An Assessment of Swine Industry in the Philippines

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ABSTRACT

This paper assessed the performance of swine industry in the Philippines by synthesizing secondary data from 1990 to 2020. Inefficiencies in major swine value chain segments were identified. The factors affecting swine production and pork consumption were determined using multiple regression analysis. The bottlenecks found along the chain are yellow corn supply deficit, fragmented structures of yellow corn and backyard farms, high disease susceptibility of backyard farms, and compromised meat quality produced from private slaughterhouses. The own price, inventory, and slaughtered animals have significant direct effects on swine production. The retail price of pork and income have significant direct influences on pork consumption, while the retail price of chicken has inverse effect. Recommendations emphasize continuous implementation of support programs for yellow corn, promotion of collective action schemes for yellow corn and backyard farms, target-specific training-seminars on disease management and control for backyard farms, and Public-Private Partnership scheme for slaughterhouse modernization.

Keywords: *swine industry, pork, situationer and assessment, supply response, demand analysis*

Introduction

The swine industry continues to provide a significant contribution to the agriculture sector, generating an average share of 14.47% of agriculture's value of production from 2000 to 2020. Its closest substitute (i.e., chicken), on the other hand, had an average percentage share of 8.21% (Philippine Statistics Authority [PSA] 2021). The swine industry is also expected to sustain its expansion due to the increasing demand for pork and pork-based processed products. However, this consistent increase in demand has also made the Philippines a major pork importer bringing around 321 thousand metric tons of pork in 2019 (PSA 2021). As cited by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD 2014), both the country's local production and importation of pork have posted increasing growth rates over the years. However, pork importation grew at a faster rate than the local production. According to Yan (2020), local production efficiency should be improved to reduce importation, thereby becoming self-sufficient. Relying too much on importation will put the local producers, especially the small-hold farmers, in a disadvantaged position.

Several research and development projects focusing on feed improvements, breeding and rearing techniques, and automation have already been implemented to help boost swine production. However, both backyard and commercial swine raisers are still being confronted by other challenges like high costs of feeds and other production inputs, the incidence of disease outbreaks (e.g., Foot and Mouth Disease, Porcine

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Reproductive and Respiratory Syndrome, and African Swine Fever), and inefficient marketing structures and practices which result to a decline in output (PCAARRD 2014). Economic theory dictates that a shortage in supply, holding other factors constant, will result in higher domestic prices, which can also affect the purchasing power of the consumers. It is, therefore, necessary that the consistently rising demand be matched with enough domestic supply. However, producers' decision-making also depends on the behavior or response of consumers concerning price and income changes. Hence, the different factors affecting supply and demand should be determined to understand how swine production can be raised to an optimum level, thereby ensuring food availability, accessibility, and affordability.

Analyzing the swine industry should not only focus on the production and consumption levels. The industry is a holistic sector that provides income and employment to several interconnected stakeholders. According to Quilloy and Sumalde (2015), the swine industry value chain in the country is composed of the following segments: (a) inbound logistics, i.e., input suppliers such as feeds, piglets, and veterinary services, (b) production, i.e., from birth to pre-slaughter, (c) outbound logistics, i.e., slaughterhouses and food supply companies, (d) sales and marketing, i.e., supermarkets, restaurants, food service, and (e) servicing, i.e., support and extension services such as education, trainings, and technology upgrades. The performance, therefore, of each segment influences another segment, which can affect the whole industry. In this sense, to investigate the entire swine industry, other key players involved in the sector should also be analyzed. The different issues and challenges in each segment over the years must also be identified to serve as bases to craft up-to-date policies and strategies to ramp up the swine industry.

Therefore, the abovementioned situations have led to these questions: "Why has there been a lack of pork supply in the country over the years? Why has domestic production posted a slower rate of increase than pork importations?" It is hypothesized that this supply deficit, which made the Philippines import pork from other countries, was caused by several production-related factors as well as the performance of major players in the swine value chain.

This paper generally aims to assess the swine industry in the Philippines from 1990 to 2020. Specifically, it intends to: (1) analyze the performance of the major players along the swine value chain, (2) determine the factors affecting live swine production and pork consumption, (3) identify the different issues or inefficiencies along the chain, and (4) propose strategies that could improve the swine industry.

Literature Review

This section highlights the results of existing studies on swine industry assessment using value chain analysis. It presents some common analytical tools used in estimating supply and demand functions for the different agricultural commodities in the Philippines. So far, there have been limited studies on the value chain analysis of swine in the country. Furthermore, studies on supply response analysis in the Philippines had dealt mostly with agricultural crops and less on livestock and poultry commodities. Demand analysis studies on fresh meat, on the other hand, are commonly done in the country. These studies only differed in terms of tools employed. The contribution of this paper to the existing literature is to provide an up-to-date assessment of the status of different major key players along the swine value chain using secondary data and estimations of the supply and demand functions of live swine and pork, respectively.

Swine Value Chain

The value chain is a sequence of activities from input supply to primary production, assembly and collection, processing, and finally marketing to end-users. As products move from farm to market, money and information are exchanged between producers, traders,

processors, retailers, and consumers, thereby adding value to the tradable product. The value chain is influenced by the enabling environment, composed of laws, regulations, rules, and other institutional factors. The performance of the value chain is also affected by the services provided by private and public institutions (Da Silva and de Souza Filho 2007).

In the swine industry, Manipol *et al.* (2014) analyzed the agricultural marketing system (or value chain) of Philippine native swine (*Sus scrofa philippinensis*) with *lechon* as the end-product. The major players identified were the backyard producers, village agents, hog dealers, lechon processors, and end-consumers. A related value chain study on *Sus scrofa* was conducted in the highland communities of Sablan, Benguet (Ayomen and Kingan 2019). The major chain participants included the pig producers, traders, meat vendors, meat processors, and consumers. It was emphasized by Manipol *et al.* (2014) that the "problems and prospects identified in the value chain study may serve as input for policy formulation and may serve as guide in decision-making of various marketing participants."

Supply Trend and Response Analysis

Supply response analysis is used to determine the response of a specific commodity to changes in factors of production. These factors include the prices, inputs, environment, risk and uncertainties, technology, and institutional factors (Tomek *et al.* 2014, as cited by Supangco 2016). Several response models have been developed to estimate the effects of these explanatory variables to supply. These models can be derived from any of the following (Lantican, Aragon, and Bathan 2008): "multiple regression analysis employing the direct or indirect methods of supply estimation using time-series data; production function analysis using cross-section data or with observed price variations; profit function estimation; and the use of a Nerlovian model with partial adjustment and price formation."

The studies of Lantican, Aragon, and Bathan (2008) and Supangco (2016) utilized both the direct and indirect methods of supply estimation. The direct method employs a single supply model to estimate the supply response of commodities. The indirect method, in contrast, estimates the area and yield response functions separately. Area and yield are considered as the factors affecting domestic production.

To analyze the supply trends and responses of cabbage and tomato to changes in their own prices, prices of competing crops, input prices, and other supply determinants from 1991 to 2006, Lantican, Aragon, and Bathan (2008) employed a multiple regression analysis in linear and double-log forms. The study of Supangco (2016), on the other hand, examined the supply trend and response of onion in the regions of Ilocos and Central Luzon from 1990 to 2014. The factors considered were the lagged prices of onion, lagged prices of rice and squash as an alternative or major intercrops, lagged prices of ammonium phosphate and complete fertilizers, lagged agricultural wage rate, amount of rainfall, and time as a proxy for technology. The Prais-Winsten regression analysis, also both in linear and double-log forms, was employed to take into account the possible autocorrelation in the time-series data model.

To have a good grasp of the supply response related to swine, the study of Nyars and Vizvari (2005) was considered. This study employed several linear and non-linear regression equations to estimate the pork supply function in Hungary. The different explanatory variables considered were the lagged corn price (8 months earlier), lagged market price, lagged piglet price, and current chicken price. Chicken was also considered as a substitute meat product to pork in Hungary. The rationale behind adopting the current price of chicken was the fact that positively lagged chicken prices do not affect pork production, as supported by correlation analysis. Results showed that both input and market prices have significant effects on pork production (measured in thousand metric tons, liveweight). Higher production is expected under good market conditions such as low input prices and high market prices, and vice-versa.

Demand Analysis

Demand analysis involves the determination of significant factors affecting the consumption of products or commodities. Malabayabas *et al.* (2009) estimated the demand elasticities for fresh pork, chicken, and beef in the Philippines using the Nonlinear Quadratic Almost Ideal Demand System (NQAIDS) model. The seemingly unrelated regression (SUR) method of SYSLIN (nonlinear systems) of SAS (Statistical Analysis System) was utilized to estimate the parameters of the NQAIDS model. Results showed that fresh pork, chicken, and beef were highly responsive to the changes in prices and income. The low-income group was the most affected by the own-price and cross-price elasticities, signifying that they would bear most of the burden in the increase in fresh meat prices.

