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ANALYZING THE LONG-RUN AND SHORT-RUN DYNAMICS BETWEEN FOOD PRODUCTION AND LABOR FORCE PARTICIPATION: A VECM APPROACH

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Abstract

This research examines the long-run and short-run relationship between the Food Production Index and the Labor Force Participation Rate for the Philippines through the Vector Error Correction Model (VECM). Informed by the Lewis dual-sector model, the study assesses how changes in agriculture productivity affect labor market activity. Spanning 1990 to 2021, the data is subjected to stationarity and cointegration tests, affirming a stable long-run relationship and significant short-run interactions between the two variables. VECM findings show that labor force participation has significant effects on food production in the short term, whereas food production also has a positive effect on labor participation. Error correction terms confirm the strong tendency for both variables to revert towards long-run equilibrium following short-run shocks. Diagnostic tests confirm adequacy of the model, although non-normality of LFPR residuals calls for careful interpretation. Forecast Error Variance Decomposition (FEVD) reveals limited cross-variable shock transmission, reflecting poor short-run interdependence. The results provide empirical evidence for integrated agricultural and labor policy measures, consistent with the Philippine Development Plan 2023–2028 and Sustainable Development Goals on food security and decent work.

Keywords: *vector error correction model (vecm); food production index; labor force participation rate; cointegration; macroeconomic dynamics*

INTRODUCTION

Agriculture remains crucial to the Philippine economy, even though its contribution to the Gross Domestic Product (GDP) has been decreasing. Serving as a primary source of income for rural communities, its relationship with labor market involvement is of significant concern for policymakers, economists, and development planners. This research aims to explore the evolving connection between food production and labor force participation in the Philippines, acknowledging that changes in agricultural productivity can lead to both short-term and long-term impacts on employment trends. Grasping this relationship is vital for achieving sustainable rural development, ensuring food security, and promoting inclusive growth. Recent literature underscores that labor issues remain central to the sustainability and governance of agrifood value chains. According to Malanski et al. (2022), the scientific community focusing on labor in agrifood value chains is relatively new but rapidly expanding, with increasing attention paid to how governance and institutional contexts shape employment and working conditions. Their scientometric review highlights that the value chain approach is particularly effective for analyzing labor arrangements and their impact on food system sustainability, offering a robust framework for understanding both upstream (production) and downstream (processing, distribution) labor dynamics. In recent years, the complex relationship between food production and labour force participation has drawn more attention, especially in light of economic development, global food security, and the resilience of agri-food value chains. Even as mechanisation and technology continue to transform the agricultural and food manufacturing industries, labour is still a vital component of food production systems (Ramsey, Goodwin, & Haley, 2021).

Policymakers and other stakeholders who want to guarantee a steady supply of food, enhance employment outcomes, and promote sustainable development must have a thorough understanding of the relationships between labour force participation and food production. In countries like the Philippines, where agriculture plays a vital role in both livelihood and national development, understanding the link between food production and labor force participation is essential. For many rural communities, farming remains a key source of income and resilience against economic disruptions, especially where alternative job opportunities are limited. However, over the past few decades, this dynamic has been shifting. Urbanization, industrial growth, and demographic changes have led to fewer people working in agriculture, raising important concerns about

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the future of food security and rural stability—particularly as the population grows and climate change intensifies these challenges. Agriculture is highly dependent on labor, so even small changes in the workforce can have a significant impact on how much food is produced. At the same time, broader factors like infrastructure, access to education, and financing also shape agricultural performance (Anderson & Feder, 2007). Labor force participation rate (LFPR), in this context, not only reflects employment levels but also serves as a signal of how well an economy can channel human resources into productive work—farming included. Romer's (1994) endogenous growth theory provides a useful lens here, emphasizing that long-term growth depends on factors like labor, productivity, and knowledge.Interestingly, the relationship between these two variables may not be one-way. Better food production could also encourage more people to participate in the workforce by improving health, income, and overall household stability. This mutual influence highlights the need for an approach that considers both short-term shifts and long-term patterns. To explore this connection, the present study applies a Vector Error Correction Model (VECM), using data from the Philippines from 1990 to 2021.

