Government Ownership of Banks

Diversifying of Potential Products and Factors to Subsidize Agriculture*

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Abstract

It has recently been shown that government ownership of banks has a significant role in addressing market failures, improving social welfare and economic development. This study explores and identifies the potential products and factors in agriculture that public banks should subsidize. In this paper, the author investigates statistical properties of the two-step generalized method of moments (GMM) estimator to analyze the direct and indirect consumption of inputs in agricultural production on national-level data for 32 crop products and 14 livestock products from Cambodia during the 1989–2018 period. Many specifications have statistical significance and negative competent production growth. These results suggest that the proposed subsidies should clearly define the types of specialty products by local producers and their potential markets, both local and international. This paper investigates some policy options for government ownership of banks to improve agriculture. However, it must also adapt to new climate change and emergency events for the long-run sustainable development of the sector. Future directions should consider studying micro-data for specific types of products and regions.

JEL Classification: E23, G32, 013, Q11, Q13.

Keywords: Generalized Method of Moments (GMM), Government Ownership of Banks, Financial Subsidy, Diversification, Potential Product, Agriculture.

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1 Introduction

Government ownership of banks is the main topic studied extensively in the past economic literature (e.g., in Dinç, 2005; Galindo and Micco, 2004; Iannotta *et al.*, 2007; La Porta *et al.*, 2002). Many government-owned banks aim to achieve political objectives, social benefits and avoid financial failures in markets that private banks cannot accomplish. Public banks subsidize the economic sector according to the national strategy and the national interest (Altunbas *et al.*, 2001; Shen *et al.*, 2014). In Cambodia, the Agricultural and Rural Development Bank (ARDB) is a government-backed monopoly of the public bank (RDB, 2010). The ARDB objectives and its operations follow the Rectangular Strategy of the Royal Government of Cambodia. Originally, the ARDB provided financial support to agriculture since the sector was the main industry in terms of economic growth and rural development (e.g., see RDB, 2010; RGC, 2015, 2018). More than 75% of the amount of ARDB credit went to the rice sector, particularly to rice miller producers and paddy traders (RDB, 2018). Thus, the subsidy supported rice production, export policy (MAFF, 2011), and agricultural development (RDB, 2018). However, financial subsidies mostly for rice, rubber, maize, cassava, pepper, coffee, sugarcane, livestock, and fisheries are not sufficient to develop agriculture and the farm household economy in Cambodia. Many farmers demand low-interest rate credit to improve production, productivity, and incomes. For example, farmers produce bananas, mangoes, oranges, chicken, pigs and other products. Generally, all types of activity related to agricultural production, processing, and other activities can be financed by the ARDB (RDB, 2014). Despite this, without encouragement and promotion of other agricultural processors, it will lose information and will not know how to access subsidies.

On the other hand, the subsidy policy is an essential mechanism for achieving the national strategy. Therefore, each expenditure should benefit directly or indirectly individuals and the sector concerned, in particular as relates to policy guidance. At present, farmers continue to face critical challenges such as low productivity, poor quality of agricultural inputs, and challenges to accessing them; lack of farm markets, low prices, lack of technical assistance, poor agricultural infrastructure, and exceptionally high interest rates on credit and debt (e.g., see Bdlink, 2017; Eliste and Zorya, 2015; MAFF, 2019; RGC, 2019; Sothorn, 2020; Sum and Khiev, 2015). Due to this situation, government-owned banks should be careful about lending to farmers and other activities related to the agricultural industry. It is necessary to ensure the loans are made to improve households and health in the economy, and not put borrowers into debt traps.

This paper aims to identify the potential products and factors in the crop and livestock subsectors that government ownership of banks should focus on to provide financial assistance. To achieve this purpose, this paper will ask the following questions: (1) Why is the diversification of agricultural products essential? (2) What products of the agricultural industry have the potential to develop? (3) What are the essential factors to stimulate production in the agrarian sector? (4) What are the critical factors in agriculture that require financial support? (5) What types of policies are necessary for government ownership of banks to respond to sustainable development in the agricultural industry?

The author investigates the two-step estimator of the generalized method of moments (GMM) to analyze the use of inputs in agricultural production. The GMM estimator is an empirical method for estimating dynamic economic systems using time-series data in both linear and non-linear instruments. The inventory behavior in this model can be estimated and tested without requiring a complete characterization of input and output (Hansen, 2001). In this case, the unknown inputs data or variables can be determined as assumption and instrument variables. The GMM estimation presented in Hansen and Singleton (1982) aims to estimate the unknown parameter vector and is employed to test these moment relations in a computationally tractable way. The formulation of the model as an optimal instrumental variable (IV) estimator under conditional homoscedasticity and a test for overidentifying restrictions (Hansen and West, 2002; Sargan, 1958). Indeed, the asymptotic error variance matrix for the coefficients of one of the relationships is obtained in the case of relationships that are estimated using instrumental variables (Sargan, 1958). In other words, the asymptotic covariance matrix for the generalized instrumental variables estimators depends on the choice of weighting W_t.

In this document, the researcher has used the same GMM specification for about 32 crop products and 14 livestock products. In this study, the author uses a time-series dataset at the macro-level of Cambodian agricultural production between 1989–2018. The dataset comes from multiple sources including national and international institutes such as the FAOSTAT, the WDI, and the National Institute of Statistics (NIS). The researcher finds that many crops and livestock production have statistically significance for the use of inputs. In addition, many specifications have negative consequences on agriculture output. While these are results of estimates, the author introduces a scheme in which some products can be classified as the potential product (cassava, dry chilies and peppers, grapefruit and pomelos, green coffee, lemons and limes, mangoes, nuts, paddy rice, pineapples, roots and tubes, duck meat, and other bird eggs in shells). Simultaneously, the researcher suggests that the dataset at the macro-level cannot satisfactorily explain microanalysis in the specific product. Even so, these results can not be concluded. It requires a set of microdata or a household survey for the use of inputs-outputs for specific agricultural products and regions. However, this paper has brought benefits to the literature on agriculture, subsidies and diversification, and the public by adding new evidence to the macroeconomic dataset in developing countries of the ASEAN region.

The remainder of the article proceeds as follows. In the next section, the author outlines the related literature. Section 3 provides background information on agriculture in Cambodia and the government subsidies to the sector. Section 4 describes the data used in the analysis and presents descriptive statistics. Section 5 explains the empirical strategy. In Section 6, the researcher shows the main empirical results and provides robustness checks. Section 7 analyzes the policy options for the public bank in terms of the development of the agricultural industry. In Section 8, the author presents concluding remarks and discusses some avenues for future research. The Appendix contains mostly the proof of the theoretical results and additional details regarding the empirical analysis.

2 Literature Review

This paper relates to the four main strands of the economic literature: a public bank, agriculture, subsidies, and diversification. First, this study contributes to the extensive literature on government ownership of banks. Many economists have illustrated the performance of government-owned banks and private banks in contributing to the stimulation of economic development and firm growth. Theoretically, public banks are less efficient and less productive than private banks because they are often manipulated to achieve political and social objectives rather than being left to the pursuit of profit maximization.

Shen *et al.* (2014) apply panel data to analyze a tremendous sample of government and private banks between 1993–2017, in many countries around the world, including Cambodia. They find that altogether the types of public banks are no less significant than expected; it is only the public banks that purchase distressed banks. Galindo and Micco (2004) show that private banks are more efficient in the development of industry growth, while public banks are less competent and do not contribute to accelerating the performance of industries. The countries with higher cooperation and involvement of government in the credit market are shown to have lower growth than other nations whose authorities have less involvement in the financing (Dinç, 2005; La Porta *et al.*, 2002). Micco *et al.* (2007) confirm with the statistical evidence to support the finding of Dinç (2005) and La Porta *et al.* (2002) indicate that the public banks located in developing countries are less profitable than private banks and have different results during election years. Similarly, Iannotta *et al.* (2007) suggest that government-owned banks have lower credit quality, as well as higher insolvency risks compared to private banks, and this phenomenon does not matter in developed countries. Sapienza's (2004) investigations found that the public banks charge lower interest rates than the private banks, which mostly support large firms and political parties. Econometric evidence from Germany and Russia, indicated that government ownership of banks is more efficient than private banks (Altunbas *et al.*, 2001; Karas *et al.*, 2008).

Evidence from China, Demetriades *et al.* (2008), and Rousseau and Xiao (2007) show that public banks play a considerable role in promoting economic growth by stimulating productivity and growth in value added to corporate credit. Andrianova *et al.* (2010) determined that the economies of the nations that have public banks on average are growing faster than countries without or having little government ownership of banks. The state plays a vital role in financial markets and social welfare, but the success of government intervention should be mixed (Stiglitz, 1993). Professor Stiglitz examines three areas of interventions, including direct credit, financial repression, and competition policy; identifying circumstances in which some financial repression can be beneficial. Interestingly, this paper is very close to theirs, despite the different empirical specifications.

Second, this paper contributes to improving economic literature on agriculture, particularly in Cambodia. Many recent studies are on agricultural productivity, market, climate change, biodiversity, agriculture input-output, and agricultural infrastructure. Sareth *et al.* (2020) and Zhang *et al.* (2020) study agricultural production. Butler and Moser (2010) use the GMM model to measure the structure of agricultural markets in developing economies. They find that agricultural producers typically receive lower prices at harvest and that consumers of final food products face higher prices where the high cost of transportation is one of the main root causes. Laitner (2000) demonstrates that agricultural consumption is important for citizens as well as these who have little income per capita. In Hornbeck (2010), land protection is a critical role in facilitating agrarian development. Costinot *et al.* (2016) analyze the impact of climate change on agriculture worldwide.

These empirical results show that climate change has reduced agriculture, trade and production patterns by about 0.26% in global GDP. In particular, in Cambodia, Eliste and Zorya (2015) determined that climate change has a damaging consequence on production growth. Aragón *et al.* (2019) used a household survey of around 53,000 observations to study climate change in agriculture in Peru between 2007–2015. They show that extreme temperatures decrease agricultural productivity when farmers increase their seeded area. By addressing the problem in Aragón *et al.* (2019), much traditional agriculture literature studied agricultural diversity such as Bareille and Letort (2018); Fiszbein (2017); Parvathi (2018).

Fiszbein suggests that agricultural diversity is a good direction to boost production growth, create a new workforce, new skills and a new market as well as being a cause for manufacturing diversification. This corresponds to Parvathi (2018) that the diversity of farming production rises dietary diversity. Emerick *et al.* (2016) have determined that the omission of technological innovation is due to a lesser extent of cultivation practice.

Third, this study contributes to the literature on subsidies. The policy of public subsidies is a good mechanism in economic development. Kim *et al.* (2004) show that the Korean government has an excellent practice in subsidy policy, but that some have less effect on development when multiple authorized and public institutions are involved in the policy. In Korea, Doh and Kim (2014) examined the grant policy finding that it has an advantageous effect in terms of the regional SMEs' innovation and development. They describe how the government plays a part in multiple interventions such as technological development assistance, patent acquisition, and new design registration of the regional SMEs. Garrone *et al.* (2019) added to the literature that subsidy policy has a positive consequence for increased labor productivity. They use the OLS, the fixed-effects and the two-step system GMM estimator to analyze a large sample from panel data (2004–2014) of 213 subsidies in the EU region. While using the system GMM estimator with the potential endogeneity of globalization, Garmann (2014) found that globalization affects public subsidies to the agriculture sector. Goodwin *et al.* (2011) discovered that the farm subsidies program has a very significant impact on the value of farmland. Karlan *et al.* (2014), O'Toole *et al.* (2014), O'Toole and Hennessy (2015), Sam (2019), and Sothorn (2020) study capital and risk constraints for smallholder farmers and medium-sized farms. Thus, it substitutes appropriate policy in subsidies of small economic scale.

Finally, this article relates to the literature on economic diversification. Dissart (2003) examines the economic diversity that leads to stable economic growth. Freire (2019) and Revilla *et al.* (2015) demonstrate that diversification can transform economic structure by adding new economic sectors, new supply and new demands as well as to provide job opportunities and generate income. Diversification has a positive influence on the corporate life cycle and performance of the industry (Shyu and Chen, 2009). Kilkenny and Nalbarte's (2002) investigation of the banking sector is appreciated for recognizing this critical sector in the rural community because it connects all activities of the rural economy.

Nevertheless, the banking sector was not a key sector in all communities due to the needs and potential of individuals and businesses. An estimated output and input composition patterns to understand the economics of scale and diversification in US agriculture by Paul and Nehring (2005) explains that the highly joint use of input and robust scale economies will lead to increased production. They result was to confirm the previous study by Culas and Mahendrarajah (2005), but Culas and Mahendrarajah suggest that measured diversification may not be sufficient economies of scale to warrant specialization in the current market. Rahman (2009) confirms that crop diversification is a key strategy in the development of agriculture in Bangladesh. He suggests that improving technology diffusion, marketing, storage, and raw material supplies are essential factors to diversification. Likewise, according to RGC (2015) agricultural diversification is the main strategy of Cambodia's government to boost export and agriculture growth as well as benefiting the processor. In addition, this article explores to provide new evidence in Cambodia about the diversification of products in agriculture to adopt climate change, the economic structure, and new market demand as well as the new technological environment.

Overall, this article adds new statistical evidence to the literature in the context of Cambodia by improving and finding the right way for the public bank to be effective and efficient.

3 Context

3.1 Government Ownership of Banks and the Financial Sector

Generally, while the financial sector is doing, it will stimulate economic growth, well-being in households, and throughout society (Stiglitz, 1993). The Cambodian financial system has entered an era of specialisation, with the emergence of the money and securities markets (ADB, 2012), and continues to improve technology, innovation, and diversity in terms of institutions and instruments (NBC, 2019). In Cambodia, according to NBC (2019), there are 46 commercial banks, 14 specialized banks, 7 microfinance deposit-taking institutions and 76 microfinance institutions. The financial industry, banks and microfinance institutions, have increased their assets and credit over the years. The rise of these firms has shown a positive change in the development of the industry. In 2015, based on NBC (2015), Cambodia's banks and microbanks which included microfinance deposit-taking institutions (MDIs) and microfinance institutions (MFIs), provided total loans of US $14.7 billion, of which US $2.3 billion or 16.5% was given to agriculture. The bank provided US $1.2 billion and microfinance provided US $1.1 billion, respectively (NBC, 2015).

In 2018, Cambodian financial institutions continued to grow their total assets to US $34 billion or 21.4% and a rise in total credit to US $19.6 billion or 20.1% compared to 2017 (NBC, 2018b). According to this figure, the total credit used in the agricultural sector is approximately US $3.01 billion, while banks contributed US $1.87 billion and MFIs arranged US $1.14 billion (NBC, 2020). Simultaneously, according to the Credit Bureau Cambodia (2018), the Kingdom's outstanding loans amounted to US $20.85 billion, which is a different number from NBC's record, representing 3.3 million active borrowers at 157 financial institutions in 2018. Additionally, by the four quarter of 2019, the Cambodia Microfinance Association (2020, January 29) declared that there were 73 MFIs with 2.25 million borrowers and outstanding loans of US $7,341.41 million, while total deposits amounted to US $3,781 million with 2.81 million depositors.

The National Bank of Cambodia continues to encourage banks and MFIs to lend to the agricultural and agro-processing sector. Banks and institutions heavily engaged in agricultural finance include ACLEDA Bank, Canadia Bank, SHB Bank, PRASAC Microfinance, AMRET Microfinance, and SATHAPANA Microfinance (Chea and Horn, 2016). Likewise, the Rural Development Bank (RDB), which holds the state monopoly, has a strong presence in the provision of finance to agriculture and the agro-processing industry. This government-owned bank, RDB, was established in 1998 by the Royal Government of Cambodia with authorization to operate as a specialized bank as an essential mechanism to support the agricultural sector and rural economy (RDB, 2010). This includes the development of the value chain and productions related to agriculture, namely manufacturing, storage, processing, distribution, and export, particularly in the rice sector (RDB, 2010, 2014, 2018). Under the August 2019 sub-decree, the Cambodian government authorized the name change of the RDB to the Agricultural and Rural Development Bank (ARDB) with additional capital of US $ 50 million and convertible licenses to commercial banking (ARDB, 2020, March 17). This change will allow the bank to expand its working capacity.

In 2015, the ARDB provided approximately US $64 million in credit to agriculture, while ACLEDA Bank, a leading agricultural lending institution, led the way with US $516 million (Chea and Horn, 2016). ARDB increased its total assets by 15%, from US $ 157 million in 2017 to US $178,28 million in 2018, and increased total loans and advances by 30% from US $122.07 million in 2017 to US $159.11 million in 2018 (RDB, 2018). Principally, the ARDB grants credit to the rice mill, and the purchase of paddy rice continues to increases over time. In 2018, total loans and advances contributed to the rice sector (76.13%), rubber, maize, cassava, pepper, coffee, and sugar cane (14.89%), and microfinance, animal-raising, and others (8.97%), respectively (RDB, 2018).

The current financial subsidies focused solely on the rice sector are in stark contrast to the real situation in Cambodia. As the domestic food supply is inadequate, and also farmers produce other products. It is estimated that the Kingdom imports fruits and vegetables worth more than US $ 300 million annually (Thou, 2020, February 16) and imported meat worth over US $100 million in 2016 (Kali and Cheng, 2017, February 24).

3.2 The Agricultural Industry in Cambodia

Historically and currently, the agricultural sector is the main sector contributing to Cambodia's economic growth. According to the study of Eliste and Zorya (2015), Cambodian agricultural growth averaged 5.3% between 2004–2012, which was one of the highest growth rates on the planet. They found that gross agricultural production increased by 8.7% during 2004–2012 mainly because of the higher growth in paddy rice production, as well as the 20% increased in maize, 51% in cassava, 22% in sugarcane, 10% of vegetables, and other production.

The Cambodian agricultural industry has contributed to poverty reduction, improved rural livelihoods, job creation and food security (Eliste and Zorya, 2015; MAFF, 2019; RGC, 2018). However, Cambodian agriculture continues to face many critical problems and presents an obstacle for farmers. The critical issues that are the lack of leadership and effective decision-making, lack of technical knowledge and skills, lack of physical and virtual infrastructure, limited financial market development (e.g., for example Eliste and Zorya, 2015; Ly, 2019; Ly *et al.*, 2019; Nith, 2020, May 21; Oum *et al.*, 2018; RGC, 2019).

In response to improved agricultural productivity, farmers decided to take out loans from merchants or traders, local lenders, MFIs, and banks. In addition, farmers or agricultural processors can borrow from the rotating savings and credit associations. Sothorn (2020) investigated the challenges affecting the sustainable utilization of credit for rice farmers in Takeo province through qualitative research, such as group interviews with farmers, key informant interviews with FMIs and secondary CMA data. He found that smallholder farmers were generally provided loans from the local lender of between US $250 and US $1,000 with an interest rate of about 10% per month. Smallholder farmers were generally not targeted by MFIs for agricultural loans (Phlong, 2009; Sothorn, 2020). For example, in Takeo province, 57% of farmers with less than one hectare, therefore, do not have sufficient guarantees for a medium-sized loan (Sothorn, 2020). At the same time, Sothorn also found that most semi-commercial farmers received loans from several MFIs. The impact of this credit could be positive or negative depending on farm profits. If the price of rice was 1,200 Riels/kg or more, farmers will be profitable and will be able to repay the loans, fertilizers and pesticides used during the crop year (Sothorn, 2020). Likewise, he found similar positive results to the study by Ovesen *et al.* (2012) that the credit to commercial farmers had contributed to improving rice production and household livelihoods.

On the other hand, under the contractual agreement (contract farming) between farmers and processors or traders, farmers can use the arrangement as a credit guarantee to purchase inputs for future planning, diversify their products and invest more in their farms (Munroe, 2019).

Keosothea and Molyaneth (2020) found that the few shortcomings of the contractual agreement and the obligation to deliver quality exported rice pose challenges for farmers and firms, when they have not been able to take legal measures and intervene in state policy.

Farmers may go into debt due to production challenges and excessive loans to join the contract system. Most farmers used credits for seeds, fertilizers, pesticides, gasoline, and irrigation water, while short-term loans were granted several months before crop income was assured (Ovesen *et al.*, 2012). With this, access to capital, irrigation, mechanization and an export market have increased rice yields from about 3 tonnes per hectare to 6 tonnes per hectare (Ovesen *et al.*, 2012; Sothorn, 2020). However, due to the problematic situation of poor farmers, credit has not been used as much to improve rice productivity but used rather to open a small business, buy livestock, trade, migrate to industrial plantations, or improve living conditions and home care (Sothorn, 2020; Sum and Khiev, 2015). As a result, many farmers were caught in a debt cycle (Sothorn, 2020). Keosothea and Molyaneth (2020) suggested that improving access to credit for the agro-processing industry could help overcome current capital constraints to pay farmers on time. As regards orders, the change in access to credit should reduce extra-contractual marketing to farmers.