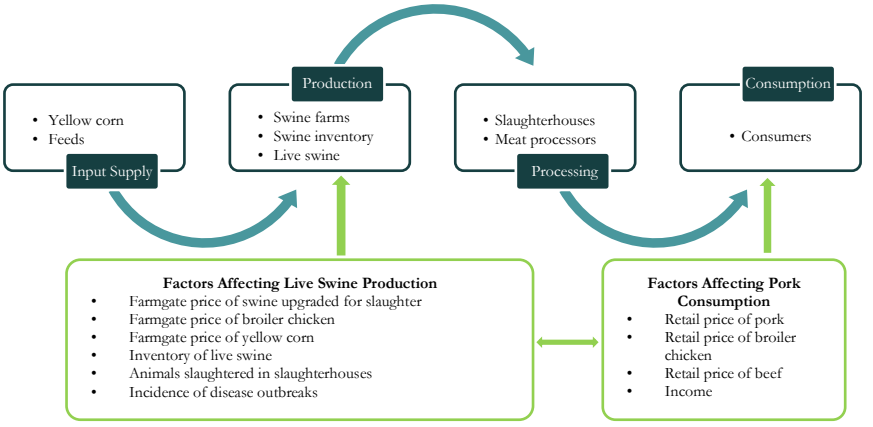
The study of Bendijo and Cruz (n.d.) employed the Ordinary Least Squares (OLS) method to estimate the own-price, cross-price, and income elasticities of demand for broiler meat in the Philippines from 1991 to 2005. The double-log regression was adopted to conduct broiler meat demand estimation and forecasts to 2020. The results conformed to economic theories: the consumer income and retail price of substitute product (i.e., pork) had direct influences on the demand for broiler meat. However, the own price had an inverse effect. The per capita demand for broiler meat was also expected to increase from 7.85 kilograms in 2005 to 8.01 kilograms by 2010 and 8.90 kilograms by 2020.

Conceptual Framework

The general value chain segments considered in this study were patterned after the study conducted by Quilloy and Sumalde (2015), with minor modifications made due to the access to and availability of relevant secondary data, which is the main limitation of this study. The value chain framework is needed since all the products in the value chain are interrelated. To provide the general situation of the swine industry in the Philippines, the status of each segment needs to be assessed. Inefficiencies along the chain should be identified as these will be detrimental to the improvement of the swine industry. The performance of one key player will have carry-over effects on the next actor/s along the chain.

As can be seen in Figure 1, the chain starts from the input supply composed of yellow corn and feeds. These inputs are being utilized by swine raisers found in the backyard and commercial farms. The live swine produced at the farm undergoes primary processing activities in slaughterhouses. Meat products from slaughterhouses are then transferred to secondary meat processors and sold to different institutional and retail markets for consumption.

To provide a complete assessment of the swine industry in the Philippines, the different factors affecting swine production and pork consumption should also be determined. Supply is defined as the amount of goods and services that the producers are both willing and able to produce and sell at a given price, *ceteris paribus* (Bello *et al.* 2009). Several factors can affect the supply of agricultural commodities. In this case, live swine production is expected to be affected by its own price, price of related products (i.e., broiler chicken), price of inputs (i.e., yellow corn as the main ingredient in feed formulation), swine population (i.e., inventory of live swine), access to processing facilities (i.e., animals slaughtered in slaughterhouses), and incidence of disease outbreaks. The own price is expected to have a direct influence on live swine production. As own price increases, swine farmers will be encouraged to raise more animals. This is what the law of supply dictates. On the other hand, it is anticipated that the prices of related products have an inverse effect on live swine production. As the farmgate price of broiler chicken increases, some swine producers will perceive broiler chicken as a more attractive venture, thereby shifting the usage of limited and scarce factor inputs to broiler production instead. Prices of yellow corn, a major ingredient for feeds, can also have an inverse



Source: Adapted and modified from Quilloy and Sumalde (2015)

Figure 1. Conceptual framework in assessing the swine industry in the Philippines, 1990-2020

effect on swine production. Higher prices of yellow corn will result in higher feed prices, constricting swine production. Meanwhile, the larger the swine population, the greater the live swine supply, other things held constant. Access to slaughterhouses, measured in terms of the number of live swine slaughtered, will encourage farmers to produce more. Lastly, disease outbreaks could increase swine mortality rate, hence decreasing swine production.

The production decision of swine raisers can also be influenced by the consumption behavior of pork and pork-based processed products. Demand refers to the amount of goods and services that the consumers are both willing and able to purchase at a given price, *ceteris paribus* (Bello *et al.* 2009). The demand for pork is expected to be affected by several factors such as own price, price of substitute products (i.e., chicken and beef), and income. The law of demand states that the quantity demanded for a good and service is inversely related to its own price, *ceteris paribus*. Hence, as the price of pork increases, consumers will purchase less, other factors remaining the same. Meanwhile, broiler chicken and beef prices are expected to induce pork consumption since consumers will shift to the relatively cheaper product. Lastly, an increase in income will improve the purchasing power of consumers, hence it is anticipated to have a direct relationship with pork consumption.

Methodology

Types and Sources of Data

This paper utilized and synthesized secondary data to assess the situation of the swine industry in the Philippines from 1990 to 2020. Specifically, data on production, consumption, and prices in each value chain segment came from the reports of different government and international institutions. These include the Philippine Statistics Authority (PSA), the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (DOST-PCAARRD), the National Economic and Development Authority (NEDA), the Department of Agriculture (DA) including its agencies, the Bangko Sentral ng Pilipinas (BSP), the Philippine Institute for Development Studies (PIDS), the World Bank (WB), and the Organisation for Economic Co-operation and Development (OECD). The results were also complemented with reports from several online news clips and other related studies.

Analytical Procedures

Trends in production, consumption, and prices were analyzed with the aid of tables and graphs. The annual growth rates were also computed using the equation below:

$$\% \text{ rate} = \frac{X_{present} - X_{previous}}{X_{previous}} \text{ x } 100 \quad (1)$$

where $X_{present}$ = present value
$X_{previous}$ = previous value

The annual percentage growth rate over the period is simply the average growth rate in each year within that period.

To analyze the supply response of swine to different explanatory variables, the multiple regression analysis was employed in linear and double-log forms:

Linear:

$$Q_t = \beta_0 + \beta_1 I_t + \beta_2 S_t + \beta_3 P_{Ht-1} + \beta_4 P_{Bt-1} + \beta_5 P_{Ct-1} + \beta_6 DI_t + e_t \quad (2)$$

Double-log:

$$\log Q_t = \beta_0 + \beta_1 \log I_t + \beta_2 \log S_t + \beta_3 \log P_{Ht-1} + \beta_4 \log P_{Bt-1} + \beta_5 \log P_{Ct-1} + \beta_6 DI_t + e_t \quad (3)$$

where
- Q_t = live swine production in year t (metric tons, liveweight)
- I_t = inventory of live swine in year t (heads)
- S_t = animals slaughtered in slaughterhouses in year t (heads)
- P_{Ht-1} = farmgate price of swine upgraded for slaughter in previous year t (PHP per kilogram, liveweight)
- P_{Bt-1} = farmgate price of broiler chicken in previous year t (PHP per kilogram, liveweight)
- P_{Ct-1} = farmgate price of yellow corn in previous year t (PHP per kilogram)
- DI_t = incidence of disease outbreak in year t (1 = there was a presence of disease outbreak, 0 = absence of disease outbreak)
- β_0 = intercept
- βi_s = regression coefficients
- e_t = error term

The multiple regression analysis, both in linear and double-log forms, was also used to assess the responses of pork consumers to different independent variables:

Linear:

$$D_t = \beta_0 + \beta_1 R_{Pt} + \beta_2 R_{Ct} + \beta_3 R_{Bt} + \beta_4 I_t + e_t \quad (4)$$

Double-log:

$$\log D_t = \beta_0 + \beta_1 \log R_{Pt} + \beta_2 \log R_{Ct} + \beta_3 \log R_{Bt} + \beta_4 \log I_t + e_t \quad (5)$$

where D_t = per capita consumption of pork in year t (kilogram per year)
R_{Pt} = retail price of pork in year t (PHP per kilogram)
R_{Ct} = retail price of chicken in year t (PHP per kilogram)
R_{Bt} = retail price of beef in year t (PHP per kilogram)
I_t = per capita Gross Domestic Product in year t as proxy for income (PHP per year)
β_0 = intercept
βi_s = regression coefficients
e_t = error term

The farmgate prices in 1989 and 2020 were not available. Since lagged prices were included in the supply response model, the period covered in the multiple regression analysis was only from 1991 to 2020, or equivalent to 30 observations. However, for the demand function, which considered the current prices, the period covered was from 1990 to 2020 (or 31 observations).

