5	**248.5**	0.0	0	0	0	**0**	19721
2025	1088	4752	907	**6747**	17930	1088	4752	350	**6189**	201	37250	**37452**	0.0	0.0	557.5	**557.6**	0.0	0	0	0	**0**	19522

Table 34 Detailed simulation result: 10. No tariff for pig products between ASEAN Plus & TPP countries

	SUPPLY (1000 tons CW)					DEMAND (1000 tons CW)							EXPORT (1000 tons CW)					IMPORT (1000 tons CW)				
	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZH	MZL	**MZ**	TP	CP	MP	**PIG**	MZ	TP	CP	MP	**PIG**	MZ
2014	845	453	54	**1352**	4673	845	453	54	**1352**	187	9190	**9377**	0.0	0.0	0.0	0.0	0.0	0	0	0	0	4704
2015	881	474	50	**1405**	4762	881	474	65	**1420**	188	9601	**9789**	0.0	0.0	0.0	0.0	0.0	0	0	15	15	5026
2016	931	502	55	**1488**	4957	931	502	67	**1500**	191	10212	**10403**	0.0	0.0	0.0	0.0	0.0	0	0	12	12	5446
2017	993	539	60	**1593**	5265	993	539	72	**1604**	191	10893	**11084**	0.0	0.0	0.0	0.0	0.0	0	0	11	11	5819
2018	1072	586	68	**1725**	5704	1072	586	77	**1735**	190	11725	**11914**	0.0	0.0	0.0	0.0	0.0	0	0	9	9	6210
2019	1169	645	79	**1893**	6303	1169	645	83	**1897**	189	12751	**12940**	0.0	0.0	0.0	0.0	0.0	0	0	4	4	6636
2020	1289	719	91	**2100**	7103	1289	719	92	**2100**	187	13989	**14176**	0.0	0.0	0.0	0.0	0.0	0	0	0	0	7074
2021	1437	812	105	**2354**	8167	1437	812	105	**2354**	186	15432	**15618**	0.0	0.0	0.0	0.0	0.0	0	0	0	0	7451
2022	1619	928	123	**2670**	9578	1619	928	123	**2670**	186	17154	**17340**	0.0	0.0	0.0	0.0	0.0	0	0	0	0	7763
2023	1843	1073	146	**3062**	11457	1843	1073	146	**3062**	190	19225	**19415**	0.0	0.0	0.0	0.0	0.0	0	0	0	0	7958
2024	2121	1257	183	**3561**	13969	2121	1257	167	**3545**	201	21873	**22074**	0.0	0.0	15.7	15.8	0.0	0	0	0	0	8105
2025	2466	1492	253	**4211**	17359	2466	1492	181	**4138**	220	25380	**25600**	0.0	0.0	72.8	72.8	0.0	0	0	0	0	8241