In reality, rice is the principal crop in Cambodia, where 75% of agricultural land is used for paddy cultivation and more than 20% of the total workforce or 3 million people work on rice production, processing, and marketing (IFC, 2015). Government policy remains focused on promoting rice export (RGC, 2019). The Kingdom has a clear vision of being a major export country for rice and paddy in the region, and hopes to supply it to the rest of the world. In this sense, Cambodia has taken a target for 2015 to reach a surplus of 4 million tonnes of paddy and to transform it into rice for the export of one million tonnes (MAFF, 2011). Despite this, Cambodia cannot meet the rice export target. Looking back to 2018 context, paddy's surplus was more than 5.836 million tonnes, which can be converted to 3.735 million tonnes of rice production (RGC, 2019). Similarly, according to the Food and Agriculture Organization, Cambodian rice and paddy production reached 10,647,212 tonnes in 2018.[1] While total production of Cambodian export rice to international markets reached 626,225 tonnes (Cambodia Rice Federation, 2019) or more than US $ 473 million against GDP in the same year (Thou, 2019, September 25). Total agricultural exports amounted to 4233,533 tonnes (MAFF, 2019).

Based on data from the National Institute of Statistics, rice export accounted for just around 0.009% of the total agricultural GDP in 2018. While total crop production was US $3,172.41 million, livestock and poultry production was US $644.78 million, fishery production was US $1,301.11 million, and forestry and logging production was US $377.29 million. During the same year, Cambodia exported cassava products, including cassava slices, fresh cassava and cassava starch, for a aggregate of more than 2.6 million tonnes, cashew nuts amounted 101,973 tonnes, red maize 204,184 tonnes, fresh mango 102,457 tonnes and banana 32,821 tonnes to the international

[1]This data can be found on the FAOSTAT website.

market (RGC, 2019). According to the Ministry of Agriculture, Forestry and Fisheries (MAFF), rubber production reached 220 thousand tonnes, with a total yield of 436.7 thousand hectares in 2018 (RGC, 2019). Total rubber exports over the past five years have increased twice from 100 thousand tonnes or $154.13 million in 2014 to 217 thousand tonnes or the equivalent of US $286.94 million in 2018 (RGC, 2019).

According to the NIS, agro-processing contributed only 2.4% of GDP or US $589.83 million, while agriculture contributed about 22% or US $ 5.47 billion of GDP. By 2015, the Ministry of Industry and Handicraft recorded that 77.6% of the 41,674 registered SMEs worked in agro-processing including the food, beverage, and tobacco industries (Sok, 2020, January 31).

Alternatively, only 10% of Cambodia's agricultural merchandise is processed, a number which has remained relatively stagnant since 1998 (Bdlink, 2017). Many Cambodia's agricultural SMEs encounter critical problems involving technical and managerial skills due to the lack of capital and limited access to finance; cumbersome, bureaucratic set-up procedures; operation and business growth; the infrastructure; and the lack of adequate institutional structures (Bdlink, 2017; RGC, 2015).

For the development of the agricultural industry, Ly (2019) and Ly *et al.* (2019) suggested that the Kingdom should explore the diversification of agricultural products as well as the expansion of animal production. They proposed that national policy should play a critical role in stimulating private and public investment. However, the policy of the Cambodian government is to improve the processing sector by promoting private investment in high-potential products such as rice, cassava, mango, cashews, bananas, rubber, vegetables, etc., and a high-value chain in agriculture (RGC, 2018). Moreover, Cambodia's government has the objective of diversifying potential products to reach 12% of total exports by 2025 (RGC, 2015).

4 Data

This section discusses the dataset and illustrates descriptive statistics to measure potential products and factors in Cambodian agriculture. In the estimation analysis, the author used the national-level dataset of agricultural inputs and outputs for the period 1989–2018. Linear interpolation, log-linear interpolation and multiplicative cubic spline interpolation were applied to calculate some missing values of some variables.[2]

[2]In mathematics, linear interpolation is a model of curve fitting that uses linear polynomials to construct new data points that are missing and unknown both in past and future value within the range of a discrete set of known data points. Log-linear interpolation is the value in log-linear interpolation at the x-coordinates specified in x using the lower and upper coordinate arguments to define the line based on the known value. Values lesser and greater than these numbers are assigned the minimum and maximum y coordinates. Multiplicative cubic spline interpolation is a cubic spline interpolation in a special case for use to avoid the problem of Runge's phenomenon. This mathematical method gives interpolating polynomials that are smoother and has smaller errors than other methods.

4.1 Agricultural Input

The main data sources are FAOSTAT, the World Development Indicators (WDI)[3] and the National Statistical Institute (NSI). The WDI program is managed by the World Bank Group, which compiles international statistics on global development. It is a database website that provides free access to approximately 1,600 time-series indicators for 217 economies, and data for many indicators dating back more than 50 years. The WDI indicator is derived from World Bank surveys and data collection efforts. Nevertheless, in the majority of cases, they are based on data originally collected, compiled and published by other sources, such as specialized United Nations agencies, national statistical offices, research and oversight bodies from the private and public sectors, and academic institutions.

Table A6 in the Data Sources Appendix presents the descriptive statistics of the independent variables. In this paper, the author classifies agricultural input into two categories, where agricultural input is direct and indirect. Land supplied with water through the irrigation system, tractor use, fertilizers, pesticides, employment, temperature change, net capital stocks, gross fixed capital formation, credit, RDB funds, technical subsidies, foreign aid and FDI in agriculture are determined as a direct input (see Table A7 for definition and identification code). For indirect inputs used as an endogenous variable, value-added in agriculture, value-added per worker, fixed consumption, final consumption and taxes less subsidies on the product are included. Data on final consumption expenditure and taxes less subsidies come from National Accounts Statistics.[4] The National Accounts are prepared by NIS, Ministry of Planning with support from the Asian Development Bank (ADB) under the Statistical System Development Project and the International Monetary Fund (IMF) under the Technical Assistance Cooperation Project. The National Account estimate used both production and expenditure methods and an income-based approach. They estimated current and constant prices, which are based on year 2000 prices. Both final consumption expenditures and taxes less subsidies on products variables, are expressed in millions of US dollars. Final consumption expenditure is a sum of household final consumption which includes food and non-food consumption, private non-profit organizations serving households and government consumption expenditures.

On the other hand, the crop and livestock index was used as an independent variable. The researcher calculated this index using Equations (2) and (3). For a detailed description of the model, see in the Production Diversity of the Model section. The production, harvested area and yield of each crop sub-sector were used as an instrument variable in crop estimation. At the same time, the yield, laying and production of each commodity in the livestock sub-sector were used as the instrument variable in the livestock estimation. The amount of agricultural land was used as an instrument variable for both crop and livestock estimation.

[3]Access WDI's development data on Cambodia free of charge via this link: https://data.worldbank.org/country/cambodia?view=chart.

[4]National Accounts Statistics of Cambodia between 1993 and the most recent year can be found at https://www.nis.gov.kh/index.php/en/21-na/41-national-accounts.

According to the WDI dataset, Cambodian farmers have used fertilizer on average at 9.76 kilograms per hectare over the past 30 years. In 2018, fertilizer was applied at a rate of 26.26 kilograms per hectare. These data are very different from informal interviews with the farmers and some Cambodian researchers who do much agricultural research.[5] Some farmers from the Boeung Preah commune, Ba Phnom district, Prey Veng province discussed their use of fertilizer indicating that they used an average of 200 kilograms of fertilizer per hectare. However, this varies depending on rainfall and rice conditions. Prey Veng farmers said the fertilizer used for the wet season paddy rice of Trapeang Run, Tram Kak district, Takeo province and Ta Daeng Thmei in Basedth district, Kampong Speu province averaged 151 kilograms per hectare (82 sample) and 265 kilograms per hectare were used in Snao in Prey Kabbas district, Takeo province (40 sample) as can see be seen in Sareth *et al.* (2020). Due to the absence and uncertainty of national data on the use of inputs in farming, such as fertilizers, pesticides, tractors, machinery and equipment, labor costs, transportation costs and other factor; it makes the analysis and evaluation ambiguous in terms of providing appropriate policies. This requires further research with a data set specification on other input variables.

RDB funds for agriculture have increased rapidly. In this analysis, RDB funds average US $44.16 million, while foreign aid to farming averages US $1,007.87 million and varies by year, donor country and type of denotation. The foreign aid variable in this study comes from a sum of foreign aid to Cambodian agriculture by country and by types of aid programs, such as agricultural input development, land resources, water resources, research, education, training and financing. It includes the development of environmental policy and administrative management, biodiversity, fisheries, agro-industry, rural development, environmental protection, forest development, and food and nutrition assistance at constant prices (2017) in millions of dollars.

4.2 Agricultural Production

The agrarian production dataset combines data from the FAOSTAT[6] program at the Food and Agriculture Organization of the United Nations (FAO). This dataset has been popularly used in the literature to study agriculture productivity. The FAOSTAT website provides free access to statistical input-output data on agriculture collected and maintained by the Statistics Division. It provided the historical dataset with numerous indicators from 1961 to the most recent year available for 245 countries around the plant and covered all FAO regional groupings. By working directly and cost-effectively with the members of each country, the Statistics Division provides practical support for the development of statistical strategies of the member countries, strength-

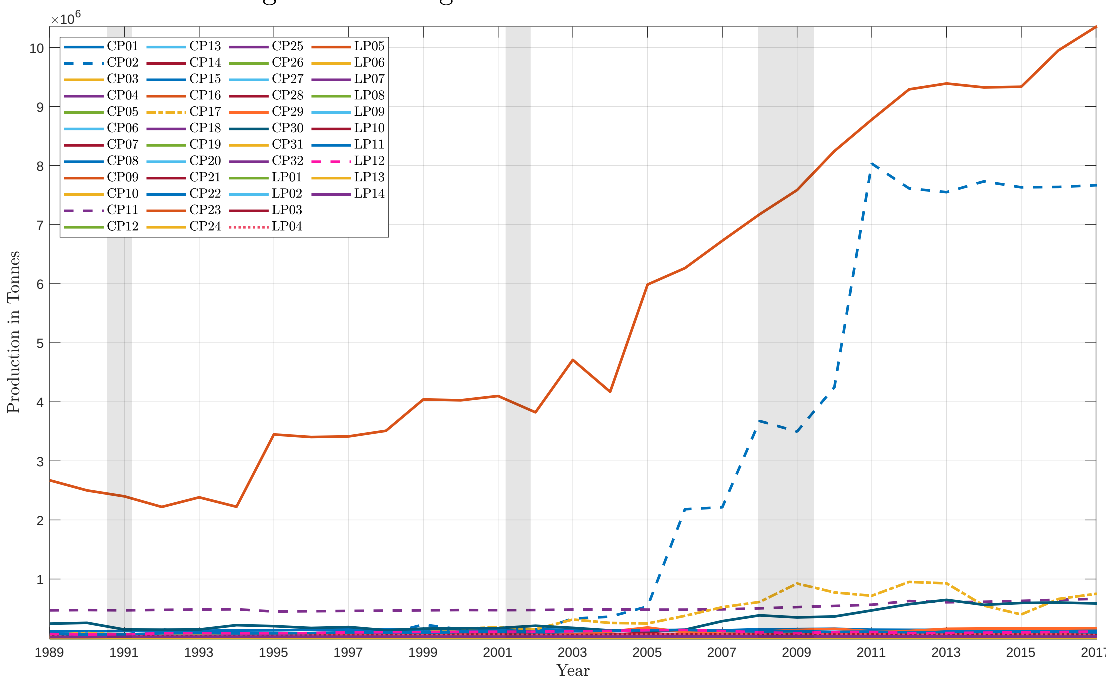
[5]This is the information that the author has interviewed some key persons. Yim Marom, Sok Chea, and Chan Tida, farmers in Ba Phnom district. Sok Pisal, an employee in an agricultural firm in Prey Veng. Sim Sokcheng and Khiev Pirom, agricultural researcher at the Cambodia Development Resource Institute (CDRI).

[6]The Cambodian dataset on agriculture, nutrition and food and the agricultural dataset of other countries with other indicators can be downloaded free of charge from the FAOSTAT website via this link: http://www.fao.org/faostat/en/#country/115.

ening institutional and technical capacity, and improving statistical systems. The FAOSTAT system is the most influential corporate system for the FAO's objectives to collect, analyze, interpret and disseminate information on global agriculture for the growth of its development and the fight against hunger and malnutrition in the world.

In this analysis, gross agricultural output is used as a dependent variable. It is measured in millions of US dollars at constant prices in 2004–2006. The author used 46 products in the agricultural sector of Cambodia, 32 in the crop sub-sector and 14 in the livestock sub-sector (Table A8 in Data Sources Appendix shows the descriptive statistics of net agricultural production used in the estimation). This research used one by one of 46 agricultural products as a dependent variable with independent variables of the farming input in the regression model. The decision to choose this quantity of products was due to missing specific data. In general, the gross value of each agricultural product is derived from FAOSTAT and differs from the MAFF dataset due to different data collection, recording, forecasting and estimation methods.

Figure 1: Net Agricultural Production in 1989–2018



Note: This figure presents the net value of each of 46 products in the crop and livestock sub-sector of Cambodian agriculture in millions of US dollars at price constant in 2004–2006. The source of this figure comes from the FAOSTAT.

Figure 1 shows the gross value of agricultural production between 1989 and 2018 at constant prices in 2004–2006. Based on the FAOSTAT dataset, the paddy rice represented in the CP23 identification code remains a leading product in Cambodia. It has averaged US $539.31 million over the past 30 years and the income from paddy has increased over time. Next is cassava, which has a CP02 identification code with an average gross production of US $391.25 million. Between 2005 and 2011, cassava regularly grew and was intensively cultivated by farmers. However, this growth appears to have stagnated between 2011 and today. Other commodities have contributed to the growth of agriculture: sugarcane has an average of US $360.09 million, US $176.74 million for fresh fruit, US $159.63 million for pork and US $151.71 million of indigenous pork over the last 30 years (see Table A8 in Data Sources Appendix section for more details on descriptive statistics).

In addition, in order to identify the concentration of the agricultural market, the researcher used the gross agricultural production of each product between 1959 and 2018 to calculate the Herfindahl-Hirschman Index (HHI) in Equation (1). The author classified the HHI into five categories, where the first category to the fourth category have a period of 15 years and the fifth category determines 60 years of market share.

5 Model

This section develops an equilibrium model that the researcher applies to quantitatively evaluate the potential products and factors in Cambodia's agriculture industry.

5.1 Power Market

The market distribution of each agricultural commodity is defined as the resource allocated to that participant articulated as a percentage of the total demand on the global market. The Herfindahl-Hirschman Index (HHI) is used to represent the diversification or the specialization of the product in the market. The index is mainly used to evaluate market concentration (Chen, 2018; Kanagala *et al.*, 2004). Many economists used the HHI to represent the diversification or the specialization variable in the agriculture industry (e.g., Culas and Mahendrarajah, 2005; Fiszbein, 2017; Rahman, 2009). In this paper, the agricultural commodity diversity is measure as agriculture gross production using the HHI as follows:

$$AgriDiversity_m = \sum_{i=1}^{N} \chi_{im}^2 \tag{1}$$

where N is the number of the agricultural commodity's participation in the market m ($N > 1$); χ_{im} is the share of product i in market m's agricultural production in value terms (with $i = 1, 2, 3, \ldots, n$). $AgriDiversity_m$ denotes the number of the agricultural diversity index in the merchandise m, where $0 \leqslant AgriDiversity_m \leqslant 1$. A zero value denotes perfect diversification and a value of one denotes perfect specialization.[7]

[7] According to the past literature, when the HHI has the value below 0.01 indicates a highly competitive industry; if it values below 0.15 it indicates an unconcentrated industry. The value of index is between 0.15 to 0.25, it indicates moderate concentration industry and the value is above 0.25, it determines high concentration industry.

5.2 Production Diversity

Crop diversity $Crop(S_t)$ using the Shannon index (see e.g., Ang *et al.*, 2018; Ibrahim *et al.*, 2010; Bareille and Letort, 2018). The author computes $Crop(S_t)$ as follows:

$$Crop(S_t) = -\sum_{i=1}^{N} s_{nt} \ln(s_{nt}) \tag{2}$$

where s_{nt} is the apportionment of land areas devoted to crops n $(n[1, N])$. The n index refers to the endogenous crops such as rice, banana, orange and plus all other land uses considered exogenous in the model. The contribution s_{nt} is defined as S_{nt}/TL_t, with the S_{nt} being the land devoted to output n and TL_t is denoted as the total agricultural area of the farm at time t. TL_t is the sum of L_t plus all areas devoted to other exogenous land uses. The researcher considers TL_t as a fixed and exogenous variable. $Crop(S_t)$ increases when habitat diversity rises, which reflects the augmentation of crop biodiversity.

Livestock diversity index $Livestock(S_t)$ has the same model as crop diversity index in the Equation (2):

$$Livestock(S_t) = -\sum_{i=1}^{N} s_{nt} \ln(s_{nt}) \tag{3}$$

where s_{nt} is the share of land areas devoted to livestock production n $(n[1, N])$. The n index refers to the endogenous livestock such as cattle, chicken, pork and plus all other farming lands considered exogenous variables in the model. The allocation s_{nt} is defined as S_{nt}/TL_t, with the S_{nt} being the land devoted to output n and TL_t is denoted as the total agricultural area of the farm at time t. TL_t is the sum of L_t plus all areas devoted to other exogenous land uses. The author considers TL_t as fixed and exogenous variables. $Livestock(S_t)$ increases when habitat diversity increases, which reflects the augmentation of livestock biodiversity.

5.3 Estimation Strategies

The generalized method of moments (GMM) was first introduced into the econometrics literature by Hansen and Singleton (1982). Many agricultural economists used the GMM to estimate agricultural production, consumption, cost of production, and crop biodiversity (see e.g., Bareille and Letort, 2018; Zhang *et al.*, 2020). A consequential feature of these estimators is that they have a limiting normal distribution under fairly weak assumptions about the stochastic processes generating the observable time series. While this, the author strategies to complicate specifying the objective functions of a subset of the agricultural agents, it is distinct from specifying the decision rules of a subset of agents without specifying the entire economic environment.[8] For example, Zhang *et al.* (2020) used the panel data with the GMM to investigate the effects of COVID-19

[8]By the economic environment, the researcher means a specification of preferences, technology, and the stochastic process underlying the forcing variables. By a decision rule, the author means a rule used by economic agents to determine the current period "decision" as a function of the current "state" of the economy.

pandemics on agricultural production. They used many agricultural inputs as the independent and instrumental variables. Importantly, Dillon *et al.* (2011) measured the agricultural income at household level with the GMM estimator, which applied the public infrastructure, access to irrigation, and landholding rainfall as independent variables.

In this paper, the researcher uses the two-step GMM to estimate agricultural products with a time series dataset that collects from multiple sources, especially from international organizations and national statistical institutes.

Consider the linear regression model:

$$y_t = x_t'\beta_0 + u_t = x_{1t}'\gamma_0 + x_{2t}'\delta_0 + u_t \tag{4}$$

where x_t is a $K\times1$ vector of stochastic regressors, β_0 is the true value of a $K\times1$ vector of unknown parameters β, and u_t is an error term in the model. Since β is a $K\times1$ parameter, these moment conditions exactly identify β. If the author had fewer than K moment conditions, then the researcher could not identify β, and if the author had more than K moment conditions, then β would be over-identified. In the model, estimation can proceed when the parameter vector is over-identified or exactly.

The common econometrics have obtained moment conditions necessary to require terms of error of the model to zero holding condition on certain variables observed. Alternatively, the researcher can specify the moment conditions directly by requiring that the error term not be correlated with certain overpowered instrumental variables. It follows that u_t and x_t may be correlated. Suppose the author has a set of instruments in the $R\times1$ vector z_t. These may be defined to be valid instruments if $\mathbb{E}[z_t u_t] = 0$ and $\beta = \beta_0$. Thus the requirement that z_t be a set of valid instruments immediately provides the appropriate moment conditions:

$$g(\beta_0) = \mathbb{E}[z_t u_t] = \mathbb{E}[z_t(y_t - x_t'\beta_0)] = 0 \tag{5}$$

Estimators are referred to as instrumental variables estimators, the function $u_t(z_t, \beta)$ may be linear and non-linear in β. For a given sample, z_t $(t = 1, 2, \dots, T)$, the researcher cannot calculate the expectation. Thus, the author replaces with sample averages to obtain the analogous sample moments:

$$g_T(\hat{\beta}) = \frac{1}{T}\sum_{t=1}^{T} z_t(y_t - x_t'\hat{\beta}) \tag{6}$$

The researcher can derives an estimator, $\hat{\beta}_{MM}$, as the solution to $g_T(\hat{\theta}_{MM}) = 0$. In the case of $R > K$ is called over-identification. Thus, more equations than parameters and no solution to $g_T(\beta) = 0$ in general. The distance is measured by the quadratic form. The author first obtains the first-step GMM estimator by minimizing:

$$\hat{\beta}_{1GMM} = \left[\frac{1}{T_0}\sum_{t=1}^{T_0} z_t(y_t - x_t'\hat{\beta})\right]' W_T \left[\frac{1}{T_0}\sum_{t=1}^{T_0} z_t(y_t - x_t'\hat{\beta})\right] \tag{7}$$

The author is interested in two-step GMM estimation of β_0 based on the moment condition in Equation (5). Let ℓ denote the lag truncation parameter used in HAC covariance matrix estimation and $T = T_0 - \ell + 1$.[9] With respect to β, where W_T is some $R \times R$ positive semi definite matrix. Then the researcher obtains the second-step GMM estimator by minimizing:

$$\hat{\beta}_{2GMM} = \left[\frac{1}{T}\sum_{t=1}^{T} z_t(y_t - x_t'\hat{\beta})\right]' \hat{S}_T^{-1} \left[\frac{1}{T}\sum_{t=1}^{T} z_t(y_t - x_t'\hat{\beta})\right] \tag{8}$$

where

$$\hat{S}_T = \hat{\Omega}^{-1} = (\hat{\beta}_{1GMM}\hat{\beta}_{1GMM}')^{-1} \tag{9}$$

or

$$\hat{S}_T = \frac{1}{T}\sum_{t=1}^{T}\left[z_t\hat{u}_t^2 z_t' + \sum_{j=1}^{\ell}\omega(\frac{j}{\ell})(z_{t+j}\hat{u}_{t+j}\hat{u}_t z_t' + z_t\hat{u}_t\hat{u}_{t+j}z_{t+j}')\right] = \sum_{j=-\ell+1}^{\ell-1}\omega(\frac{j}{\ell})\hat{\Gamma}_j \tag{10}$$

is the HAC covariance matrix estimator for the moment function from Equation (5), $\hat{u}_t = y_t - x_t'\hat{\beta}$, and $\omega(\cdot)$ is a kernel.

