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FOOD AND AGRICULTURAL SECTOR IN INDONESIA'S ECONOMIC GROWTH DURING COVID-19 PANDEMIC: AN ARDL APPROACH

Purpose. *Global-scale financial crises, either in the financial sector itself or in other fields such as zoonotic disasters, in the form of the spread of viruses resulting in deaths and significant economic contraction, are becoming more frequent and are expected to occur in the future. This study aims to assess the crisis's impacts, in this case, COVID-19 pandemic, on the food and agriculture sector's role in Indonesia's economic growth.*

Methodology / approach. *This study used ARDL bound test to cointegration approach to analyze whether COVID-19 pandemic had a negative impact on Indonesia's economic growth with regard to the food and agricultural sector. The relation pattern of particular interests includes (i) the relation between agriculture and economic growth, (ii) the relation between food and beverage industry and economic growth, and (iii) the causal relation between agriculture, food and beverage industry, and economic growth.*

Results. *In the long run, economic growth, agricultural output, and food and beverage industry's output have a dynamic causal relation (bi-directional causality). Partially, COVID-19 pandemic influences economic growth negatively but insignificantly. However, the effect is simultaneously significant, but the regression coefficient is very small, and not strong enough to disrupt the positive effect of agricultural output and food and beverage industry's output. COVID-19 does not negatively influence agricultural production and food and beverage industry as the regression coefficients are positive, insignificant, and very small.*

Originality / scientific novelty. *This research is the first (particularly in Indonesia) to analyze COVID-19's impacts on economic growth with regard to food and agriculture sector using an econometric operation with time series statistical data, covering data during the pandemic. Therefore, the parameter test results have higher predictability.*

Practical value / implication. *This study presents evidence that COVID-19 pandemic influences economic growth not through disruption of production in the agriculture and food and beverage sectors, but induction by demand. Therefore, the most appropriate policy to deal with the crisis is to simultaneously handle health aspect as the source of crisis and maintain demand for agricultural and food products directly through fiscal stimulus in the form of social safety net for poor and near-poor households and indirectly through supporting micro, small and medium enterprises (MSMEs) from bankruptcy in the prevention of mass unemployment. In the future, however, there will be a need to further study agricultural resilience by subsector and investigate food and beverage industry's role in an open economic model. In addition, it is quite advisable to further study the impacts of the government's safety net program in the form of basic food assistance and delivery cost subsidy for online shopping to stimulate demand-driven growth that can support farmers in production and service demand through contactless marketing.*

Key words: *food and agricultural sector, economic growth, financial crisis, COVID-19 pandemic and agriculture, Indonesia's economy.*

Introduction and literature review. Globalization, which makes countries

interdependent, contributes to global economic prosperity through trade liberalization and capital transfer [1–3]. On the other hand, however, globalization also creates the risk of vulnerability to economic shocks. Close economic linkages result in immediate contagious effect, where a financial/economic crisis/shock in one country has harmful transmission in various countries without distinguishing between those with developing or advanced economies [4; 5]. Because of such negative impacts, some criticize globalization [6]. Financial crises have occurred more frequently and at shorter intervals [7]. There were 11 financial crises from 1901–1990 (in 90 years), but in the last 30 years (1991–2019), the world had suffered 18 financial crises, 11 of which occurred in the 21st century (2001–2019). As [8] has mentioned, the next financial crisis is imminent – we do not know where it is coming from.

Financial crises no longer only originate from the financial sector, but also from external factors such as zoonotic disasters like viral spread resulting in death and significant economic contraction [9; 10]. The world has witnessed Flu development since Spanish Flu in 1918, followed by Asian Flu (1957), Hong Kong Flu (1986), Avian Flu (H5N1 and H7N7) since 1997, SARS (2002), Mexican Flu (H1N1) in 2009 and Corona (COVID-19) in 2020 and 2021. Biological disasters, in this case, the spread of various types of Flu, show a high frequency and fast emergence of new types of viruses. On this basis, [11] warns that "the flu pandemic is at our doorstep". Thus, a zoonotic disaster such as the COVID-19 outbreak is not accurately called a black swan event [12], and therefore measures need to be prepared to deal with their future reoccurrence [13; 14].

The COVID-19 pandemic is a disaster in almost all fields, including [15–18]: health, environment, social, and global economy. Likewise, the pandemic has had an uneven impact on industries and businesses, affecting the workforce and individual economy [12; 19]. Close-contact industry and service are the areas affected the most, e.g. [6]. To restrain the viral spread through personal contact, almost all governments throughout the world implemented quarantine measures covering [20]: school closure, workplace closure, cancellation of public events, restriction of public gatherings, restriction of internal movements, and international travel control. The lockdown and mobility restrictions created economic stress, resulting in a pandemic-induced recession and mass job losses and, subsequently, a shortfall in income [21; 19; 17].

Various sectors have implemented work-from-home recommendations in order to hold down the spread of COVID-19. However, working from home is impractical for the food and agriculture sector since its various stages of operations require workers' presence on site regularly. Thus, the pandemic will shock the supply and demand parts of the market through disruption in at least one of the five phases of the food supply chain [15], including agricultural production, postharvest handling, processing, distribution / retail / services, and consumption. In the production phase, farmers in developed countries face situations that contrast with those in developing countries, especially in Asia. In European countries, Canada, and the United States, farmers are generally unable to do their activities due to lack of seasonal workers for non-food crop cultivation such as fruits and vegetables that rely on hired labors for planting and

harvesting [16]. In Asian countries such as India, where small farms dominate, the pandemic's impact on agricultural production is minimal as labors available from family members are plentiful. Lockdowns have forced migrant workers, as well as small-scale shopkeepers, to close their businesses and return home in reverse migration [22]. This phenomenon is more popularly known as de-urbanization in Pacific Island Countries [23]. Furthermore, most small farmers run their farms like usual, continuing to grow the same crops with nothing changing in input use [24].