Real prices were used to eliminate the effects of inflation. The consumer price indices for corn and meat were specifically used to deflate the nominal farmgate and retail prices of yellow corn and meat products (swine/pork, broiler chicken, and beef), respectively, with 2012 as the base year (2012 = 100). The consumer price indices for all items, on the other hand, were used to deflate the nominal per capita Gross Domestic Product (2012 = 100). The following formula was employed to compute for the real values:

$$\text{Real value} = \text{Nominal value} \times \frac{\text{CPI}_{\text{base year (2012)}}}{\text{CPI}_{\text{current year}}} \quad (6)$$

The most appropriate regression model was selected based on the following criteria (Lantican, Aragon, and Bathan 2008, Supangco 2016): (1) significance of the model by looking into the F-value, (2) goodness of fit based on the coefficient of determination (R^2), (3) number of significant factors exhibited in the model, and (4) consistency of the signs of the coefficients based on economic theories. The serial correlations in the models were also corrected using the Newey-West Standard Errors. According to Zaiontz (n.d.), the Newey-West method handles autocorrelation and corrects heteroscedasticity (heterogeneity of variances). Specifically, however, the Breusch-Pagan (B-P) test was employed to determine whether heteroscedasticity is present in the models. Under the B-P test, if the test statistic has a p-value below an appropriate threshold (i.e., $p < 0.05$), then the null hypothesis of homoscedasticity is rejected, thereby accepting the presence of heteroscedasticity. The multiple regression models also assume that the residuals are normally distributed. The Jarque-Bera normality test was utilized. The test rejects the null hypothesis of normality when the p-value is less than 0.05. The models were also subjected to a multicollinearity test through the Variance Inflation Factor (VIF). As a rule of thumb, the VIF of all explanatory variables should be below 10 to avoid problems caused by multicollinearity (Lohninger n.d.).

Results and Discussion

The Performance of the Major Swine Value Chain Segments

Yellow Corn

Among all inputs, yellow corn takes up over 50% of the local feed requirements[1]. Therefore, the availability and affordability of this commodity have a significant impact on the operations of feed millers and swine producers. In this section, the historical performance of the yellow corn industry is investigated.

As reported by the PSA (2021), most of the yellow corn has been produced in Luzon (50.13%), particularly in the province of Isabela (19.92%). Mindanao also has a significant share of 45.70%, with Bukidnon (14.34%), South Cotabato (9.29%), and North Cotabato (6.39%) as major contributors. The volumes of production had increased by 4.89% and 4.50% annually, on the average, from 1990 to 1999 and 2000 to 2010, respectively (see Figure 2 and Appendix Table 1). These were driven by the improvements in productivity or yield by 4.92% and 2.90% per year during the said periods due to the adoptions of hybrid corn seeds and Bt corn, respectively. The adoption of hybrid corn substantially increased from 38,611 hectares in 1982 to 422,222 hectares in 1994 (Logroño, Lopez, and Alejandro 1996). Furthermore, according to Mutuc *et al.* (2012), the Philippines was the first country in Asia to commercialize Bt corn in response to the infestation of the Asian corn borer (*Ostrinia furnacalis*), which negatively affected the yields and profits of local yellow corn farmers. However, the rate of increase in the volume of production from 2011 to 2020 has slowed down to 3.80% per year due to the decline in growths of both the area harvested (2.22%) and yield (1.49%). This is perhaps the implication of efforts in increasing the production without expanding the area of operations.

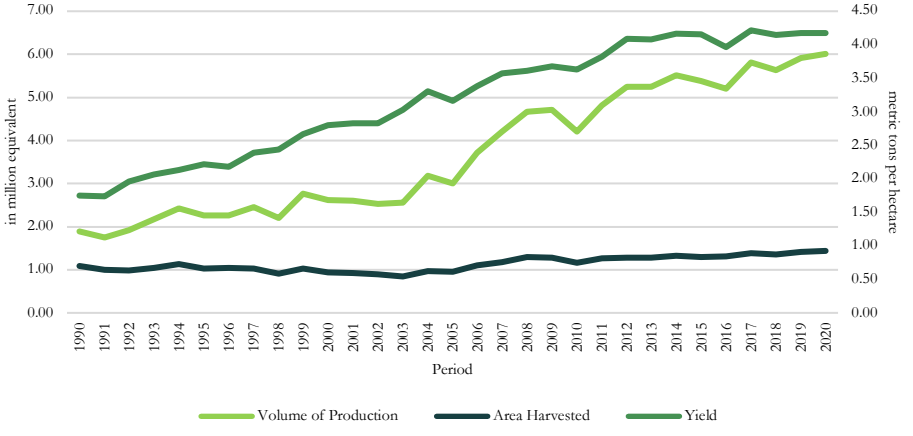
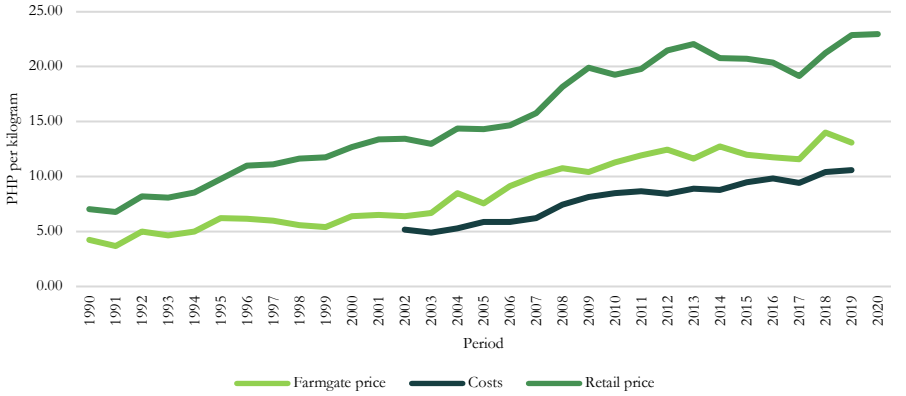


Figure 2. Volume of production (in million metric tons), area harvested (in million hectares), and yield (in metric tons per hectare) of yellow corn, Philippines, 1990-2020 (PSA 2021)

To sustain farm operations, the farmgate price must cover all the costs incurred in production, with enough profit remaining. Based on the data released by the PSA (2021), the farmgate price of yellow corn is way above the costs per kilogram of production from 2002 to 2019 (Figure 3). A kilogram of yellow corn can be produced at the cost of PHP 7.89 and sold for PHP 10.67, on the average. However, the rate of increase in farmgate prices (4.78%) has

[1] See article posted at the Manila Standard Business *(Feed millers agree to buy more local corn)* at https://www.manilastandard.net/mobile/article/334256.

been approximately at par with that of costs (4.51%). There are also instances where increases in costs have not been matched with improvements in farmgate prices. This, for instance, is most noticeable in 2019, where farmgate prices declined by 6.71%, but costs increased by 1.73%. The African Swine Fever (ASF), which started to spread in the Philippines during this period, has made the demand for pork products to decline. Given that yellow corn and pork industries are interconnected, this event had also led to a decline in demand for yellow corn, making its farmgate prices to drop significantly. This scenario is detrimental to yellow corn farmers as this would result to lower net income, holding other factors constant.



Note: Cost data from 1990 to 2001 are not available. Farmgate price and cost data in 2020 are also not available.

Figure 3. Costs of production, farmgate prices, and retail prices of yellow corn, Philippines, 1990-2020 (PSA 2021)

It can also be observed that retail prices of yellow corn can reach up to PHP 23.00 per kilogram. This reflects that corn traders charge a huge mark-up. However, given the small holder nature and fragmented structure of yellow corn farms in the country, the farmers have low bargaining power making them price-takers. According to Adriano (2020)[2], the medium-term solution for this is to link the farmers directly to feed milling companies via a contract growing scheme. This will incentivize the farmers to produce more since inputs will become more accessible, and their products will have a sure market.

Feed Millers

The feed milling industry has also been proven to play a crucial role in the development of the agriculture sector, particularly in the swine industry (Sison 2014). Most registered commercial feed manufacturers (approximately 70%) can be found in Luzon, while the rest are scattered in Visayas and Mindanao. This makes access to major feed ingredients such as yellow corn much easier. However, the local production of yellow corn is not enough to meet the needs of feed milling industries. The Philippine Association of Feed Millers, Inc. (PAFMI), a group of 33 companies producing around 70% of the country's animal feed products, reported that a total of 10 million metric tons of yellow corn are needed every year, forcing stakeholders to import corn from neighboring countries to fill in the deficit[3]. According to Salazar *et al.* (2021), corn is mostly imported from the United States of America, Argentina, and other member-countries of the Association of South-East Asian Nations (i.e.,

[2] See article posted at The Manila Times *(Corn, livestock and poultry industries: Drivers of agricultural growth*) at https://www.manilatimes.net/2020/12/17/business/agribusiness/corn-livestock-and-poultry-industries-drivers-of-agricultural-growth/812174/.

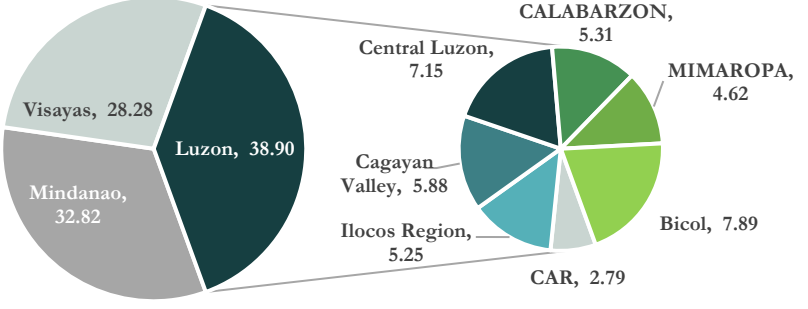
[3] See articles posted at the Philippine Daily Inquirer *(Feed millers worried about rising corn prices)* and at the Manila Bulletin *(Big PH feed millers ramps up local corn buying)* at https://business.inquirer.net/306103/feed-millers-worried-about-rising-corn-prices and https://mb.com.ph/2020/09/30/big-ph-feed-millers-ramps-up-local-corn-buying/, respectively.