The researcher considers the distribution of the studentized statistic of a linear combination of the parameter, $T^{\frac{1}{T}}(c'\hat{\psi}_T c)^{-\frac{1}{2}}c'(\hat{\beta}_T - \beta_0)$ were $\hat{\psi}_T = ((\frac{1}{T})\sum_{t=1}^{T} x_t z_t' \hat{S}_T^{-1}(\frac{1}{T})\sum_{t=1}^{T} z_t x_t')^{-1}$ and c is an arbitrary nonzero K-dimensional vector. The author considers the distribution of the J test statistic[10]:

$$J_T = \left[\frac{1}{\sqrt{T}}\sum_{t=1}^{T} z_t(y_t - \hat{\beta}_T' x_t)\right]' \hat{S}_T^{-1} \left[\frac{1}{\sqrt{T}}\sum_{t=1}^{T} z_t(y_t - \hat{\beta}_T' x_t)\right] \tag{11}$$

Hansen's J statistic used to determine the validity of the overidentifying restrictions in a GMM model. At the same time, Hansen's J statistic can be accurately reported when more instruments than endogenous regressors are specified under additive errors and multiplicative errors. In this analysis, the author has more instruments than endogenous regressors. Hansen's J statistic is valid only when the weight matrix is optimal (Baum *et al.*, 2003; Stock and Weight, 2000), meaning that the inverse of the covariance matrix is equal to the moment conditions. See the weight matrix in Equation (9) and (10).

6 Empirical Results

This section discusses the main results of the quantitative exercise. The author first points out the market concentration in Cambodia's farming industry, particularly in the crop and livestock sub-sector. In the second step, the researcher performs a full estimation of the crop and livestock goods with direct and indirect input used as endogenous variables and instrument variables. The purpose of this working paper is to identify the potential products and factors in agriculture that have led to the success and failure of agricultural production. The final part of this section explores key determinants of the model's success.

[9] The author uses T observation and the modified HAC covariance matrix estimator $\hat{S}_T$ to obtain asymptotic refinements for symmetric confidence intervals and the J test statistic.

[10] This is the J-test or the Hansen test for over-identifying restrictions. In linear models it is often referred to as the Sargan test. J_T is not a test of the validity of model or the underlying economic theory and it considers whether the $R - K$ moments are in line with the K identifying moments.

6.1 Market Concentration

The author measures market concentration at the national level using the Herfindahl-Hirschman Index (HHI) on 46 agricultural products. In this study, the researcher presumes that the entire market for agriculture includes these commodities without the fishery and forestry sub-sectors and other products in crop and livestock sub-sector. The main reason for this is the deficiency of datasets on these products.

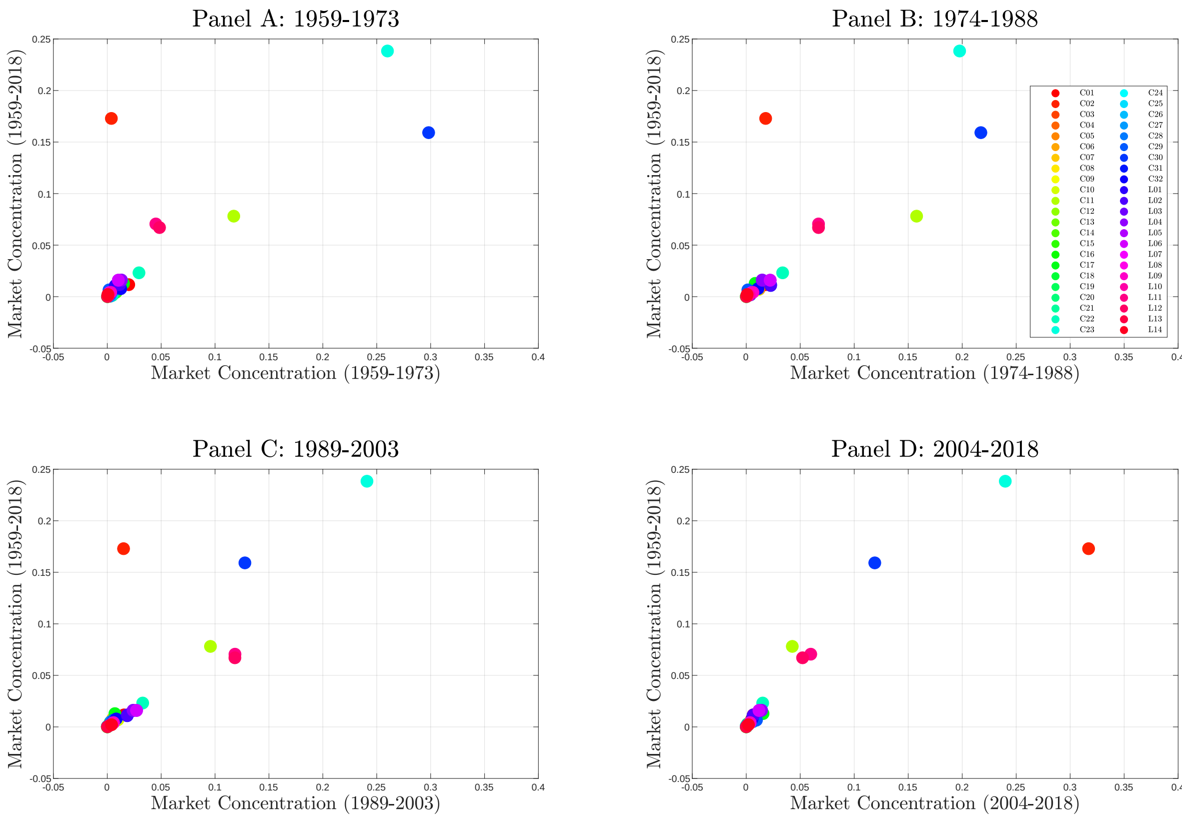
Table A1 reports the market concentration of the Cambodian agricultural sector, from the HHI in Equation (1). In this table, the author classified in five categories, where four categories were identified for a period of 15 years and one combined over the last 60 years (as seen in columns (1)–(4) and (5) in Table A1). The agrarian economic structure in columns (1) and (4) reported an exceptionally higher HHI than others. Simultaneously, it showed that the agriculture industry is moderately specialized, which represents 0.1775 in 1959–1973 and 0.1820 in 2004–2018. This result has provided an excellent view to reflect on the theory of specialization. Many of the economic literature has demonstrated that specializations have a positive effect on economic and export growth. Alternatively, in the context of Cambodia, over the past decade have been rejected theorems. The contribution of economic growth from the agricultural industry has only increased a little (see Context section for details on the agricultural situation). In column (4), cassava makes many contributions to the market, which represents on average at 31.71% of the full agricultural market over the last 15 years.[11] It was followed by paddy rice represented at 23.99%, 11.91% for sugarcane, 5.98% pork, 5.22% indigenous pork and 4.27% for fresh vegetables. On the other hand, many products have a marginally low market concentration. The product with a lower overlap in the market, such as cottonseed have shared on average 0.0004%, 0.0008% for jute, 0.0022% for seed cotton, 0.0023% for cotton lint and 0.0035% for castor oilseed. Before column (1), the top three leading contributions are 29.81% for sugarcane, 25.99% for paddy rice, and 11.73% for fresh vegetables. While the three lowest commercial shares are castor oilseed and nuts at 0.0137%, and 0.0252% for silkworm coiling cocoons at total market concentration.

In column (5), the structure of agricultural markets was found to be moderately diversified, with a negligible index value at 0.1301. Paddy rice, cassava, sugarcane, fresh vegetables, and pork products remained in reserve to be the highest concentration in the market. However, the percentage contribution has changed slightly, as seen in Table A1 in the Results Table section. On average, with 46 products shared to market at about 0.0217%. Moreover, more than 60% of the total products shared were below 0.0069%. The smallest contribution of products in the agricultural economy are induced castor oil seed (0.0066%), jute (0.0085%), cottonseed (0.0089%), and 0.0104% for nuts.

Figure 2 represented the concentration of agriculture between 1959–2018 and compared to four other 15 years categories in the economic structure. In general, very few products have a significant market apportionment. Five or six products contribute significantly. More detail

[11] Full market here refers to the total market of 46 commodities that were used in this paper.

Figure 2: The Agricultural Product Diversity



Note: The figure presents about the agricultural economic structure between each of four categories of 15 years and one of 60 years. This figure comes from the result on Equation (1) and (2), can be seen in Table A1. Panel A shows the market contribution between 1959–1973 and 1959–2018. Panel B shows the share between 1974–1988 and 1959–2018, Panel C between 1989–2003 and 1959–2018. Finally, Panel D presents the concentration between 2004–2018 and 1959–2018. All values are measured in parentage. The sample used in this plot comes from the FAOSTAT program of the FAO between 1961–2018. From 1959–1960 and some missing values in this dataset were used to predict the linear interpolation method.

about the root cause have been provided in the Empirical Results section. However, the result of this section can give a big picture view of Cambodia's agriculture industry.

6.2 Crop Estimation Results

Table A2 presents the estimation results for the dynamic model of agricultural output determinants from Equation (8). All reported system GMM results are two-step estimates with the time-series sample dataset. Across all thrifty-two crop specifications, one can see a common pattern of results.

Column (1) reports the results of the specification C01 with multiple lagged endogenous variables and some exogenous variables. This specification represents banana production. Labour used in farming and taxes less subsidies on the product is highly statistically significant. The consumption of fertilizers and fixed capital used in the cultivation industry is statistically significant at 90% and has a negative efficiency compared to the banana specification. At the same time, net capital shocks in agriculture are statistically significant at 95%. Nevertheless, many lagged endogenous variables such as crop index, water used by the irrigation system, tractors, pesticides, temperature changes, gross fixed capital information, credit, RDB founds, technical grants, foreign aid, FDI in agriculture, value-added per capita, aggregate value-added in agriculture, and final consumption expenditure has not been statistically impacted. This specification is a very close correlation of variance with a determination coefficient of 90.74%. Even so, the Hansen tests for the GMM estimates using the collapsed instrument matrix in column (1) reject the null value of the validity of the overidentifying restrictions.

Column (2) presents the regression results of the cassava specification. The results show that cultivation credit and FDI in agriculture are highly statistically significant and positively correlated. Fertilizer and final consumption expenditure are complementary efficient to cassava products with a statistically advantage at 90% and 95%. Climate change which is represented by temperature change variables and taxes less subsidies on the product has a statistically weak negative at 90% and 95% with a coefficient at (−114.31) and (−1.44). This specification has a very accurate correlation with r-squared at 99.79%. However, many lagged endogenous variables do not affect cassava production. The instrument variable in this and other crop specifications include agriculture land, production, harvested areas, yield used with the specific product, and all endogenous variables. The Hansen tests of the exogenous variables in this column (2) reject the null hypothesis with a Hansen p-value at 0.0085.

Column (3) indicates the results of the specification C03. This identification code represents castor oil seed. Many lagged endogenous variables in this estimator are markedly statistically significant in the adverse effect to castor oil seed output. The more essential inputs such as crop index, fertilizer, pesticides, gross fixed capital information, credit, and RDB funds in the past does not afford an appropriate side in the development of castor oil seed. Nonetheless, it is not surprising that the fertilizers and pesticides used have not had a positive effect the growth in the production of castor oilseed. This finding confirms that of Eliste and Zorya (2015) that the primary agricultural input used in Cambodia has not had much effect compared to the neighbouring countries of Thailand and Vietnam. Only Hansen tests for the GMM estimates using the collapsed exogenous variables do not reject the null hypothesis. The C03 specification is the highest of all crop specifications, where it has the most lagged endogenous variable that negatively influences output production. Overall, it can be determined that this product is not the potential product for development. All the same, it is challenging to draw definitive conclusions due to the lack of theoretical and econometric studies on the use of input and the specific size of the market for this product. In this Table A2, the specification in column (20), (15), (10), (12), (13), (14), (17), (25), (27), (30), (16), (27), and (29) contains many independent variables whose statistical significance has a negative impact on agricultural production. For example, the result of fresh fruit is represented in the specification in column (10). Tractors, pesticides, employment, value-added per worker, taxes less subsidies have the sign of the coefficient positive statistical significance. While the other eight independent variables had statistically significant affirmative results, and others are not statistically significant at any p-value level. The fresh fruit product in this document include several fruit commodities and it represents the total of fresh fruit in the country. For the demand side, fresh fruit consumption in Cambodia has increased over time, while production in the local market has limited and high prices compared to export fruits. The import of fruit production remained a critical thing to demand a complete supply of fruit for consumption. This analysis cannot suggest to the policy-maker or in particular to the ARDB bank to pay attention to the development or intervention on fresh fruit due to the lack of studing on specific fruit commodities.

Column (13) reports the two-step GMM regression result of green coffee products. This specification is not much different from the grapefruit and pomelo product that can be seen in column (12). Many independent variables are statistically significant with negative impact. Labour, net capital stocks, value-added per worker, final consumption, and taxes less subsidies have positive statistically significant. All variables in the C13 coffee regression model have a strong correlation with r-squared 98.89% and it does not reject the null hypothesis in the Hansen tests for the validity of overidentifying restrictions. Coffee production, according to FAOSTAT, increased by 1.33% compared to 2017 to reach 381 tonnes in 2018. While looking at the period from 1979 to the present, the life cycle of this product increased continuously. Nevertheless, the green coffee market and the price are not yet clear. Uncertain to the valuation, therefore, cannot confirm its potential in the context of Cambodia.

Column (17) represent the GMM regression result of maize production. The three inputs have statistically significant and positive effects on the model: tractors, net capital shocks and value-added per worker. Many endogenous variables are negative and statistically significant, and not considerable for the specification. The FAOSTAT, in 2019, showed maize production at 890 thousand tonnes. Before reaching this level, it reached a minimum of 40 thousand tonnes in 1983. The main areas of cultivation of this product are Battambang, Preah Vihear, Kandal, Kampong Cham, Tbong Khmum, and Pailin province and each hectare produces about 4.5 tonnes.[12] Farmers said that maize is more marketable and more profitable than cassava. Even if the price drops in some years, they can still be free of debt. On the other hand, maize is also a product for which the ARDB[13] has financial assistance, but the regression report shows that it is not statistically significant.

Next, the regression of the sugarcane dependent variable is shown in column (30). RDB

[12] According to Lor Reaksmey, spokesman of the Ministry of Agriculture Forestry and Fisheries, though he gave an interview with the Phnom Penh Post on June, 22, 2017. See details via this link: https://www.phnompenhpost.com/business/maize-has-local-farmers-ears.

[13] See in the Phnom Penh Post, July 25, 2017. Cambodia's government provided an emergency fund of about US $27 million to maize farmers and the rice sector during the failure of price in 2017. Can be checked here: https://www.phnompenhpost.com/business/government-opens-27m-emergency-fund-corn-farmers.

funds, technical support and others have a statistically significant negative impact on the model. Many sugarcane firms are run by FDI and some local SMEs. Likewise, FDI in agriculture has a positive statistically significant at 90%. The Rui Feng (Cambodia) International Co., Ltd., the Yellow Field (Cambodia) International Ltd., the Koh Kong Sugar Industry Co., Ltd., and the Phnom Penh Sugar Co., Ltd. comprise the main sugarcane industry in Cambodia.[14] The MAFF showed that the sugarcane industry has enormous potential for farmers to boost their cultivation to meet the industry's production. However, based on the result of this article, the author shows that it does not rapidly increase sugarcane growth for farmers as many input variables have a negative affect on sugarcane production.

The regression of soybean production is in column (29). The result shows that many principal inputs such as tractors, fertilizers, pesticides, labour, and credit used had a negative coefficient of 0.0136, 1.4206, 0.0034, 0.0467, and 0.1019 with a highly statistically significant. The final consumption variable is more accurate with a coefficient of 0.04. The Hansen test in this estimator has rejected the null hypothesis of the instrument variable. The researcher also found that temperature change has a statistical significance and an advantageous effect on soybean production with a coefficient of 6.6442. It is not dissimilar to the finding of Belfield *et al.* (2011) and Farquharson *et al.* (2013) that temperature and humidity negatively affect soybean growth. The optimal temperature for soybean growth is between 20–30°C, and measurements above 35°C are considered growth limiting. The main soybean production area for the past 30 years has been in Kampong Cham, and in recent years, it has increased in northwestern Cambodia, especially in Battambang, Siem Reap, Kandal and Takeo province.[15] Some researchers have suggested that soybean is a potential product for the market, but it should be noted that a clear policy to improve productivity and develop local agro-processing is needed.

Column (18), specification C18 indicates the GMM regression result of mango, mangosteen and guava production. The crop index, water used based on irrigation, fertilizers, pesticides, labour and other independent variables are insignificant for the model. Only tractors, RDB funds and consumption, have positive and negative consequences on the model. The instrument variable does not reject the null hypothesis. This result confirms the interview with Ms Khiev Pirom, Research Associate at the Agricultural Policy and Rural Development Research Centre of the Cambodia Development Resource Institute (CDRI). She shows that mango products address many critical challenges such as financing, technical and modern equipment, and contract agriculture.[16] Alternatively, it can be classified as a leading potential product when Cambodia has a free agreement with China to export agricultural products, but the demand is for high-quality

[14]See the Phnom Penh, November 13, 2017 go through this link: `https://www.phnompenhpost.com/business/sugarcane-huge-potential-farmers`.

[15]See for detail on Belfield *et al.* (2011). At the same time, they showed that about 80% of Cambodia's soybeans are exported for processing in Vietnam and Thailand. In contrast, three prominent local companies involved in soybean processing are the Heng Heang Co., Ltd., the Hagar Soya, and the CP Cambodia.

[16]Based on the interview with Ms Khiev Pirom on October 16, 2020. Currently, she has been studying to understand the mango production value chain.

products.

Natural rubber production is represented in column (19) in the specification C019. Labour used, net capital shocks and taxes less subsidies have a significant and positive effect on the product, which have many independent variables unrelated to the model. Technical subsidies have a statistical significance of (−0.0062) and tractors of (−0.0018). In addition, the main sources of inputs to rubber production are land, labour and capital (Hing and Thun, 2009). However, in this specification, two out of three inputs do not correspond to rubber production. It should be noted that the land data used in this study were combined into the crop index and instrument variables. The author cannot suggest that rubber is a potential product for ARDB subsidies because many major inputs have a detrimental effect on efficiency and other factors, not on correlation. On the other hand, the price of this product has not changed; it is based mainly on the international market.

Column (23) summarises the GMM result in two steps of paddy rice production. Fertilizers, credit, RDB funds, foreign aid, value-added in agriculture have a positive statistical significance for paddy rice production. While the crop index, tractors, pesticides, labour, gross fixed capital and value-added per capita have a negative consequence, and other lagged endogenous variables are insignificant for the model. The Hensen test does not reject the null of the validity of the overidentifying restrictions. This specification cannot find statistical evidence on the use of water by irrigation systems, whose reality contributes to the growth of paddy rice. Similarly, the recent study by Wokker *et al.* (2014) found that water used by irrigation during the wet season has a minimal effect on rice production. They showed that for every 1% increase in the amount of water used, the rice yield increases by only 0.06%. Cambodian rice production traditionally depends on rainfall rather than irrigation. For dry season rice, farmers depend on small ponds and groundwater. Nevertheless, due to limited storage capacity and the financing contract, farmers are having difficulty accessing water (Sareth *et al.*, 2020). Sareth *et al.* (2020) has shown that the irrigation system is the main factor in increasing land use and labour, increasing rice production and improving the physical and chemical properties of the soil. The rice sector has export potential, but there are many gaps, such as varieties used, low-quality seeds, limited extension services, and post-harvest problems (Chhun *et al.*, 2020). Here, according to Chhun *et al.* is the study on the rice market and export in Takeo province.

Column (24) reports the estimation result of the pepper and piper spp production. Surprisingly, many lagged endogenous variables do not correspond to the dependent variable. Hansen's test positively rejected the null of validity value. In the past, value-added per worker, labour, pesticides and tractors used in agriculture showed significant and positive signs for pepper and piper spp input. Nevertheless, the input used in this product does not contribute much to growth, but it has market potential. The Minister of the MAFF, Veng Sakhon told the Phnom Penh Post that pepper has been vital to international markets in recent years.[17] However, the view

[17] See the Phnom Penh Post on November 4, 2020. This article was written by Thou Vireak, can be found online here: https://www.phnompenhpost.com/business/kampot-pepper-growers-quit.

of the president of the Kampot Pepper Promotion Association, Nguon Lay is different from the minister's statement that "the association produced much pepper, but not the market".[18] In the first nine months of 2020, Cambodian traded more than 4,121 tonnes of finished pepper products to the international market, increase of about 21% over the same period compared to 2019.