By doing so, it aims to uncover how shocks in one area might influence the other, and what these dynamics mean for future workforce policies, agricultural development, and national food strategies. Although its share in GDP is declining, agriculture in the Philippines remains an important source of livelihood for a significant part of the population. It is significant to study the dynamics of food production and their effects on labour markets, considering the current drive towards the Sustainable Development Goals (SDGs), particularly Goal 2 (Zero Hunger) and Goal 8 (Decent Work and Economic Growth). Current studies indicate that farm performance and employment participation go hand in hand, and ignoring this correlation might minimize the effectiveness of labour and macroeconomic policies (Alvarez & Serin, 2022; Dizon & Reyes, 2023). In order to investigate the short- and long-term connections between food production and labor force participation in the Philippines, this study uses a Vector Error Correction Model (VECM). With theoretical and practical implications for development planning, the VECM framework is especially helpful for comprehending how short-term changes line up with long-term equilibrium tendencies. By separating short-term fluctuations from long-term equilibrium relationships, the VECM framework makes it possible to gain a more sophisticated understanding of how shocks and adjustments spread over time across the food system. The study intends to offer empirical evidence on the causal relationships and adjustment mechanisms that define the labor-food production nexus by using this econometric method.

RESEARCH METHODS

This research used a quantitative, time series research design to examine the long-run and short-run dynamic relationships between the foddprodindex (food production index) and lfpr (labor force participation rate). The main methodological tool used was the Vector Error Correction Model (VECM) suitable for multivariate time series data with non-stationary but cointegrated variables. The selection of VECM was guided by initial tests such as the Augmented Dickey-Fuller (ADF) test for stationarity and the Johansen cointegration test. These diagnostics identified that both the variables are integrated of order one, I(1), and have a long-run equilibrium relationship.

VEC specifications were appropriate because they capture short-run deviations and long-run equilibrium adjustments of the endogenous variables at the same time. The cointegration that exists requires adding an error correction term (ECT) to the model, reflecting the rate at which variables restore equilibrium following a short-run shock. This framework enabled strong policy-relevant interpretation by separating the effect of disequilibrium in the food production index, say, on the adjustment behavior of the labor force participation rate over time.

Data were treated with econometric modeling techniques, such as the estimation of the VECM, forecast error variance decomposition (FEVD), and diagnostic tests like the Ljung-Box test for autocorrelation and the Jarque-Bera test for normality. These procedures guaranteed model adequacy and the validity of statistical inference.

Vector Error Correction Model (VECM) Formula

The general form of the VECM used in this study for two variables Y_{1t} (e.g. foodprodindex) and Y_{2t} (e.g., lpfr), is expressed as:

$$\Delta Y_t = \prod \quad Y_{t-1} + \sum_{i=1}^{k-1} \quad \Gamma_i \, \Delta Y_{t-1} + \, u_t$$

Where:

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$Y_t = [\, Y_{1t}\ Y_{2t}\,]$ is the vector of endogenous variables.
ΔY_t denotes the first difference of the variables, capturing short-run dynamics.
$\prod Y_{t-1}$ is the error correction term, where $\prod = \alpha\beta'$, with:
β representing the cointegrating vectors (long-run relationships),
α capturing the speed of adjustments coefficients.

Γ_i are the matrices of short-run coefficients.
u_t is a vector of white noise error terms.
k is the original optimal lag length determined by information criteria (e.g., AIC, BIC)

This specification combines both short-run dynamics and equilibrium correction and permits an exhaustive understanding of temporal interdependence between labor force participation and food production.

RESULTS AND DISCUSSION

This research seeks to examine the dynamic relationship between the food production index and the labor force participation rate (LFPR) using a Vector Error Correction Model (VECM) with a focus on how shocks to one variable affect the other in the long run through the use of impulse response functions (IRFs) and forecast error variance decomposition (FEVD). In order to confirm the reliability and stability of the model, diagnostic tests like the Ljung-Box test for autocorrelation and the Jarque-Bera test for normality are also conducted. In general, the research aims to reveal both the long-run equilibrium relationship and the short-run adjustments between these two most important macroeconomic variables.