Indonesia, Thailand, Vietnam, and Myanmar). It was also pointed out that feed wheat, another major feed ingredient, has been considered a significant input by the local feed milling industry. In fact, about 30% of whole feed ingredients come from feed wheat which is mostly imported from Australia (Salazar *et al.* 2021). The local yellow corn production, therefore, has also been challenged by this competition. The international prices, without tariff, of imported corn and feed wheat decreased from 2014 to 2018, which were way below the local prices of yellow corn. When a tariff is considered, the cost of importing feed wheat is still lower than the domestic wholesale price of yellow corn. This has made PAFMI to initially purchase 81,200 metric tons of feed wheat from the Black Sea and Australia in 2020, which when delivered to Manila, would only cost PHP 12.00 per kilogram, vis-à-vis the domestic price of yellow corn of PHP 17.50 per kilogram[4]. It can be deduced that the local feed milling industry is gearing towards using more feed wheat supplemented with local yellow corn to compensate for the low quality of feed wheat (Salazar *et al.* 2021).

Swine Farms

In the Philippines, swine are raised either in backyard or commercial farms. Backyard farms maintain less than 10 sows, purchase commercial feeds, but have no business permits and generally lack farm records. Commercial farms, on one hand, can be classified as small, medium, and large. Small-scale commercial farms maintain less than 100 sows and purchase commercial feeds. Medium-scale farms maintain 100 to 300 sows, have business permits, operate a specialized farm structure, and usually mix their feeds. Lastly, large-scale commercial farms raise more than 300 sows, maintain breeding stocks with superior genetics, adopt artificial insemination, have their feed mills and business permits, keep computerized farm records, and usually have water treatment facilities (Sison 2014).

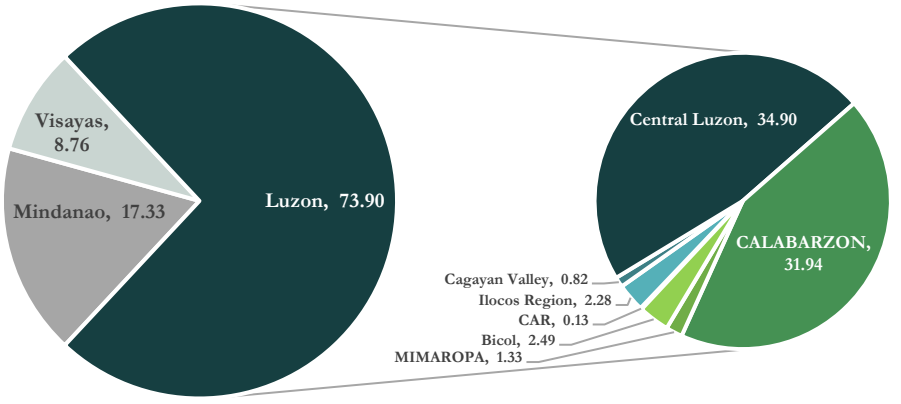
As shown in Figure 4, backyard farms are evenly distributed throughout the country. This is in conjunction with the fact that smallholder farms in the Philippines are fragmented. They are dispersed in different locations, which makes it harder for them to access inputs and relevant market information to increase production and command for more favorable prices. On the contrary, commercial farms are strategically located near the National Capital Region and adjacent major urban consuming centers. They are heavily concentrated in Luzon, specifically in the provinces of Bulacan in Central Luzon, and Batangas in CALABARZON, making the inputs (i.e., yellow corn and feeds) more accessible to them (Figure 5).



Note: Inventories of live swine by farm type (backyard) from 1990 to 1993 are not available.

Figure 4. Top-producing regions of live swine (in terms of inventory as of January 1 of every year), backyard farms, Philippines, 1994-2020 (PSA 2021)

[4] See article posted at The Philippine Star *(High corn prices hurting feed millers)* at https://www.philstar.com/business/2020/08/28/2038263/high-corn-prices-hurting-feed-millers.

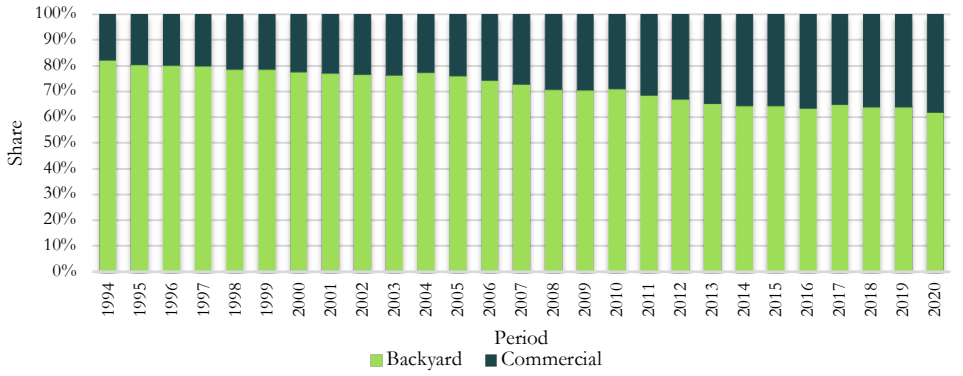


Note: Inventories of live swine by farm type (commercial) from 1990 to 1993 are not available

Figure 5. Top-producing regions of live swine (in terms of inventory as of January 1 of every year), commercial farms, Philippines, 1994-2020 (PSA 2021)

Backyard farms produce most of the country's swine population, with an average share of almost 72% from 1994 to 2020 (see Appendix Table 2). This shows that several small-scale farmers are engaging in swine production, citing high return on investment and income augmentation to meet household needs as the primary reasons. However, the contribution of backyard farming has been declining over the years (Figure 6). From 82.25% in 1994, the share went down to 62.30% in 2020. The participation of backyard swine raisers in the value chain is limited, which usually ends up in the production stage without the capacity to perform value-adding activities (Quilloy and Sumalde 2015). Due to small size, backyard farms have limited access to production inputs, technical and veterinary services, credit, and market information (Maharjan and Fradejas 2005). They are also more susceptible to volatility in input prices. High costs of inputs, feeds for instance, can easily affect their production.

Meanwhile, commercial farms can take advantage of the economies of scale by adopting high-end facilities and technologies in their operations. Unlike the backyard farms, commercial swine raisers play several roles in the value chain. According to Quilloy and Sumalde (2015), the operations of commercial farms are integrated from feed milling and breeding up to processing, marketing, and distribution. They can also perform different value-adding activities, which enables them to produce and sell processed meat products. There are also instances where commercial farms assist backyard farms via contract growing schemes. As commercial farms dominate the value chain, the backyard swine raisers would find it more challenging to compete and increase their market participation. This significant structural transformation in the swine industry reflects the proliferation of swine production in urban and peri-urban areas (where commercial farms are mostly located) in response to the growing demand for animal products like pork (Sison 2014).

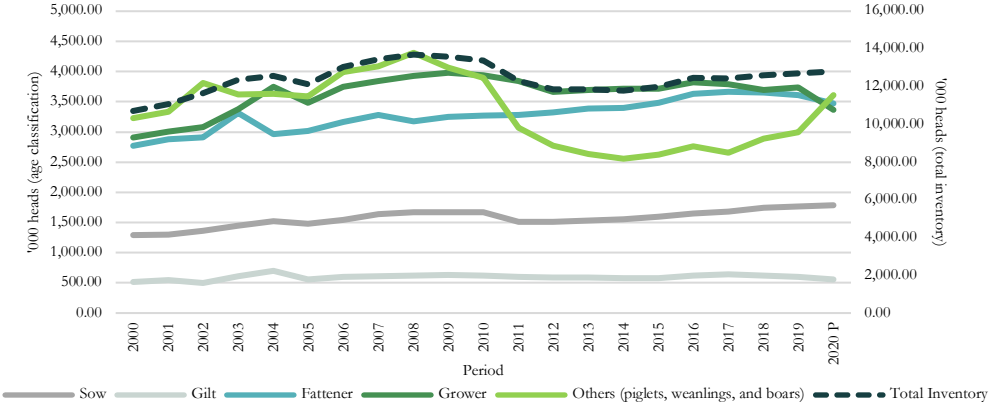


Note: Inventories of live swine by farm type from 1990 to 1993 are not available.

