The Value-Added and Linkage Effect Analysis of Taiwan's Agricultural Sector

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Abstract

There is an increasing consensus in Taiwan that for agricultural development and policy planning the traditional production-based agriculture perspective should be replaced with a value chain perspective. Accordingly, when considering the value-added contribution of Taiwan's agricultural sector, its relationship with upstream, midstream and downstream sectors should be considered and estimated altogether. In this study, we use the demand-side input-output (IO) methodology to compute and analyze the value-added and linkage effects of Taiwan's agricultural sector. We found that if all the contribution along the value chain is considered, agriculture sector accounts for approximately between 10.56% and 11.85% of GDP, which is a sevenfold increase compared to contribution based on its mere production value (i.e., 1.65% - 1.87% of GDP). This study recommends that future agricultural policy planning, in addition to focusing only on the primary production agriculture, should also include the distribution sector and food and beverage services sector, such as regulations for e-commerce sales channels for agricultural products, food hygiene regulations for the food and beverage industry, and cold chain logistics regulations for agricultural products.

Keywords

Production Agriculture, Food Value Chain, Value-Added, Linkage Effect, Input-Output (IO) Analysis, Gross Domestic Product (GDP)

1. Introduction

For the economists who specialized in economic development or agricultural

economics, analyzing the role that agriculture should have in the development has been an important issue. Of major interest is the analysis of the relationships between agriculture and other economic sectors during the economic development, the use of resources (land, labor, capital) and the influence of institutional and technological factors in the long-run performance of agricultural sector. For this important issue, Pinilla and Willebald (2018) provide a general overview of the process of agricultural transformations and their interaction with the rest of the economy. In particular, Andersson and Till (2018) elaborate the most influential views of the role of agriculture in development theory, as well as explain the fluctuating scholarly attention to agriculture sector over time.

For the development of Taiwan's agriculture sector, Shih and Huang (2006) show that the rapid development and the structural transformation of Taiwan's economy have caused the relative position of agriculture in the total economy to decrease. According to the Directorate-General of Budget, Accounting and Statistics, Executive Yuan (DGBAS), agricultural production accounted for about 32% of GDP (gross domestic product) since 1952, but by 2003, this percentage had plummeted to 1.8%. Although the contribution of agriculture to the overall economy has declined in terms of production, the non-economic function of agriculture is increasingly important, such as ensuring food security, providing green landscapes and promoting ecological balance. It is irreplaceable for other sectors, and the importance of agriculture cannot be measured solely by its production value only. With rapid urbanization and globalization, the traditional perspective on production agriculture may need to be extended into food supply (value) chain perspective.

In the 1990s, Imamura (1998) proposed the idea of "sixth industrialization (1 × 2 × 3 = 6)", which combines agriculture, food processing, and retail to create new products or services by using agricultural products to increase their consumption and value-added, where primary agricultural production is the basis of the "sixth level". The sixth level of industrialization will not be effective if the economy only meets the needs of industrialization to the exclusion of primary agricultural producers.

Porter (1990), the pioneer of value chain analysis, believes that any industrial value chain is composed of a series of value activities, and the industrial value chain is a huge value system. The industrial value chain includes upstream suppliers—such as providers of raw materials, equipment and procurement services needed for the value chain—as well as the marketing channels and final consumers that complete the value chain activities downstream. Different industrial linkages form a value system, which encompasses supplier value chain, enterprise value chain, channel value chain, and consumer value chain. Competitive advantage can be strengthened whenever value is added to the raw material or intermediate product along this chain until it reaches the consumers.

Hu (2014) pointed out that although the three vital functions of agriculture (production, ecology and life) depend primarily on farmers, but the value of agricultural production is still determined by consumers. Thus, the quality, processing,

packaging and marketing of agricultural products, which affect customer satisfaction, must be regarded as being crucial to the agricultural value chain; and should not, therefore, be set aside when discussing industrial development. Indeed, this multi-purpose value consideration of agriculture has become the international consensus in calculating agricultural output value. The agricultural sectors of many advanced agricultural countries truly reflect the importance of agriculture for the overall economy, and their GDP contribution comprises value-added from agricultural and agriculture-related industries in the upstream and downstream industries.

Taiwan's agriculture sector accounted for more than 2% of the total gross domestic product (GDP) before 2000, but with the change in Taiwan's industrial structure, it has fallen below 2% since 2001 (See Figure 1). Although the proportion of agricultural primary products in the overall economy has tumbled down over the years, one must bear in mind the dependence of industry and service sectors on the primary sector. This agricultural degringolade is an inevitable trend, yet this study argues and shows that the agricultural sector's direct and indirect contribution to the overall economic development is not as trivial as most policymakers might reckon.