Unmanufactured tobacco production regression result are represented in column (32). Tobacco has been a main agricultural product since the Norodom Sihanouk regime. According to the FAOSTAT dataset, Cambodia produced about 5,661 tonnes of tobaccos in 1961 which increased to 13,856 tonnes in 2018. The result of the specification C32 shows that many lagged endogenous variables have a 99% statistical significance and positive consequences for tobacco production. Only labour, net capital shocks, gross fixed capital information and fixed capital consumption are not correlated to the model. The province along the Mekong river such as Kratie, Kampong Cham, Kandal and Prey Veng province are the main cultivated tobacco regions (Samrech, 2008). Samrech added that tobacco is a crop grown during the dry months between October to May.[19] He also found that the number of farmers cultivating tobacco has declined over the last three years due to declining income and productivity. Even now, tobacco remains Cambodia's main export product.

6.3 Livestock Estimation Results

Table A3 in the Results Table in the Appendix section reports the two-step GMM regression result of the product in this sub-sector. Many endogenous variables in the specification of livestock products are not correlated to production inputs.

Column (14) presents the two-step GMM results of whole fresh cow's milk. Many endogenous variables have statistical significance and are negatively efficient to the model compared to others. Gross fixed capital information, credit in agriculture, RDB funds, value-added in agriculture, and consumption of fixed capital in agriculture have a statistical significance and negative consequence to fresh cow milk output. The r-squared is highly correlated with 87.94% and the Hensen test of instrument variable does not reject the hypothesis of the null value of the validity of the overidentifying restrictions with p-value at 0.0969.

Cambodia's income from whole fresh cow milk production is not high compared to other agricultural production. According to the FAOSTAT, in 2018, 24,273 tonnes were produced with total revenue of approximately US $10.12 million, while in 2017, it produced 24,495 tonnes with gross production about US $9.62 million.

In Cambodia as a whole, there are not many fresh cow milk firms. The leader are Khmer Fresh Milk Co., Ltd., Moo Moo Farm, and Techo Sen Russey Trip Dairy Farm. Khmer Fresh Milk has 300 hectare of farms with capital invested US $10 million located in a remote valley in the Phnom Tamao mountain range in Kandoeng commune in Takeo province. Currently, Khmer

[18] Lay Nguou gave an interview on NPR on March 14, 2020. It be fond here: https://www.npr.org/2020/03/14/813608491/cambodias-prized-kampot-pepper-nearly-wiped-out-by-khmer-rouge-makes-a-comeback.

[19] See about the tobacco production in Samrech (2008).

Fresh Milk has the ability to produce 5,000–6,000 litres of fresh milk per day and uses modern technology. Moo Moo Farm can produce 1,300–1,500 litres of fresh milk per day. This farm is located in Arey Ksat commune in Lvea Em district, Kandal province. Techo Sen Russey Trip Dairy Farm can produce 600–700 litres of fresh milk per day. In the past, fresh milk was not the target of financial support due to this product not requesting working capital as the firms themselves can cover it. An investment project in fresh milk requires a lot of money.

Column (6) reports the regression result of indigenous chicken meat production. Consumption expenditure has a statistical significance to the model and a positive effect to production. Livestock index, temperature, gross fixed capital formation, FDI in agriculture, and taxes less subsidies on products have a negative impact on indigenous production. Other endogenous variables are not correlated with the estimator. Indigenous chicken meat is preferred by many Cambodians because of the great taste, leanness, pigmentation and suitability in Cambodians special dishes. Column (7) reports the two-step GMM result of duck meat production. In this specification, many endogenous variables are not correlated to the model. Livestock index, employment, net capital shock in agriculture have a positive efficiency for duck meat production. While gross fixed capital formation, FDI in agriculture, and capital fixed on consumption have statistical significant and negative impacts. Duck meat production is lower than chicken meat due to consumer preference. Duck farming is low. According to FAOSTAT, over the last 60 year, gross production of duck meat has averaged US $8.97 million while chicken meat has averaged US $36.27 million.

Column (11) presents an estimated result of the pork products and column (12) reports the result of the indigenous pork products. In these two specifications, many endogenous variables are not correlated to the model. There are two reasons why many independent variables have no statistical significance. First, the total direct and indirect agriculture input does not contribute much to the growth of pig meat and indigenous products. Second, the input dataset used in these specifications does not contain microdata, therefore, requiring enquire specific microdata from many of the inputs used in pork production.

Column (3) shows the estimated result of the cattle product. Many endogenous variables are not correlated with dependent variables, which is similar to other specifications for livestock products. Only labour forces used in agriculture have a statistical significance and are positively efficient for cattle products. In column (4) present the result of indigenous cattle meat products. Based on the FAOSTAT dataset, the average net income of indigenous cattle meat during the last 30 year between 1989–2018 was US $56.55 million, while cattle meat has an average at US $55.05 million. The indigenous cattle farming in Cambodia is essentially traditional, based on natural growth and feeding such as grass and grain. From 1989–2009, indigenous cattle production has increased rapidly from 26,640 tonnes to 64,680 tonnes, but growth seems to have slowed from 2010 to the present.

6.4 Robustness Checks

The target of robustness analysis is to evaluate the model to the empirical properties of agricultural productivity. The researcher performed several robustness tests and unveils the central role of production data. The robustness analysis focuses only on agricultural production but the author's conclusions are also valid for estimation models.

The robustness tests for crop specification are given in Table A4 in the Results Table of the Appendix section. The author used the same model as in the main estimation from Equation (8). Alternatively, only direct agricultural input was used as endogenous variables such as agricultural land, land with full access to water based on irrigation system, tractors, fertilizers, pesticides, employment, net capital schock in agriculture, credit in agriculture and RDB funds in agriculture. More than 21 variations were used as instrument variables in different specifications of crop products. The instrument variables in this robustness analysis include crop index, temperature change, gross fixed capital in agriculture, technical support, foeign aid in agriculture, value-added per capita, value-added in agriculture, capital fixed of consumption, taxes less subsidies on products, harvested area, yield and production of each product. All endogenous variables were also used as instrument variables.

The result of this robustness is not significantly different from the main result in Sub-section 6.2. When reducing the number of endogenous variables in the estimator, many specifications from (1)–(32) have an increased positive coefficient and many independent variables have a different statistical significance level. Likewise, numerous specifications of the crop in two-step GMM estimation do not reject the null hypothesis of the validity of overidentifying restrictions.

Column (23) reports robustness test result of specification C23 that represented pappy rice. For example, pappy rice in this estimation shows that land with full access to water by irrigation, tractors and net capital shock of agriculture have statistical significance at 99% and positive consequence on the growth of pappy rice. An increase of 3.24% water through the irrigation system will lead to an increase of 1% for pappy rice growth. Agricultural land and pesticides used have a negative impact on production growth when other inputs used such as fertilizers, employment, credit in agriculture, and RDB funds do not have consequences for the estimator. But when the author look at the main estimation result of pappy rice in Table A4, the answer shows that credit used and RDB funds have a statistical significance and positive effect on pappy rice output.

Table A5 in the Appendix section reports a robustness test result of livestock products. Similarly, in the robustness test of the crop product, many indirect inputs were used as the instrument variables and only direct inputs were used as endogenous variables. The results show that many specifications have statistical significance and positive impact on the production growth. In addition, the Hansen test of all specifications do not reject the null hypothesis of the validity of overidentifying restrictions. This answer is different from the main estimation result in Table A3 while many endogenous variables do not correlate with dependent variables. The change due to many variable joints in the model is the main cause of specifications weakness and non correlation. For example, column (3) reports the result of the cattle meat estimator. The result shows that agricultural land, employment, net capital shock, and credit in farming have statistical implication at different levels and are positive and negative efficient to the cattle meat production. Nevertheless, the results from column (3) in Table A3, only employment and gross fixed capital formation in farming have a correlation to the model.

7 Policy Discussion

When we think about agricultural and rural development policy, it is clear that the Cambodian government's objective is to reduce poverty and ameliorate household income (RGC, 2018). The establishment of the ARDB is a roadmap and an indicator to achieve this long-term goal. Nevertheless, so far, there is insufficient statistical evidence on the results obtained by the ARDB to contribute directly to the economic improvement of household farming. In addition, based on RDB information (2010; 2014; 2018) the credit and capital revenue of the ARDB have increased year by year, showing that it has performed well (see descriptive statistics in Table A6).

Recently, the Cambodian authorities have guided the ARDB to explore options for loans in the livestock and fisheries sub-sector hoping to have the capacity to access complete food security in the local market and to reduce food imports. According to this vision, ARDB's current investment loans have focused on SMEs and farmers in these sub-sectors.

The ARDB provides operative capital credit to local SMEs related to agriculture and processing, farmers, and agricultural communities. The credit it provides can be short-term, for one year, and more than one year. Each SMEs can apply to request working capital. All applicants are assessed, with verification of reference information and observations by the ARDB specialist team. The special working capital package evaluates only two day and investment loans have a long process to evaluate between 15 to 30 days. Successful applicants will receive funding for use in farming production, processing, and investment. The main problem for applicants in accessing capital from the ARDB is collateral. Many applicants do not have solid administrative documents, portfolios and land ownership plan.[20] Low interest rates can go a long way to helping SMEs that have limited short- and medium-term financing and working capital.

The ARDB alone cannot help much in financing with low interest rates. For example, many farmers and SMEs discussed credit from the bank, microfinance and local lenders to invest in their production and agricultural value chain at high interest rates. Previously, more than 75% of ARDB financing was provided to the rice sector for use in collecting paddy from farmers and rice millers (see detail on the Context section). In general, Cambodia has a paddy surplus around 4 million tonnes which requires working capital approximately US $400 million for paddy traders and rice millers to use to buy the product from farmers. Overall, the core activity of the ARDB

[20]Interview between the ARDB CEO Kao Thach with Apsara TV. See on ARDB YouTube chancel: https://www.youtube.com/watch?v=Gsj5KN6xeTg.

is based on policy set by the authorities and includes emergency events in agriculture.

Based on the two-step GMM result in Section 6, production and net income of each product (as see in Table A2 and A3), shows different performance due to the effectiveness of input use and market. These results have shown that crops such as cassava, dry chilies and peppers, grapefruit and pomelos, green coffee, lemons and limes, mangoes, nuts, paddy rice, prineapples, roots and tubes have increased income over time (see in Figure 3 of the Additional Graphics in Appendix). Simultaneously, Figure 4 shows that gross income of duck meat and other bird eggs in shells has been radically enhanced over the period of the last 60 years. Other products described above have had irregular incomes over a period of time due to market conditions, production, climate change, insects and other natural destruction. The researcher would like to suggest government ownership of banks should afford financial support to all of these products that have mentioned above. Even some products in this suggestion have negative efficiency of direct and indirect inputs used according to the main estimation results. But it cannot be denied that all of these products are not potential products due to the income of these products increasing rapidly over a period. However, a conclusion like this may cause much judgment in social sciences. It calls for the specific study of one product to one product in the value chain, production flow, productivity, income, market flow and market cycles. After that, finally, we can do the comparison between one product to one product.

In addition, some researchers suggest mangos and bananas can be considered as significant products for export to China though the China-Cambodia Free Trade Agreement (CCFTA). Investors normally inquire about working capital in the harvest season to buy mangoes and bananas from farmers, spending on packaging, and transportation to the international market. Many SMEs working in these products lack working capital in the harvest season, therefore, they discuss loans from the banks and MFIs at high interest rates. Revising the government owned-bank's budget for these products is a good thing that could help the growth of agricultural exports.

Policy Recommendation

This section provides some policy options to optimize public bank use financing and help to improve Cambodia's agricultural sector. Several suggestions may be far-fetched and difficult for the ARDB to achieve but attempt to do something new that conveys and accomplishes alternatives to solve the financial problems and deficiency of agricultural techniques.

Option 1 The government-owned bank should work instantly and efficiently with the MAFF and other technical agricultural agencies with the aim of raising the use of lenders' credit. Although the banks have experts to analyze the credit risks, it would be advisable that the farming technical institutes help in production risk analysis, technical support to agriculture, and develop business partnerships. Credit provision and technical corroboration have been successful in numerous agriculturally developed countries and some developing parts of the agricultural worlds.

Public banks experts support financial management, financial analysis and investment analysis, and the customer service department provides information to almost all business partners (see detail in Option 3). Lastly, the government-owned banks' partner should support as a technical consultant and assistant, and technology assistant. While the above conditions are met, it requires farm investors with good budget management, leadership, mission, vision, and excellent communication and marketing. Thus, the power of investment loans and working capital loans will have a double positive impact on the agriculture sector's growth and public banks.

Option 2 The government-owned bank should provide loans and bonds for farm investment projects managed by farmers, agricultural communities, and farm businesses with a high commitment. It cannot afford to borrow money at the high bank and microfinance interest rates. Interventions such as by this suggestion can help promote new investors and those who want to continue working in the agricultural sector. The public bank should consider loans for products that researchers suggest (see in Policy Discussion section) by further studying completely about those items, the market and the ability to increase revenues from their production. At the same time, credit processes and administrative services must be fast, agile, reliable, of good quality, and secure. Public banks should improve their work process though the addition of new technology innovation such as the creation of online platforms or mobile applications in order to enable customers to fill out loans and savings forms, and finance flows like transfer and repayment of interest through fast and highly secure technology systems. This new technology platform can be the right place to store data, receive information from customers and ask questions about farm credit, development, business partners and technical aspects. It is difficult for customers who have some knowledge about the use of technology in the early stages, especially farmers and seniors. However, before and after introducing technology into the financial system, starting immediately is the best time. As a first step, the bank should train staff and stakeholders on the use of new technologies, so that they are able to use all the resources to provide services to clients and provide guidance on how to use the new system. The second step is to introduce the technology to tech-savvy teenagers and then try to extend that use to an older group of clients who have less understanding of this use of technology.

Option 3 The market is a crucial factor in contributing to the growth of agriculture. Success and failure in agriculture are mostly dependent on the market. Although this work is far from being the role of public banks, it would be preferable for the bank to partner with the agricultural buyer for commodities in raw materials, intermediates and final products. If banks have partnerships with agriculture experts, agriculture development agencies, financial experts, management experts, and buyers and sellers in agriculture, it will make the public bank an ideal place for data sources relevant to agriculture sector. Government ownership of banks can create a new role for them as a consultant and informant on agricultural markets. When agricultural investors borrow money, the bank guides business partners to purchase products and supply raw materials, especially to introduce partners that can be supportive in various ways. Once investors have all this information and get the money to invest, the investor tries to grow his job and his ability to negotiate with buyers and supplies on the next job. Furthermore, this information should be made to outsiders who have not borrowed money from the state banks and the MAFF.

Option 4 All-new targets set by the government for state-owned banks must not affect former and existing jobs. Immediate targeting includes urgent areas in the agricultural sector, such as declining agricultural prices, lack of market, lack of products to sell in the market, or for export. While creating an urgent task for the bank, add new actors can be enabled to help in the role with awareness being given to the fact that many staff from different institutions have worked together to solve these issues previously. It is important to make changes that will not cause more problems. There must be a division of roles between the institution involved and a central facilitator who can effectively encourage individuals from different workplaces to work collaboratively. In addition, efforts to improve work efficiency, meeting with experts and stakeholders to find new ideas and consultations are also crucial for public banks during times of financial crisis and other urgent events in agriculture. The government's new aid emergency package assistance program must be used with transparency and accountability to ensure that those most affected can get help.

8 Conclusion

Agriculture remains a significant sector in terms of rural economic development, food security and exports. The Cambodian agricultural sector has grown remarkably slowly. Farming development has been slow in a not yet modernized system. It cannot respond to climate change, and is unable to produce in high quality.

This paper endeavors to identify potential productions and factors in Cambodia's agriculture sector that government ownership of banks should subsidize while creating useful policies to support. With this, the ARDB is a monopoly public bank in Cambodia that has the role of supporting business links to agricultural production. This article finds that agricultural inputs such as water through irrigation, tractors, fertilizers, employment, and net capital stock in agriculture are not very efficient for crop production. This result confirms the findings of Chhun *et al.* (2020); Eliste and Zorya (2015); Sareth *et al.* (2020); Wokker *et al.* (2014). The author also finds that many direct and indirect inputs are not correlated with livestock product estimators. Simultaneously, this research notes that value-added per capita in agriculture, consumption of agricultural products, and taxes on fewer subsidies in the products cannot be a significant driver of growth in production in the crop and livestock sub-sector.

This paper contributes to the literature on agriculture financing for small businesses, diversification, government ownership of banks, subsidy, and two-step GMM estimator in agriculture by moving that research to the agricultural sector. As with other economic sectors in Cambodia, the limited of microdata on specific products and market information in the crop and livestock sub-sector reveals a significant gap in this paper. The explicit comparison of the potential products and factors in agriculture due to alleviating production data and market information constraints is beyond the scope of this paper. The results indicate that research addressing the combination of these other econometric methods with theoretical methods and policy discussions on the micro datasets in specific products, market information and value chains in the crop and livestock sub-sector in a particular region or province would be a useful addition to the literature.

References

ADB (2012). *Cambodia: Financial Sector Development Strategy 2011-2020*. Policy Paper, Asian Development Bank.

Altunbas, Y., Evans, L. and Molyneux, P. (2001). Bank Ownership and Efficiency. *Journal of Money, Credit and Banking*, **33** (4), 926–954.

Andrianova, S., Demetriades, P. and Shortland, A. (2010). *Is Government Ownership of Banks Really Harmful to Growth?* DIW Berlin Discussion Paper 978, Social Science Research Network.

Ang, F., Mortimer, S. M., Areal, F. J. and Tiffin, R. (2018). On the Opportunity Cost of Crop Diversification. *Journal of Agricultural Economics*, **69** (3), 794–814.

Aragón, F. M., Oteiza, F. and Rud, J. P. (2019). *Climate Change and Agriculture: Subsistence Farmers' Response to Extreme Heat*. Working Paper.

ARDB (2020, March 17). Announcement: Renaming the Rural Development Bank (Specialized Bank) to the Agricultural and Rural Development Bank (Commercial Bank). https://twitter.com/bank_rural/status/1239729924711178240.

Bareille, F. and Letort, E. (2018). How do Farmers Manage Crop Biodiversity? A Dynamic Acreage Model with Productive Feedback. *European Review of Agricultural Economics*, **45** (4), 617–639.

Baum, C. F., Schaffer, M. E. and Stillman, S. (2003). Instrumental Variables and GMM: Estimation and Testing. *Stata Journal*, **4** (1), 1–31.

Bdlink (2017). *Agriculture and Agro-Processing Sector in Cambodia*. Report, Bdlink (Cambodia) Co., Ltd.

Belfield, S., Brown, C. and Martin, R. (2011). *A Guide to Upland Cropping in Cambodia: Soybean*. ACIAR Monograph No. 146, Australian Centre for International Agricultural Research.

Butler, J. S. and Moser, C. (2010). Structural Model of Agricultural Markets in Developing Countries. *American Journal of Agricultural Economics*, **92** (5), 1364–1378.

Cambodia Microfinance Association (2020, January 29). Latest Data for Cambodian Microfinance. Cambodia Microfinance Association. https://cma-network.org/.

Cambodia Rice Federation (2019). *Achievement of Cambodia Rice Federation 2nd Mandate*. Report, Cambodia Rice Federation.

Chea, S. and Horn, T. (2016). *Agriculture Financing*. Research Paper, National Bank of Cambodia.

Chen, J. (2018). *Economic Diversity and Regional Development: Geographical Scale, Structural Measurement, and Modeling Method*. Graduate Theses, Dissertations, and Problem Reports 7166, West Virginia University.

Chhun, C., Vuthy, T. and Keosothea, N. (2020). The Production, Marketing, and Export of Rice in Takeo. In R. Cramb (ed.), *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin*, Palgrave Macmillan.

Costinot, A., Donaldson, D. and Smith, C. (2016). Evolving Comparative Advantage and the Impact of Climate Change in Agricultural Markets: Evidence from 1.7 Million Fields Around the World. *Journal of Political Economy*, **124** (1), 205–248.

Credit Bureau Cambodia (2018). *CBC Annual Report 2018*. Report, Credit Bureau Cambodia.

Culas, R. and Mahendrarajah, M. (2005). Causes of Diversification in Agriculture over Time: Evidence from Norwegian Farming Sector. In *The Future of Rural Europe in the Global Agri-Food System*, The 11th Congress of the European Association of Agricultural Economists.

Demetriades, P. O., Du, J., Girma, S. and Xu, C. (2008). Does the Chinese Banking System Promote the Growth of Firms? In *The 21st Australasian Finance and Banking Conference 2008 Paper*, World Economy & Finance Research Programme Working Paper No. 0036, University of Leicester, Social Science Research Network.

Dillon, A., Sharma, M. and Zhang, X. (2011). *Estimating the Impact of Access to Infrastructure and Extension Services in Rural Nepal*. IFPRI Research Monograph, International Food Policy Research Institute.

Dinç, I. S. (2005). Politicians and Banks: Political Influences on Government-Owned Banks in Emerging Markets. *Journal of Financial Economics*, **77** (2), 453–479.

Dissart, J. C. (2003). Regional Economic Diversity and Regional economic Stability: Research Results and Agenda. *International Regional Science Review*, **26** (4), 423–446.