Figure 6. Shares of backyard and commercial farms to total swine inventory (as of January 1 of every year), Philippines, 1994-2020 (PSA 2021)

Inventory by Age Classification

The total inventory of live swine is composed of sows, gilts, fatteners, growers, piglets, weanlings, and boars. As shown in Figure 7, the consistent increase in total swine inventory from 10.71 million heads in 2000 to 13.70 million heads in 2008 (or 3.17% annually) can be attributed to the increasing trend in breeding sow inventory by 3.28% annually. However, the succeeding periods of 2009 to 2014 registered a declining trend in swine inventory of 2.41% per year. This was mainly due to the 8.12% annual drop in the inventory of piglets, weanlings, and boars during the same period. This can also be caused by the Porcine Reproductive and Respiratory Syndrome (PRRS) outbreak, which severely impacted the local swine industry from 2007 to 2012 (Abao *et al.* 2014, Kedkovid, Sirisereewan, and Thanawongnuwech 2020). PRRS led to reproductive failure in sows and respiratory disease in swine (Albina 1997, as cited by Abao *et al.* 2014). Another major disease outbreak recorded in 2005 to 2006, 2010, and 2014 to 2015 causing high piglet mortality was the Porcine Epidemic Diarrhea (PED) (Garcia *et al.* 2018). The total inventory slightly improved after that, growing at an average rate of 1.37% annually.



Notes: P – Preliminary; Sow – female, 6 months old and above; Gilt – female, less than 6 months old; Fattener – 5 months old and above; Grower – 2 months to 5 months
Inventories of live swine by age classification from 1990 to 1999 are not available.

Figure 7. Swine inventory by age classification (as of January 1 of every year), Philippines, 2000-2020 (PSA 2021)

The number of growers and fatteners primarily held for slaughter and/or sale grew by 0.86% and 1.23% per year, respectively, from 2000 to 2020 (see Appendix Table 3). However, it can be noticed that growers and fatteners are also susceptible to diseases. Growers and fatteners recorded for instance, contractions of 9.85% and 3.73%, respectively, from 2019 to 2020 due to the ASF outbreak. Many swine have been culled to contain the spread of this contagious animal disease to different parts of the country. In 2020, the ASF had already affected 25 provinces in the country, culling approximately 350,000 heads[5].

Live Swine Production

Improvements in the swine population could also result in an increased volume of production. The volume of production, in this case, pertains to the animals disposed for slaughter measured in metric tons liveweight (PSA 2021). From 1990 to 2018, the volume of production increased consistently, recording an average annual growth rate of 2.96% (Figure 8). However, the production declined in the succeeding years due to the ASF outbreak, which affected several backyard and commercial farms in Luzon, contracting by 3.85% per year, on the average.

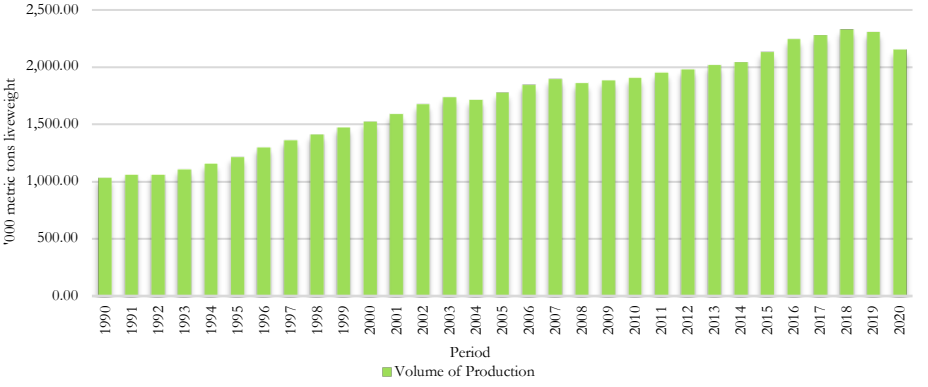


Figure 8. Volume of production of swine, Philippines, 1990-2020 (PSA 2021, Domingo and Olaguera 2017)

Unlike commercial farms, backyard farms normally have no capacity to adopt strict quarantine protocols. Swine in backyard farms are usually fed a variety of waste food or by-products (i.e., swill feeding), often supplemented with commercial feeds. Swill feeding has been said to be the main culprit behind ASF, which originated from Rizal province[6].

Slaughtered in Slaughterhouses

Slaughterhouses are premises involved in butchering animals for human consumption (PSA 2021). There are two types of accreditation for slaughterhouses in the Philippines. These are the National Meat Inspection Service (NMIS)-accredited slaughterhouses and the Locally-Registered Meat Establishments (LRMEs). The live swine produced in backyard farms are mostly slaughtered in LRMEs, unlike those produced in commercial farms, which are mostly slaughtered in NMIS-accredited facilities.

The NMIS-accredited slaughterhouses are further categorized into class A, class AA, and class AAA. Class AAA slaughterhouses are equipped with state-of-the-art facilities (i.e., meat laboratory and cold storage compliant with the international standards), permitting their

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[5] See article posted at INQUIRER.net (*Close to 350K hogs culled due to ASF)* at https://newsinfo.inquirer.net/1350716/da-culled-hogs-due-to-asf-nearing-350000.

[6] See article posted at Rappler *(Pork from China caused African swine fever outbreak in Philippines)* at https://www.rappler.com/business/pork-from-china-caused-african-swine-fever-outbreak-philippines.

meat products to be exported to other countries, with the condition that there is no incidence of animal diseases in the country. Classes AA and A slaughterhouses are also equipped with facilities but are only accredited to market locally produced meat products within the country. Class A slaughterhouses usually have lower production capacity than class AA.

LRMEs, on the other hand, are slaughterhouses allowed to operate by the city/municipal government but are not accredited by the NMIS[7]. The sale and distribution of meat products produced in LRMEs are confined within the respective cities/municipalities only. Upgrading LRMEs to accredited slaughterhouses is, thus, important to expand the distribution areas of local swine farmers. In addition, constructing modern slaughterhouses will prevent unauthorized and illicit slaughtering. Some private slaughterhouses are reported to have low hygiene standards, posing both health and environmental hazards to the community[8]. However, establishing an accredited slaughterhouse requires a huge amount of capital. For instance, the first government-owned class AAA slaughterhouse built in Tanauan City, Batangas required PHP 187 million worth of capital[9]. A modern class AA slaughterhouse, planned to be constructed in Daraga, Albay, is budgeted at PHP 60 million[8].

As of the latest list issued by the NMIS, there are 132 accredited slaughterhouses in the Philippines – 122 of which are class AA, while the remaining 10 are class AAA (see Appendix Table 4). Most of both classes are in Luzon. There are no A-rated slaughterhouses included in the list, implying that several existing slaughterhouses are working towards upgrading their accreditation.

Figure 9 shows the number of animals slaughtered in NMIS-accredited slaughterhouses and LRMEs. As can be noticed, there is an improvement in the number of animals slaughtered in slaughterhouses. From 1990 to 1999, it increased by 3.96% per year, on the average. However, from 2000 to 2010, the trend became relatively flat, growing at 0.93% annually, on the average. The trend significantly improved to 3.12% from 2011 to 2020. This should be maintained, or much better if further improved, to ensure the production of safe, affordable, and high-quality meat products for both the domestic and international markets.

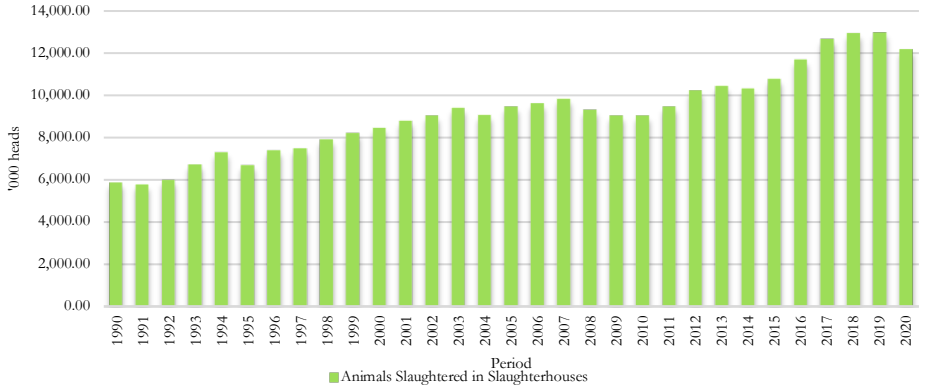


Figure 9. Number of swine slaughtered in slaughterhouses, Philippines, 1990-2020 (PSA 2021)

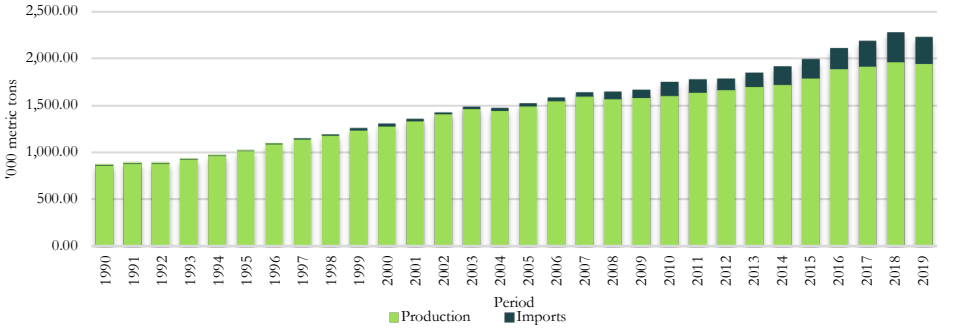
[7] DA Administrative Order No. 6, s. 2012 at https://www.officialgazette.gov.ph/2012/01/12/da-administrative-order-no-6-s-2012/.

