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Transformation of the Agricultural Sector in Sulawesi Island: A Panel Data Approach

Lestari Gita Nur'aini[1], Teguh Endaryanto[2]*, Muhammad Irfan Affandi[2]

ABSTRACT

Technological revolutions, globalization, and complicated market dynamics have expedited the transformation of economic structures. This process is further influenced by the diversity of natural resources among regions, which drives economic development. In today's world, understanding economic change is critical for promoting long-term economic growth. The purpose of this study was to examine structural changes in the agriculture sector and its subsectors on Sulawesi Island, as well as the variables that affect them. The analytical approaches used include descriptive analysis of panel data processed with Microsoft Excel and panel data regression. The findings demonstrate that between 2010 and 2022, Sulawesi's agriculture industry lost 6.24% of its GDP contribution, as did all its subsectors. This decrease was complemented by a rise in the industrial sector's contribution of 5.43%. In the regression analysis, the fixed effect model (FEM) proved to be the best fit. Population density ($X1$) and the Indonesian democracy index (IDI) ($X3$) had a positive and significant influence on economic transformation, whereas farmers' terms of trade (FTT) ($X4$) and the number of people living in poverty ($X5$) had a negative and significant impact on Sulawesi's agricultural economy transformation. It is suggested that agribusiness operators vary processed products based on agricultural raw materials to aid and balance economic transition.

Keywords: economic transformation, fixed effect model, panel data regression, sectoral GDP contribution, structural shift

INTRODUCTION

Economic conditions in Indonesia differ by region, based on the potential of their natural resources. These variations are reflected in each region's gross regional domestic product (GRDP). Java Island contributes the most to the national GDP, accounting for 58.69%, followed by Sumatra (21.01%), Kalimantan (8.21%), Sulawesi (6.73%), and Papua (1.99%). Each area has a specific dominant sector that contributes the majority of its GRDP. The manufacturing sector dominates Java (28.33%), Sumatra agricultural (23.02%), Kalimantan and Papua mining (32.29% and 36.61%, respectively), and Sulawesi agriculture (21.43%) (BPS 2023). The primary sectors that contribute to each region's GRDP highlight these disparities in economic structure. According to studies by Taufiqqurrachman (2022) and Suryani (2019), the manufacturing industry dominates Java's economy and has been found to be a major sector in many regions of the island. Sumatra relies largely on agriculture, which is consistent with the conclusions of Irza (2021), Martauli (2021), and Fabiany (2021), who identified agriculture, forestry, and fisheries as the region's key sectors. Suciyanti *et al.*

(2018), Karmin *et al.* (2022), and Mahrita *et al.* (2016) found that the mining and quarrying sectors benefit both Kalimantan and Papua. Meanwhile, Sulawesi continues to rely on agriculture, as evidenced by research by Arsana *et al.* (2020), Cahyono *et al.* (2021), and Darman and Afi (2016), which confirm that agricultural remains a critical sector in numerous districts of Sulawesi.

Sulawesi, with an area of 174,600 km², is Indonesia's fourth largest island and the eleventh largest in the world (Ministry of Public Works and Housing 2017; Aninsi 2021). This large land area supports the agriculture sector's important contribution to Sulawesi's GDP, which has been a key contributor since 2010. In 2022, agriculture contributed 22.32%, down from 27.68% in 2010. This loss represents a structural economic shift, also known as economic transformation, which is a fundamental transition toward a more contemporary, efficient, and diverse economic system (Risza 2014). Sulawesi's economic development is heavily reliant on intersectoral links. For example, the manufacturing industry has both backward and forward links to agriculture and trade. The disparities in prominent sectors between provinces point to an economic structure shift, with the primary sector, particularly agriculture, playing a declining role. The Covid-19 pandemic has hastened this transition by considerably affecting the national economy (Fahrika and Roy 2020). During the pandemic, almost all economic sectors had negative growth, except for

[1] Department of Agribusiness, Faculty of Agriculture, Mulawarman University, Samarinda 75123

[2] Agribusiness Study Program, Faculty of Agriculture, University of Lampung, Bandar Lampung 35145

* Corresponding Author:
  Email: teguh.endaryanto@fp.unila.ac.id

agriculture, information and communication, and health and social services (Sadiyah 2021).

Given the different events that have generated economic transformations, it is critical to consider how these changes have impacted on the agriculture sector. As a result, the purpose of this study was to examine the transformation of the agricultural sector on Sulawesi Island between 2010 and 2022, as well as to identify the elements that affect this transition. The study's findings are intended to help policymakers improve Sulawesi's economic development.