Doh, S. and Kim, B. (2014). Government Support for SME Innovations in the Regional Industries: The Case of Government Financial Support Program in South Korea. *Research Policy*, **43** (9), 1557–1569.

Eliste, P. and Zorya, S. (2015). *Cambodia Agriculture in Transition: Opportunities and Risks*. Report No. 96308-KH, World Bank Group.

Emerick, K., De Janvry, A., Sadoulet, E. and Dar, M. H. (2016). Technological Innovations, Downside Risk, and the Modernization of Agriculture. *American Economic Review*, **106** (6), 1537–1561.

Farquharson, B., Spriggs, J., Fitzgerald, R., Scott, F., Sotheary, E., Van, T. and Kynal, K. (2013). *Enhancing Production and Marketing of Maize and Soybean in North-Western Cambodia and Production of Summer Crops in North-Eastern Australia*. FR2013 No.28, Australian Centre for International Agricultural Research.

Fiszbein, M. (2017). *Agricultural Diversity, Structural Change and Long-Run Development: Evidence from the U.S.* NBER Working Paper 23183, National Bureau of Economic Research.

Freire, C. (2019). Economic Diversification: A Model of Structural Economic Dynamics and Endogenous Technological Change. *Structural Change and Economic Dynamics*, **49**, 13–28.

Galindo, A. and Micco, A. (2004). Do State Owned Banks Promote Growth? Cross-Country Evidence for Manufacturing Industries. *Economics Letters*, **84** (3), 371–376.

Garmann, S. (2014). Does Globalization Influence Protectionism? Empirical Evidence from Agricultural Support. *Food Policy*, **49** (P1), 281–293.

Garrone, M., Emmers, D., Lee, H., Olper, A. and Swinnen, J. (2019). Subsidies and Agricultural Productivity in the EU. *Agricultural Economics*, **50** (6), 803–817.

Goodwin, B. K., Mishra, A. K. and Ortalo-Magné, F. (2011). *The Buck Stops Where? The Distribution of Agricultural Subsidies*. NBER Working Paper 16693, National Bureau of Economic Research.

Hansen, B. E. and West, K. D. (2002). Generalized Method of Moments and Macroeconomics. *Journal of Bussiness Economic Statistics*, **20** (4), 460–469.

Hansen, L. P. (2001). Generalized Method of Moments Estimation: A Time Series Perspective. *International Encyclopedia of Social and Behavioral Sciences*, pp. 9743–9751.

— and Singleton, K. J. (1982). Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models. *Econometrica*, **50** (5), 1269–1286.

Hing, V. and Thun, V. (2009). *Agricultural Trade in the Greater Mekong Sub-region: The Case of Cassava and Rubber in Cambodia*. Working Paper 43, Cambodia Development Resource Institute.

Hornbeck, R. (2010). Barbed Wire: Property Rights and Agricultural Development. *Quarterly Journal of Economics*, **125** (2), 767–810.

Iannotta, G., Nocera, G. and Sironi, A. (2007). Ownership Structure, Risk and Performance in the European Banking Industry. *Journal of Banking & Finance*, **31** (7), 2127–2149.

Ibrahim, H., Rahman, S., Envulus, E. and Oyewole, S. (2010). Income and Crop Diversification Among Farming Households in a Rural Area of North Central Nigeria. *Agro-Science*, **8** (2), 84–89.

IFC (2015). *Cambodia Rice: Export Potential and Strategies*. Cambodia Agribusiness Series No. 4, International Finance Corporation.

Kali, K. and Cheng, S. (2017, February 24). Meat Imports Rack Up $100M. Phnom Penh Post. https://www.phnompenhpost.com/business/meat-imports-rack-100m-tab.

Kanagala, A., Sahni, M., Sharma, S., Gou, B. and Yu, J. (2004). A Probabilistic Approach of Hirschman-Herfindahl Index. IEEE PES Power Systems Conference and Exposition, vol. 3, pp. 1277–1282.

Karas, A., Schoors, K. J. L. and Weill, L. (2008). *Are Private Banks More Efficient than Public Banks? Evidence from Russia*. BOFIT Discussion Paper 3, Social Science Research Network.

Karlan, D., Osei, R., Osei-Akoto, I. and Udry, C. (2014). Agricultural Decisions after Relaxing Credit and Risk Constraints. *Quarterly Journal of Economics*, **129** (2), 597–652.

Keosothea, N. and Molyaneth, H. (2020). Contract Farming of High-Quality Rice in Kampong Speu. In R. Cramb (ed.), *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin*, *16*, pp. 309–326.

Kilkenny, M. and Nalbarte, L. (2002). Keystone Sector Identification. In G. J. D. Hewings, M. Sonis and D. Boyce (eds.), *Trade, Networks and Hierarchies*, Advances in Spatial Science, Springer-Verlag Berlin Heidelberg, pp. 289–314.

Kim, H. J., Byun, S. K. and Park, M. C. (2004). Mobile Handset Subsidy Policy in Korea: Historical Analysis and Evaluation. *Telecommunications Policy*, **28** (1), 23–42.

La Porta, R., Lopez-De-Silanes, F. and Shleifer, A. (2002). Government Ownership of Banks. *Journal of Finance*, **57** (1), 265–301.

Laitner, J. (2000). Structural Change and Economic Growth. *Review of Economic Studies*, **67** (3), 545–561.

Ly, S. (2019). *Cambodia Economic Update: Upgrading Cambodia in Global Value Chains*. Report, World Bank Group.

—, Martin, S., Eduardo, M., Phim, R., Ky, L., Tong, K., Provo, A. M., Nagpal, S. and Vashakmadze, E. T. (2019). *Cambodia Economic Update : Recent Economic Developments and Outlook*. Report, World Bank Group.

MAFF (2011). *Action Plan for Policy Implementation on Rice Production and Exportation*. Policy Paper, Ministry of Agriculture Fisheries and Forestry.

— (2019). *Agricultural Development Policy: 2019-2023*. Policy Paper, Ministry of Agriculture Fisheries and Forestry.

Micco, A., Panizza, U. and Yañez, M. (2007). Bank Ownership and Performance. Does Politics Matter? *Journal of Banking & Finance*, **31** (1), 219–241.

Munroe, N. (2019). *Impact Study on Credit Reporting in Cambodia*. Report, CRS Insights Limited.

NBC (2015). *National Bank of Cambodia: Annual Report 2015*. Report, National Bank of Cambodia.

— (2018a). *Financial Stability Review*. Report, National Bank of Cambodia.

— (2018b). *National Bank of Cambodia: Annual Report 2018*. Report, National Bank of Cambodia.

— (2019). *Economic and Monetary Statistics*. Series No. 313-27th Year, National Bank of Cambodia.

— (2020). Banks and MFIs Data. National Bank of Cambodia. https://www.nbc.org.kh/english/economic_research/banks_reports.php.

Nith, K. (2020, May 21). Cambodia's Agricultural Sector is in Dire Need of Revitalization. Southest Asia Globle. https://southeastasiaglobe.com/cambodias-agricultural-sector-is-one-in-dire-need-of-revitalising.

O'Toole, C. M. and Hennessy, T. (2015). Do Decoupled Payments Affect Investment Financing Constraints? Evidence from Irish Agriculture. *Food Policy*, **56**, 67–75.

—, Newman, C. and Hennessy, T. (2014). Financing Constraints and Agricultural Investment: Effects of the Irish Financial Crisis. *Journal of Agricultural Economics*, **65** (1), 152–176.

Oum, S., Thangavelu, S. and Nuth, M. (2018). A Case Study of Cambodia's Agro-industry. In Jeremy and J. P.S. Intal (eds.), *Reducing Unnecessary Burdens in ASEAN: Country Studies*, *5*, ERIA, pp. 118–143.

Ovesen, J., Trankell, I.-B., Kimvan, H. and Sochoeun, C. (2012). *Rice Farming and Microcredit in Takeo Province, Cambodia*. Report, Uppsala University and Intean Poalroath Rongroeurng Ltd.

Parvathi, P. (2018). Does Mixed Crop-Livestock Farming Lead to Less Diversified Diets Among Smallholders? Evidence from Laos. *Agricultural Economics*, **49** (4), 497–509.

Paul, C. J. and Nehring, R. (2005). Product Diversification, Production Systems, and Economic Performance in U.S. Agricultural Production. *Journal of Econometrics*, **126** (2), 525–548.

Phlong, P. (2009). *Informal Credit Systems in Cambodia*. Department of Anthropology, Northern Illinois University.

Rahman, S. (2009). Whether Crop Diversification is a Desired Strategy for Agricultural Growth in Bangladesh? *Food Policy*, **34** (4), 340–349.

RDB (2010). *Rural Development Bank: Annual Report 2010*. Report, Rural Development Bank.

— (2014). *Rural Development Bank: Annual Report 2014*. Report, Rural Development Bank.

— (2018). *Rural Development Bank: Annual Report 2018*. Report, Rural Development Bank.

Revilla, D., García-ándres, A. and Sánchez-juárez, I. (2015). Identification of Key Productive Sectors in the Mexican Economy. *Expert Journal of Economics*, **3** (1), 22–39.

RGC (2015). *Cambodia Industrial Development Policy 2015-2025*. Policy Paper, Royal Government of Cambodia.

— (2018). *Rectangular Strategy for Growth, Employment, Equity and Efficiency: Building the Foundation Toward Realizing the Cambodia Vision 2050, Phase IV*. Policy Paper, Royal Government of Cambodia.

— (2019). *National Strategic Development Plan (NSDP) 2019-2023*. Policy Paper, Royal Government of Cambodia.

Rousseau, P. L. and Xiao, S. (2007). Banks, Stock Markets, and China's 'Great Leap Forward'. *Emerging Markets Review*, **8** (3), 206–217.

Sam, V. (2019). *Access to Formal Credit and Gender Income Gap: The Case of Farmers in Cambodia*. MPRA Paper No. 97052, University Library of Munich.

Samrech, P. (2008). *Survey of Tobacco Farming in Cambodia*. Report, Southeast Asia Tobacco Control Alliance.

Sapienza, P. (2004). The Effects of Government Ownership on Bank Lending. *Journal of Financial Economics*, **72** (2), 357–384.

Sareth, C., Cramb, R. and Fukai, S. (2020). The Role of Irrigation in the Commercialisation of Rice Farming in Southern Cambodia. In R. Cramb (ed.), *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin*, *13*, Palgrave Macmillan.

Sargan, J. (1958). The Estimation of Economic Relationships Using Instrumental Variables. *Econometrica*, **26** (3), 393–415.

Shen, C.-H., Hasan, I. and Lin, C.-Y. (2014). The Government's Role in Government-Owned Banks. *Journal of Financial Services Research*, **45** (3), 307–340.

Shyu, J. and Chen, Y.-L. (2009). Diversification, Performance, and the Corporate Life Cycle. *Emerging Markets Finance and Trade*, **45** (6), 57–68.

Sok, C. (2020, January 31). Demand to Modernise Agriculture. Khmer Times. https://www.khmertimeskh.com/50686215/demand-to-modernise-agriculture.

Sothorn, K. (2020). The Use of Credit by Rice Farmers in Takeo. In R. Cramb (ed.), *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin*, *15*, pp. 309–326.

Stiglitz, J. E. (1993). The Role of the State in Financial Markets. *The World Bank Economic Review*, **7** (Suppl 1), 19–52.

Stock, J. H. and Weight, J. H. (2000). GMM with Weak Identification. *Econometrica*, **68** (5), 1055–1096.

Sum, S. and Khiev, P. (2015). *Contract Farming in Cambodia: Different Models, Policy and Practice*. CDRI Working Paper Series No. 104, Cambodia Development Resource Institute.

Thou, V. (2019, September 25). Rice Exports $265M in First Eight Months. Phnom Penh Post. https://www.phnompenhpost.com/business/rice-exports-265m-first-eight-months.

— (2020, February 16). Organic Vegetable Retailer Unveils QR Code Scheme for Origin Source. Phnom Penh Post. https://www.phnompenhpost.com/business/organic-vegetable-retailer-unveils-qr-code-scheme-origin-source.

Wokker, C., Santos, P. and Bansok, R. (2014). Irrigation Water Productivity in Cambodian Rice Systems. *Agricultural Economics*, **45** (4), 421–430.

Zhang, S., Wang, S., Yuan, L., Liu, X. and Gong, B. (2020). The Impact of Epidemics on Agricultural Production and Forecast of COVID-19. *China Agricultural Economic Review*, **12** (3), 409–425.

Appendix

A Results Table

A.1 Market Sharing in Agriculture

Table A1: Cambodian Agricultural Market Participation Between 1959–2018

Code	Commodity	1959-1973 (1)	1974-1988 (2)	1989-2003 (3)	2004-2018 (4)	1959-2018 (5)
C01	Bananas	0.0199	0.0178	0.0155	0.0064	0.0116
C02	Cassava	0.0038	0.0180	0.0151	0.3171	0.1729
C03	Castor oil seed	0.0001	0.0001	0.0001	0.0000	0.0001
C04	Coconuts	0.0082	0.0118	0.0099	0.0048	0.0072
C05	Cotton lint	0.0027	0.0005	0.0001	0.0000	0.0005
C06	Cottonseed	0.0005	0.0001	0.0000	0.0000	0.0001
C07	Dry beans	0.0096	0.0100	0.0050	0.0080	0.0078
C08	Dry chillies and peppers	0.0021	0.0028	0.0022	0.0011	0.0017
C09	Fibre crops	0.0007	0.0003	0.0002	0.0001	0.0002
C10	Fresh fruit	0.0045	0.0110	0.0098	0.0056	0.0069
C11	Fresh vegetables	0.1174	0.1578	0.0958	0.0427	0.0781
C12	Grapefruit and pomelos	0.0011	0.0004	0.0003	0.0001	0.0003
C13	Green coffee	0.0010	0.0003	0.0005	0.0003	0.0004
C14	Groundnuts with shell	0.0083	0.0047	0.0027	0.0038	0.0044
C15	Jute	0.0003	0.0002	0.0001	0.0000	0.0001
C16	Lemons and limes	0.0006	0.0001	0.0002	0.0001	0.0002
C17	Maize	0.0151	0.0083	0.0071	0.0156	0.0129
C18	Mangoes, mangosteens and guavas	0.0066	0.0031	0.0036	0.0027	0.0035
C19	Natural rubber	0.0061	0.0035	0.0045	0.0011	0.0028
C20	Nuts	0.0001	0.0001	0.0001	0.0001	0.0001
C21	Oilseeds	0.0046	0.0021	0.0009	0.0001	0.0012
C22	Oranges	0.0294	0.0337	0.0329	0.0152	0.0232
C23	Paddy rice	0.2600	0.1976	0.2409	0.2399	0.2383
C24	Pepper and piper spp	0.0020	0.0018	0.0019	0.0009	0.0014
C25	Pineapples	0.0042	0.0023	0.0023	0.0014	0.0021
C26	Roots and tubers	0.0005	0.0011	0.0017	0.0011	0.0011
C27	Seed cotton	0.0027	0.0005	0.0001	0.0000	0.0005
C28	Sesame seed	0.0049	0.0035	0.0033	0.0062	0.0051
C29	Soybeans	0.0016	0.0015	0.0057	0.0095	0.0066
C30	Sugarcane	0.2981	0.2173	0.1277	0.1191	0.1591
C31	Sweet potatoes	0.0019	0.0038	0.0022	0.0012	0.0018
C32	Unmanufactured tobacco	0.0125	0.0109	0.0083	0.0055	0.0077
L01	Buffalo meat	0.0075	0.0226	0.0185	0.0062	0.0108
L02	Buffalo meat (indigenous)	0.0116	0.0226	0.0187	0.0066	0.0117

Table A1 continued from previous page

Code	Commodity	1959-1973 (1)	1974-1988 (2)	1989-2003 (3)	2004-2018 (4)	1959-2018 (5)
L03	Cattle meat	0.0128	0.0148	0.0239	0.0137	0.0158
L04	Cattle meat (indigenous)	0.0131	0.0148	0.0241	0.0142	0.0162
L05	Chicken meat	0.0103	0.0222	0.0272	0.0119	0.0160
L06	Chicken meat (indigenous)	0.0103	0.0222	0.0271	0.0118	0.0159
L07	Duck meat	0.0021	0.0050	0.0056	0.0036	0.0040
L08	Duck meat (indigenous)	0.0021	0.0050	0.0056	0.0036	0.0039
L09	Hen eggs in shell	0.0032	0.0062	0.0058	0.0034	0.0042
L10	Other bird eggs in shell	0.0013	0.0028	0.0020	0.0010	0.0015
L11	Pork	0.0451	0.0669	0.1185	0.0598	0.0705
L12	Pork (indigenous)	0.0485	0.0669	0.1184	0.0522	0.0670
L13	Silkworm coiling cocoons	0.0003	0.0002	0.0002	0.0001	0.0001
L14	Whole fresh cow milk	0.0006	0.0008	0.0040	0.0021	0.0021
46	HHI	0.1775	0.1251	0.1170	0.1820	0.1301

Note: The table presents the agricultural market participation between 1959–2018. The author assumed that the total participation equated to 46 agricultural commodities; it means a hundred percent participation in the market. The full contribution of each agricultural product to market is equal to 1 or a hundred percent. The researcher used gross agricultural production value at a price constant between 2004–2006 to build the coefficient. An HHI between 0.15–0.25 (or 1,500–2,500) indicates moderate concentration. As a result of the Herfindahl–Hirschman Index, We see that between 1959–1973 and 2004–2018; the agricultural sector is not a very competitive industry. But between 1959–2018 and others, the agricultural sector is an unconcentrated industry because the value of HHI is below 0.15 (or 1,500).

A.2 Results of Crop GMM Estimation

Table A2: Estimation Results for the Two-Step GMM Model of the Crop

Variable	C01 (1)	C02 (2)	C03 (3)	C04 (4)	C05 (5)	C06 (6)	C07 (7)	C08 (8)
CIndex	-8.1983	194.4893	-0.1588***	0.4917	0.1208*	-0.0300*	130.7735***	1.7623**
	(7.1843)	(317.0582)	(0.0175)	(16.2212)	(0.0474)	(0.0141)	(36.4040)	(0.5542)
LandIrrigation	-0.0008	-3.0621	-0.0001	-0.1249*	0.0002	-0.00001	-0.1014	0.0007
	(0.0313)	(1.6506)	(0.0001)	(0.0506)	(0.0002)	(0.00005)	(0.1181)	(0.0032)
Tractors	-0.0014	-0.0356	0.000003*	0.0004	0.000002	0.0000008	-0.0059	0.0002**
	(0.0010)	(0.0532)	(0.000002)	(0.0013)	(0.000005)	(0.000001)	(0.0034)	(0.0001)
Fertilizer	-0.1787*	4.0408	-0.0017***	0.4029*	0.0006	-0.0001	0.9544*	0.0128
	(0.0880)	(5.6267)	(0.0003)	(0.1849)	(0.0006)	(0.0002)	(0.4447)	(0.0081)
Pesticides	0.0001	0.0211*	-0.000002**	-0.0010***	0.000001	-0.0000005	-0.0004	0.00003**
	(0.0002)	(0.0107)	(0.0000006)	(0.0003)	(0.000001)	(0.0000003)	(0.0007)	(0.00001)
Employment	0.0092***	0.0639	0.000002	-0.0007	-0.000004	0.000006*	-0.0226***	0.0009***
	(0.0018)	(0.1122)	(0.000007)	(0.0031)	(0.000008)	(0.000002)	(0.0064)	(0.0001)
Temperature	0.6721	-114.3193*	-0.0035	-0.4799	0.0037	-0.0004	4.1952*	-0.0024
	(0.7139)	(51.2306)	(0.0019)	(0.5897)	(0.0029)	(0.0008)	(1.9033)	(0.0647)
NCSAgri	0.1708**	-3.1271	0.0014***	0.1628	-0.0004	0.0006***	-0.3871	0.0143**
	(0.0648)	(5.5452)	(0.0004)	(0.1846)	(0.0004)	(0.0001)	(0.4028)	(0.0051)
GFCFAgri	-0.0597	6.6983*	-0.0006***	-0.0990	0.0002	-0.0003***	-0.2556	-0.0037
	(0.0384)	(2.8438)	(0.0002)	(0.1034)	(0.0002)	(0.0001)	(0.2238)	(0.0026)
CreditAgri	-0.0083	1.0954***	-0.0002***	-0.0110	0.0001*	-0.00002	0.0752*	0.0012**
	(0.0075)	(0.2565)	(0.00002)	(0.0150)	(0.00005)	(0.00001)	(0.0312)	(0.0004)
RDBFunds	-0.0109	-0.5203	-0.0003***	0.0570**	0.0001	-0.00003	0.0941	0.0008
	(0.0126)	(0.5805)	(0.00003)	(0.0214)	(0.0001)	(0.00008)	(0.0630)	(0.0009)
TechnicalGrants	-0.0097	0.2688	-0.0001***	-0.0075	0.0001	-0.00002	0.0923***	0.0002
	(0.0057)	(0.1858)	(0.00001)	(0.0073)	(0.00004)	(0.00001)	(0.0236)	(0.0003)
ForeignAid	0.0001	-0.0063	-0.000005**	0.0013	0.000005	0.0000006	0.0036	0.0001*
	(0.0005)	(0.0349)	(0.000002)	(0.0011)	(0.000003)	(0.0000009)	(0.0024)	(0.000006)
FDIAgri	0.0011	1.6561***	-0.00002	0.0169*	0.000007	0.000005	0.0344*	0.0009*
	(0.0049)	(0.2591)	(0.00001)	(0.0068)	(0.00002)	(0.000005)	(0.0144)	(0.0004)
VAAgri	-0.0045	0.2098	-0.0001***	-0.0091	0.00002	-0.00002*	0.0403**	0.0002
	(0.0029)	(0.1780)	(0.00009)	(0.0082)	(0.00002)	(0.000007)	(0.0152)	(0.0003)
VAWorker	0.0306	-0.7168	0.0002***	0.0415*	-0.0002	0.0001*	-0.2116***	0.0029**
	(0.0180)	(0.9590)	(0.0001)	(0.0194)	(0.0001)	(0.000003)	(0.0526)	(0.0009)
CFCAgri	-2.5482*	42.6882	-0.0200***	-2.7361	0.0053	-0.0096***	5.0401	-0.2257**
	(1.0451)	(90.1353)	(0.0058)	(3.0117)	(0.0059)	(0.0023)	(6.4513)	(0.0843)
FCE	-0.0039	0.2386**	0.00004***	0.0069*	-0.00002	0.000001	0.0259***	-0.0008***
	(0.0021)	(0.0900)	(0.000003)	(0.0027)	(0.00001)	(0.000003)	(0.0069)	(0.0001)
TaxesSubsidies	0.0304***	-1.4487**	-0.00004***	-0.0083	0.00003	0.000004	-0.0753***	0.0013**
	(0.0088)	(0.4799)	(0.000009)	(0.0073)	(0.00003)	(0.000008)	(0.0169)	(0.0004)
Constant	0.0886	-146.1604	0.2640***	40.8144**	0.0599	0.0116	23.5871	-1.4612*
	(8.1903)	(517.4292)	(0.0346)	(14.7409)	(0.0387)	(0.0119)	(32.6795)	(0.6881)
Observations	30	30	30	30	30	30	30	30
R-squared	0.9074	0.9979	0.7235	0.8475	0.8034	0.7351	0.9611	0.9940
Hansen test	0.0062	0.0085	0.2300	0.0653	0.0622	0.0246	0.0797	0.0167