[8] See articles posted at the Philippine News Agency *(DA-Bicol okays construction of P60-M abattoir in Albay town)* at https://www.pna.gov.ph/articles/1114570.

[9] See article posted at The Philippine Star *(DA to operate Batangas slaughterhouse)* at https://www.philstar.com/business/2020/09/02/2039383/da-operate-batangas-slaughterhouse.

Pork Production

The pork supply in the country has been sourced out both from domestic production and importation. The total volume of pork consistently increased by 3.50% annually, on the average, from 0.87 million metric tons in 1990 to 2.27 million metric tons in 2018 (Figure 10). This consistent improvement was brought about by increasing trends in both domestic production and importation. However, the total pork supply declined in the succeeding year (2019) by 2.16%. This decline was due to the ASF outbreak. The outbreak affected not just domestic production but also led to a ban on importation of pork meat products from other countries.



Note: Data in 2020 are not available.

Figure 10. Pork supply in the Philippines, 1990-2019 (PSA 2021)

It can also be noticed that from 1990 to 2019, the growth of importation (31.35%) has been faster vis-à-vis the domestic production (2.82%). Pork importation is needed to fill in the gap between domestic production and the increasing demand for pork due to the increasing population in the country. PCAARRD (2014) also cited that meat processors usually utilize imports as ingredients of processed meat products.

Meat Processors

Filipinos are fond of consuming pork-based processed products like *longganisa* (fresh or smoked sausage), *tocino* (cured pork), ham, hotdogs, bacon, and *lechon*, to name a few. Meat processors are the ones responsible for producing different types of pork-based processed products. As of the latest report of the Department of Trade and Industry (DTI 2021), there are 175 meat processors in the country, the majority of which are in Luzon (i.e., National Capital Region, Region III, and Region IV-A).

Due to the increasing demand and proliferation of meat processors, the Philippines becomes a net exporter of processed meat products (DTI 2021). The major export markets are the United Arab Emirates, Qatar, Saudi Arabia, Kuwait, Japan, United States of America, Canada, Guam, and Taiwan. However, the meat processors require industrial-grade meat and in turn need to import from neighboring countries for quality meat (Peñaflor 2016). In fact, 85% of the raw materials needed by the local meat processing industry were imported from other countries (DTI 2021). The local swine raisers sell their products primarily to wet markets as "table meat". This is also the reason why the Philippines has become one of the major importers of pork. In 2018, the total volume of pork imports was recorded at 316,195 metric tons, which was 15.98% higher than the 272,614 metric tons imported in 2017 (PSA 2021). To ensure a steady supply of high-quality raw materials for meat producers and processors, the Philippine Association of Meat Processors, Inc. (PAMPI), which has 36 active member-

processors providing around 80% of the country's processed meat products, suggested that modernized and world-class slaughterhouses must be established in the country[10].

Pork Consumption

As shown in Figure 11, pork has been the most consumed meat product in the country, recording an average annual per capita consumption of 12.67 kilograms from 1990 to 2020. This has been followed by chicken and beef with an average annual per capita consumption of 8.26 kilograms and 2.81 kilograms, respectively. The latest report of PSA in 2017[11] indicated that consumers in Cagayan Valley were the biggest consumers of pork, with an estimated annual per capita consumption of 14.00 kilograms, followed by Metro Manila with 13.60 kilograms. The Autonomous Region in Muslim Mindanao (ARMM) posted the least per capita pork consumption with 0.46 kilogram.

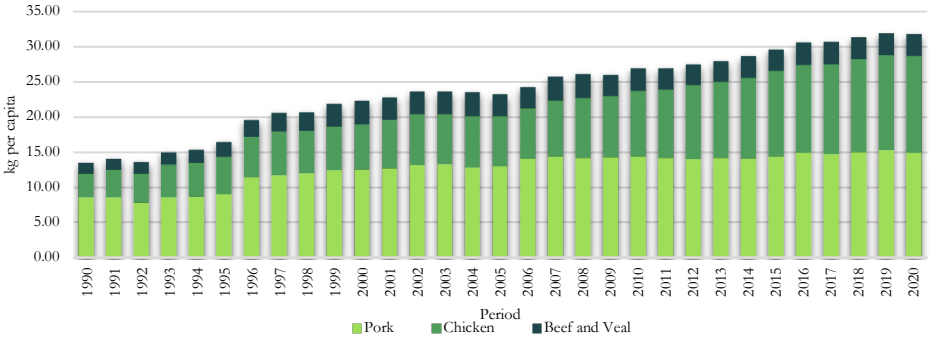


Figure 11. Annual per capita consumption of major meat products, Philippines, 1990-2020 (OECD 2021)

However, the rate of increase in per capita consumption of pork (1.97%) has lagged behind that of chicken (4.82%). This can be attributed to the level and variability in the prices of meat products. A fully dressed broiler chicken, for instance, can be bought on average for PHP 105.05 per kilogram between 1990 to 2020. This price is much cheaper than pork meat (PHP 136.15 per kilogram) and lean beef meat (PHP 178.52 per kilogram) during the same period (Figure 12). Also during the same period, retail prices of pork grew by 5.04% per year, while chicken and beef grew at 3.70% and 5.03%, respectively.

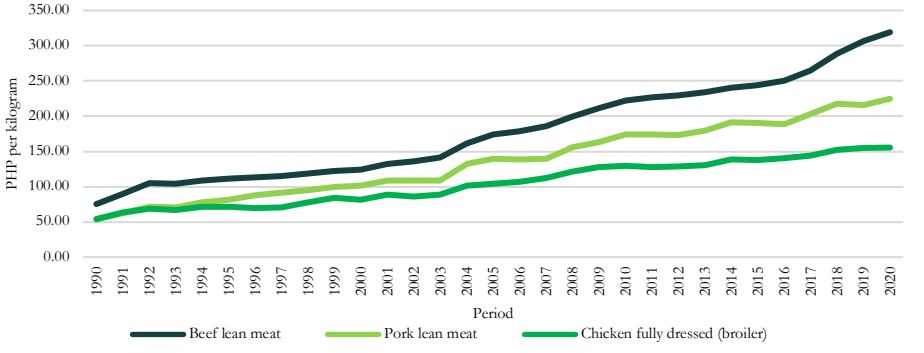


Figure 12. Retail prices of major meat products, Philippines, 1990-2020 (PSA 2021)

[10]See article posted at the SunStar Cebu *(Meat processors lobby for triple a slaughterhouses)* at https://www.sunstar.com.ph/article/1813374.

[11]See article posted at the Philippine Daily Inquirer *(In the know)* at https://business.inquirer.net/281939/in-the-know-2.

Factors Affecting Live Swine Production

In this section, the different factors affecting live swine production are identified and analyzed through a regression. After being subjected to different diagnostic tests, the double-log form was found to be the more appropriate regression model for the supply estimation. The adjusted R^2 was 0.98, signifying that 98% of the variation in the supply or production can be explained by the independent variables. The model is significant based on the computed F-value. The study did not detect multicollinearity since the values of the VIF are less than 10. Serial correlation was corrected by using the Newey-West method. The residuals are normally distributed since the p-value is higher than 0.05, as depicted by the Jarque-Bera normality test. The model also exhibited homoscedasticity since the p-value is higher than 0.05, as reflected in the Breusch-Pagan test. Table 1 shows the results of the regression analysis using the double-log model.

Table 1. Results of double-log regression analysis on factors affecting live swine production in the Philippines, 1991-2020

Variable	Coefficient	Newey-West Standard Error	P-value	VIF
Constant	-5.870***	1.556	0.000	
Inventory of live swine (head)	0.562***	0.069	0.000	4.824
Animals slaughtered in slaughterhouses (head)	0.646***	0.076	0.000	7.577
Farmgate price of swine upgraded for slaughter (PHP per kg, liveweight)	0.333***	0.115	0.010	1.445
Farmgate price of broiler chicken (PHP per kg, liveweight)	-0.120	0.085	0.172	4.165
Farmgate price of yellow corn (PHP per kg)	-0.074	0.053	0.339	3.560
Incidence of disease outbreak	-0.015	0.020	0.470	2.193
Adjusted R^2	0.980			
F-value	238.900***			
Prob > F	0.0000			
Jarque-Bera	2.281			
Prob > chi^2	0.320			
Breusch-Pagan	0.080			
Prob > chi^2	0.771			

Note: ***statistically significant at 1% probability level

Based on the results, the inventory of live swine, number of animals slaughtered in slaughterhouses, and farmgate price of swine have been found to be statistically significant at 1% probability level.

Inventory of Live Swine

The inventory of live swine, composed of all age classifications, is a significant factor influencing swine production. Specifically, a 1% increase in inventory would result in 0.562% increase in live swine production, *ceteris paribus*. Therefore, it is important to ensure continuous adoption of strategies to boost breeding sows' productivity. In fact, according to PCAARRD (2016), low sow productivity and high mortality rate due to inefficient diagnostic tools are some of the production constraints in swine farms.