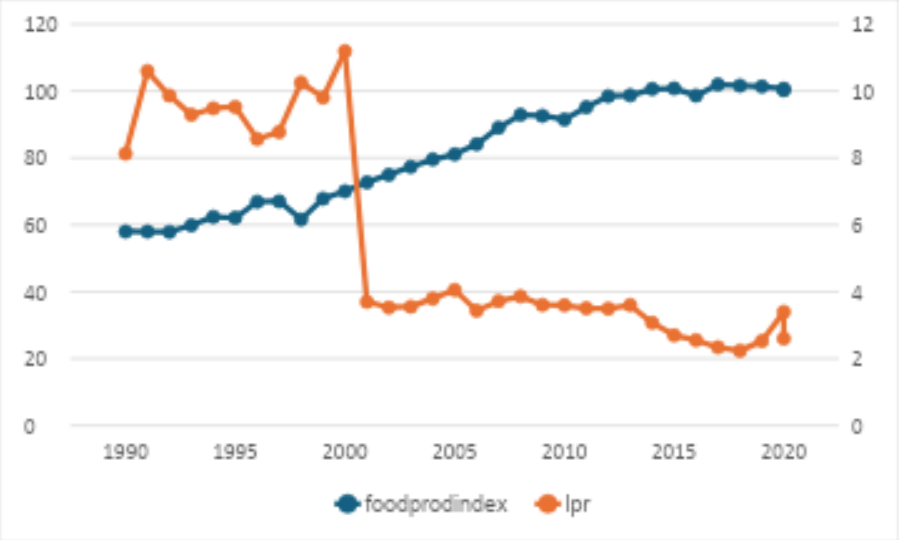

Figure 1. Food Production Index and Labor force Participation Rate, 1990 – 2021, Philippines

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Table 1. ADF Test

Metrics	foodprodindex	lfp
tau-stat	-4.33452	-6.69126
tau-crit	-1.95212	-1.95212
aic	4.874852	3.644214
bic	4.921559	3.690921
lags	0	0
coeff	-0.7867	-1.17379
p-value	< .01	ti< .01

The following table shows the results of unit root tests on the variables food production index and labor force participation rate (LFPR), both of which are seen to be stationary at level. The tau-statistics for the food production index (-4.33) and the LFPR (-6.69) are considerably lower than the critical tau-value of −1.95, leading to a rejection of the null hypothesis of unit root at 1% level of significance ($p < .01$). Both series were tested for zero lags, as established by information criteria. The corresponding AIC and BIC values are quite low, in favor of model parsimony—AIC values of 4.87 and 3.64, and BIC values of 4.92 and 3.69 for food production index and LFPR, respectively. The autoregressive coefficients are negative and large, at −0.79 for food production index and −1.17 for LFPR, further validating mean-reverting behavior. These results confirm that the two variables are stationary at levels and ready to be modeled with further time series analysis, such as cointegration or Vector Error Correction Modeling (VECM).

The graph shows the trends in the Philippines' food production index and labor force participation rate (LFPR) from 1990 to 2021. The further question if which food production index (blue line) starts around 80 in 1990, jumps with fluctuations and then around 1998 drops down drastically until 2002, then keeps going up to around 100 in 2021. The orange line represents the LFPR, starting at approximately 10 in 1990, demonstrating a steep descent approximately at the same time as when the food production index decreased and stabilizing between 6 and over between most of the remaining years until 2021. This visual presentation of the process elucidates the evolution of food production and labor force participation over the years through markings of important turning points and stabilization phases.

Table 2. Vector Error Correction Model Results for foddprodindex and lfpr

Equation	**Regressor**	**B**	**SE**	**z**	**p**	**95% CI**
foddprodindex	L1.foddprodindex	0.217	0.209	1.038	0.299	[-0.192, 0.626]
	L1.lfpr	1.011	0.242	4.177	<.001	[0.537, 1.485]
lfpr	L1.foddprodindex	0.437	0.178	2.448	0.014	[0.087, 0.786]
	L1.lfpr	-0.164	0.207	-0.794	0.427	[-0.569, 0.241]
Error Correction (Adjustment Coefficients, α)						
Equation	Error Correction Term (ec1)	B	SE	z	p	95% CI
foddprodindex	ec1	-1.476	0.328	-4.504	<.001	[-2.118, -0.834]
lfpr	ec1	-0.916	0.28	-3.27	0.001	[-1.464, -0.367]
Cointegration Vector (Normalized on foddprodindex)						
Variable	β	SE	z	p	95% CI	
foddprodindex	1	0	—	—	[1.000, 1.000]	
lfpr	1.232	0.22	5.604	<.001	[0.801, 1.663]	

Vector Error Correction Model (VECM) was estimated in order to test the short- and long-term dynamics between the Food Production Index (foddprodindex) and the Labor Force Participation Rate (lfpr). The model incorporated both the short-term coefficients (lagged endogenous variables and deterministic terms) and long-term cointegration relationships.

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For the foddprodindex equation, the lagged dependent variable (L1.foddprodindex) was not statistically significant, \(b = 0.217 \), SE = 0.209, z = 1.038, p = .299, which implies that previous food production does not have significant predictive power for its current values in the short run. Yet, the lagged lfpr was extremely significant, (β= 1.011), SE = 0.242, z = 4.177, p <.001, indicating a strong positive short-run impact of labor force participation on food production.