Table A2 continued from previous page

Variable	C09 (9)	C10 (10)	C11 (11)	C12 (12)	C13 (13)	C14 (14)	C15 (15)	C16 (16)
CIndex	0.0853	-10.8461**	107.3922**	-0.1024	-1.1047***	-9.2977	-0.5848*	-0.4778**
	(0.0886)	(3.3299)	(40.7379)	(0.0564)	(0.2158)	(9.7827)	(0.2730)	(0.1734)
LandIrrigation	0.00001	-0.0034	-0.3397	-0.0019***	-0.0007	-0.1806***	0.0039***	-0.0031***
	(0.0002)	(0.0110)	(0.2065)	(0.0002)	(0.0009)	(0.0386)	(0.0008)	(0.0006)
Tractors	0.0001***	0.0013***	0.0043	0.00003***	-0.00004	0.0044**	0.00003	0.00005***
	(0.000008)	(0.0002)	(0.0049)	(0.000008)	(0.00002)	(0.0014)	(0.00002)	(0.00001)
Fertilizer	-0.0003	-0.1130**	1.5208*	0.0003	-0.0069*	0.1680	-0.0157***	-0.0021
	(0.0009)	(0.0431)	(0.7755)	(0.0008)	(0.0032)	(0.1734)	(0.0034)	(0.0025)
Pesticides	0.000005**	0.0002***	-0.0040**	0.000005***	-0.00001	0.0004	-0.00001*	0.000003
	(0.000002)	(0.0001)	(0.0013)	(0.00007)	(0.000001)	(0.0004)	(0.000006)	(0.000004)
Employment	0.00003	0.0031***	0.0062	0.0001***	0.0003***	-0.0063**	-0.0003***	0.0002***
	(0.00002)	(0.0006)	(0.0089)	(0.00001)	(0.0001)	(0.0024)	(0.0001)	(0.00004)
Temperature	-0.0002	-0.4242*	1.3313	-0.0048	0.0266	-0.2222	-0.0010	-0.0018
	(0.0047)	(0.1647)	(3.0001)	(0.0032)	(0.0175)	(0.8909)	(0.0184)	(0.0100)
NCSAgri	-0.0009	0.0831*	0.1949	0.0031***	0.0091***	-0.0461	-0.0154***	0.0039
	(0.0006)	(0.0339)	(0.4156)	(0.0007)	(0.0028)	(0.0872)	(0.0017)	(0.0022)
GFCFAgri	0.0004	-0.0040	0.1764	-0.0010*	-0.0056***	0.0609	0.0079***	-0.0014
	(0.0004)	(0.0177)	(0.2698)	(0.0004)	(0.0013)	(0.0538)	(0.0009)	(0.0011)
CreditAgri	0.00002	-0.0093**	0.0058	-0.0002**	-0.0010***	-0.0208*	-0.0005	-0.0004*
	(0.0001)	(0.0032)	(0.0382)	(0.00002)	(0.0002)	(0.0099)	(0.0002)	(0.0002)
RDBFunds	-0.0001	-0.0214***	0.1007	-0.0003***	-0.0007	-0.0519**	-0.0014***	-0.0005*
	(0.0001)	(0.0055)	(0.0851)	(0.0001)	(0.0004)	(0.0197)	(0.0004)	(0.0003)
TechnicalGrants	0.0001	-0.0075***	-0.0172	-0.0002***	-0.0007***	-0.0080	0.0002	-0.0004**
	(0.00005)	(0.0021)	(0.0266)	(0.000005)	(0.0002)	(0.0078)	(0.0002)	(0.0001)
ForeignAid	-0.000007	-0.0004	0.0008	0.000002	-0.00002	-0.0017*	-0.0001***	-0.000008
	(0.000006)	(0.0002)	(0.0035)	(0.000005)	(0.00002)	(0.0008)	(0.00002)	(0.00001)
FDIAgri	-0.0001***	0.0042*	-0.0118	0.0001*	-0.0005***	-0.0172*	-0.0006***	-0.0001
	(0.00003)	(0.0016)	(0.0261)	(0.00002)	(0.0001)	(0.0076)	(0.0001)	(0.0001)
VAAgri	-0.0000005	-0.0018	0.0083	-0.0001***	-0.0003*	0.0011	-0.0002	-0.0001
	(0.00004)	(0.0019)	(0.0228)	(0.00002)	(0.0001)	(0.0043)	(0.0001)	(0.0001)
VAWorker	0.0001	0.0294***	0.0603	0.0010***	0.0016**	0.0558**	-0.0016***	0.0014***
	(0.0001)	(0.0054)	(0.0698)	(0.0001)	(0.0005)	(0.0215)	(0.0005)	(0.0003)
CFCAgri	0.0135	-1.3677*	-2.1141	-0.0515***	-0.1326**	0.1382	0.2600***	-0.0612
	(0.0109)	(0.5412)	(7.0113)	(0.0119)	(0.0449)	(1.4454)	(0.0281)	(0.0355)
FCE	-0.00002	-0.0011**	-0.0072	0.000005	0.0002**	0.0111***	0.0001*	0.0001
	(0.00002)	(0.0004)	(0.0074)	(0.00002)	(0.0001)	(0.0022)	(0.00004)	(0.00002)
TaxesSubsidies	-0.00004	0.0133***	-0.1207**	-0.0001**	0.0004*	-0.0387***	-0.0003*	-0.0001
	(0.00004)	(0.0021)	(0.0409)	(0.00003)	(0.0002)	(0.0109)	(0.0001)	(0.0001)
Constant	0.0686	8.3269***	75.0958	0.3756***	0.0254	48.4922***	1.0695***	0.3651*
	(0.0981)	(2.1064)	(41.0947)	(0.0679)	(0.2380)	(8.5314)	(0.1714)	(0.1463)
Observations	30	30	30	30	30	30	30	30
R-squared	0.9960	0.9944	0.9417	0.9960	0.9889	0.9726	0.8557	0.9890
Hansen test	0.0074	0.1709	0.0026	0.0573	0.2165	0.0107	0.2986	0.0442

Table A2 continued from previous page

Variable	C17 (17)	C18 (18)	C19 (19)	C20 (20)	C21 (21)	C22 (22)	C23 (23)	C24 (24)
CIndex	-37.2330	-2.2461	1.6208	-0.1221***	3.0255	-50.8646*	-591.175***	-0.6930
	(56.8386)	(3.2449)	(6.2917)	(0.0242)	(1.9046)	(21.4335)	(99.9941)	(0.5442)
LandIrrigation	-0.9713***	-0.0147	0.0092	-0.0006***	0.0465***	-0.2946***	0.3041	0.0041
	(0.2732)	(0.0086)	(0.0276)	(0.0001)	(0.0066)	(0.0628)	(0.5690)	(0.0030)
Tractors	0.0234***	0.0005***	-0.0018*	0.0001***	0.0001	-0.0003	-0.0480**	0.0005***
	(0.0063)	(0.0002)	(0.0009)	(0.000005)	(0.0002)	(0.0021)	(0.0166)	(0.0001)
Fertilizer	-0.2079	-0.0292	-0.1604	-0.0014**	-0.0597*	-0.1236	4.2471*	-0.0162*
	(0.7943)	(0.0290)	(0.1011)	(0.0005)	(0.0248)	(0.2204)	(2.0970)	(0.0082)
Pesticides	-0.0110***	-0.00002	-0.0001	0.000006***	-0.000006	-0.0001	-0.0292***	0.0001**
	(0.0014)	(0.0001)	(0.0002)	(0.0000009)	(0.00004)	(0.0004)	(0.0040)	(0.00002)
Employment	-0.0227*	0.0004	0.0072***	0.0001***	-0.0004	0.0112***	-0.0998***	0.0008***
	(0.0100)	(0.0007)	(0.0016)	(0.00009)	(0.0003)	(0.0031)	(0.0282)	(0.0001)
Temperature	-11.5304**	0.0970	0.5053	-0.0073***	0.0507	-1.8284	-10.4679	0.0044
	(3.8175)	(0.1091)	(0.4564)	(0.0022)	(0.1320)	(1.1439)	(26.3349)	(0.0379)
NCSAgri	1.6177**	0.0124	0.1963**	0.0007	0.0014	0.2514**	1.2213	-0.0066
	(0.5474)	(0.0250)	(0.0661)	(0.0005)	(0.0143)	(0.0923)	(1.4830)	(0.0066)
GFCFAgri	-0.2106	-0.0115	-0.0765	0.0002	0.0182*	-0.1394	-1.7319*	0.0087
	(0.3096)	(0.0129)	(0.0406)	(0.0003)	(0.0084)	(0.0719)	(0.7153)	(0.0044)
CreditAgri	-0.2371***	-0.0037	-0.0033	-0.0001***	0.0012	-0.0415*	0.4017***	-0.0004
	(0.0515)	(0.0031)	(0.0057)	(0.00002)	(0.0017)	(0.0190)	(0.0839)	(0.0005)
RDBFunds	-0.0102	-0.0064*	-0.0116	-0.0003***	-0.0077*	-0.0395	1.1772***	-0.0023
	(0.0988)	(0.0031)	(0.0110)	(0.0001)	(0.0033)	(0.0297)	(0.2440)	(0.0012)
TechnicalGrants	-0.0445	-0.0022	-0.0062*	-0.0001***	0.0010	-0.0435**	0.1378	-0.0008*
	(0.0292)	(0.0014)	(0.0029)	(0.00001)	(0.0011)	(0.0159)	(0.0782)	(0.0003)
ForeignAid	-0.0107*	-0.0002	0.0004	0.0000004	-0.0001	-0.0012	0.0313**	-0.000009
	(0.0047)	(0.0002)	(0.0005)	(0.000002)	(0.0001)	(0.0012)	(0.0112)	(0.00005)
FDIAgri	-0.0163	-0.0015	0.00005	0.00003	-0.0016	0.0091	0.1682	-0.0004
	(0.0350)	(0.0013)	(0.0040)	(0.00002)	(0.0009)	(0.0089)	(0.0900)	(0.0004)
VAAgri	0.0467	-0.0005	-0.0042	-0.00003*	-0.0027**	0.0032	0.6554***	-0.0009***
	(0.0254)	(0.0014)	(0.0022)	(0.00001)	(0.0010)	(0.0097)	(0.0490)	(0.0002)
VAWorker	0.3463***	0.0056	0.0226	0.0006***	-0.0071**	0.1357***	-0.7755**	0.0042***
	(0.0941)	(0.0038)	(0.0126)	(0.00004)	(0.0027)	(0.0302)	(0.2540)	(0.0010)
CFCAgri	-20.3361*	-0.1885	-2.9954**	-0.0125	0.0795	-4.1325**	-21.1141	0.1119
	(9.0057)	(0.4234)	(1.0979)	(0.0088)	(0.2327)	(1.5574)	(23.3088)	(0.1091)
FCE	-0.0483***	0.0019***	-0.0037*	-0.000003**	-0.0015***	0.0110*	0.0466	-0.0004*
	(0.0097)	(0.0005)	(0.0016)	(0.00001)	(0.0004)	(0.0045)	(0.0391)	(0.0002)
TaxesSubsidies	-0.0059	-0.0016	0.0243***	-0.00004*	0.0030**	-0.0392***	0.0240	-0.0004
	(0.0411)	(0.0014)	(0.0070)	(0.00002)	(0.0010)	(0.0097)	(0.1125)	(0.0006)
Constant	-18.5166	4.3251	-18.3803*	-0.0310	-4.6775**	67.3187***	307.5397	-0.2211
	(62.0870)	(3.2368)	(9.0371)	(0.0375)	(1.5810)	(13.2100)	(171.7835)	(0.7044)
Observations	30	30	30	30	30	30	30	30
R-squared	0.9868	0.9956	0.9100	0.9981	0.9721	0.9690	0.9979	0.9885
Hansen test	0.0024	0.1442	0.0170	0.1122	0.1186	0.1035	0.0647	0.0038

Table A2 continued from previous page

Variable	C25 (25)	C26 (26)	C27 (27)	C28 (28)	C29 (29)	C30 (30)	C31 (31)	C32 (32)
CIndex	-3.5640*	0.5307	-0.6005***	59.0134	-18.1869	-0.0878*	12.8889*	97.4332***
	(1.3939)	(0.6156)	(0.0631)	(42.0358)	(34.8045)	(0.0353)	(5.4102)	(15.7228)
LandIrrigation	-0.0009	-0.0098***	0.0024***	1.2236***	1.0155***	-0.0006***	0.0769***	0.3614***
	(0.0050)	(0.0030)	(0.0004)	(0.3150)	(0.1607)	(0.0001)	(0.0220)	(0.0662)
Tractors	0.0002*	0.0004***	0.00005***	-0.0242***	-0.0136***	0.0001***	-0.0018*	-0.0127***
	(0.0001)	(0.0001)	(0.000009)	(0.0060)	(0.0038)	(0.000005)	(0.0007)	(0.0015)
Fertilizer	-0.0321*	0.0174*	-0.0082***	-0.7758	-1.4206***	-0.0006	-0.1154	0.9297**
	(0.0155)	(0.0086)	(0.0012)	(0.6528)	(0.4235)	(0.0005)	(0.1119)	(0.3049)
Pesticides	-0.0001*	0.0001***	-0.000005*	-0.0060***	-0.0034***	0.000006***	-0.0007*	0.0017**
	(0.00003)	(0.00001)	(0.000002)	(0.0010)	(0.0008)	(0.0000009)	(0.0003)	(0.0006)
Employment	-0.0004	0.0011***	-0.00003	-0.0556***	-0.0467***	0.0001***	0.0002	-0.0057
	(0.0002)	(0.0001)	(0.00002)	(0.0089)	(0.0066)	(0.00001)	(0.0017)	(0.0048)
Temperature	-0.0496	0.0026	-0.0064	1.6067	6.6442*	-0.0101***	1.3729**	5.6426***
	(0.0408)	(0.0400)	(0.0053)	(2.6458)	(2.7021)	(0.0019)	(0.5304)	(1.3377)
NCSAgri	-0.0021	0.0158*	-0.0013	-1.3738***	-0.4985	0.0014***	0.1922*	-0.5237
	(0.0105)	(0.0067)	(0.0014)	(0.3873)	(0.3737)	(0.0004)	(0.0891)	(0.3038)
GFCFAgri	0.0017	-0.0074*	0.0022**	-0.2448	-0.1703	-0.0003	-0.1313**	0.1345
	(0.0054)	(0.0037)	(0.0007)	(0.2220)	(0.2170)	(0.0002)	(0.0478)	(0.1541)
CreditAgri	-0.0044***	0.0005	-0.0005***	0.0162	-0.1019***	-0.0001	-0.0031	0.1173***
	(0.0013)	(0.0004)	(0.0001)	(0.0450)	(0.0308)	(0.00003)	(0.0054)	(0.0123)
RDBFunds	-0.0057**	0.0006	-0.0011***	0.0724	-0.0243	-0.0002*	-0.0079	0.1955***
	(0.0020)	(0.0011)	(0.0001)	(0.1014)	(0.0579)	(0.0001)	(0.0091)	(0.0253)
TechnicalGrants	-0.0016**	0.0001	-0.0001	0.0046	-0.0105	-0.0001***	0.0067	0.0476***
	(0.0006)	(0.0004)	(0.0001)	(0.0327)	(0.0179)	(0.00001)	(0.0041)	(0.0085)
ForeignAid	-0.0003***	0.0001	-0.00004***	-0.0019	-0.0045	0.000004	0.0004	0.0071***
	(0.0001)	(0.00004)	(0.000006)	(0.0033)	(0.0028)	(0.000003)	(0.0006)	(0.0015)
FDIAgri	0.0013*	0.0004	-0.0002***	-0.2297***	-0.1508***	0.00004*	0.0006	0.0282**
	(0.0006)	(0.0004)	(0.00005)	(0.0322)	(0.0177)	(0.00002)	(0.0038)	(0.0100)
VAAgri	-0.0009	0.0002	-0.0004***	0.0111	-0.0314*	-0.00003*	-0.0040*	0.0604***
	(0.0008)	(0.0003)	(0.00004)	(0.0252)	(0.0146)	(0.00001)	(0.0018)	(0.0062)
VAWorker	0.0053**	0.0045***	0.0002	-0.5220***	-0.2757***	0.0006***	-0.0084	-0.1618***
	(0.0017)	(0.0012)	(0.0002)	(0.0982)	(0.0536)	(0.00004)	(0.0116)	(0.0330)
CFCAgri	0.0990	-0.2642*	0.0336	22.8732***	10.8381	-0.0238***	-2.6921	6.1136
	(0.1689)	(0.1102)	(0.0232)	(6.3367)	(6.0581)	(0.0063)	(1.4544)	(4.9026)
FCE	0.0007***	-0.0002*	-0.000002	0.0800***	0.0397***	-0.00002*	-0.0017	-0.0117***
	(0.0002)	(0.0001)	(0.00002)	(0.0148)	(0.0082)	(0.000009)	(0.0012)	(0.0034)
TaxesSubsidies	-0.0018**	0.0004	0.00003	-0.1223**	0.0140	-0.00003	0.0182**	0.0554***
	(0.0006)	(0.0003)	(0.0001)	(0.0375)	(0.0229)	(0.00002)	(0.0063)	(0.0141)
Constant	4.2074***	-0.7826	0.1871*	-72.5890	-47.3051	-0.0731	-24.5867***	-70.3773***
	(1.0867)	(0.6092)	(0.0797)	(61.9699)	(41.5487)	(0.0512)	(6.7614)	(18.1845)
Observations	30	30	30	30	30	30	30	30
R-squared	0.9951	0.9981	0.8231	0.9057	0.9717	0.9982	0.7781	0.9411
Hansen test	0.0299	0.0242	0.1239	0.0210	0.0090	0.0934	0.0089	0.0352

Note: All models are two-step GMM estimates. The row for the Hansen J-test reports the p-values for the null hypothesis of instrument validity. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.3 Results of Livestock GMM Estimation