Animals Slaughtered in Slaughterhouses

The number of animals slaughtered in slaughterhouses was used to represent the access of swine raisers and traders to slaughterhouses. It is evident based on the results that access to these primary processing facilities would induce live swine production. The coefficient of 0.646 indicates that a 1% increase in the number of animals slaughtered in

slaughterhouses would increase production by 0.646%, *ceteris paribus*. Swine raisers will be enticed to produce more since access to these facilities will expand the distribution areas of their meat products.

Farmgate Price of Swine Upgraded for Slaughter

The law of supply states that the quantity supplied of a product is directly related to its own price, holding other factors affecting supply constant. The results conform to this economic theory. The incentive to sell more will increase as the price of live swine increases. Specifically, a 1% increase in farmgate price the previous year will translate to an increase in production by 0.333% in the current year, *ceteris paribus*. This shows that own price has a significant direct influence on future production decisions of swine farmers.

Factors Affecting Pork Consumption

The same procedures were done to select the more appropriate regression model to estimate the demand function for pork in the Philippines. The linear model was found to be the more appropriate model. The model is significant based on the computed F-value. It also obtained a high adjusted R^2 of 0.853. The retail price of beef was dropped from the model to address the issue of multicollinearity. This made the values of VIF to be less than 10. The Newey-West Standard Errors method was also employed to correct the serial correlation. The residuals are normally distributed, and the model also exhibited homoscedasticity. The results can be seen in Table 2.

Table 2. Results of linear regression analysis on factors affecting demand for pork in the Philippines, 1990-2020

Variable	Coefficient	Newey-West Standard Error	P-value	VIF
Constant	9.894**	5.761	0.015	
Retail price of pork (PHP per kg)	0.083**	0.046	0.021	3.083
Retail price of chicken (PHP per kg)	-0.101***	0.019	0.000	4.903
Per capita Gross Domestic Product as proxy for income (PHP per year)	$2.370x10^{-5}$**	0.000	0.038	2.764
Adjusted R^2	0.853			
F-value	58.960***			
Prob > F	0.000			
Jarque-Bera	0.643			
Prob > chi^2	0.725			
Breusch-Pagan	1.700			
Prob > chi^2	0.192			

Notes: ***, **statistically significant at 1% and 5% probability levels, respectively

The results of linear regression revealed that retail price of pork, retail price of broiler chicken, and income could significantly affect the demand for pork.

Retail Price of Pork

The own price and quantity demanded for the product are inversely related, as stated by the law of demand. Interestingly, the regression results do not conform to this. A one-peso increase in pork retail price will increase per capita pork consumption by 0.083 kilogram per year, *ceteris paribus*. This shows that over the years, pork has become a necessity good for Filipinos. Villegas (2020), as cited by Arcalas (2020)[12], mentioned that the demand for meat

[12] See article posted at the Business Mirror *(The meat of the matter: New threats compound recurring problems for animal protein industry)* at https://businessmirror.com.ph/2020/01/30/the-meat-of-the-matter-new-threats-compound-recurring-problems-for-animal-protein-industry/.

over time had been driven by youth. These mostly include the Filipino professionals with increasing purchasing power and preference/lifestyle towards pork consumption.

Retail Price of Chicken

Chicken is expected to be a substitute product for pork. Therefore, theoretically, its price should have a direct effect on pork consumption. However, this is not supported by the results. As can be observed in Table 2, as chicken becomes more expensive relative to pork, consumers will decrease their pork consumption. One possible reason for this is the fact that the difference between the retail prices of pork and chicken is quite large. As mentioned, the average price of a fully dressed broiler chicken is PHP 105.05 per kilogram, which is much cheaper than pork meat at PHP 136.15 per kilogram.

Income

A higher income results in a greater ability to buy, thereby increasing the demand for goods and services. The regression results conform to this economic theory. Specifically, a PHP 1,000.00 increase in income would raise the per capita pork consumption by 0.024 kilogram per year, *ceteris paribus*.

Evaluation of the Swine Value Chain

After discussing the status and performance of each major key player in the swine value chain, including the different factors affecting the live swine production and pork consumption, the overall performance of the value chain was assessed by identifying and summarizing the positive and negative drivers (i.e., strengths and weaknesses) towards the improvement of the local swine industry.

Input Supply

The adoption of hybrid corn seeds and Bt corn led to improvements in productivity or yield of yellow corn in the country. However, a group of feed milling companies reported that there was still a shortage of yellow corn supply which affects feed production. Perhaps, this can also be attributed to the small holder nature and fragmented structure of most yellow corn farms in the country. Access to yellow corn from fragmented farms can also be more costly, which has made the commercial feed millers to import feed ingredients (i.e., feed wheat) from neighboring countries. The local yellow corn industry, therefore, has also been challenged by this trade competition. However, it is important to note that even though feed wheat is still much cheaper, it does not give the required energy that yellow corn can provide. This means that yellow corn and feed wheat are not perfect substitutes but rather complementary inputs.

In addition, a deficit in the local supply of yellow corn can make local feeds expensive. High costs of feeds would result in the underutilization of inputs in swine farms, especially by the backyard raisers, which constricts the production and supply of pork in the country.

Production

Among the livestock and poultry industries, the swine has the most organized production system. The adoption and application of science and technology (S&T)-based interventions in both backyard and commercial swine farms have improved the production, productivity, and quality of swine produced in the country (PCAARRD 2014). However, the main bottleneck on the production side is the preparedness of backyard farms against disease outbreaks. They have weaker and slower responses (i.e., quarantine protocols) vis-à-vis the commercial farms. If not mitigated, this will be detrimental to the population and inventory of live swine, and hence pork production. The fragmented structure of backyard swine farms in the country has also been found to be a challenge that makes it harder for them to have access to sufficient inputs and market information. In effect, this induces them to utilize food

wastes and/or by-products instead (i.e., swill feeding), which have been found to be the main cause of the African Swine Fever in the country.

Processing

The number of swine slaughtered in slaughterhouses has significantly improved over the years. It is important to note that access to these facilities will improve the local swine production as this will incentivize the producers to expand the market reach of their meat products. Pork meat produced in LRMEs and private slaughterhouses are often unsafe and unclean. Producing safe and high-quality or industrial-grade meat will also give enough raw materials to meat processors. However, this can only be achieved by modernizing and upgrading the existing slaughterhouses in the country. Without these modern slaughterhouses, the meat processors have no choice but to import high-quality meat from other countries.

Consumption

There has been a growing domestic market of pork in the country which can be attributed to the increasing per capita consumption brought by the growing population. Over the years, pork has become a necessity because of the increasing preference of Filipinos for pork. However, the increasing prices of pork in the market relative to other meat products such as chicken could lower the purchasing power of pork consumers.

Conclusions and Recommendations

The growing demand for and consumption of pork and pork-based products gives an opportunity for the swine industry to sustain its expansion. However, this consistently rising demand should be matched with improvement in supply. Otherwise, this could lead to a domestic supply deficit and pork importations. This paper, therefore, assessed the performance of the Philippine swine industry from 1990 to 2020. The strengths and inefficiencies in each major value chain segment of the swine industry have been identified. This has been complemented with the determination of significant factors affecting swine production and pork consumption using multiple regression analysis.

The following were identified to be the main reasons behind the supply deficit and importations of pork in the country: (a) shortage of yellow corn supply which led to high dependency on imported feed ingredients and high costs of feeds, (b) fragmented structures of yellow corn farms and backyard swine farms, (c) incidence of disease outbreaks, (d) compromised meat quality produced from some private slaughterhouses due to low hygiene standards, and (e) industrial-grade meat requirements of the meat processors.

The double-log regression analysis identified the inventory of live swine, number of animals slaughtered in slaughterhouses, and farmgate price of swine to have significant direct influences on live swine production. This suggests that live swine production has been driven primarily by the production and primary processing aspects in the value chain. Meanwhile, on the consumption side, the linear regression analysis showed that the factors which significantly affect pork consumption are the own price of pork, retail price of chicken, and income. The retail price of pork and income have direct significant effects on per capita pork consumption. This depicts that pork has become a necessity food item for Filipinos over the years which, in effect, can also capacitate the local swine industry. However, the retail price of chicken, a substitute product for pork, has an inverse relationship which also does not conform to economic theory. One possible reason for this is a huge gap between the average retail prices of pork and chicken.

Policy implications suggest a need to continuously implement and monitor government programs that aim is to increase the yield of yellow corn in the country to meet the raw material needs of feed millers. The fragmented structure of yellow corn and backyard

swine farms can also be addressed through contract growing and/or collective action schemes via the formation of cooperatives. To prepare the swine raisers for future disease outbreaks, the continuous implementation of target-specific trainings and seminars on disease management and control should be conducted. LRMEs should be converted into accredited slaughterhouses, while the existing accredited slaughterhouses should be modernized to produce safer, high-quality, and more competitive pork products. However, since the conversion and modernization will require a huge amount of capital, a Public-Private Partnership (PPP) scheme can be explored. The private sector can design, build, and operate the facilities during the contracted period, and control will be transferred back to the government after a specified duration.