By comparison, the lfpr equation revealed that the lagged foddprodindex had a statistically significant impact on lfpr, (β = 0.437), SE = 0.178, z = 2.448, p =.014, which suggests that food production positively influences labor force participation in the short run. Yet, the own lag (L1.lfpr) was insignificant, (β = -0.164 \), SE = 0.207, z = -0.794, p =.427.

The error correction terms (α) were substantial for both equations, establishing the existence of a long-run equilibrium relationship between the variables. For the foddprodindex equation, the adjustment coefficient was (α = -1.476), SE = 0.328, z = -4.504, p <.001. This large and statistically significant negative coefficient suggests immediate correction of deviations from the long-run equilibrium in the food production equation. In the same way, the lfpr equation also had a large adjustment coefficient, (α = -0.916), SE = 0.280, z = -3.270, p = .001, showing that labor force participation rate deviations from equilibrium also elicit adjustments, but at a little bit slower rate.

The normalized cointegrating vector, with foddprodindex as the dependent variable (normalized to 1), indicates that lfpr enters the long-run equation with a coefficient of (β = 1.232 \), SE = 0.220, z = 5.604, p <.001. This indicates that, in the long run, one unit increase in lfpr is correlated with a 1.232 unit increase in foddprodindex, supporting the theoretical expectation of strong long-term connection between labor participation and food production.

Table 3. Ljung-Box Test Results for Autocorrelation and Jarque-Bera Test Results for Normality

Lag	foddprodindex χ^2	p-value	lfpr χ^2	p-value
1	0.041	0.84	0.698	0.403
2	1.022	0.6	2.588	0.274
3	2.611	0.456	4.066	0.254
4	2.794	0.593	4.114	0.391
5	4.037	0.544	5.409	0.368
6	5.427	0.49	5.751	0.452
Variable	JB Statistic	p-value	Skewness	Kurtosis
foddprodindex	2.181	0.336	-0.537	3.733
lfpr	12.3	0.002	0.516	5.908

The Ljung-Box test was run through lag 6 to determine the existence of autocorrelation in the residuals for both foddprodindex and lfpr. For foddprodindex, all p-values are significantly higher than the standard 0.05 threshold (between 0.490 and 0.840), which means that there is no significant autocorrelation at any of the lags tested. This implies that the residuals are white noise, which confirms model adequacy. The same can be said of the lfpr series, where non-significant results appear in all lags, with p-values between 0.254 and 0.452. This again suggests that there is no systematic autocorrelation in the residuals of either series, which again supports the fact that the models utilized to generate these residuals are probably well specified with regards to reflecting time-dependence.

The Jarque-Bera test was employed in order to test for normality of the residuals. The outcomes for foddprodindex provide a JB statistic of 2.181 with a p-value of 0.336, which means that the residuals do not fall significantly away from normality. The skewness of -0.537 and kurtosis of 3.733 are near to the values expected under a normal distribution (i.e., skewness = 0, kurtosis = 3). Conversely, lfpr exhibits a JB statistic of 12.300 with a highly significant p-value of 0.002, which suggests that it deviates significantly from normality. Lfpr's residuals are positively skewed (0.516) and leptokurtic (kurtosis = 5.908), indicating heavier tails and more frequent extreme values than a normal distribution would predict.

Both series are free from autocorrelation in the residuals according to the Ljung-Box test. Yet, whereas foddprodindex residuals are normally distributed, the lfpr residuals do not meet the normality assumption, and this might have consequences for inference and model interpretation if normality assumptions are essential in the analysis context.

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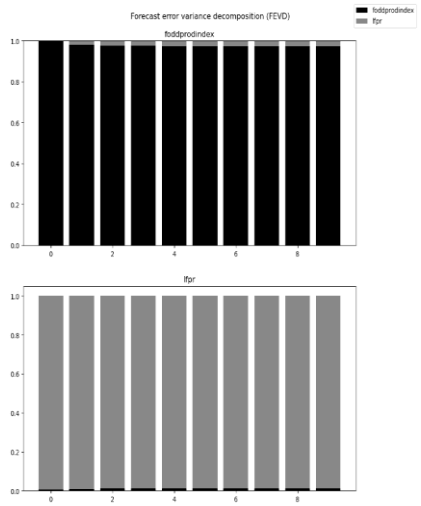

Figure 2. Forecast Error Variance Decomposition (FEVD)

Figure 2 shows the Forecast Error Variance Decomposition (FEVD) outcome of the endogenous variables foddprodindex and lfpr. The top panel reveals that the variance of forecast error for foddprodindex is practically fully self-explained for all periods, showing a high degree of exogeneity with negligible influence from lfpr. In contrast, the bottom panel shows that the variance of the forecast error of lfpr is also dominated by its own shocks, with minimal contributions from foddprodindex. This indicates that both variables are largely driven by their own history of innovations and not by cross-variable influences, supporting the weak interdependence in terms of shock transmission across the forecast horizon.