Table A3: Estimation Results for the Two-Step GMM Model of the Livestock

Variable	L01 (1)	L02 (2)	L03 (3)	L04 (4)	L05 (5)	L06 (6)	L07 (7)
LIndex	-30.5980	-26.8487	21.7303	19.8166	-140.2263***	-135.8415***	36.4574***
	(27.6738)	(25.2397)	(45.3714)	(40.1902)	(16.0302)	(11.3303)	(5.7823)
Employment	0.0015	0.0025	0.0171*	0.0127	0.0062	0.0036	0.0056***
	(0.0068)	(0.0058)	(0.0078)	(0.0069)	(0.0039)	(0.0032)	(0.0015)
Temperature	-0.4370	-0.6641	-2.4070	-2.8166*	-1.9736*	-1.9432***	-0.5797
	(1.0327)	(0.9222)	(1.6889)	(1.4006)	(0.8485)	(0.5692)	(0.4544)
NCSAgri	0.1278	0.1743	0.3648	0.3444	-0.0323	-0.0277	0.1555*
	(0.1998)	(0.1673)	(0.2261)	(0.1873)	(0.1694)	(0.1434)	(0.0637)
GFCFAgri	0.0149	-0.0103	-0.2124*	-0.2457**	-0.1729*	-0.1850**	-0.0816**
	(0.0806)	(0.0662)	(0.1064)	(0.0752)	(0.0754)	(0.0607)	(0.0257)
CreditAgri	-0.0097	-0.0094	-0.0030	-0.0147	0.0197**	0.0018	-0.0038
	(0.0061)	(0.0059)	(0.0107)	(0.0100)	(0.0076)	(0.0049)	(0.0032)
RDBFunds	-0.0476***	-0.0404***	0.0223	0.0416	0.0074	0.0128	-0.0010
	(0.0110)	(0.0106)	(0.0284)	(0.0223)	(0.0145)	(0.0080)	(0.0060)
TechnicalGrants	-0.0104	-0.0147**	-0.0022	-0.0011	0.0071	0.0046	-0.0025
	(0.0061)	(0.0054)	(0.0157)	(0.0113)	(0.0069)	(0.0053)	(0.0030)
ForeignAid	-0.0002	-0.0003	0.0012	0.0001	0.0021*	-0.0002	-0.0002
	(0.0009)	(0.0009)	(0.0017)	(0.0014)	(0.0011)	(0.0006)	(0.0004)
FDIAgri	0.0059	0.0095	-0.0036	-0.0054	-0.0071	-0.0115*	-0.0133***
	(0.0094)	(0.0092)	(0.0215)	(0.0194)	(0.0067)	(0.0048)	(0.0026)
VAAgri	-0.0069	-0.0076*	-0.0020	-0.0037	0.0025	0.0019	-0.0010
	(0.0038)	(0.0033)	(0.0048)	(0.0049)	(0.0051)	(0.0046)	(0.0027)
VAWorker	0.0616**	0.0704***	0.0433	0.0354	-0.0112	-0.0104	0.0121
	(0.0227)	(0.0190)	(0.0327)	(0.0273)	(0.0189)	(0.0170)	(0.0092)
CFCAgri	-2.1967	-2.8150	-5.9576	-5.2280	-0.0242	0.2777	-2.3388*
	(3.0902)	(2.5880)	(3.4743)	(2.9124)	(2.6627)	(2.2570)	(0.9763)
FCE	0.0009	-0.0010	-0.0001	0.0009	0.0149***	0.0149***	-0.0019
	(0.0064)	(0.0057)	(0.0081)	(0.0073)	(0.0037)	(0.0029)	(0.0012)
TaxesSubsidies	-0.0191	-0.0155	0.0287	0.0238	-0.0255	-0.0317**	0.0120*
	(0.0213)	(0.0194)	(0.0303)	(0.0271)	(0.0135)	(0.0103)	(0.0050)
Constant	70.9555	58.7389	-65.4513	-54.6891	262.1270***	252.3085***	-75.1185***
	(67.6453)	(60.5071)	(92.5921)	(84.6693)	(37.2487)	(27.8570)	(13.6150)
Observations	30	30	30	30	30	30	30
R-squared	0.8721	0.8105	0.9563	0.9713	0.9479	0.9630	0.9855
Hansen test	0.0408	0.0206	0.0088	0.0070	0.0028	0.0289	0.8812

Variable	L08 (8)	L09 (9)	L10 (10)	L11 (11)	L12 (12)	L13 (13)	L14 (14)
LIndex	35.3257***	26.6621*	2.7378***	-227.0047	510.4103**	-0.3033	1.2241
	(4.8066)	(11.8848)	(0.7760)	(224.5299)	(182.5438)	(0.3241)	(9.7418)
Employment	0.0058***	0.0048	0.0006***	-0.0557	0.1331**	0.0000006	0.0080***
	(0.0014)	(0.0027)	(0.0002)	(0.0528)	(0.0463)	(0.0001)	(0.0024)
Temperature	-0.4342	-1.3840	0.0651	-23.2213***	4.8656	0.0037	-0.0222
	(0.4113)	(0.9069)	(0.0456)	(6.5969)	(9.3787)	(0.0156)	(0.4356)
NCSAgri	0.1491*	0.1426	0.0063	-1.8934	2.4040	0.0032	0.2900**
	(0.0581)	(0.0942)	(0.0081)	(1.9874)	(2.0568)	(0.0021)	(0.1116)
GFCFAgri	-0.0779**	-0.0161	-0.0056	-0.5199	-1.2340	-0.0043***	-0.0956**
	(0.0244)	(0.0370)	(0.0042)	(0.6046)	(0.8077)	(0.0010)	(0.0360)
CreditAgri	-0.0027	-0.0109*	-0.0002	0.0043	0.0326	0.00004	-0.0107***
	(0.0031)	(0.0055)	(0.0004)	(0.0474)	(0.0900)	(0.0001)	(0.0021)
RDBFunds	-0.0039	-0.0098	-0.0011	0.1048	-0.3866*	0.0003	-0.0208***
	(0.0059)	(0.0098)	(0.0008)	(0.1296)	(0.1739)	(0.0003)	(0.0061)
TechnicalGrants	-0.0022	-0.0015	-0.00004	-0.0287	-0.2059**	0.0001	-0.0053
	(0.0029)	(0.0033)	(0.0005)	(0.0639)	(0.0754)	(0.0001)	(0.0045)
ForeignAid	-0.0002	0.0018	-0.0001	-0.0016	0.0100	0.00002	0.0008*
	(0.0003)	(0.0010)	(0.00004)	(0.0039)	(0.0073)	(0.00001)	(0.0003)
FDIAgri	-0.0136***	-0.0012	-0.0001	0.0452	0.1549***	-0.0002	-0.0001
	(0.0027)	(0.0040)	(0.0005)	(0.0388)	(0.0432)	(0.0002)	(0.0023)
VAAgri	-0.0016	-0.0028	-0.0004	0.0733	-0.0882	0.00005	-0.0129***
	(0.0026)	(0.0027)	(0.0003)	(0.0558)	(0.0794)	(0.0001)	(0.0024)
VAWorker	0.0111	0.0184	0.0005	-0.0606	0.6464*	-0.00001	0.0581***
	(0.0084)	(0.0101)	(0.0010)	(0.2718)	(0.3005)	(0.0002)	(0.0130)
CFCAgri	-2.2856*	-1.9745	-0.0898	27.2991	-41.3014	-0.0615	-4.5148**
	(0.8908)	(1.4726)	(0.1288)	(30.7990)	(31.9085)	(0.0329)	(1.7436)
FCE	-0.0011	-0.0061*	0.0002	0.1347**	0.0282	0.0001	-0.0010
	(0.0009)	(0.0027)	(0.0002)	(0.0498)	(0.0393)	(0.0001)	(0.0022)
TaxesSubsidies	0.0102*	0.0221*	0.0006	-0.5763***	-0.2056	0.0008*	0.0023
	(0.0042)	(0.0092)	(0.0005)	(0.1602)	(0.1138)	(0.0004)	(0.0082)
Constant	-72.4037***	-56.4672*	-3.3053*	638.5401	-1114.5857*	0.9886	-28.3137
	(11.3279)	(27.4613)	(1.6309)	(555.6171)	(438.3674)	(0.6932)	(23.7258)
Observations	30	30	30	30	30	30	30
R-squared	0.9846	0.9201	0.9882	0.9487	0.9163	0.9112	0.8794
Hansen test	0.6787	0.0863	0.0208	0.0263	0.0008	0.0018	0.0969

Note: Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All models are two-step GMM estimates. The row for the Hansen J-test reports the p-values for the null hypothesis of instrument validity.

A.4 Robustness Checks on Crop Estimator

Table A4: The Two-Step GMM Results of Crop Robustness

Variables	C01 (1)	C02 (2)	C03 (3)	C04 (4)	C05 (5)	C06 (6)	C07 (7)	C08 (8)	C09 (9)
AgriLand	-0.00850*	-0.826	-0.00000356	0.0129**	-0.00000794	-0.00000725	0.0850***	-0.000715**	0.000134*
	(0.00376)	(0.449)	(0.0000221)	(0.00482)	(0.0000126)	(0.00000480)	(0.0128)	(0.000233)	(0.0000580)
LandIrrigation	0.0204*	0.434	-0.0000547	-0.00893	-0.0000790*	-0.0000150	-0.166***	0.00699***	0.000281
	(0.00982)	(1.319)	(0.0000946)	(0.0167)	(0.0000323)	(0.0000135)	(0.0408)	(0.000499)	(0.000199)
Tractors	0.000328	0.143	0.00000676	-0.000963	0.00000223	0.00000258	-0.0122***	0.000138*	0.00000889
	(0.000860)	(0.0974)	(0.00000521)	(0.00127)	(0.00000337)	(0.00000140)	(0.00274)	(0.0000624)	(0.0000127)
Fertilizer	-0.301***	20.20*	-0.000731***	0.0772	0.000119	-0.0000184	-0.329*	-0.00207	-0.000518
	(0.0722)	(9.594)	(0.000221)	(0.0861)	(0.000140)	(0.0000728)	(0.157)	(0.00512)	(0.00113)
Pesticides	0.0000508	-0.0699***	0.00000207**	-0.000221	-0.00000178***	2.39e-08	-0.000984**	0.0000193	0.00000371*
	(0.000168)	(0.0140)	(0.000000728)	(0.000227)	(0.000000289)	(0.000000238)	(0.000377)	(0.0000113)	(0.00000176)
Employment	0.00878***	-0.365***	0.00000162	0.00174	-0.0000179***	-0.00000253***	-0.0139***	0.000606***	0.0000343***
	(0.000488)	(0.0918)	(0.00000288)	(0.00118)	(0.00000185)	(0.000000750)	(0.00256)	(0.0000622)	(0.00000789)
NCSAgri	0.000546	2.500***	-0.0000235*	-0.00899*	0.0000330***	0.00000197	0.0611***	0.0000623	-0.0000446
	(0.00275)	(0.471)	(0.0000119)	(0.00442)	(0.00000925)	(0.00000327)	(0.00719)	(0.000225)	(0.0000393)
CreditAgri	0.00858***	-0.491	0.00000366	0.00896*	-0.0000253***	-0.00000394	-0.0374***	0.000715***	0.0000315
	(0.00182)	(0.387)	(0.00000830)	(0.00411)	(0.00000656)	(0.00000229)	(0.00604)	(0.000161)	(0.0000273)
RDBFunds	-0.00748	0.270	-0.0000819*	0.0276*	0.0000188	-0.00000907	-0.0851***	-0.000388	0.0000394
	(0.00669)	(1.290)	(0.0000323)	(0.0119)	(0.0000210)	(0.00000990)	(0.0177)	(0.000569)	(0.000127)
Constant	31.07*	3020.7	0.203*	-38.71*	0.215***	0.0620***	-308.7***	3.032**	-0.487*
	(13.89)	(1726.5)	(0.0799)	(17.50)	(0.0486)	(0.0183)	(45.70)	(0.947)	(0.219)
Observations	30	30	30	30	30	30	30	30	30
Instruments	23	23	23	23	21	21	23	23	21
R-squared	0.867	0.980	0.320	0.773	0.697	0.261	0.970	0.990	0.988
Hansen test	0.201	0.340	0.271	0.244	0.266	0.666	0.558	0.201	0.0932

Table A4 continued from previous page

Variables	C10 (10)	C11 (11)	C12 (12)	C13 (13)	C14 (14)	C15 (15)	C16 (16)	C17 (17)	C18 (18)
AgriLand	-0.0110***	0.00139	-0.0000772	-0.000472	0.0110	0.000417**	-0.000228	-0.122***	0.000521
	(0.00297)	(0.0140)	(0.0000434)	(0.000274)	(0.00838)	(0.000141)	(0.000119)	(0.0227)	(0.00133)
LandIrrigation	0.0722***	-0.278***	0.000714***	0.00300***	0.0380	-0.000933**	0.000447	-0.0641	0.0101*
	(0.0107)	(0.0377)	(0.000151)	(0.000715)	(0.0283)	(0.000320)	(0.000415)	(0.0897)	(0.00443)
Tractors	0.00290***	-0.00247	0.0000228**	0.000102	0.000265	-0.0000949**	0.0000730**	0.0289***	0.000694*
	(0.000552)	(0.00381)	(0.00000868)	(0.0000581)	(0.00156)	(0.0000367)	(0.0000252)	(0.00464)	(0.000279)
Fertilizer	-0.170***	1.522***	-0.000701	-0.00610*	0.280	-0.00210	-0.000424	-0.363	-0.0390*
	(0.0361)	(0.344)	(0.000674)	(0.00242)	(0.158)	(0.00158)	(0.00114)	(0.908)	(0.0181)
Pesticides	0.000000376	-0.00623***	0.00000907***	0.0000346***	0.0000746	-0.00000904**	0.0000165***	-0.0121***	0.0000443
	(0.000102)	(0.00111)	(0.00000128)	(0.00000444)	(0.000224)	(0.00000338)	(0.00000269)	(0.00192)	(0.0000293)
Employment	0.00290***	-0.0189***	0.000132***	0.000551***	-0.00311**	-0.000135***	0.000262***	-0.0425***	0.00144***
	(0.000423)	(0.00285)	(0.00000968)	(0.0000343)	(0.00108)	(0.0000271)	(0.0000173)	(0.00455)	(0.000239)
NCSAgri	0.00129	0.135***	-0.000200***	-0.000603***	-0.00130	0.000267**	-0.000369***	0.320***	0.00182*
	(0.00180)	(0.0126)	(0.0000383)	(0.000159)	(0.00493)	(0.0000989)	(0.0000817)	(0.0261)	(0.000886)
CreditAgri	0.00250*	-0.0716***	0.000204***	0.000686***	-0.00443	-0.000211***	0.000374***	-0.205***	0.00131*
	(0.00124)	(0.0121)	(0.0000314)	(0.000129)	(0.00299)	(0.0000570)	(0.0000663)	(0.0223)	(0.000588)
RDBFunds	-0.0114*	0.142***	-0.000122	-0.000301	0.0393***	-0.000317	0.0000953	0.187**	-0.00181
	(0.00566)	(0.0292)	(0.0000927)	(0.000584)	(0.0115)	(0.000196)	(0.000242)	(0.0585)	(0.00182)
Constant	34.95***	219.6***	0.359*	0.535	-46.57	-1.080	0.486	484.6***	-6.002
	(10.22)	(52.80)	(0.158)	(1.006)	(29.84)	(0.561)	(0.429)	(80.73)	(4.746)
Observations	30	30	30	30	30	30	30	30	30
Instruments	22	23	23	23	23	23	23	23	23
R-squared	0.987	0.911	0.973	0.959	0.955	0.735	0.963	0.966	0.994
Hansen test	0.0815	0.0390	0.145	0.150	0.414	0.272	0.178	0.0596	0.230

Table A4 continued from previous page

Variables	C19 (19)	C20 (20)	C21 (21)	C22 (22)	C23 (23)	C24 (24)	C25 (25)	C26 (26)	C27 (27)
AgriLand	-0.0103***	-0.0000978**	-0.000922	-0.00978	-0.554***	-0.00000141	0.000243	0.0000113	0.00000832
	(0.00197)	(0.0000315)	(0.00159)	(0.0108)	(0.163)	(0.000499)	(0.000785)	(0.000464)	(0.0000324)
LandIrrigation	0.0160*	0.000956***	-0.00553	0.140***	3.247***	0.00754***	0.0141***	0.00506***	0.0000307
	(0.00627)	(0.000120)	(0.00421)	(0.0274)	(0.662)	(0.00150)	(0.00280)	(0.00140)	(0.000131)
Tractors	0.000766	0.0000516***	0.000161	0.00178	0.138***	0.000147	0.00000365	0.000183	-0.00000646
	(0.000424)	(0.00000567)	(0.000381)	(0.00234)	(0.0321)	(0.0000983)	(0.000161)	(0.000101)	(0.00000821)
Fertilizer	-0.323***	-0.00121*	-0.0179	-0.0866	4.278	-0.00346	-0.0189**	0.00513	0.000280
	(0.0571)	(0.000493)	(0.0189)	(0.122)	(2.908)	(0.00609)	(0.00732)	(0.00602)	(0.000378)
Pesticides	-0.000250	0.0000123***	-0.000218***	0.00199***	-0.0263***	0.0000990***	0.0000208	0.0000704***	-0.00000236*
	(0.000194)	(0.00000102)	(0.0000605)	(0.000253)	(0.00382)	(0.0000178)	(0.0000131)	(0.0000154)	(0.000000916)
Employment	0.00448***	0.000117***	-0.00270***	0.0251***	0.0291	0.000944***	0.000616***	0.00121***	-0.0000218***
	(0.000313)	(0.00000687)	(0.000206)	(0.00139)	(0.0303)	(0.0000948)	(0.000105)	(0.0000884)	(0.00000624)
NCSAgri	0.00306	-0.000278***	0.00512***	-0.0457***	0.539***	-0.00244***	0.000597	-0.000725*	0.0000329*
	(0.00219)	(0.0000309)	(0.00101)	(0.00851)	(0.124)	(0.000426)	(0.000406)	(0.000317)	(0.0000164)
CreditAgri	0.00450**	0.000198***	-0.00386***	0.0377***	0.0537	0.00172***	0.000673*	0.00156***	-0.0000243*
	(0.00143)	(0.0000275)	(0.000915)	(0.00627)	(0.0824)	(0.000390)	(0.000284)	(0.000271)	(0.0000120)
RDBFunds	-0.0183***	-0.000107	-0.00443	-0.0172	0.335	0.000265	-0.00164	0.00105	0.0000556
	(0.00485)	(0.0000816)	(0.00297)	(0.0274)	(0.342)	(0.00121)	(0.00126)	(0.000843)	(0.0000466)
Constant	33.72***	0.110	13.84*	5.394	1417.3*	-0.585	-3.102	-2.633	0.140
	(6.856)	(0.112)	(6.099)	(40.52)	(594.9)	(1.856)	(2.861)	(1.658)	(0.130)
Observations	30	30	30	30	30	30	30	30	30
Instruments	23	23	23	23	23	23	23	23	23
R-squared	0.870	0.988	0.871	0.907	0.989	0.957	0.990	0.994	0.307
Hansen test	0.271	0.221	0.166	0.275	0.199	0.120	0.146	0.0577	0.847

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Table A4 continued from previous page

Variables	C28 (28)	C29 (29)	C30 (30)	C31 (31)	C32 (32)
AgriLand	0.0518	0.104***	-0.0000801***	0.00815**	-0.0102
	(0.0421)	(0.0219)	(0.0000224)	(0.00308)	(0.0178)
LandIrrigation	-0.0673	-0.0504	0.000956***	0.00909	0.326***
	(0.136)	(0.0639)	(0.0000992)	(0.0120)	(0.0598)
Tractors	-0.00120	-0.0155***	0.0000480***	-0.00229***	-0.00407
	(0.00822)	(0.00431)	(0.00000482)	(0.000691)	(0.00311)
Fertilizer	0.123	-1.226***	-0.00130**	-0.326***	-0.00696
	(0.539)	(0.294)	(0.000402)	(0.0719)	(0.144)
Pesticides	-0.00142	-0.000103	0.0000122***	-0.000652***	-0.000839**
	(0.00175)	(0.000663)	(0.00000111)	(0.000143)	(0.000323)
Employment	-0.00649	-0.0269***	0.000118***	-0.00206**	-0.00993***
	(0.00590)	(0.00369)	(0.00000754)	(0.000659)	(0.00226)
NCSAgri	-0.00611	0.0837***	-0.000280***	0.0168***	0.0234**
	(0.0231)	(0.0127)	(0.0000326)	(0.00296)	(0.00815)
CreditAgri	0.00539	-0.0690***	0.000202***	-0.00623**	-0.0139*
	(0.0127)	(0.00740)	(0.0000297)	(0.00197)	(0.00585)
RDBFunds	-0.00740	-0.104***	-0.000130	-0.0273***	0.0302
	(0.0532)	(0.0285)	(0.0000914)	(0.00757)	(0.0247)
Constant	-185.6	-387.2***	0.0320	-34.49**	2.108
	(148.8)	(76.70)	(0.0774)	(11.79)	(64.05)
Observations	30	30	30	30	30
Instruments	23	23	23	23	23
R-squared	0.635	0.916	0.988	0.642	0.818
Hansen test	0.629	0.637	0.206	0.258	0.312

Note: This table reports the robustness checks results through the two-step GMM estimator. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. From column (1)–(32), represents regression results of each crop sub-sector in agriculture with many endogenous variables such as agricultural land, land access water to irrigation, tractors, fertilizer, pesticides, employment, net capital shock, credit and RDB funds. All endogenous variables were used as the instrument variable. Other instrument variables: crop index, temperature, gross fixed capital, technical support, foreign aid, FDI in agriculture, value-added per capita, value-added in agriculture, capital fixed of consumption, and taxes less subsidies. The harvested area, yield and production of each product were used as instrument variables for specific specification. The sample between 1989–2018 used in this estimate comes from FAOSTAT, WDI and NIS in Cambodia. Some missing values were predicted by linear interpolation, log-liner interpolation and multiplicative cubic spline interpolation.