Disruptions in the distribution phases occur in all countries for two reasons, domestically due to travel restrictions and internationally many countries close their borders in the prevention of viral spread. In a looser form, there is mandatory two-week quarantine for people from abroad. This reduces exports, especially perishable agricultural products such as fruits and vegetables. Disruptions in the procurement of agricultural products for raw materials in the food processing industry have hampered food production, disrupting the global food system [25]. This way, [17] believes that disruption in distribution – especially agri-food products – can potentially be as damaging as the pandemic itself. Various studies conclude that COVID-19 is negatively impacting agriculture across all four pillars of food security – availability, access, utilization, and stability / reliability [26; 19; 27]. The reason is that the pandemic has threatened people's food security worldwide and may potentially magnify the acute hunger caused by war-induced conflict and climate change [22]. Thus, COVID-19 pandemic has widely exposed the global agri-food system's vulnerability to shocks and stresses [16] which before COVID-19 pandemic was already facing serious threats in the context of global food and nutritional security [19]; in other words, COVID-19 pandemic has put the global food supply system under the severe strain [22].

Indonesia is not exempted from COVID-19's impact. Its proximity to China and the close relation between governments, businesses, and personal ASEAN fellows have resulted in very high mobility of capital, goods, and persons across ASEAN countries. Even in case of slow discovery of virus transmission and the spread is concentrated in Java and some big cities outside Java, this is more due to Indonesia's geographical condition as an archipelago. The Indonesian Government has also implemented various restrictions to halt the virus transmission internally and externally from abroad. This step will shock the economy, including the food and agriculture sector.

The food and agriculture sector are one key sector of Indonesia's economy. This sector contributed about 20 % to the 2019 GDP (prior to the COVID-19 pandemic), where the agricultural sector decreased while the food and beverage manufacturing sector increased to offset the decline agricultural sector. Nevertheless, agriculture's overall contribution to GDP is more significant since the food industry relies on agricultural inputs to contribute added value to the economy. In addition to food and beverage manufacturing, sectors related to agriculture include food services and eating and drinking places. In USA's experience, agricultural food, and related industries contributed about ten times the output of America's farms to GDP [28]. Besides, for most Indonesian households, farming, and plantations remain the vital source of income. In 2022, the agricultural sector provided jobs to approximately 40.6 million

Indonesians, representing 30 % of the country's total labor force. Thus, agriculture is still the sector contributing the most to employment, followed by the wholesale and retail, industry, and eating and drinking sectors, 19 %, 14 %, and 7 %, respectively.

Given the strategic position of Indonesia's food and agriculture sector, it is essential to understand COVID-19 pandemic's impact on this sector. The research results are a provision to address the possibility of external shocks due to financial crises and zoonotic disasters that have recently shaken the world economy and are likely to repeat.

The agricultural sector plays a key role in Indonesia's economy due to its positive impact on economic growth and other sectors' growth [29]. Thus, agriculture can be classified as an engine of growth, and the agriculture-driven growth hypothesis applies in Indonesia [30]. Whether the impact of agriculture (raw material production) and processed goods (food and beverage industry) on Indonesia's economic growth is disrupted by COVID-19 pandemic is this study's main question.

So far, many studies on the impact of COVID-19 on agriculture are mostly in the form of literature reviews both at global level such as [15; 27; 31] and [32] and more specifically at national level such as [33] for the United States, [34] for Turkey, and [35] for India. Research employing econometric analysis is still greatly limited to cross-section data collected from primary data, which cannot provide long-term predictions such as [16] comparing the impact and response of adaptation in the US, Norway, and China; [25] examining agricultural resilience in California with special attention to agricultural marketing aspects; [22] in India; and [36] in Nigeria. This study is the first (at least for Indonesia) to use time-series data, covering 11 observations on a quarterly basis during COVID-19 pandemic, the first quarter of 2020 to the third quarter of 2022 (Q1 2020 to Q3 2022) using a dummy variable to cover include more than 30 observations. Hence, it is feasible to carry out econometric operations properly.

The purpose of the article. This study aims to assess the impact of COVID-19 on the food and agriculture sector's role in Indonesia's economic growth with a specific formulation: to find out the causal relation between agricultural sector's output, food and beverage manufacturing's output, and Indonesia's economic growth during COVID-19 pandemic.

Methodology. To analyze food and agriculture sector's role in economic growth, we broke food and agriculture sector down into agricultural output (Agri), and food and beverage manufacturing output (FnB); Gross Domestic Product (GDP) represented economic growth. Studies have been conducted to identify the causal relationship between GDP and constituent variables (pseudo-supply-side analysis: agricultural and economic growth) by [37] for North Cyprus and [38] for Tunisia. Observations during the COVID-19 pandemic used dummy variables with the value one, i.e., from Q1 of 2020 to Q3 of 2022, while data before 2020 were zero. Quarterly data on GDP, agricultural output (Agri), and food and beverage manufacturing output (FnB) are available in "Statistik Ekonomi Keuangan Indonesia" (Indonesian Economic and Financial Statistics) published monthly by Bank Indonesia (Indonesia's Central Bank). The whole data are in billions of Rupiah (IDR) at constant prices (2010=100) and transformed into a logarithm. The analysis covers 31 quarters for eight years (2015–

2022).

The cointegration and error correction model is superior to the traditional regression method in determining the effect of one variable on another, since [39]: (i) cointegration techniques test the long run theoretical relation between variables and Granger causality between variables, while traditional regression techniques only make assumptions of the theoretical relationship between variables, (ii) financial variables are mostly non-stationary, thus, ordinary regression operations on such variables will have invalid results, given that statistical tests such as t-ratio and F-statistics are statistically invalid when applied to non-stationary variables. Regression operations in the differential form of these variables will solve one problem, while regression operations in the variables in their differential form will effectively eliminate the long-run trend. Thus, differential regression variables only capture short-term, cyclical, or seasonal effects. Regression in differential form does not test long-run or theoretical relations, (iii) the data empirically prove causality in cointegration, whereas in traditional regression, causality is only a presumption.

This study employed the autoregressive distributed lag (ARDL) bound test to cointegration. The ARDL approach was an OLS-based dynamic econometric model. This model is considered superior for small samples and does not require stationary variables to be of the same order as long as they are in I(0) and I(1) [40; 41].