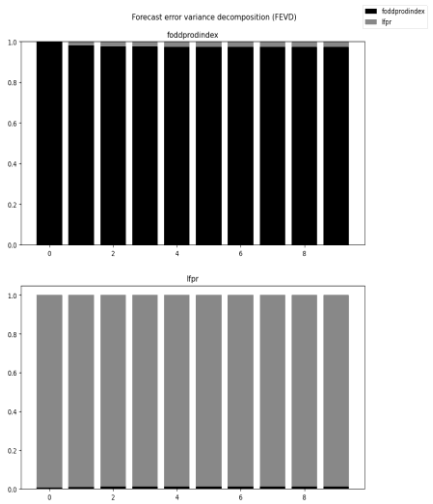

Figure 3. Forecast Error Variance Decomposition (FEVD)

Figure 3 shows the Forecast Error Variance Decomposition (FEVD) of two variables: foddprodindex (top panel) and lfpr (bottom panel). For both, the variance in forecast errors is overwhelmingly due to the variable's own shocks for all forecast horizons from period 0 through 9. The bars for foddprodindex are almost completely black, while the bars for lfpr are completely gray, meaning zero to minimal cross-variable influence. This finding indicates a lack of substantial dynamic interaction between the two variables, which means that each series develops quite independently in terms of shock transmission within the system.

The findings from the Vector Error Correction Model (VECM) suggest a clear long-term relationship between food production and labor force participation in the Philippines. This supports early development theories, such as those by Lewis (1954) and Ranis and Fei (1961), which propose that structural changes in the labor market—especially between agriculture and other sectors—play a key role in shaping economic development. In the case of the Philippines, labor force participation appears to have a meaningful influence on food production, both in the short and long run. These results highlight that labor dynamics and agricultural output are closely tied, particularly in an economy where rural employment and food security remain major policy concerns.

From a practical perspective, the study suggests that any policy aimed at boosting food production should also consider the availability and participation of the labor force, especially in rural areas. Policies that support rural employment—such as investment in agricultural training, access to credit for small farmers, and improvements in farm-to-market infrastructure—could not only enhance productivity but also help maintain the stability of food systems. Similarly, efforts to modernize agriculture should be cautious not to displace labor without providing alternative opportunities, as this could create unintended consequences for both food security and employment.

While the model performed well in many respects, some limitations should be acknowledged. One concern is the non-normality of residuals in the labor force participation equation, as shown by the Jarque-Bera test. Although this does not invalidate the model, it does suggest that the distribution of errors could affect the reliability of some statistical inferences. Also, the analysis focused solely on two variables and did not include other relevant factors like education, rural wages, or weather shocks, which may also influence food production and labor force dynamics. Including these in future research could provide a more complete picture.

Despite these limitations, the study offers valuable insights. It shows that food production and labor force participation do not operate in isolation but instead respond to each other over time. As such, policies aimed at improving one must consider the effects on the other. Strengthening this connection could support broader development goals and contribute to more resilient and inclusive agricultural and labor systems in the Philippines.

ACKNOWLEDGEMENT

This research confirms the existence of both long-run and short-run dynamic relationships between the food production index and labor force participation rate in the Philippines using a VECM approach. The results reveal that labor participation positively influences food production in the short term, while food production, in turn, encourages higher labor participation. The significant error correction terms suggest a strong tendency for both variables to return to long-run equilibrium after short-run disturbances. However, the limited cross-variable influence shown in the FEVD results indicates weak short-term interdependence. Based on these findings, policymakers are encouraged to design integrated strategies that simultaneously enhance agricultural productivity and rural employment. Investments in rural infrastructure, farmer training programs, and inclusive labor policies can yield mutual benefits for food security and workforce stability. Future research should incorporate additional variables—such as education, climate factors, and rural wages—to enrich the understanding of these dynamics.

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