Through value chain and input-output (IO) analysis, this study aims to reveal the enduring role of Taiwan's agriculture to GDP from a broader perspective, emphasizing its contribution through related industries along the value chain, including transformation and storage, processing and distribution, leisure and tourism. This moves beyond the narrow concept of agriculture as merely for production agriculture, which only contributes less than 2% to Taiwan's GDP since 2001.

2. Literature Review

The importance of Taiwan's agricultural sector has been generally assessed by the proportion of its value-added to the gross domestic product. Su (1980) emphasizes the position of a sector in the overall economic development should not
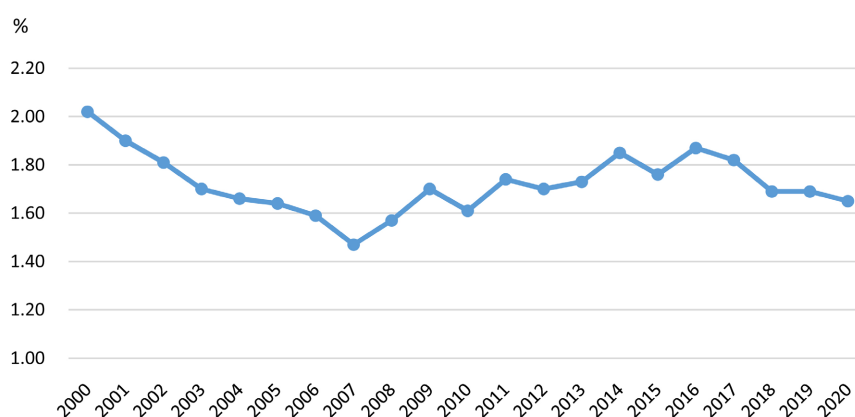
Figure 1. Taiwan's agricultural GDP share, 2000-2020. Source: The directorate general of budget, accounting and statistics of the executive yuan, Taiwan.

only be judged by the output of the sector as a percentage of the GDP in the development process, because this only considers the direct impact of the sector's development on the overall economy, but in which the indirect impact of the sector's development on the overall economy is ignored. That is, both the direct and indirect impacts of the development of the sector on overall economic development should be measured in terms of the overall economy. Hsu (1999) analyzed the dynamic interaction between structural transformation and adjustment of the non-agricultural and agricultural sectors through a dynamic computable general equilibrium (CGE) model. He found that changes in final demand in the agricultural sector would also lead to changes in demand in the non-agricultural sector, for example, an increase in demand for horticultural crops would lead to an increase in demand in the horticultural materials industry. Yeh (2004) also used CGE and found that research and development in the agricultural sector contributed to the growth of non-agricultural sector. Therefore, when measuring the importance of the agricultural sector, its relevance to other sectors ought not to be neglected.

To measure the importance of agriculture, Xiao (1993) used Taiwan's input-output (IO) table data and Industry, Commercial, and Service census data to estimate the output value of food processing and transportation derived from the production of agricultural, livestock, and fishery products in Taiwan, and incorporated it into agricultural output value.

Lin, C.Y. (2005) also studied the relationship of agriculture with other sectors in Taiwan using IO analysis. The results show that the share of the transportation service sector is 2 to 3 times higher than that of primary agricultural products. Likewise, Edmondson (2002) used the inter-industry independence coefficient matrix and national income data to estimate the domestic and foreign consumers' demand for US agricultural products over the years and their contribution to the entire economic system. After having analyzed the correlation between primary agriculture and related industries, he found that transport services accounts for the largest share of the agricultural value along its whole value chain.

Lipton et al. (1998) estimated that the agricultural primary industry in the US in 1996 only accounted for less than 1% of the GDP of the US. But after taking into account agriculture's connection with related industries—such as agricultural fertilizers, pesticides, feed, and agricultural machinery, and downstream food processing, freezing, transportation, warehousing, transportation and marketing, insurance, catering, and even leisure farms—it was found that the total contribution of agriculture and agriculture-related sectors to US GDP was as high as 13%.

Chang et al. (2009) used the 2004 IO table in Taiwan to analyze the contribution of the agricultural sector to other related sectors. The results of the study showed that, after considering the indirect contribution of agriculture, its production value is 8.6% of the economy's total output value, while its value-added comprises 13.5% of GDP. If only direct contributions are considered, these ratios

will only be 1.4% and 2.1%, respectively. From these numbers, one cannot deny the role of primary industry in the development of other upstream and downstream agricultural enterprises.

A number of researchers have used econometric modelling to reveal the contribution of agriculture to overall national GDP. For example, Chongela (2015) used Mean Model to show that agriculture sector in Tanzania accounted for about 26% of its GDP, making it the highest contributor in their economy. They further decomposed the results by subsector: crops (18.93%), livestock (4.70%), and fisheries (2.25%). In light of this, he recommended that agriculture policy in Tanzania should not neglect these sub-sectors.