A.5 Robustness Checks on Livestock Estimator

Table A5: The Two-Step GMM Results of Livestock Robustness

Variables	L01	L02	L03	L04	L05	L06	L07
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
AgriLand	-0.00709***	-0.00714***	0.0181***	0.0172***	-0.00246	-0.00337	0.00774***
	(0.00204)	(0.00201)	(0.00347)	(0.00286)	(0.00230)	(0.00189)	(0.000763)
Employment	0.000435	0.000959	0.0185***	0.0162***	0.0263***	0.0239***	0.00308***
	(0.00176)	(0.00148)	(0.00248)	(0.00203)	(0.00133)	(0.00125)	(0.000441)
NCSAgri	0.00334	0.000517	-0.0140*	-0.00906	-0.0312***	-0.0247***	-0.00494**
	(0.00407)	(0.00334)	(0.00667)	(0.00546)	(0.00372)	(0.00209)	(0.00153)
CreditAgri	-0.00519	0.000819	0.0194**	0.0181***	0.0438***	0.0352***	0.00635***
	(0.00433)	(0.00343)	(0.00682)	(0.00533)	(0.00375)	(0.00226)	(0.00145)
RDBFunds	-0.0129	-0.00514	0.0257	0.0359*	-0.0115	-0.00264	0.00274
	(0.0124)	(0.0105)	(0.0187)	(0.0151)	(0.0179)	(0.0113)	(0.00465)
Constant	64.97***	65.08***	-98.71***	-89.37***	-12.49	-3.848	-33.48***
	(7.599)	(7.691)	(14.21)	(11.07)	(9.259)	(7.086)	(3.104)
Observations	30	30	30	30	30	30	30
Instruments	17	17	17	17	17	18	17
R-squared	0.710	0.548	0.949	0.958	0.763	0.785	0.978
Hansen test	0.156	0.140	0.109	0.172	0.500	0.336	0.0750

Table A5 continued from previous page

Variables	L08 (8)	L09 (9)	L10 (10)	L11 (11)	L12 (12)	L13 (13)	L14 (14)
AgriLand	0.00790***	-0.000703	0.00101***	0.166***	0.223***	0.000380***	-0.000200
	(0.000772)	(0.000706)	(0.0000494)	(0.0245)	(0.0299)	(0.0000217)	(0.000871)
Employment	0.00311***	0.000682	0.000566***	0.0763***	0.108***	0.000157***	0.00144
	(0.000413)	(0.000430)	(0.0000738)	(0.0164)	(0.0236)	(0.0000238)	(0.00102)
NCSAgri	-0.00501***	0.0122***	-0.000383*	-0.255***	-0.447***	-0.000675***	0.00168
	(0.00151)	(0.00168)	(0.000167)	(0.0488)	(0.0813)	(0.0000510)	(0.00169)
CreditAgri	0.00597***	-0.00867***	0.000957***	0.230***	0.377***	0.000516***	-0.000619
	(0.00142)	(0.00182)	(0.000185)	(0.0472)	(0.0819)	(0.0000587)	(0.00194)
RDBFunds	0.00180	0.000296	-0.000574	-0.144	-0.451*	-0.000494	0.00347
	(0.00486)	(0.00633)	(0.000625)	(0.173)	(0.208)	(0.000258)	(0.00612)
Constant	-34.25***	3.060	-2.747***	-650.4***	-889.5***	-1.551***	2.709
	(3.114)	(3.228)	(0.224)	(102.1)	(138.5)	(0.0803)	(4.407)
Observations	30	30	30	30	30	30	30
Instruments	17	19	19	17	17	17	19
R-squared	0.981	0.886	0.980	0.827	0.744	0.776	0.457
Hansen test	0.0635	0.628	0.228	0.0857	0.0798	0.451	0.429

Note: This table shows the robustness checks results through the two-step GMM estimator. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. From column (1)–(14), represents regression results of each livestock sub-sector in agriculture with many endogenous variables such as agricultural land, employment, net capital shock, credit and RDB funds. All endogenous variables were used as the instrument variable. Other instrument variables: livestock index, temperature, gross fixed capital, technical support, foreign aid, FDI in agriculture, value-added per capita, value-added in agriculture, capital fixed of consumption, and taxes less subsidies. The laying area, yield and production of each product were used as instrument variables for specific specification. The sample used in this estimate comes from FAOSTAT, WDI and NIS in Cambodia. Some missing values were predicted by linear interpolation, log-linear interpolation and multiplicative cubic spline interpolation.

B Data Sources

B.1 Agricultural Input Variables

Table A6: List of Independent Variables

Variable	Unit	1989-2018				Source
		Min	Mean	Max	St. Dev.	
CIndex	Number	0.78	0.96	1.14	0.12	Author's Calculation
LIndex	Number	1.65	1.74	1.87	0.07	Author's Calculation
Agriland	1000 Hectares	4435.00	5044.03	5566.00	428.22	FAOSTAT
LandIrrigation	1000 Hectares	230.00	309.72	354.00	44.04	FAOSTAT
Tractors	Number	1190.00	3292.75	5696.98	1747.25	FAOSTAT
Fertilizer	Kg per Hectare	3.00	9.76	26.26	7.57	WDI
Pesticides	Tonnes	17.09	3873.26	16572.33	5473.89	FAOSTAT
Employment	1000 Peoples	3027.09	3845.27	4708.94	490.63	ILOSTAT
Temperature	Celsius (°C)	0.18	0.60	1.37	0.32	FAOSTAT
NCSAgri	Millions US $	559.10	1168.98	2563.57	616.28	FAOSTAT
GFCFAgri	Millions US $	65.00	141.51	289.67	86.13	FAOSTAT
CreditAgri	Millions US $	8.33	328.95	1857.22	558.72	FAOSTAT
RDBFunds	Millions US $	3.28	44.16	104.78	30.30	WDI
TechnicalGrants	Millions US $	24.35	406.63	682.12	188.55	WDI
ForeignAid	Millions US $	1.36	1007.87	3342.84	781.20	FAOSTAT
FDIAgri	Millions US $	1.12	48.72	176.48	53.63	FAOSTAT
VAAgri	Millions US $	1597.77	2907.33	4412.07	974.61	WDI
VAWorker	US $	262.45	727.92	1417.25	301.99	WDI
CFCAgri	Millions US $	31.94	69.94	155.00	36.93	FAOSTAT
FCE	Millions US $	1609.11	5299.44	11377.44	3053.73	NIS
TaxesSubsidies	Millions US $	23.50	448.92	1274.40	376.23	NIS

Note: The table shows descriptive statistics of independent variables used for analysis. The variable in this table is also used as the instrument variables in the robustness check testing in Section 6.4.

B.2 Definition of Endogenous Variables

Table A7: Definition of Independent Variables in the Estimation

Variable	Description
CIndex	The Crop diversity index represents the number of farmland used for each commodity.
LIndex	The livestock diversity index represents the number of agricultural laying used for each commodity.
Agriland	Area of arable land, under permanent crops or permanent pasture on 1000 hectares.
LandIrrigation	Area equipped to provide water through the irrigation system to crops in 1000 hectares.
Tractors	Agricultural machinery refers to the total number of wheeled and crawler tractors used in agriculture.
Fertilizer	Fertilizer consumption measures the number of plant nutrients used in kilograms per hectare of arable land.
Pesticides	Pesticide consumption measures the number of plant nutrients used in tonnes of total arable land.
Employment	The total labour force employed in agriculture represents thousands of people.
Temperature	Temperature change in degrees Celsius.
NCSAgri	Net capital stocks in agriculture, forestry and fisheries at constant prices 2010 in millions of US $.
GFCFAgri	Gross fixed capital formation in agriculture, forestry and fisheries at constant prices 2010 in millions of US $.
CreditAgri	Credit to agriculture, forestry and fisheries at constant prices 2010 in millions of US $.
RDBFunds	Net financial flows of the Agricultural and Rural Development Bank at concessional prices in millions of US $.
TechnicalGrants	The transfer of technical and managerial skills or technologies with the aim of strengthening general national capacities at current prices in millions of US $, including autonomous grants and excluding technical cooperation grants.
ForeignAid	Foreign aid to the agricultural sector in term of the development of agricultural inputs, agro-industry, rural development, research, training, and financing at constant prices 2017 in millions of US $.
FDIAgri	FDI inflows into agriculture, forestry, and fishing at constant prices in 2010 in millions of US $.
VAAgri	Value added in agriculture, forestry, and fishing at constant prices 2010 in millions of US $.
VAWorker	Value added per worker in agriculture, forestry, and fishing at constant prices 2010 in US $.
CFCAgri	Fixed capital consumption in agriculture, forestry, and fisheries at constant prices 2010 in millions of US $.
FCE	Final consumption expenditure includes household final consumption, private non-profit organizations serving households and government consumption expenditure at constant prices in 2010 in millions of US $.
TaxesSubsidies	Taxes on products less subsidies at constant prices 2010 in millions of US $.

Note: The table shows the definitions of endogenous variables and exogenous variables used in the Estimation Strategies and Robustness Checks. Based on the economic literature, the author used the Shannon index method to calculate crop diversity and livestock diversity index. Variables in this table come from the FAOSTAT, the WDI and the NIS. See Table A6 for sources and descriptive statistics.

B.3 Dependent Variables

Table A8: Descriptive Statistics of Gross Agricultural Production in 1959–2018

Code	Commodity	1959–1988 (Million US $)				1989–2018 (Million US $)				1959–2018 (Million US $)			
		Min	Mean	Max	St. Dev.	Min	Mean	Max	St. Dev.	Min	Mean	Max	St. Dev.
C01	Bananas	11.95	22.80	34.77	6.08	24.34	29.88	34.55	2.38	11.95	26.34	34.77	5.82
C02	Cassava	3.30	11.88	66.19	13.72	12.76	770.63	2926.18	991.71	3.30	391.25	2926.18	797.35
C03	Castor oil seed	0.01	0.13	0.44	0.14	0.15	0.17	0.18	0.01	0.01	0.15	0.44	0.10
C04	Coconuts	4.79	11.72	16.31	2.79	15.31	20.72	25.83	3.01	4.79	16.22	25.83	5.36
C05	Cotton lint	0.04	2.14	11.71	3.36	0.11	0.11	0.13	0.01	0.04	1.13	11.71	2.58
C06	Cottonseed	0.01	0.38	2.09	0.60	0.01	0.02	0.02	0.00	0.01	0.20	2.09	0.46
C07	Dry beans	5.80	11.69	19.83	2.96	5.31	23.82	50.14	15.99	5.31	17.76	50.14	13.00
C08	Dry chillies and peppers	1.85	2.83	3.60	0.46	3.42	4.72	5.92	0.72	1.85	3.78	5.92	1.12
C09	Fibre crops	0.18	0.63	1.37	0.41	0.25	0.41	0.52	0.09	0.18	0.52	1.37	0.32
C10	Fresh fruit	3.67	8.78	14.70	3.56	15.07	22.52	27.93	4.41	3.67	15.65	27.93	7.95
C11	Fresh vegetables	120.51	161.75	183.22	17.85	171.77	191.73	239.71	16.56	120.51	176.74	239.71	22.83
C12	Grapefruit and pomelos	0.26	0.94	2.78	0.74	0.48	0.63	0.72	0.07	0.26	0.78	2.78	0.54
C13	Green coffee	0.02	0.87	2.31	0.69	0.58	1.12	1.43	0.27	0.02	0.99	2.31	0.54
C14	Groundnuts with shell	0.60	8.12	18.33	5.22	2.14	11.66	21.62	7.07	0.60	9.89	21.62	6.46
C15	Jute	0.02	0.31	0.95	0.23	0.02	0.08	0.24	0.07	0.02	0.19	0.95	0.21
C16	Lemons and limes	0.09	0.49	1.50	0.48	0.25	0.48	0.64	0.12	0.09	0.48	1.50	0.35
C17	Maize	5.17	14.60	33.48	7.68	5.78	43.79	129.49	39.45	5.17	29.20	129.49	31.95
C18	Mangoes, mangosteens and guavas	1.56	6.13	12.77	3.43	4.67	9.86	15.67	3.48	1.56	7.99	15.67	3.93
C19	Natural rubber	1.15	5.97	12.22	3.53	3.28	6.86	10.42	2.14	1.15	6.41	12.22	2.95
C20	Nuts	0.07	0.17	0.23	0.05	0.15	0.30	0.40	0.08	0.07	0.24	0.40	0.10
C21	Oilseeds	1.28	4.22	8.55	2.39	0.43	1.14	3.42	1.04	0.43	2.68	8.55	2.40
C22	Oranges	22.56	37.54	50.75	7.49	47.37	67.26	73.59	8.75	22.56	52.40	73.59	16.95

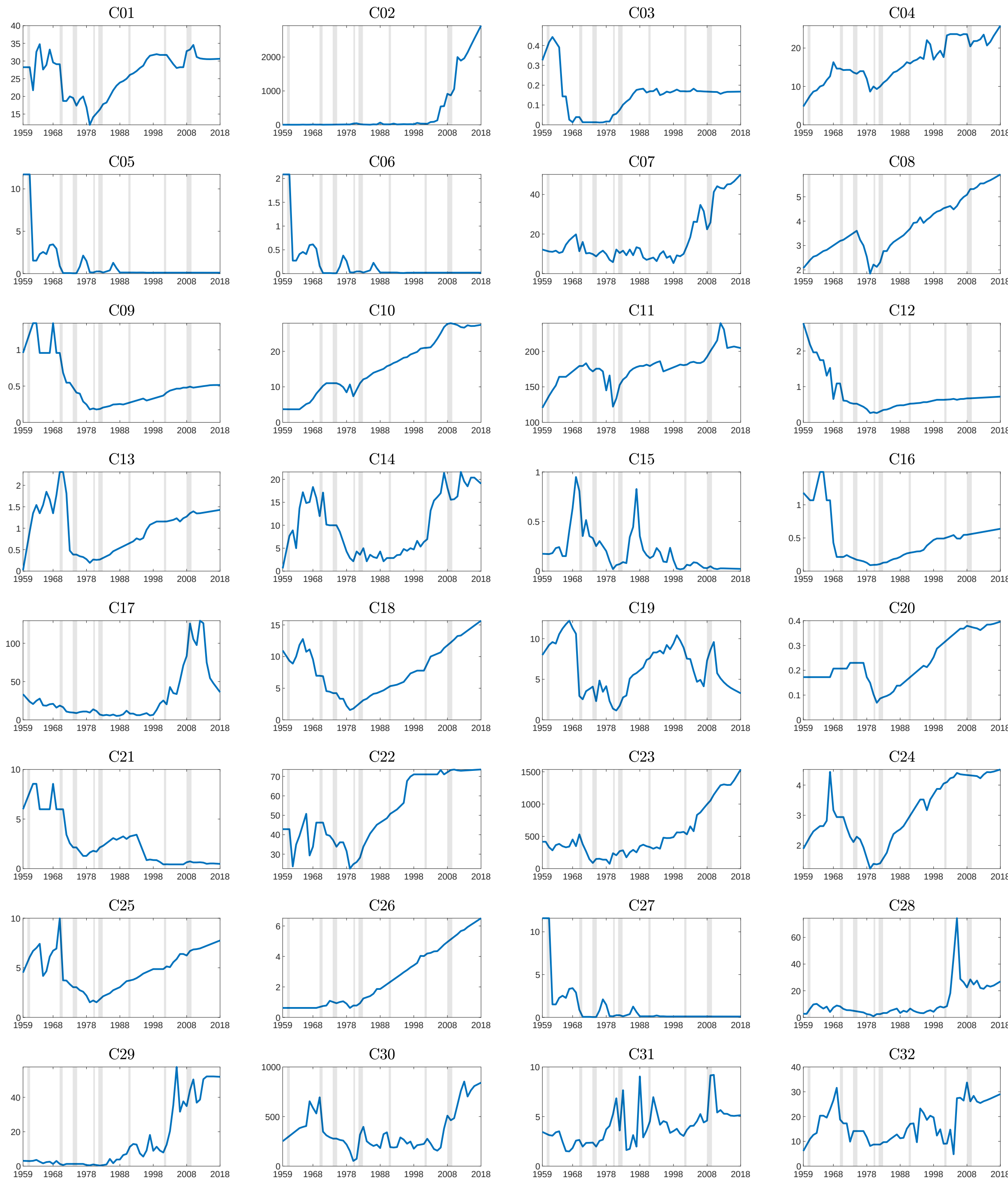
Table A8 continued from previous page

Code	Commodity	1959–1988 (Million US $)				1989–2018 (Million US $)				1959–2018 (Million US $)			
		Min	Mean	Max	St. Dev.	Min	Mean	Max	St. Dev.	Min	Mean	Max	St. Dev.
C23	Paddy rice	74.74	279.89	529.88	110.94	308.56	798.72	1535.96	396.98	74.74	539.31	1535.96	390.19
C24	Pepper and piper spp	1.23	2.30	4.44	0.65	2.64	3.93	4.52	0.55	1.23	3.12	4.52	1.01
C25	Pineapples	1.52	4.07	9.98	2.12	3.35	5.61	7.75	1.35	1.52	4.84	9.98	1.94
C26	Roots and tubers	0.62	0.91	1.86	0.36	2.02	4.29	6.51	1.34	0.62	2.60	6.51	1.95
C27	Seed cotton	0.04	2.12	11.59	3.32	0.10	0.11	0.22	0.02	0.04	1.12	11.59	2.55
C28	Sesame seed	0.83	5.17	10.15	2.43	3.14	17.97	74.41	15.17	0.83	11.57	74.41	12.61
C29	Soybeans	0.32	1.90	4.18	1.14	5.55	27.95	57.63	18.42	0.32	14.93	57.63	18.44
C30	Sugarcane	52.87	316.17	693.89	145.89	156.18	404.02	853.12	241.26	52.87	360.09	853.12	204.14
C31	Sweet potatoes	1.48	3.24	9.05	1.77	2.90	4.82	9.20	1.46	1.48	4.03	9.20	1.80
C32	Unmanufactured tobacco	6.13	14.16	31.59	5.79	4.80	20.84	33.73	7.45	4.80	17.50	33.73	7.46
L01	Buffalo meat	1.15	16.80	30.70	11.43	24.91	32.28	38.84	4.05	1.15	24.54	38.84	11.55
L02	Buffalo meat (indigenous)	4.28	19.59	31.39	8.74	28.85	33.26	38.84	2.95	4.28	26.42	38.84	9.44
L03	Cattle meat	8.39	16.42	25.82	4.67	29.10	55.05	70.65	12.98	8.39	35.73	70.65	21.63
L04	Cattle meat (indigenous)	8.39	16.63	25.84	5.16	29.10	56.55	70.65	13.92	8.39	36.59	70.65	22.55
L05	Chicken meat	7.82	18.49	42.72	7.76	37.65	54.05	70.39	6.97	7.82	36.27	70.39	19.25
L06	Chicken meat (indigenous)	7.82	18.49	42.72	7.76	37.65	53.61	70.39	6.75	7.82	36.05	70.39	19.01
L07	Duck meat	0.91	4.02	7.42	1.68	7.54	13.92	18.41	3.85	0.91	8.97	18.41	5.77
L08	Duck meat (indigenous)	0.91	4.02	7.42	1.68	7.54	13.80	17.68	3.72	0.91	8.91	17.68	5.68
L09	Hen eggs in shell	3.33	5.37	7.87	1.28	8.48	13.49	20.19	3.29	3.33	9.43	20.19	4.76
L10	Other bird eggs in shell	0.55	2.31	3.15	0.83	3.18	4.35	5.31	0.68	0.55	3.33	5.31	1.27
L11	Pork	13.05	65.39	149.09	37.67	150.58	253.88	344.16	46.66	13.05	159.63	344.16	103.34
L12	Pork (indigenous)	13.05	67.71	149.09	35.33	150.58	235.71	341.69	45.44	13.05	151.71	341.69	93.34
L13	Silkworm coiling cocoons	0.14	0.29	0.34	0.07	0.21	0.33	0.47	0.08	0.14	0.31	0.47	0.08
L14	Whole fresh cow milk	0.59	0.86	1.10	0.13	0.91	8.74	10.75	2.26	0.59	4.80	10.75	4.25

Note: The table presents the descriptive statistics of gross agricultural production of each commodity in Cambodia between 1959 to 2018 at a price constant in 2004–2006 in millions of US dollars. The author used data from FAOSTAT with 46 agricultural products between 1961–2018. At the same time, the researcher used linear interpolation and multiplicative cubic spline interpolation to estimate the gross agricultural production value between 1959–1960 and some missing data based on FAOSTAT data.

C Additional Graphics

Figure 3: Gross Crop Production in Cambodia Between 1959–2018



Note: This figure presents the gross agricultural production of the crop product in millions of US dollars at constant prices in 2004–2006. The author used the FAOSTAT dataset between 1961–2018 on crop production. From 1959–1960 and other missing values in the dataset are used as a linear interpolation method to predict. The 32 crop products are represented by the identification code from C01–C32. The definition of each crop identification code is shown in Table A8. According to the dataset, cassava, dry chilies and peppers, grapefruit and pommels, green coffee, lemons and limes, mangoes, nuts, paddy rice, pineapples, roots and tubes are rapidly increasing production and incomes.

Figure 4: Gross Livestock Production in Cambodia During 1959–2018

Note: The figure reports gross agricultural production of livestock product in millions of US dollars at constant prices in 2004–2006. The author used the FAOSTAT dataset during the last 60 year of livestock production in Cambodia. From 1959–1960 and other missing values in the dataset are used as a linear interpolation method to predict. The 14 livestock products are represented by the identification code from L01–L14. The definition of each livestock identification code in this figure is presented in Table A8. Based on the dataset, it shows that duck meat and other bird eggs in shell products have a good slide that has increased income over time. Regardless, other products in the livestock sub-sector have a different condition for growth in gross production in terms of productivity growth and product consumption.