Unit root test was used to check whether variables were stationary. If the variable were not stationary [42]: (i) the behavior studied was only limited to the period under observation. Thus, each variable was a particular episode that was unlikely to be generalized for other time periods, thus it had little practical value for forecasting purposes, (ii) the analysis carried out would produce an invalid or nonsensical regression. The most prevalent unit root test is the augmented Dickey-Fuller (ADF) test. In brief, [43] formulates the order p ADF regression as follows (1):

$$\Delta Y_t = \alpha + \mu\,(1 - \emptyset)_t - (1 - \emptyset)Y_{t-1} + \sum_{i=1}^{p} \psi_i\,\Delta Y_{t-i} + \varepsilon_t, \qquad (1)$$

which is a combination of three Dickey-Fuller tests, including random walk, model without drift, and model with drift [42]. In equation (1), Y is the time series variable, ε_t is the white noise error term and p is chosen that the residuals of the equation, ε_t, are not serially correlated. In practice, model selection criteria such as Akaike information criterion (AIC), or Schwarz Bayesian Criterion (SBC), are used to select p. The unit root hypothesis is:

$$H_0: \emptyset = 1 \text{ against } H_1: \left|\emptyset\right| < 1.$$

According to [44], Phillips-Perron (PP) unit root test is more robust in an error term process. The PP unit root test is an extension of Dicky-Fuller test. The PP test corrects serial correlation and heteroscedasticity in the error term of the test regression equation (1). The PP unit root test operation steps, models with intercept and with and without trend can be observed in [43].

The ARDL model can generate a dynamic error correction (ECM) model that integrates short-run dynamics and long-run equilibrium through a simple transformation. This advantage makes ARDL bound test to cointegration increasingly popular and

widely used recently [44–48]. According to [39], ARDL bound test approach gives efficient and reliable results once a single equation cointegration relation exists among the variables. The Granger procedure also tests the direction of causality in the vector error correction (VECM) models. If a set of variables is cointegrated, they are guaranteed to have an error correction term (ECT). The advantage of VECM is the reintroduction of information lost due to difference in time series. This step is crucial for investigating short-run dynamics and long-run equilibrium.

Equation (2) presents the long-run relationship between economic growth and food and agriculture sector:

$$GDP_t = \beta_0 + \beta_1\, Agri_t + \beta_2\, FnB_t + DUM + \varepsilon_t. \tag{2}$$

The ARDL bound test to cointegration model, which is an unrestricted ECM (error correction model) for equation (2), is formulated in equation (3):

$$\Delta GDPt = \beta_0 + \beta_1\, Agri_{t-1} + \beta_2\, FnB_{t-1} + \sum_{i=1}^{p} \alpha i\, \Delta GDP_{t-i} + \sum_{j=1}^{q} \alpha j\, \Delta Agri_{t-j} +$$
$$+ \sum_{k=1}^{r} \alpha k\, \Delta FnB_{t-k} + DUM + \varepsilon_t, \tag{3}$$

where *p, q,* and *r* are the optimal lags with their respective variables and ε_t is the error term. The bound testing procedure tests the joint *F*-statistics of the null hypothesis of no cointegration relation:

$$H_0: \beta_1 = \beta_2 = 0, \quad \text{against the alternative} \quad H_1: \beta_1 \neq \beta_2 \neq 0$$

The cointegration test results from the *F*-statistics obtained using the ARDL bound test are found. If the *F*-statistics is higher than the upper critical bound (UCB), there is cointegration, but if it is lower than the low critical bound (LCB), there is no cointegration among the variables [41; 48]. The long-run relations are inconclusive if LCB<F-statistics<UCB [49]. In case of evidence of a long-run relation (cointegration) between the variables, the steps to estimate the long-run and the short-run models are presented in equation (4):

$$\Delta GDPt = \beta_0 + \sum_{i=1}^{p} \alpha i\, \Delta GDP_{t-i} + \sum_{j=1}^{q} \alpha j\, \Delta Agri_{t-j} + \sum_{k=1}^{r} \alpha k\, \Delta FnB_{t-k} + DUM$$
$$+ \psi\, ECT_{t-1} + \varepsilon_t, \tag{4}$$

where ψ is the coefficient of error correction term (ECT), representing the variable's adjustment speed to long-run equilibrium after a shock.

The long-run and short-run causality between agricultural output, food and beverage manufacturing output, and economic growth is investigated using Granger causality with vector error correction. Granger causality is expressed in matrix form, as formulated in the model in equation (5):

$$(1-L)\begin{bmatrix} GDP_t \\ Agr_t \\ FnB_t \end{bmatrix} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} \alpha_{11}\,\alpha_{12}\,\alpha_{13} \\ \beta_{21}\,\beta_{22}\,\beta_{23} \\ \gamma_{31}\,\gamma_{32}\,\gamma_{33} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{bmatrix}\begin{bmatrix} GDP_{t-1} \\ Agr_{t-1} \\ FnB_{t-1} \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \end{bmatrix}, \tag{5}$$

where $(1-L)$ is the difference in operator. Long-run causality is determined by the significance of the lagged error coefficient, while short-run causality is determined by the significance of the *F*-statistics using the Wald test.

Results and discussion. First of all, this section describes the spread of COVID-19 in Indonesia, along with the food and agriculture sector's condition during the pandemic. This is followed by the analysis on the correlation between the agricultural

sector, food and beverage manufacturing, and economic growth using ARDL approach. The ARDL approach was performed in the following steps: unit root test, cointegration test, and causality analysis.

COVID-19 Spread in Indonesia. Various efforts had been conducted to prevent COVID-19 entry into Indonesia, especially at cross-country entry points such as seaports and airports, but Indonesia could not isolate itself from the COVID-19 pandemic. The first case was confirmed on 2 March 2020, and the first death case was confirmed on 11 March 2020, coinciding with WHO's declaration of COVID-19 as a global pandemic. In just one month, the whole 34 Indonesian provinces reported the viral spread. Until Q3 2022, Indonesia went through three different major infection waves which are closely related to viral mutations with different variants, including: Q1 2021 (Alpha Wave) reaching peak in the fourth week of January, Q3 2021 (Delta Wave) in the second week of July, and Q1 2022 (Omicron Wave) in the second week of March [50].

The Indonesian Government declared COVID-19 a non-natural disaster on 14 April 2020 under Presidential Decree No. 12. On that day, the total cases reached 4,839, with 400 total deaths and 60 daily deaths. Besides, the mitigation measures through mobility restrictions and health campaigns such as wearing masks, washing hands with soap, and social distancing/avoiding crowds, the government also launched a program called the national economic recovery with components covering basic food aid, wage subsidies, pre-employment cards, etc., including online shopping fee subsidies, aiming to drive the economy and maintain food security for those affected, countless informal sector workers who practically ceased their activities. In 2020 there were 56.64 % workforce in the informal sector.