Through co-integration analysis, Khan et al. (2020) tested the long-run relationship of the primary sector with the secondary and tertiary sectors, and overall GDP. They likewise found a statistically significant linkage between these sectors to agriculture. Therefore, the authors highlighted the importance of coordinating the general economic strategies and agricultural policies, notably in allotting national budget for agricultural research, transportation, education, and extension services. Bint Zaman et al. (2021) also tested for such long-run relationships in Pakistan using autoregressive distributed lag bounds test and error correction model. Their results showed that a one-percent increase in real agricultural value-added has a significant long-run contribution of 0.35% on real GDP per capita. Hence, agricultural policies will definitely have an undeniable impact on the future development of their country.

Studies in other sectors have also made the use of IO models for such analyses. Wang (1990) and Lin, Y.C. (2008) explore the effects of the public engineering sector in driving other industries. Gupta (2014) also used India's 1982-2007 IO table to analyze the relationship between the Indian automotive industry and other industries and found that the automotive industry has driven the development in related industries such as machinery, automation electronics, information, materials and chemical industries.

There are important relationships between production agriculture and other related sectors that cannot be ignored. The past literature lacked an empirical analysis of the overall contribution from the agricultural supply (or value) chain, which was mainly divided into upstream (production agriculture), midstream (processing), and downstream (transportation, distribution and services). In order to further explore Taiwan's agricultural sector's contribution, we will use the input-output methodology to calculate its direct and indirect effects on other sectors along the whole value chain. For example, the increase in demand from the food and beverage sector will drive the production of the agricultural sector, and the contribution to the agricultural value chain can be calculated through the matrix of inter-industry interdependence coefficients.

3. Methodology and Database

3.1. Methodology

In this study, we apply the Leontief input-output model of Miller and Blair

(2009) to calculate the linkage effects of the agricultural value chain in Taiwan based on the agricultural value chain scope defined by Lin and Chang (2004). We also use the domestic IO tables (Z^D) to estimate the economic effect of agricultural sector production in Taiwan. In which a time series of Taiwanese consumers' final demand for agricultural and related products in Taiwan is constructed using domestic IO tables for 2011 and 2016, as well as national income, imports, exports, and agricultural fixed capital formation from 2011 to 2019. The difference between purchaser's price and producer's price was then used to convert the purchaser-priced final demand to producer-priced final demand. Finally, the producer-priced final demand matrix was used to estimate the final demand for domestic products by sector using the final demand for domestic products ratio in 2011 and 2016 (i.e., 2011 to 2015 final demand using 2011 IO table; and 2016 to 2019 final demand using 2016 IO table). The final demand matrix for domestic products is then used to calculate the value-added of Taiwan agricultural, forestry, fishery and animal husbandry (AFFH) related products from 2011 to 2019. The basic formula for this calculation is:

$$GDP = v * (I - A^D) * d * (1 - m) * C * Y_{NI} \tag{1}$$

The GDP represents the value-added vector, which represents the value-added created by the production of the final demand for products related to AFFH in Taiwan; v represents the value-added rate, which is the ratio between primary inputs and total output; the matrix $(I - A^D)$ represents the degree of industry linkage for domestic products; d represents the proportion of domestic products in the final demand for each sector in the 2011 and 2016 IO tables; m represents the difference between the purchasers' and producers' price; C is the matrix of the percentage of total expenditures in each sector that are related to the agricultural sector; and finally, Y_{NI} is a vector containing the historical expenditure amount of GDP by expenditure use in the National Income Statistics.

The inter-industry interdependence coefficients matrix is calculated through the matrix of sales distribution coefficient per unit of output product, considering the direct and indirect effect, and calculating the effect on the output of other related sectors. Since this study considers the value-added of agricultural and related sectors created by the final demand, the Leontief input-output model is used.

The Leontief input-output model can be expressed as follows:

$$\begin{aligned}
X_1 &= (Z_{11} + Z_{12} + \cdots + Z_{1n}) + F_1 \\
X_2 &= (Z_{21} + Z_{22} + \cdots + Z_{2n}) + F_2 \\
&\vdots \\
X_n &= (Z_{n1} + Z_{n2} + \cdots + Z_{nn}) + F_n
\end{aligned} \tag{2}$$

(total output = intermediate demand + final demand).