METHODS

The study was purposefully done on Sulawesi Island, which still relies heavily on agriculture to support its economy. Sulawesi is Indonesia's fourth largest island and the world's tenth largest (Aninsi 2021). The study was conducted from August 2023 to January 2024 using secondary data, which included the Gross Regional Domestic Product (GRDP) at constant 2010 prices, population density, investment, the Indonesian Democracy Index (IDI), Farmers' Terms of Trade (FTT), and the number of people living in poverty in all provinces of Sulawesi from 2010 to 2022. Data were gathered from the provincial and central offices of Statistics Indonesia (BPS), as well as pertinent scholarly publications. Data was gathered through a literature review and documentation of pertinent sources.

The initial analytical method used was descriptive analysis with Microsoft Excel software. Panel data regression analysis with EViews 9 software was used to discover the elements impacting agriculture economic transformation. The data analysis method involved the following steps:
(1) Selecting an estimating model (Common Effect Model, Fixed Effect Model, Random Effect Model),
(2) Choosing an estimation approach (Chow Test, Hausman Test, Lagrange Multiplier Test),
(3) Conducting traditional assumption tests (multicollinearity and heteroscedasticity), and
(4) Interpreting findings using the best-fitting model.

RESULTS AND DISCUSSION

Economic Transformation

Structural economic transformation is the process of moving the economic structure away from low-productivity activities like traditional agriculture and toward more modern and productive sectors like industry and services. Since the Industrial Revolution, this change has been regarded as critical to economic progress and development. Table 1 details the economic evolution of Sulawesi Island's agricultural industry. The occurrence of economic transition in Sulawesi Island is evidenced by a 6.24% drop in the agriculture sector's contribution to GRDP from 2010 to 2022. In contrast, the industrial sector saw the greatest rise in contribution, at 5.43%, indicating a shift in economic structure from the primary to the secondary sector. Furthermore, Dahuri (2023) stressed that one of the important priorities in economic sector transformation (EST) is agricultural sector modernization, which must be aligned with agricultural resource carrying capacity as well as environmental sustainability. This modernization intends to increase the agriculture sector's productivity, efficiency, competitiveness, inclusivity, and sustainability. As a result, although economic change is focusing on the industrial sector, the agricultural sector, which serves as the cornerstone of the primary sector, must not be overlooked.

Table 1 also shows that Central Sulawesi had the highest reduction in the agricultural sector contribution, at −19.39%. Since 2020, the manufacturing industry has supplanted this sector as the primary contributor to GRDP. The manufacturing and mining sectors have driven the region's economic growth, mainly due to increasing nickel pig iron (NPI) production capacity by

Table 1 Structural shift in the agricultural sector of Sulawesi Island, 2010–2022 (%)

Location	Increased contribution		Decreased contribution	
	Sector	Value (%)	Sector	Value (%)
Sulawesi Island	Manufacturing	5.43	Agriculture	6.24
	Others	3.41	Others	2.60
South Sulawesi	Information and Communication	2.81	Agriculture	3.11
	Others	4.46	Others	4.16
North Sulawesi	Information and Communication	1.26	Agriculture	3.92
	Others	4.10	Others	1.44
Central Sulawesi	Manufacturing	26.16	Agriculture	19.39
	Others	8.68	Others	15.45
West Sulawesi	Manufacturing	1.94	Agriculture	3.92
	Others	3.58	Others	1.60
Southeast Sulawesi	Trade	1.63	Agriculture	5.26
	Others	5.72	Others	2.09
Gorontalo	Trade	2.89	Agriculture	2.60
	Others	4.04	Others	4.33

various enterprises in Morowali and North Morowali (Bank Indonesia 2022).

Gorontalo Province experienced the smallest reduction in the agriculture sector contribution in Sulawesi, at only 2.6%. This relatively moderate fall is supported by government programs targeted at boosting the agricultural sector, such as the allocation of IDR 2.1 billion in agricultural machinery and equipment in 2023 (Lipu 2023). Despite the pandemic, the agricultural industry continued to develop positively, with a 0.38% increase in the second quarter of 2021. Corn remains a flagship commodity, with production rising from 605,781 tons to 1.8 million tons in a decade, considerably benefiting farmer welfare and the livestock industry (Limanseto 2021).