As the consequence of the pandemic, from 2020 to 2022, labor statistics show the formal sector contracted by 6 %. The informal sector increased by 15.6 %, indicating that the government's various economic recovery programs played a more significant role in boosting the economic activities in the informal sector, including opening up opportunities for those laid off from the formal sector to start businesses in the informal sector.

Vaccination, a permanent solution to the COVID-19 pandemic, had only been implemented in Indonesia from 13 January 2021, targeting four vaccine doses for every person. As the vaccination started, the cases had reached over 850,000, with death toll up to 25,000 people. Until the end of 2022, 87.5 % of the population had been vaccinated with one dose, and 73.5 % had been fully vaccinated (two doses). 160 thousand people died, and 6.65 million were infected [51].

Indonesia's Food and Agriculture Sector during COVID-19 Pandemic. Overall, Indonesia's economy went into recession in Q2 2020 when there was little understanding of COVID-19, so information on mitigation measures needed greater consistency. For example, the health ministry stated that those healthy did not need to wear medical masks. Only those sick and health workers were to wear masks. In the face of this misunderstanding, many local governments took measures, some even applied lockdowns by closing cross-regional roads and curfew to main urban roads. This step paralyzed the economic activities, while on the other hand, the government's economic recovery policies were still formulated, especially related to the target groups

and distribution mechanism. Indonesia's GDP contracted 5.32 % year-on-year by Q2 2020. GDP continued to recover, but until Q3 2022, the GDP growth was below the pre-pandemic trend, as shown in Figure 1.
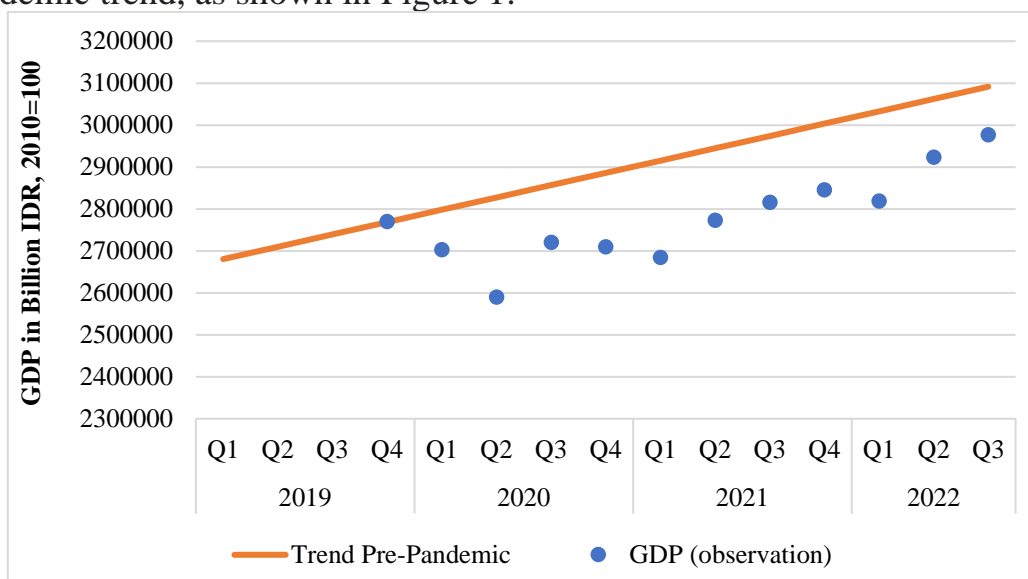

Figure 1. Indonesia's economic growth during COVID-19 pandemic compared to pre-pandemic trend (in Billion IDR, 2010 = 100)

Source: author's estimation.

The agricultural output shows a seasonal oscillatory pattern. Production peaks in the second quarter each year, then declines and reaches the lowest point in the fourth quarter to increase again in the next quarter. This pattern applied to pre-pandemic and did not change during the pandemic. This seasonality applies to the five main agricultural sub-sectors: food, horticulture, plantation, livestock, and fisheries. Table 1 presents the growth of agricultural output per subsector year-on-year (y-o-y) and quarter-on-quarter (q-o-q).

Table 1

Indonesia's agricultural output growth per subsector 2019–2022, %

Year	Quarter	Food		Horticulture		Plantation		Livestock		Fisheries	
		y-o-y	q-o-q	y-o-y	q-o-q	y-o-y	q-o-q	y-o-y	q-o-q	y-o-y	q-o-q
2019	Q1	-6.02	73.49	6.18	7.06	3.36	-0.03	7.87	8.84	5.66	1.88
	Q2	5.05	10.70	6.06	23.79	4.50	28.14	7.70	4.22	5.59	-0.26
	Q3	-4.73	-11.27	12.38	6.96	4.96	10.41	7.69	0.49	5.68	1.90
	Q4	-1.08	-41.95	4.92	-25.99	5.23	-25.60	7.86	-5.38	5.50	1.88
2020	Q1	-10.25	57.40	2.61	4.70	3.97	-1.22	2.68	3.62	3.52	-0.03
	Q2	9.24	34.74	0.94	21.78	0.18	23.46	-1.90	-0.43	-0.63	-4.26
	Q3	7.24	-12.89	-1.23	4.66	0.68	10.97	-0.24	2.19	-1.03	1.50
	Q4	26.06	-31.76	7.85	-19.18	1.14	-25.26	-1.88	-6.93	1.06	4.03
2021	Q1	12.24	40.14	3.27	0.26	2.17	-0.22	2.12	7.84	-1.31	-2.37
	Q2	-7.97	10.48	1.85	20.10	0.32	21.23	6.74	4.08	9.69	6.41
	Q3	-5.66	-10.71	-5.22	-2.60	8.33	19.83	-2.47	-6.63	4.55	-3.25
	Q4	-13.96	-37.77	3.80	-11.50	2.28	-29.44	-5.24	-9.58	8.99	8.44
2022	Q1	-0.08	62.74	3.31	-0.20	-0.24	-2.68	6.92	21.69	-0.51	-10.89
	Q2	1.11	11.81	1.23	17.67	0.68	22.35	3.56	0.81	2.73	9.87
	Q3	-7.97	-18.73	5.56	1.57	2.74	22.28	7.40	-3.17	6.38	0.19

Source: author's calculation.