Where $i = 1, \cdots, n$ and $j = 1, \cdots, n$ industries; X_i represents the output of the i-th industry; and Z_{ij} represents the amount of X_i used as input in the j-th industry, F_i represents the final demand for products of i-th industry in

the economic system, including household sector consumption, private investment, government expenditure, net exports, etc. Equation (2) can be written in matrix form:

$$X = Z + F \tag{3}$$

where X represents the total output vector; Z represents the inter-industry trading matrix (also known as the intermediate input or intermediate demand matrix); and F represents the final demand vector. Among them, the intermediate input and final demand (excluding the imported part) can be further subdivided into demand for domestic products (Z_D, Y_D) and for imported products (Z_M, Y_M), so (3) can be rewritten as follows:

$$X = Z_D + Z_M + Y_D + Y_M - M \tag{4}$$

Since $Z_M + Y_M = M$, the above formula can be further transformed to:

$$X = Z_D + Y_D \tag{5}$$

Under the assumption of the fixed coefficient of the IO model, the technical relationship between input and output is fixed, that is,

$$a_{ij} = Z_{ij} / X_j \tag{6}$$

or

$$a_{ij}^D = Z_{ij}^D / X_j \tag{7}$$

Technically, a_{ij} is called "direct input coefficient" or "technical coefficient"; a_{ij}^D is called "domestic direct input coefficient".

The following equations in matrix can be obtained from Equations (6) and (7):

$$Z = AX \tag{8}$$

or

$$Z^D = A^D X \tag{9}$$

where A represents an input coefficient matrix or a technical coefficient matrix whose elements are a_{ij}; A^D represents a national product input coefficient matrix whose elements are a_{ij}^D. Substituting (8) and (9) into Equations (3) and (5), respectively:

$$(I - A)X = F \tag{10}$$

or

$$(I - A^D)X = Y^D \tag{11}$$

$(I - A)$ is called the Leontief Matrix; $(I - A^D)$ is called the domestic Leontief matrix. When it is a nonsingular matrix, the solution X can be solved as follows:

$$X = (I - A)^{-1} F \tag{12}$$

or

$$X = (I - A^D)^{-1} Y^D \tag{13}$$

$(I - A)^{-1}$ is the Direct plus Indirect Requirements Matrix, also known as the Inter-industry Interdependence Coefficients Matrix or the Leontief Inverse Matrix; and $(I - A^D)^{-1}$ is a matrix of domestic inter-industry interdependence coefficients.

Let $B = (I - A)^{-1}$, where b_{ij} represents the elements in the matrix, which denote the amount that the j-th industry must purchase directly and indirectly from the i-th industry in order to meet the final demand for product j. Let $B^D = (I - A^D)^{-1}$, where b_{ij}^D represents the element in the matrix, which denote the amount that the j-th industry must purchase directly and indirectly from the domestic i-th industry in order to meet the domestic final demand for product j.

3.2. Scope Definition

Because Taiwan area's agricultural structure is very similar to that of Japan, both being densely populated small island economies, following Lin and Chang (2004), the final demand for AFFH-related products follows the definition and scope of the Agriculture and Food System (AFS) of the Ministry of Agriculture, Forestry and Fisheries of Japan.

1) Primary industry: including agriculture, forestry, and fisheries.

2) Food industry: food manufacturing for the production of processed foods.

3) Materials supply industry: mainly feed, chemical fertilizers, organic fertilizers and pesticides.

4) Related investments: agricultural machinery, food processing machinery, fishing vessels, and food manufacturing related to the production of fixed capital, agricultural and forestry relations public utilities, fishing ports and other investments.

5) Catering: Mainly based on restaurants.

6) Related circulation industry: including commercial trading and transportation.

7) Leisure agriculture.

It mainly includes AFFH and processed food, and excludes other non-food processing sectors (such as textiles, leather, wood and bamboo products), because most of the raw materials in these non-food sectors come from imports. Since DGBAS publishes IO tables every five years, to measure the final demand for AFS output from 2011 to 2019, we used the growth rate of expenditures on each related product in the national income account as the basis for estimation. A table comparing the items in the national income expenditure account with those in the IO sector classification is provided in Appendix A1.

3.3. Database and Estimation Procedures

The components of final demand, such as private consumption, government consumption, fixed capital formation, inventory change, and exports, as revised according to the AFS definition, are described below.

1) Private consumption

Since the AFS only includes AFFH and processed foods, unrelated sectors are excluded from the 2011 and 2016 IO tables. In recent years, with the development of food and agriculture education, many agricultural and fishery operators have transformed to engage in leisure agriculture and fishery operations. This has gradually produced indirect effects on the development of agriculture and fishery-related industries, and therefore included in the scope of AFS.