Southeast Sulawesi likewise had a fall in agricultural contribution, albeit a slight one. This was primarily due to delayed harvests and the shutdown of irrigation systems in various crop areas (Bank Indonesia 2023). Nonetheless, government assistance helped to maintain an average rice surplus of 26,747 tons each year from 2019 to 2022. Diversification initiatives were carried out by cultivating sorghum and porang, constructing farm roads, providing 4,153 units of agricultural machinery, and exporting vital commodities such as cashews, palm oil, and cocoa (Musyafir 2023).

Factors Influencing Economic Transformation

Economic change can be seen in shifts in regional GRDP, which can have a considerable impact on economic growth, employment, and wellbeing. A thorough grasp of the factors that influence economic transition is consequently required. In this study, the difference in GRDP contribution between the agricultural and industrial sectors was used to assess the dependent variable (Y), which represents the agricultural economic sector change in Sulawesi Island. This measurement was based on the observed pattern of diminishing agricultural contribution and increasing industrial contribution, with the assumption that the economy was transitioning from agriculture to industry. The independent variables predicted to influence the transformation are population density ($X1$), investment ($X2$), the Indonesian Democracy Index (IDI) ($X3$), farmers' terms of trade (FTT) ($X4$), and the number of people living in poverty (X_5).

The best model was chosen utilizing estimate techniques, notably the Chow test and the Hausman test. According to the results of these tests, the probability values were less than the significance level of 0.05, indicating that the Fixed Effect Model (FEM) is the best model to adopt. Choosing the best-fitting model is an important step in ensuring that research findings are relevant, valid, and applicable to policymaking. The results of the Chow and Hausman tests are shown in Table 2.

According to numerous authors, panel data has the advantage of not necessitating extensive traditional assumption testing (Ajija *et al*. 2011). However, conventional assumption tests were still required to analyze multicollinearity and heteroscedasticity, as indicated by Basuki and Yuliadi (2014) and Napitupulu *et al*. (2021). The results of these two assumption tests are shown in Table 3. It shows the results of the multicollinearity test, in which all independent variables have variance inflation factors (VIF) values less than 10. This finding is consistent with research conducted by Wasiaturrahma and Rohmawati (2021) and Ameh and Lee (2022), suggesting that the data are not multicollinear. Heteroscedasticity analysis is critical, particularly when working with cross-sectional data (Maziyya *et al*. 2015). The heteroscedasticity test findings clearly reveal that the data are not heteroscedastically distributed. All independent variables have probability values greater than or equal to 0.05, which supports this conclusion.

As previously stated, the best-fitting model in this investigation is the fixed effect model (FEM), as seen in Table 4. The equation generated from the best-fitting model, specifically the fixed effect model (FEM), is as follows:

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + E_{it}$$

Table 2 The result of Chow and Hausman tests

Chow test			
Effects test	Statistics	d.f.	Prob.
Cross-section F	33.728622	(5.60)	0.0000
Cross-section chi-square	94.985060	5	0.0000
Hausman test			
Test Summary	Chi–Sq. Statistics	Chi–Sq. d.f.	Prob.
Cross-section random	168,643108	5	0.0000

Table 3 The result of multicolinearity and heterocedasticity test

Independent variable	VIF	Probability
Population density	1.457	0.6100
Investation	1.697	0.4483
Indonesian democracy index	1.278	0.0529
Farmers' terms of trade	1.145	0.6471
Number of people living in poverty	1.782	0.1574

$$Y_{it} = 9{,}255{,}815 + 302{,}8711 X_{1it} + 0.088621 X2it + 67.21602 X3it - 148.8209 X4it - 43.05982 X5it$$

Y represents economic sector transformation (IDR billion), X_1 is population density (people/km^2), X_2 is investment (IDR billion), X_3 is the Indonesian Democracy Index (IDI) (points), X_4 is the farmers' terms of trade (FTT) (points), and X_5 is the number of people living in poverty (thousands), β_1 to β_5 is the regression coefficients for each independent variable, t is the time period (2010−2022), i is the location, and E is the error term.

According to Table 4, the coefficient of determination is 0.982437, which means that the variables population density ($X1$), investment ($X2$), Indonesian Democracy Index ($X3$), farmers' terms of trade ($X4$), and number of people living in poverty ($X5$) explain 98.2437% of the variation in economic structural transformation. The remaining 1.7563% is explained by variables not included in the model. This high R-squared value indicates that the chosen model has significant explanatory power.