Table 1 shows Indonesia's agricultural production is not affected by COVID-19 pandemic as generally occurring in Asia [22; 24]. Overall, the agricultural sector's GDP growth follows the pre-pandemic trend. Every second and third quarters are above the trend, and the fourth and first quarters are below the pre-pandemic trend, as shown in Figure 2.
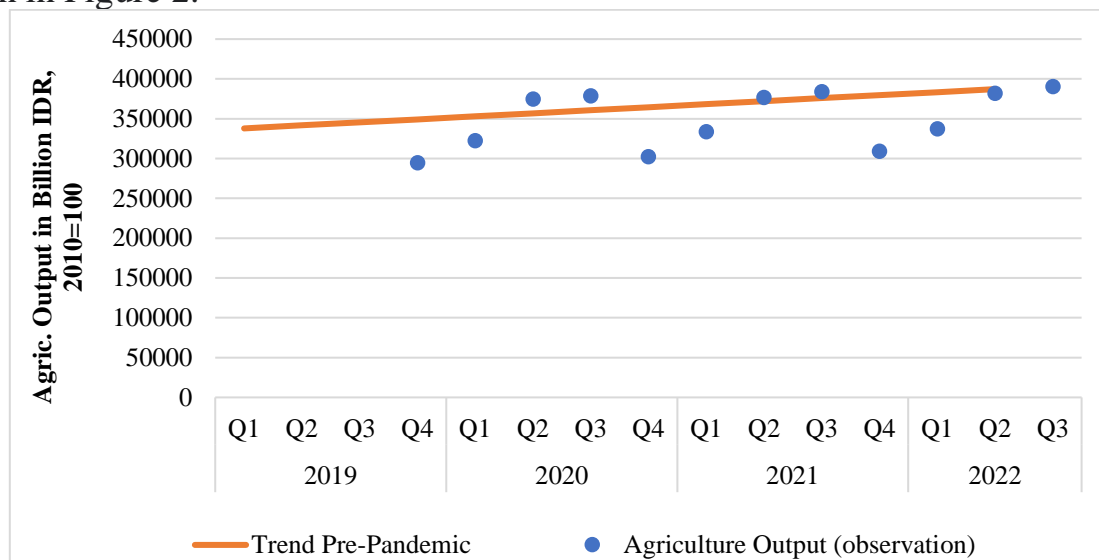

Figure 2. Indonesia's agricultural output growth during pandemic COVID-19 compared to pre-pandemic trend

Source: author's calculation.

As numerous studies have reported e.g. [6; 21; 52; 26; 19], the restrictive measures to deal with the spread of COVID-19 had disrupted the economic activities in service and manufacturing sectors which were close-contact-related. The food and beverage manufacture also belongs in this category at a certain level. Likewise, during a pandemic, this sector always recorded positive growth (year-on-year) that continued since Q1 2014. Meanwhile, the quarter-on-quarter growth tends to follow the agricultural sector's seasonal pattern as the supplier of raw materials, which posts negative growth in the 4th quarter each year. The food and agriculture exports had positive growth (year-on-year) during the pandemic after having pressure from 2018–2019 due to the USA-China trade war (in 2018, the US and China imposed high import tariffs on each other, and these retaliatory actions evolved into a US-China trade war) [53]. Bilateral trade disputes have far-reaching consequences beyond the countries involved in the dispute and beyond the restricted commodities [54]. The negative spillover impacts of this trade war on Indonesian exports are as described by [55]. Likewise, the quarter-on-quarter growth contracted in six out of the 11 quarters observed. Thus, trade barriers such as closing borders and quarantining ports for two weeks also affect Indonesia's exports even on practically non-perishable goods such as CPO (crude palm oil) and crumb rubber. Indonesia's food and agricultural exports grew 34.81 % (quarter-on-quarter) and 12.36 % (year-on-year) in quarter 3 of 2022. Indonesia's GDP growth, along with selected components including agricultural output, food and beverage manufacturing, and food and agricultural exports, is presented in Table 2.

Table 2

Indonesia's GDP growth and selected sectors, 2018–2022, %

Year	Quarter	GDP		Agriculture		Food and Beverage		Food and Agric. Export	
		y-o-y	q-o-q	y-o-y	q-o-q	y-o-y	q-o-q	y-o-y	q-o-q
2018	Q1	5.06	-0.41	3.34	16.41	12.77	-0.77	-9.54	-10.39
	Q2	5.27	4.21	4.74	10.02	8.39	4.46	-4.59	-8.28
	Q3	5.17	3.09	3.67	3.21	8.10	3.45	-0.35	14.03
	Q4	5.18	-1.69	3.92	-21.39	2.74	-4.20	-10.01	-4.00
2019	Q1	5.07	-0.52	1.86	14.10	6.77	3.13	-13.65	-14.01
	Q2	5.05	4.20	5.33	13.77	7.99	5.65	-13.22	-7.81
	Q3	5.01	3.05	3.06	0.99	8.33	3.78	-13.49	13.68
	Q4	4.96	-1.74	4.24	-20.48	7.95	-4.54	3.70	15.08
2020	Q1	2.97	-2.41	-0.02	9.43	3.94	-0.70	9.96	-8.82
	Q2	-5.32	-4.19	2.15	16.24	0.22	1.87	7.85	-9.59
	Q3	-3.48	5.05	2.17	1.01	0.66	4.23	11.40	17.42
	Q4	-2.17	-0.40	2.63	-20.13	1.66	-3.59	26.30	30.47
2021	Q1	-0.70	-0.94	3.45	10.31	2.45	0.07	38.42	-0.07
	Q2	7.07	3.31	0.53	12.95	2.95	2.37	59.19	3.98
	Q3	3.51	1.55	1.43	1.92	3.49	4.78	74.86	28.98
	Q4	5.02	1.06	2.28	-19.46	1.23	-5.69	27.53	-4.85
2022	Q1	5.01	-0.95	1.19	9.14	3.75	2.56	15.53	-9.47
	Q2	5.44	3.72	1.37	13.15	3.68	2.30	7.50	-3.24
	Q3	5.72	1.82	1.65	2.20	3.57	4.67	12.36	34.81

Source: author's calculation.