The catering related to leisure agriculture has been included under the catering service industry. Therefore, in order to avoid double counting, the calculation can only cover the expenditure on transportation and accommodation when the people are engaged in leisure activities in the leisure agriculture. Therefore, the agriculture-related consumption in the "catering service sector", "travel service sector", "accommodation service sector", and "transportation sector" were included in the calculation as follows:

a) Catering service sector

According to the private consumption amount in the 2011 and 2016 IO tables from DGBAS, the final demand of this sector was NTD 487.862 billion and NTD 711.131 billion. In other years, the private consumption of the catering service sector is estimated based on the annual growth rate of national food consumption over the years based on data from DGBAS.

b) Travel service sector

Based on the 2011 and 2016 IO tables from DGBAS, final demand for the whole travel service sector amounted to NTD 23.53 billion and NTD 37.58 billion, respectively. A survey of the COA reveals that the proportion of Taiwanese people who travelled to participate in leisure agricultural tourism was about 24% in 2006. This percentage if used to estimate the consumption of leisure agricultural tourism in Taiwan in 2011 and 2016, i.e., NTD 5.65 billion and NTD 9.01 billion for 2011 and 2016, respectively. Because IO tables are only published every five years. Remaining years are estimated based on the historical growth rate of the "Entertainment" category in the national income from the DGBAS.

c) Accommodation services sector

The accommodation service within leisure agriculture was calculated starting from a base figure on consumer spending on leisure agriculture calculated by Zheng (1992). Then, annual growth rates of the "Entertainment" category from the national income was used to calculate the 2011 and 2016 spending on leisure agriculture. Finally, it was multiplied by the proportion of accommodation expenses in the "2011 National Tourism Survey" and "2016 National Tourism Survey" (Tourism Bureau of the Ministry of Communications, 2012, 2017), which were estimated at 17.6% and 17.1%, respectively. The consumer demand for accommodation in leisure agriculture for both years were computed as NT$4.86 billion and NT$7.12 billion, respectively.

d) Transportation sector

Among the transportation sectors, the transportation expenditure items belonging to the leisure agriculture include the petroleum refining sector, the rail vehicle transportation sector, and other land transportation sector. As in the case

of the accommodation service sector, the 2011 and 2016 consumption expenditure on leisure agriculture were estimated using Zheng (1992) as base year and projected to 2011 and 2016 using annual growth rates from the "Entertainment" category in the national income. This was followed by multiplying the proportion of expenditure in the transportation sector in the "2011 National Tourism Survey" (Tourism Bureau of the Ministry of Communications, 2012, 2017) and the "2016 National Tourism Survey" by 25.4% and 24.4%, respectively. The calculated transportation expenses for leisure agriculture amounted to NTD 7.96 billion and NTD 7.27 billion, respectively. This study assumes that half of the tourists who go to leisure farms and forest recreation areas drive by themselves, and the other half go by public transportation. The household demand for the transportation sector related to agriculture in 2011 and 2016 was calculated. Therefore, the expenditures for fuel costs (petroleum refining sector) in 2011 and 2016 are estimated to be approximately NTD 4.54 billion and NTD 4.68 billion, respectively. NTD 1.19 billion and NTD 0.81 billion were spent on railroads, and NTD 2.24 billion and NTD 1.78 billion were spent on roads in 2011 and 2016, respectively.

2) Government consumption

As "government consumption" is processed internally, government consumption for all sectors is listed in the Public Administration Service (Sector 157 in 2011 and Sector 155 in 2016). In order to calculate the final demand for each sector within the AFS, the correlation effect can be calculated through the domestic inter-industry interdependence coefficient matrix, therefore, the data of Public Administration service is taken as government spending.

3) Agricultural fixed capital formation

We calculate data on fixed capital formation in agriculture based on the COA data. The sectoral classifications under the IO table and COA data structure are mapped on Appendix A2.

4) Changes in inventory

Since agricultural products cannot be stored for long periods of time, there are no significant inventory changes. We calculated the relevant inventory changes based on the information from the COA and the Ministry of Economic Affairs. The two sectors with the highest production value among the primary products are paddy rice and hogs, so they were selected for this analysis. For the processed foods—the frozen food, dairy products, tobacco and wine sectors—changes in inventory are based on the actual industrial production statistics of the food processing industry. The following are the calculation methods and results for the major sectors.

a) Paddy rice:

In this study, reference is made to the "rice stocks" and annual average "rice price" in the Agricultural Statistics Report of the COA from 2011 to 2019 to obtain inventories and price data. See Table 1.

b) Hogs:

Data for the number of hogs raised were sourced from the Agricultural Statistics Annual Report of COA. Hogs are classified into three types depending on weight. In order to calculate the total weight at the end of the year, the average

weights of per type were multiplied by the quantity of hogs per type. Since piglets are normally between 7 to 10 kg, the average weight of each piglet is assumed to be 8.5 kg. Hogs that are less than 30 kg are assumed to each weigh 15 kg; and finally, average weight for hogs between 30 to 60 kg is assumed to be 45 kg. Livestock price from the Agricultural Statistics Annual Report were used to obtain the dollar value of inventory and annual change thereof as shown in Table 2.

c) Frozen food, wine, dairy products, edible fats and oils:

This study uses the Ministry of Economic Affairs' "Industrial Production Statistics Annual Report" from 2011 to 2019 to estimate inventory changes for this industry. Using annual sales amount and sales volume for each item on Table 3,

Table 1. Changes in paddy rice inventory from 2011 to 2019.