This study also opens opportunities for further assessment of the swine industry in the Philippines. Since this study utilized secondary data, some of which have been found to be scarce or limited, other supply chain participants were not included in this paper. Future studies can incorporate these other participants. The market structure, conduct, and performance of the swine industry can also be conducted. Moreover, the supply and demand estimations for live swine and pork can be further examined by utilizing more robust statistical tools and include other relevant variables.

JEMAD's Non-Participation Declaration

Asst. Prof. Christian Paul L. Fang is an editorial assistant of JEMAD but was not involved during the peer review process of this manuscript.

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Appendices

Appendix Table 1. Volume of production (in million metric tons), area harvested (in million hectares), and yield (in metric tons per hectare) of yellow corn, Philippines, 1990-2020

Year	Volume	Area Harvested	Yield
1990	1.89	1.08	1.75
1991	1.75	1.01	1.74
1992	1.92	0.98	1.96
1993	2.17	1.05	2.07
1994	2.43	1.14	2.13
1995	2.27	1.02	2.22
1996	2.27	1.04	2.18
1997	2.45	1.03	2.39
1998	2.20	0.90	2.44
1999	2.76	1.03	2.67
2000	2.62	0.94	2.80
2001	2.61	0.92	2.83
2002	2.52	0.89	2.83
2003	2.56	0.84	3.03
2004	3.19	0.96	3.30
2005	3.00	0.95	3.16
2006	3.72	1.10	3.39
2007	4.21	1.18	3.57
2008	4.67	1.29	3.61
2009	4.72	1.28	3.68
2010	4.21	1.16	3.63
2011	4.82	1.26	3.82
2012	5.24	1.28	4.09
2013	5.25	1.29	4.08
2014	5.51	1.32	4.17
2015	5.38	1.30	4.15
2016	5.20	1.31	3.97
2017	5.81	1.38	4.22
2018	5.63	1.36	4.14
2019	5.91	1.42	4.17
2020	6.01	1.44	4.18
Average			
1990-1999	2.21	1.03	2.15
2000-2010	3.46	1.05	3.26
2011-2020	5.48	1.33	4.10
1990-2020	3.71	1.13	3.17
Average Growth Rate (%)			
1990-1999	4.89	-0.13	4.92
2000-2010	4.50	1.40	2.90
2011-2020	3.80	2.22	1.49
1990-2020	4.39	1.21	3.04

Source of basic data: Philippine Statistics Authority (2021)

Appendix Table 2. Swine inventory (in '000 heads as of January 1 of every year) by farm type, Philippines, 1990-2020

Year	Backyard		Commercial		Total Inventory
	Number	% Share to Total Inventory	Number	% Share to Total Inventory	
1990	n/a	n/a	n/a	n/a	8,000.00
1991	n/a	n/a	n/a	n/a	8,079.00
1992	n/a	n/a	n/a	n/a	8,022.00
1993	n/a	n/a	n/a	n/a	7,954.00
1994	6,766.06	82.25	1,460.47	17.75	8,226.53
1995	7,181.34	80.32	1,759.86	19.68	8,941.20
1996	7,238.98	80.20	1,786.97	19.80	9,025.95
1997	7,788.17	79.86	1,964.01	20.14	9,752.18
1998	8,030.58	78.65	2,179.89	21.35	10,210.47
1999	8,179.13	78.67	2,217.87	21.33	10,397.00
2000	8,327.29	77.75	2,383.40	22.25	10,710.69
2001	8,541.80	77.21	2,521.34	22.79	11,063.14
2002	8,935.40	76.68	2,717.30	23.32	11,652.70
2003	9,462.97	76.53	2,901.35	23.47	12,364.32
2004	9,722.03	77.39	2,839.66	22.61	12,561.69
2005	9,257.90	76.26	2,881.79	23.74	12,139.69
2006	9,728.64	74.57	3,318.04	25.43	13,046.68
2007	9,825.51	73.00	3,633.82	27.00	13,459.34
2008	9,726.82	70.99	3,974.20	29.01	13,701.03
2009	9,602.82	70.63	3,993.58	29.37	13,596.40
2010	9,542.19	71.22	3,855.60	28.78	13,397.79
2011	8,466.93	68.82	3,836.17	31.18	12,303.09
2012	7,981.67	67.28	3,881.35	32.72	11,863.02
2013	7,750.24	65.44	4,092.81	34.56	11,843.05
2014	7,656.83	64.88	4,144.83	35.12	11,801.66
2015	7,782.29	64.85	4,217.43	35.15	11,999.72
2016	7,959.93	63.79	4,518.78	36.21	12,478.71
2017	8,120.09	65.34	4,307.70	34.66	12,427.79
2018	8,092.94	64.21	4,511.50	35.79	12,604.44
2019	8,167.86	64.27	4,541.38	35.73	12,709.25
2020	7,971.40	62.30	4,824.32	37.70	12,795.72
Average					
1994-1999	7,530.71	79.99	1,894.84	20.01	9,425.55
2000-2010	7,790.92	74.75	2,048.67	25.25	9,839.58
2011-2020	8,017.66	65.12	2,175.58	34.88	10,193.24
1994-2020	8,300.40	72.35	2,330.64	27.65	10,631.03
Average Growth Rate (%)					
1994-1999	3.90		8.94		4.84
2000-2010	1.46		5.29		2.38
2011-2020	-1.70		2.32		-0.41
1994-2020	0.71		4.85		1.78

Source of basic data: Philippine Statistics Authority (2021)
Note: n/a – Not available

Appendix Table 3. Swine inventory (in '000 heads as of January 1 of every year) by age classification, Philippines, 2000-2020

Year	Sow[1]	Gilt[2]	Fattener[3]	Grower[4]	Others[5]	Total Inventory
2000	1,291.32	515.00	2,770.58	2,907.71	3,228.31	10,712.92
2001	1,300.21	543.31	2,880.35	3,002.87	3,336.40	11,063.14
2002	1,359.85	497.88	2,908.63	3,079.20	3,807.14	11,652.70
2003	1,448.41	607.58	3,310.16	3,381.57	3,616.60	12,364.32
2004	1,520.09	699.23	2,965.81	3,747.78	3,628.78	12,561.69
2005	1,480.95	561.63	3,020.99	3,484.54	3,591.58	12,139.69
2006	1,539.43	595.27	3,167.82	3,750.26	3,993.90	13,046.68
2007	1,634.94	612.27	3,276.94	3,848.18	4,087.01	13,459.34
2008	1,666.40	625.01	3,173.36	3,924.87	4,311.39	13,701.03
2009	1,666.96	627.43	3,253.31	3,980.50	4,068.20	13,596.40
2010	1,674.78	619.90	3,267.31	3,941.73	3,894.07	13,397.79
2011	1,514.71	598.29	3,278.45	3,845.76	3,065.88	12,303.09
2012	1,514.93	584.89	3,319.50	3,667.65	2,776.05	11,863.02
2013	1,537.46	586.83	3,385.26	3,699.23	2,634.27	11,843.05
2014	1,552.55	581.64	3,394.46	3,716.58	2,556.43	11,801.66
2015	1,597.02	580.78	3,482.32	3,720.01	2,619.60	11,999.72
2016	1,647.48	616.44	3,627.14	3,821.11	2,766.54	12,478.71
2017	1,675.98	636.82	3,665.41	3,793.42	2,656.16	12,427.79
2018	1,739.15	620.47	3,656.00	3,695.01	2,893.81	12,604.44
2019	1,761.63	604.15	3,609.47	3,735.56	2,998.44	12,709.25
2020[P]	1,786.14	552.97	3,474.67	3,367.75	3,614.19	12,795.72
Average						
2000-2010	1,507.58	591.32	3,090.48	3,549.93	3,778.49	12,517.79
2011-2020	1,632.71	596.33	3,489.27	3,706.21	2,858.14	12,282.65
2000-2020	1,567.16	593.70	3,280.38	3,624.35	3,340.23	12,405.82
Average Growth Rate (%)						
2000-2010	2.67	2.47	1.83	3.21	2.09	2.31
2011-2020	0.71	-1.06	0.64	-1.50	-0.16	-0.41
2000-2020	1.69	0.70	1.23	0.86	0.96	0.95

Source of basic data: Philippine Statistics Authority (2021)
Notes: P – Preliminary
[1] Female, 6 months old and above
[2] Female, less than 6 months old
[3] 5 months old and above
[4] 2 months to 5 months
[5] Include piglets, weanlings, and boars

Appendix Table 4. List of accredited slaughterhouses in the Philippines, as of March 2021

Region	Accreditation Classification	
	AA	**AAA**
NCR	16	0
CAR	3	0
I	12	0
II	3	0
III	19	2
IV-A	27	4
IV-B	3	0
V	5	0
VI	4	0
VII	5	1
VIII	1	0
IX	1	0
X	5	0
XI	8	2
XII	5	1
XIII	5	0
TOTAL	122	10

Source of basic data: National Meat Inspection Service (2021)