The Nexus between Agriculture, Food and Beverage Manufacture and Economic Growth. An ARDL bound test was employed to estimate the effect of agriculture's output and the output of food and beverage manufacture on economic growth and their causal relation. The unit root test was conducted to ascertain that there were no variables stationary in order two [I(2)], or more. This study used two different test tools, ADF (augmented Dicky-Fuller) and PP (Phillips-Perron), with and without trend. Table 3 displays the test results. All variables are stationary at I(0) or I(1). According to Phillips-Perron, all variables (GDP, agriculture's output and food and beverage manufacture's output) are stationary at 1 % level of significance at the first different intercept and intercept and trend. The unit root results render the ARDL technique valid in estimating food and agriculture sector's influence on Indonesia's economic growth.

Table 3

Unit root test result

Variable		ADF		PP	
		Intercept	Trend and Intercept	Intercept	Trend and Intercept
Level	GDP	-0.9729	-3.1037	-1.5009	-3.0738
	Agri	-2.9544*	0.2921	-4.3143***	-8.0966***
	FnB	-2.3351	-1.2824	-2.3121	-3.1994
First difference	Δ GDP	-7.4852***	-7.3663***	-7.4959***	-7.5695***
	Δ Agri	-0.7670	-69.8297***	10.6932***	-10.4437***
	Δ FnB	-1.6672	-2.6433	-8.1541***	-8.9162***

Note. *, ** and *** are significant at p < 0.1, p < 0.05, and p < 0.01, respectively.
Source: author's computation using EViews 10.

Table 4 displays the ARDL bound test results as formulated in equation (3). It is obvious that all of the three equations produce *F*-statistics bound test values higher than the upper critical bound at 1 % confidence level. Thus, we may conclude there is a long-run relation among the variables.

Table 4

ARDL cointegration test results

Estimated models		Optimal lag length	F-bound test	Decision
GDP	Agri, FnB, DUM	(1,0,1,0)	13.7166	Cointegration
Agri	GDP, FnB, DUM	(1,1,1,0)	18.8684	Cointegration
FnB	GDP, Agri, DUM	(1,0,0,0)	18.4200	Cointegration
Indicators		Significant (finite sample, n = 30)		
			Lower bound, I(0)	Upper bound, I(1)
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

Source: author's computation using EViews 10.

Confirmation of the long-run cointegration relation is a condition for using ARDL to estimate the long-run model. As a result, there is a tendency for the variables to move together toward the long-run equilibrium. Table 5 presents the results of coefficients estimated using the ARDL model and the results of the error correction model (ECM), respectively. In the long run, agriculture and food and beverage manufacture positively and significantly influence economic growth. The food and beverage industry's influence is greater on economic growth than agricultural output, where 1 % growth of the food industry will lead to 0.23 % economic growth, while an increase in agricultural output will only contribute 0.10 % respectively. COVID-19 pandemic negative influences economic growth, but this impact is insignificant. However, the simultaneous effect of COVID-19 pandemic and agriculture and food and beverage manufacture is significant on Indonesia's economic growth. In the short run, only agriculture has a causal relation with economic growth. The system will return to long-run equilibrium in case of short-run shock, at adjustment speed of 48.60 % per quarter.

Table 5

Results of coefficient estimation of long- and short-run economic growth equation

ARDL Regression Dependent variable: GDP, ARDL (1,0,1,0)			ECM Regression Dependent variable: Δ GDP		
Independent variable	Coefficient	t-statistic	Independent variable	Coefficient	t-statistic
GDP_{t-1}	0.5140	3.6549***	Δ Agri	0.1022	5.8433***
Agri	0.1022	2.2085**	ECT	-0.4860	-8.9450***
$Agri_{t-1}$	0.0634	2.0717**			
FnB	0.2320	2.0549**			
DUM	-0.0124	-1.6012			
R^2 = 0.9731					
F-stat = 173.9342 ***					
Residual diagnostic: there is no heteroscedasticity, serial correlation, autocorrelation, or partial correlation.					

Note. ***, **, and * are significant at $p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively.
Source: author's computation using EViews 10.

The stability test on the economic growth model, as presented in Table 5, is stable according to CUSUM (the cumulative sum of recursive residuals) and CUSUMSQ (the cumulative sum of squares of recursive residuals). Figure 3 presents the test results.
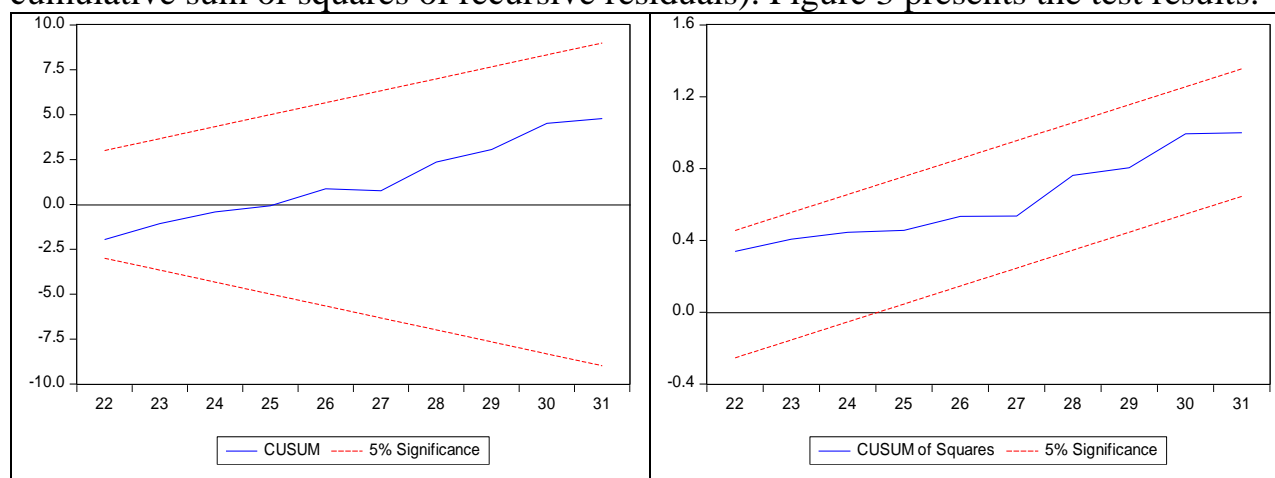

Figure 3. Stability test of economic growth model

Source: author's computation, EViews 10.