Year	Price (NTD/ton)	Stock (tons)	Inventory amount (NTD million)	Change in inventory (NTD million)
2011	21,603	614,376	13,272	3953
2012	23,098	735,889	16,998	3726
2013	22,174	907,256	20,118	3120
2014	24,025	900,008	21,622	1505
2015	23,079	790,812	18,251	−3371
2016	23,905	758,770	18,138	−113
2017	23,640	864,260	20,431	2292
2018	21,980	988,561	21,728	1297
2019	21,660	1,101,509	23,858	2130

Source: COA, the paddy rice inventory of agricultural statistics annual report 2019.

Table 2. Changes in inventory of Hogs from 2011 to 2019.

Year	Piglets (quantity)	Hogs (<30 kg) (quantity)	Hogs (30 - 60 kg) (quantity)	Weight (1,000 kg, or tons)	Price (NTD/ton)	Stock (NTD million)	Changes in inventory (NTD million)
2011	907,023	1,596,821	1,527,327	100,392	71,980	7226	320
2012	855,744	1,494,697	1,488,286	96,667	63,100	6100	−1126
2013	808,322	1,432,041	1,467,985	94,411	64,510	6090	−9
2014	765,784	1,378,514	1,407,385	90,519	78,090	7069	978
2015	754,453	1,345,728	1,416,131	90,325	71,440	6453	−616
2016	749,189	1,355,969	1,369,837	88,350	71,580	6324	−129
2017	752,138	1,373,532	1,355,631	88,000	77,200	6794	469
2018	764,322	1,391,527	1,337,819	87,571	70,390	6164	−629
2019	768,129	1,418,864	1,333,070	87,800	71,810	6305	141

Source: COA, the hog inventory of agricultural statistics annual report 2019.

annual average unit prices could be estimated. These are then multiplied by year-end inventory of each item and summed to obtain the inventory of frozen foods. Finally, the value of inventory change was calculated. The results are shown in Table 3.

5) Customs output

This study collected export data on the relevant sectors under the AFS definition from the International Trade Center (ITC) trade map database.

However, it is important to take into account the industry classification adjustments in 2011 and 2016. Table 4 shows the comparison between the classification of agriculture and related industries in 2011 and 2016.

Table 3. Changes in inventory of frozen foods, alcohol, and dairy products from 2011 to 2019 (unit: NTD million).

Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019
Frozen foods	456	−482	−579	334	595	393	64	−229	493
Fats	911	−265	−238	−472	−82	63	138	−376	17
Alcohol	494	178	−545	−42	530	−645	1190	848	−967
Dairy products	−150	−34	3	−54	71	11	−76	17	27

Source: Ministry of economic affairs, the frozen foods, alcohol, and dairy products inventory of "industrial production statistics annual report" 2011-2019.

Table 4. Classification of agricultural and agriculture-related sectors in 2011 and 2016.

Sector	2011 (166 sectors)	2016 (164 sectors)
Agriculture	Sector 001-011	Sector 001-011
Agricultural input		
Mining industry	Sector 012-014	Sector 012-013
Material manufacturing	Sector 031-109	Sector 030-107
Hydropower construction	Sector 110-120	Sector 108-118
Financial Services	Sector 139-144	Sector 137-142
Business advertising service	Sector 133-138, 145-166	Sector 131-136, 143-164
Food processing industry		
Food	Sector 015-027, 029	Sector 014-026, 029
Tobacco and alcohol	Sector 028, 030	Sector 027, 029
Transportation service industry		
Transportation warehousing	Sector 124-130	Sector 122-128
Wholesale and retail	Sector 121-123	Sector 119-121
Food and Beverage service	Sector 132	Sector 130
Accommodation service	Sector 131	Sector 129

Source: This study.

4. Empirical Results and Analysis

First, the domestic final demand matrix defined by the AFS for 2011 to 2019 is multiplied by the domestic IO table $\left(I - A^D\right)^{-1}$ domestic inter-industry interdependence coefficients matrix for 2011 and 2016, respectively, to obtain the output created by Taiwan's agriculture and related industries. Afterward, this vector is multiplied by the value-added rate of the industry in the year to get the effect of AFS on the value added of agriculture and related industries.

By using the broad definition of AFS agriculture, the upstream and downstream related industries are taken into account, and both direct and indirect effects, which comprise the actual impact of agriculture on the overall economy, are fully captured. The results show that if we look at the agricultural production, the impact on the overall economy is about 1.8% only, and if we consider the upstream factor inputs driven by agriculture, such as pesticides and fertilizers, as well as the downstream food and beverage services, and wholesale and retail, it will reach about 11%. The study also provides insight into the individual driving effects of agricultural production on the agricultural input industry, food processing industry, and transportation service industry.