The estimation results in Table 4 also show that the probability of the F-statistics is 0.0000, indicating that population density ($X1$), investment ($X2$), IDI ($X3$), FTT ($X4$), and poverty rate ($X5$) all have a significant influence on the transformation of the agricultural economy at the 1% level. This low F-statistics probability indicates the regression model's statistical validity and suitability for application. According to the t-test results, four of the five independent variables: $X1$, $X3$, $X4$, and $X5$, were found to have a substantial impact on agricultural economic transformation. This importance is evidenced by p-values less than 0.10, which indicates that these factors are independently linked with the dependent variable.

Population density has a positive and significant impact on economic structural transformation, with a p-value of 0.000 and a coefficient of 302.8711 at the 99% confidence level. Increasing population density by 1 person per km² might result in an economic change worth IDR 302.8711 billion. This result validates the findings of Hidayat $et\ al.$ (2021), who discovered that population density can influence regional economic growth. Similarly, Ansofino $et\ al.$ (2020) suggest that population size can be a benefit when combined with enough resources and quality of life, but it can also be a burden if it exceeds the region's capacity. Emile Durkheim, a French sociologist, noted that high population density promotes competition, which improves education and skills (Alma 2019). Such good rivalry can boost both the quality and quantity of human resources, fostering economic development.

The Indonesian Democracy Index (IDI) has a positive effect on economic transformation, with a p-value of 0.0987 and a coefficient of 67.21602 at the 95% confidence level. This means that a one-point increase in IDI results in an increase in economic transformation of IDR 67.21602 billion. These findings are consistent with Ansofino $et\ al.$ (2020), who underlined the significance of political, social, psychological, and cultural aspects in economic development. Apipudin (2023) also stated that political stability and security are critical for attracting international investment. This is supported by Agustian and Apriani (2021), that investors are extremely sensitive to legal and political situations, demanding a favorable policy environment to encourage investment. Thus, better political conditions can boost investor confidence and hasten economic transition.

Farmers' terms of trade (FTT) had a negative and significant impact on structural transformation, with a p-value of 0.0027 and a coefficient of −148.8209 at the 99% confidence level. This suggests that each one-point increase in FTT reduces economic transformation by IDR 148.8209 billion. The negative link suggests that higher FTT represents increased agricultural productivity, which strengthens the primary sector and slows the transfer to the secondary sector. This supports Riyadh's (2015) finding that an increase in FTT is favorably connected with agricultural productivity. Economic transformation, on the other hand, is distinguished by a move from the primary to the secondary sector, as seen by the growth of both resource-based and non-resource-based manufacturing businesses (Dahuri 2023).

The poverty rate has a negative and significant impact on economic transformation, with a p-value of 0.0006 and a coefficient of −43.05982 at the 99% confidence level. This means that every 1,000 people who fall into poverty costs the economy IDR 43.05982 billion. Poverty can stifle economic progress and hinder

Table 4 The result fixed effect model (FEM) output estimation

Variable	Coefficient	Std. error	t–Statistics	Prob.
C	9,255.815	7,731.173	1.197207	0.2359
$X1$	302.8711	46.76005	6.477134	0.0000***
$X2$	0.088621	0.106111	0.835167	0.4069
$X3$	67.21602	40.08513	1.676832	0.0987**
$X4$	−148.8209	47.62967	−3.124543	0.0027***
$X5$	−43.05982	11.94868	−3.603731	0.0006***
F–statistics				398.1703
Prob (F–statistics)				0.000000
R–squared				0.984911
Adjusted R–squared				0.982437

the structural transition from the primary to secondary sectors. Economic transformation is essential for achieving long-term growth and poverty reduction (Sugiarto 2019). Similarly, Maulan *et al.* (2022) stated that effective economic growth is critical for poverty reduction. Several other research have proven the negative and significant association between economic growth and poverty (Alish and Yulhendri 2021; Padang and Murtala 2020; Lestari *et al.* 2022; Prasetyawa *et al.* 2017).

CONCLUSION

This analysis shows that, between 2010 and 2022, the agricultural sector's contribution to Sulawesi Island's gross domestic product (GDP) decreased by 6.24%, while the industrial sector increased by 5.43%. Based on the estimation results, the fixed effect model (FEM) is the best fit. Simultaneously, the variables population density ($X1$), investment ($X2$), Indonesian democracy index ($X3$), farmers' terms of trade ($X4$), and poverty rate ($X5$) all have a substantial impact on economic structural transformation. $X1$ and $X3$ have a considerable favorable effect, whereas $X4$ and $X5$ have a significant negative impact. These findings emphasise the significance of boosting agricultural-based industrial product diversification to support the economy's continuous structural transition. Given that this study focuses exclusively on the agricultural sector, future research should include other economic sectors to provide a more thorough understanding of structural change.

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