Cointegration in a model indicates that at least one independent variable has a causal relation with the dependent variable. The analysis continued with the ARDL-Granger test, of which results are shown in Table 6. The three variables have a long-run causal relation, and their causality is bi-directional (dynamic relation). There is no significant impact of COVID-19 in all of the three equations, as the DUM's (dummy variable represented the situation during COVID-19 pandemic) coefficient is insignificant. However, in the short run, only agriculture has a causal relation with economic growth (GDP). Meanwhile, economic growth has a causal relationship with agriculture in the short- and long-run. In contrast, the causal relation between economic growth and food and beverage manufacture only appears in the long run.

Table 6

ARDL-Granger causality analysis

Dependent variable	ARDL optimal lag	Short run causality (F-stat of Wald-test)				ECT
		Δ GDP	Δ Agri	Δ FnB	DUM	
Δ GDP	(1,0,1,0)	-	0.1022**	0.2320	-0.0124	-0.4860***
Δ Agri	(1,1,1,0)	1.5431**	-	1.5321***	0.0323	-1.1971***
Δ FnB	(1,0,0,0)	0.5631	0.2037	-	0.0063	-0.4976***

Note. ***, **, and * are significant at $p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively.

Source: author's computation using EViews 10.

The three variables have a long-run causal relation, and their causality is bi-directional (dynamic relation). Highlighting the short-run causal relations between these variables, the information in Table 6 is presented in the form of drawing as in Figure 4.

The economic growth model in equation (2), of which regression estimation results are as shown in Table 5, indicates a dummy variable representing COVID-19 pandemic does not change the agriculture and food industry sectors' role in Indonesia's economic growth, as the results of studies by [29; 30]. Both agriculture and food and beverage manufacturing positively and significantly influence Indonesia's GDP with

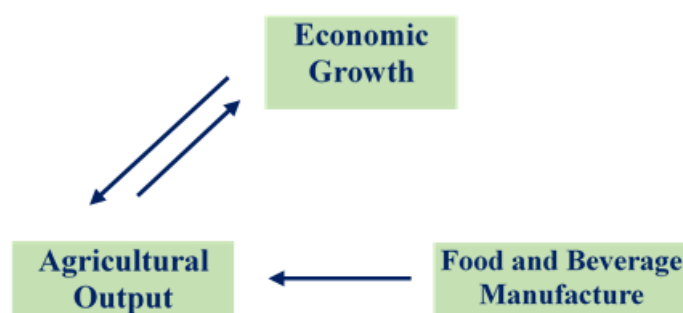food processing industry sector's greater contribution.

Figure 4. Short-run ARDL-Granger causality of agricultural output, food and beverage manufacture's output and economic growth

Source: built by the author.

A 1 % increase in food and beverage manufacturing output and agricultural output will have GDP increased by 0.23 % and 0.10 %, respectively. The dummy variable's regression coefficient is negative, indicating that COVID-19 pandemic negatively influences Indonesia's economic growth despite its partial insignificance. Nevertheless, COVID-19 pandemic's negative effect cannot be disregarded completely considering that simultaneously, along with agricultural production and food industry, COVID-19 pandemic has a significant effect as indicated by the F-test of regression estimation which is significant at 1 %. Likewise, with a regression coefficient of -0.01, COVID-19 pandemic is not strong enough to disrupt the influence of agriculture and food processing industry on Indonesia's economic growth. In the short run, COVID-19 pandemic's effect does not appear at all.

The economic growth with regard to the food processing industry sector's production partially and simultaneously shows a positive and significant impact on the growth of Indonesia's agricultural sector. Although the agricultural sector's contribution to GDP decreases continuously, agriculture still serves a crucial role as food provider to satisfy household's needs for private consumption, which is the main component of Indonesia's GDP from the demand part, and as supplier of raw materials for food industry. A 1 % increase in GDP will encourage the agricultural sector to stimulate an increase in production by 1.54 % while food and beverage manufacturing's output growth will encourage an increase in agricultural output by 1.53 %. COVID-19 pandemic has no negative impact on agricultural production as indicated by the dummy variable's positive but insignificant regression coefficient. This confirms the estimate of [20] that the pandemic hit less agriculture in China, Indonesia, and Lao PDR.

In analyzing the pandemic conditions, in the short run the estimated regression coefficients on the agricultural output equation can also be interpreted in reverse, i.e. if Indonesia's economy contracts by 1 %, the agricultural production will decrease by 1.54 %. Likewise, if food and beverage manufacturing output decreased by 1 %, the agricultural output will also decrease by 1.53 %. Thus, the results of the study can generalize previous results that use cross-section data and conclude that changes in the agricultural output are mostly induced by demand part e.g. [53] through the following

mechanism: unemployment due to lockdown measures and mobility restrictions have resulted in a shortfall in income [21; 19; 17], thus the demand for agricultural products both directly and through related industries decreases. Therefore, COVID-19 pandemic is more of a supply-chain bottleneck problem [52; 26; 32] rather than a production problem. The economic growth model indicates a dummy variable representing COVID-19 pandemic does not change agriculture and food industry sectors' role in Indonesia's economic growth, as the results of studies by [29; 30].

It should also be noted that the agricultural equation's ECT is higher than one (Table 6), reflecting the seasonal pattern of production in Indonesia's agricultural sector resulting in an oscillating pattern of adjustment to shocks. This conforms to Figure 2 illustrating that during COVID-19 pandemic, the agricultural production pattern has not changed. According to [56], the error correction term with a coefficient -1 to -2 means that it does not converge monotonically to the equilibrium path directly, but rather the error correction process fluctuates around the long-run value in a dampening manner. Once this process is complete, the convergence to the equilibrium path is rapid. According to [48], the deviation from the long-run equilibrium level of agricultural output in the current period is corrected by 119.71 % in the next period to restore equilibrium when there is a shock to the steady-state relation, but an ECT higher than 100 % means it has a type of convergence that oscillates to the long-run equilibrium and takes less than a quarter of the time to return to the long-run.

In the short run, there is no noticeable effect of economic growth or agricultural production on the food industry. The relation between these three variables is only noticeable in the long run with a dynamic causality pattern. In the long run, GDP and agricultural output both partially and simultaneously have a positive and significant effect on food and beverage manufacturing, where GDP's influence is greater than agriculture's effect. A 1 % increase in GDP and agricultural output will increase food and beverage processing industry's output by 0.56 % and 0.20 %, respectively. COVID-19 pandemic does not negatively affect Indonesia's food industry since the regression coefficient results are positive and insignificant. Although the simultaneous effect of COVID-19 and the other two variables is significant, this effect is very small with a regression coefficient 0.0063. Thus, the opinion of [20] that COVID-19 pandemic negatively influences manufacturing industry, taking double blows of disruptions to the supply of raw materials and capital goods and logistics shortages, cannot be generalized for Indonesia's food and beverage industry.