Table 5 and Table 6 show that the value-added of Taiwan's agricultural value chain in 2011 to 2019 ranged from NTD 1542 billion to 2243 billion, accounting

Table 5. Contribution of Taiwan AFS to GDP using inter-industry interdependence coefficients matrix (value-added; in NTD million).

Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019
Agriculture primary products	245,783	242,400	255,728	289,642	282,034	327,502	328,835	312,562	318,543
Agricultural input	188,928	196,850	203,246	210,284	216,480	268,597	274,048	290,629	298,653
Mining industry	1389	1202	1229	1271	1265	993	1047	1159	1085
Material manufacturing	32,479	34,157	34,974	36,568	36,948	38,248	39,936	42,744	43,660
Hydropower construction	58,124	61,663	63,196	64,959	67,174	79,363	80,380	85,445	87,640
Financial Services	30,626	29,530	31,359	32,041	32,780	49,451	50,947	54,261	54,788
Business advertising service	61,695	65,424	67,429	70,135	72,789	100,542	101,737	107,020	111,480
Food processing industry	203,975	212,958	216,432	220,449	230,099	260,966	269,454	296,954	310,576
Food	108,480	117,028	120,842	125,551	131,077	152,046	155,943	165,149	175,408
Tobacco and alcohol	95,495	95,930	95,590	94,898	99,022	108,920	113,511	131,805	135,168
Transportation service industry	908,129	973,759	995,098	1,013,951	1,067,560	1,172,763	1,167,968	1,265,734	1,315,925
Transportation warehousing	29,017	30,706	31,606	32,788	33,863	42,999	43,449	46,017	47,622
Wholesale and retail	645,420	699,260	713,006	717,547	760,940	820,270	806,337	885,691	917,577
Food and Beverage service	232,583	242,607	249,265	262,352	271,444	308,741	317,440	333,242	349,914
Accommodation service	1108	1186	1221	1265	1313	752	742	784	812
total	1,542,200	1,621,093	1,665,443	1,729,016	1,790,649	2,029,828	2,040,305	2,165,880	2,243,697

Source: Computed in this study.

Table 6. Contribution of AFS to GDP using inter-industry interdependence coefficients matrix (percentage).

Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019
Agriculture primary products	**1.72**	**1.65**	**1.68**	**1.80**	**1.68**	**1.87**	**1.83**	**1.70**	**1.68**
Agricultural input	**1.29**	**1.31**	**1.30**	**1.27**	**1.26**	**1.53**	**1.52**	**1.58**	**1.58**
Mining industry	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Material manufacturing	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.23	0.23
Hydropower construction	0.41	0.42	0.41	0.40	0.40	0.45	0.45	0.47	0.46
Financial Services	0.21	0.20	0.21	0.20	0.20	0.28	0.28	0.30	0.29
Business advertising service	0.43	0.45	0.44	0.44	0.43	0.57	0.57	0.58	0.59
Food processing industry	**1.43**	**1.45**	**1.42**	**1.37**	**1.37**	**1.49**	**1.50**	**1.62**	**1.64**
Food	0.76	0.80	0.79	0.78	0.78	0.87	0.87	0.90	0.93
Tobacco and alcohol	0.67	0.65	0.63	0.59	0.59	0.62	0.63	0.72	0.71
Transportation service industry	**6.35**	**6.63**	**6.53**	**6.29**	**6.37**	**6.68**	**6.49**	**6.89**	**6.95**
Transportation warehousing	0.20	0.21	0.21	0.20	0.20	0.24	0.24	0.25	0.25
Wholesale and retail	4.51	4.76	4.68	4.45	4.54	4.67	4.48	4.82	4.85
Food and Beverage service	1.63	1.65	1.64	1.63	1.62	1.76	1.77	1.81	1.85
Accommodation service	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
total	**10.78**	**11.04**	**10.93**	**10.73**	**10.68**	**11.56**	**11.35**	**11.79**	**11.85**

Source: Computed in this study.

for 10.68% to 11.85% of Taiwan's GDP. Furthermore, the value-added created by AFS is divided into four categories: primary (unprocessed) products, agricultural inputs, food processing, and transportation service sector. The agricultural inputs are the related upstream industries, whereas the food processing and transportation service sector are the related downstream industries. This shows internal structure of agricultural value chain and its changes. The largest proportion is in the transportation services sector, which accounts for about 60% of the total AFS contribution to GDP in 2011 (6.35/10.78 = 58.91%; see Table 6); followed by the agricultural primary product sector, which accounts for about 16% (6.35/10.78 = 15.96%) in 2011; and the food processing industry, which accounts for 13%. The smallest contribution is made by the agricultural input industry with only about 12%.