According to [20] Indonesia's economy recovered faster and [57], argued that in that recovery, the agricultural sector played a very important role. In comparison, the Asian financial crisis in 1997/1998 took about 20 quarters for Indonesia's economy to recover to the pre-crisis levels, while the COVID-19 crisis took only six quarters to reach the pre-pandemic levels. Thus, in the face of COVID-19 pandemic, Indonesia's economy not only did not fall too deeply (Q2-2020 GDP contracted by 4.4 %, below that of Thailand, Singapore, Malaysia, and the Philippines, which contracted by 9.2 %, 9.6, 9.9, and 14.3 % respectively), but it also recovered quickly. This was predicted by [58] that if the pandemic could be controlled, the country's economy would recover.

Several factors supported Indonesia's economy not falling too deeply in the face of crisis, categorized as the worst crisis of all time after the great depression of the 1920s [59]. One contributing factor was the character of Indonesia's agricultural sector, as the economy's driving force in times of crisis, as it was in the previous financial crises in 1998 and 2008. During times of crisis, most laborers, especially low-skilled laborers, shift to the agricultural sector [60]. The economic recovery is also an integral part of the rapid progress in the health sector, including global collaboration in developing vaccines, cheaper tracing techniques with rapid results for faster treatment of infected people, either by self-isolation or isolation at hospitals, and the application of better therapies [6]. This, coupled with the results of intensive campaigns such as wearing masks in public spaces, social distancing, and hand washing, had successfully controlled COVID-19 within two years.

All countries in the world undertook fiscal interventions to halt the economic downturn caused by crises. In developed countries, the measures taken were corporate fiscal bailouts and bailouts for banks and financial institutions [61]. The Indonesian Government implemented fiscal policy instruments in the form of fiscal stimulus, which was an increase in government consumption as conceptually found in [62], namely, the budget disbursed for dealing with COVID-19 reflecting a balance between public health and the economy, including (i) health, (ii) social protection of life support aid for poor and near-poor families, and (iii) protecting businesses from mass bankruptcy, especially MSMEs (Micro, Small and Medium Enterprises). These three aspects were handled simultaneously at the national and local levels, of which fund was from the central government. All of these measures expended IDR 1,645.45 trillion from 2020 to 2022, increasing government debt by 52 % from 2019 and July 2022 from IDR 4,779.26 trillion to IDR 7,733.99 trillion [63; 64]. However, the government's measures were in line with the nature of Indonesia's economy, that is domestic demand-driven growth [65; 66].

Given the dynamic causal relation between economic growth, agricultural output, and food and beverage processing industry's output, and the fact that the economic shocks caused by COVID-19 were induced by the demand, instead of disruptions in production, the most effective policy was to stimulate domestic consumption growth as the economy's driving force through fiscal stimulus aimed at maintaining household demand for food and agricultural products and protecting industries from bankruptcy in order to prevent mass unemployment. Fiscal policy was implemented in parallel with the measures to deal with the pandemic, which was the source of economic shock.

Compared to the other ASEAN (Association of Southeast Asian Nations) countries, Indonesia recovered faster and fell into a more superficial recession, reminding us that the strategy to develop agriculture-based industries first to satisfy domestic needs and later satisfy foreign demand (exports) is an important choice, given that this strategy has shown more resilient results (strong enough to withstand the crisis's impacts leading to quicker economic recovery) even if under normal conditions it has not shown spectacular growth. Thus, building a strong agro-industrial system to develop a sustainable contribution to the economy as an engine of growth is one

mitigation measure in the face of crisis, which is inevitable.

Conclusion. Indonesia's food and agriculture sector and economic growth show a dynamic causality (bi-directional causality) between agricultural sector and economic growth, food and beverage processing industry and economic growth, and agricultural sector and food and beverage manufacturing. In the short run, bi-directional causality occurs between agricultural sector and economic growth and unidirectional causality from food and beverage processing industry to agriculture. COVID-19 pandemic partially had an insignificantly negative effect on economic growth, but at the same time, this negative effect was also significant, despite the quite low regression coefficient of -0.01 that this effect was not strong enough to disrupt agricultural sector and food and beverage processing industry's positive effect. With the insignificantly positive regression coefficient, COVID-19 pandemic did not negatively affect agricultural production and food and beverage industry. Indonesia's agricultural sector, which was heavily influenced by seasonality, showed an oscillating production pattern before the pandemic. This pattern had also not been disrupted by COVID-19 pandemic that the quarterly down and up cycles were still visible during the pandemic just like previously before the pandemic. Indonesia's economy recovered faster than other ASEAN countries thanks to the global health sector's rapid progress and the Indonesian government's policies effectively maintaining balance between health and economy in dealing with COVID-19. In line with the health measures such as healthy lifestyle campaigns and international collaboration in vaccine development, the Indonesian Government launched a fiscal stimulus of social safety net in support of the poor and near-poor households and protecting MSMEs (micro, small, and medium enterprises) from bankruptcy and possible massive unemployment.

This study's limitation is that it uses aggregate agricultural data assuming that the agricultural output is homogeneous, which is essentially quite diverse between food crops and horticulture which are predominantly managed by small farmers in rural areas aiming at local market production for fresh products versus plantations of which output is dominated by large companies aiming at export after processing into semi-finished or finished/consumable goods, and fisheries, as a combination of the two previous product groups. It is necessary to further explore whether agricultural sector's resilience to the crisis (in this case originating from COVID-19 pandemic) is more evenly distributed across all subsectors or whether only one subsector is strongly resilient with a very large contribution to agricultural GDP so that it can totally cover the other subsectors' downturn. In addition, due to quarterly data limitations, this study uses a closed economy model that does not include international trade and its associated macroeconomic variables in the analysis. Further exploration will be needed in the future with an open economy model. In addition, the role of the government social safety net program in providing basic food assistance and subsidizing shipping costs for online purchases in encouraging demand growth should be explored, which can serve as a signal producing farmers to continue production to meet demand through contactless marketing.

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