In the transportation service industry, the most influential sub-sector is wholesale and retail, which consistently reached about 5% throughout the period covered in the study. This indicates that the contribution of agriculture, in addition to the production of crops, livestock and fishery, also drives the value-added of the wholesale and retail sector. The food and beverage service sector was the next largest, at an average of 1.7% across the study period. Therefore, when con-

sidering the contribution of agricultural sector, we should not only think from the perspective of production agriculture, but also from the perspective of the whole agricultural value chain.

5. Concluding Remarks

With rapid urbanization and globalization, the perspective of production agriculture has been extended to the perspective of food value chain. As a normal development trend, the GDP contribution of production agriculture is expected to decline due to trade liberalization and structural change. However, the GDP contribution of food value chain or agricultural sector from the value chain perspective may still be too important to be ignored. That is, when considering the value-added of Taiwan's agricultural sector, the contribution of upstream, midstream and downstream sectors should be added together to reflect how important the current agricultural sector is.

From a narrow production viewpoint, Taiwan's agriculture contributes about 1.8% to the overall economy; but from the broader agricultural value chain viewpoint, this study found that Taiwan's agriculture contributes about 11% to the overall economy. The difference is due to the inclusion of both direct and indirect impacts of agriculture on its upstream and downstream related industries. This approach will provide a clearer understanding of which industries are driven by agriculture's contribution through linkage effects. When formulating agricultural policies in the future, apart from the traditional production side, complementary policies in other industry chains must also be considered.

And based on the decomposition of the contribution of the agricultural value chain to GDP, we find that the transportation service sector has the highest share of over 6%. Within this sector, the subsector with the highest contribution is the wholesale and retail sector, followed by the food and beverage services sector. Hence, this study recommends that future agricultural policy planning, in addition to focusing on the primary agricultural production sector, should also do a more complete planning, which includes the sales channel and food and beverage services sector, such as regulations for e-commerce sales channels for agricultural products, food hygiene regulations for the food and beverage industry, and cold chain logistics regulations for agricultural products. This will be more beneficial to Taiwan's future agricultural development and overall economic prospects.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix A1. Sectoral Comparison between National Income Account and Input-Output Table

Name of National Income account	Name of related sectors of input-output table
Food	Cereals, Special Crop, Vegetable, Fruit, Misc. Horticulture Crop, Misc. Livestock, Forestry, Fisheries, Slaughter, Fats, Dairy, Rice, Flour, Animal Feed, Candy and baked Product, Sugar, Seasonings, Misc. Food, Catering service
Beverage	Non-Alcohol, Alcohol
Cigarette	Tobacco
Entertainment	Petroleum refining, Accommodation service, Rail Vehicle transportation, Other land transportation, Travel Service

Source: the Directorate General of Budget, Accounting and Statistics of the Executive Yuan, Taiwan, 2011 and 2016 Taiwan IO Table.

Appendix A2. Estimation of Agricultural Fixed Capital Formation for Related Sectors in Input-Output Table

Name of sector	Agriculture Fixed Capital Formation in Taiwan from COA
Misc. Horticulture Crop	Based on the historical growth rate of capital formation for land improvement and orchard development in the national income statistics.
Hogs	It is estimated based on the amount of breeding stock and dairy cattle in the national income statistics, and the proportion of hogs to the fixed capital formation of all livestock in the input-output table in 2011 and 2016.
Misc. Livestock	It is estimated based on the amount of breeding stock and dairy cattle in the national income statistics, and the proportion of misc. livestock to the fixed capital formation of all livestock in the input-output table in 2011 and 2016.
Forestry	It is estimated based on the historical growth rate of capital formation and afforestation by the Agricultural Commission.
Misc. Special Machinery	1) Agricultural and livestock industry machinery and equipment 2) Forestry logging machinery and equipment 3) Forestry other machines and equipment 4) Other machines and equipment for fishing 5) Agricultural products, marketing and other agricultural products processing and storage machinery and equipment
Car	1) Farming and transportation vehicles 2) Forestry transportation vehicles 3) Fishery land transportation vehicles 4) Agricultural transportation and transportation vehicles
Ship Build	1) Fishing vessel construction and repair transport equipment 2) Fishing boat mechanized operation equipment

Continued

Not Residence Build	1) Non-residential housing for agriculture and livestock 2) Farm and livestock farm equipment 3) Agricultural products, rice and fertilizer warehouse 4) Agricultural product distribution and sales yard expansion and consignment equipment 5) Agricultural fruit and vegetable wholesale market and equipment 6) Agricultural meat wholesale market and equipment 7) Agricultural fish wholesale market and equipment 8) Slaughterhouse and its equipment	
Public Work	1) Flood control irrigation 2) Farmland cultivation and improvement 3) Construction and fish conservation 4) Construction of fishing port and onshore equipment	
Misc. Construction	1) Forest Road Construction and Maintenance 2) Forest protection equipment 3) Forest amusement equipment	

Source: the COA of the Executive Yuan, 2011; 2016 Classification of input-output tables in Taiwan.