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Economic development, inequality, and nutritional outcomes: A 2SLS panel analysis of protein consumption in Indonesia

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Abstract

This study examines the relationship between per capita protein consumption and poverty levels in Indonesia using a Two-Stage Least Squares (2SLS) approach within a simultaneous equations framework. The analysis employs panel data from 34 provinces over the period 2015-2024, based on provincially aggregated household-level data, to capture the reciprocal interaction between nutritional outcomes and economic well-being, while accounting for socio-economic factors such as income, education, food prices, and income inequality. The results show that protein consumption variations are more strongly linked to structural factors, especially education and income inequality, rather than short-term income fluctuations. Income inequality significantly shapes protein consumption patterns, reflecting unequal access to animal-based protein across income groups. In terms of prices, beef prices exhibit a more pronounced effect on aggregate protein consumption, while chicken prices tend to be absorbed through substitution mechanisms and price stabilisation, resulting in a weaker direct impact. The findings also confirm a bidirectional relationship between protein consumption and poverty, where higher poverty levels are associated with lower protein intake, and improved protein consumption contributes to poverty reduction through indirect channels such as health and productivity. These results emphasize the need to address poverty reduction and improved access to protein as complementary policy goals. Policy interventions should therefore focus on reducing income inequality, strengthening human capital, and maintaining food price stabilisation to promote more inclusive and sustainable development outcomes.

Keywords: income inequality, protein consumption, poverty, two-stage least squares

1 Introduction

Protein is a crucial macronutrient that plays an essential role in human health and development, including muscle growth, enzyme formation, and immune system functions (FAO, 2021; Maleky & Ahmadi, 2025). Adequate protein consumption is also linked to reduced risk of stunting and overall improvements in health status (Fatatul & Eko, 2025; Haryani *et al.*, 2023; Wu, 2016). However, in many developing countries, including Indonesia, per capita protein consumption varies significantly across regions, reflecting disparities in fulfilling basic nutritional needs (Al Hasan *et al.*, 2022; Khusun *et al.*, 2022).

Poverty is often seen as a key barrier to accessing nutritious food, as low-income households have limited purchasing power for high-quality protein sources (Muleya *et al.*, 2022; Vissamsetti *et al.*, 2024). Furthermore, development literature suggests that increasing per capita income and education play a vital role in shaping the quality of food consumption, both through enhancing purchasing power and altering consumption behaviour and nutritional knowledge (Azizi *et al.*, 2021; French *et al.*, 2019; Shabnam *et al.*, 2021).

Income inequality, in turn, affects the distribution of welfare and access to adequate food. Economic growth, when not accompanied by equitable income distribution, can limit the benefits of development for low-income groups and exacerbate poverty (Dogbe *et al.*, 2024; Hossain *et al.*, 2020; Vega *et al.*, 2025). At the same time, food prices, especially the prices of protein sources such as chicken and beef, have shown mixed empirical results in explaining the variation in protein consumption at the aggregate level (Azizi *et al.*, 2021; Günal *et al.*, 2025).

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While the relationship between economic conditions and food consumption has been widely studied, most research uses a one-way approach that risks overlooking the reciprocal relationship between nutrition and poverty. Theoretically, nutrition and poverty are interconnected. Limited access to adequate nutrition can lead to reduced economic productivity, as low-income nutritional intake directly affects health, cognition, and physical capacity, all of which are crucial for participation in the labour market and overall economic development. On the other hand, poverty limits the ability to secure nutritious food, perpetuating a cycle where low-income nutrition contributes to worsening economic conditions, further entrenching poverty (Aguilera & Daher, 2019; Siddiqui *et al.*, 2020).

In this context, it is essential to understand the mechanisms driving the relationship between nutrition and poverty. First, at the household level, limited income restricts purchasing power, thereby limiting the ability to buy higher-quality foods, including protein-rich items. This is compounded by education levels, where higher levels of education often lead to better knowledge of nutrition, healthier food choices, and more efficient allocation of limited resources. Moreover, income inequality plays a crucial role: when income is more evenly distributed, there is a higher likelihood that lower-income households can access nutritious food. In contrast, high levels of inequality mean that wealth is concentrated in a few hands, leaving large segments of the population with limited access to adequate nutrition (Gouri & Schauder, 2020; Ravikumar *et al.*, 2022).

Additionally, food prices, particularly those of protein-rich foods like chicken and beef, are central to this dynamic. Price fluctuations have direct effects on household consumption patterns, especially for lower-income groups, who are more sensitive to changes in food prices (Baladina *et al.*, 2024; Khoiriyah *et al.*, 2020). Thus, the interplay between economic factors such as income, education, inequality, and food prices creates a complex, multifaceted relationship between protein consumption and poverty.

Given this theoretical framework, this study aims to analyse the simultaneous relationship between per capita protein consumption and poverty levels across provinces in Indonesia using a simultaneous equations model, estimated with the Two-Stage Least Squares (2SLS) method. Beyond methodological estimation, the study seeks to clarify how structural socio-economic factors shape nutritional disparities across regions and to provide evidence relevant for rural development and poverty alleviation strategies. This approach allows for addressing the endogeneity of the bidirectional relationship between the two variables while also accounting for the roles of per capita income, education, chicken prices, meat prices, and income inequality. By utilising panel data from 34 provinces over the period 2015-2024, the study contributes new empirical insights by capturing regional heterogeneity and the structural interactions between nutrition and poverty, thereby informing policy debates on inclusive growth and equitable access to adequate nutrition, an area that remains underexplored in the literature.

2 Materials and methods

2.1 Empirical framework

This study uses panel data covering 34 provinces in Indonesia over the period from 2015 to 2024, based on provincially aggregated indicators published by Statistics Indonesia (BPS) and derived from nationally representative household surveys. The use of panel data allows for a more comprehensive analysis as it combines cross-sectional and time series variations. With this approach, the study aims to capture the dynamics of changes in economic and social conditions at the regional level. This study analyses the relationship between poverty rates and per capita protein consumption, while accounting for factors such as regional income levels, education, chicken and beef prices, and income inequality. The variables used in this study can be viewed in Table 1.

2.2 Identification and estimation method

The estimation method used in this study is two-stage least squares (2SLS) within a simultaneous equations framework to analyse the reciprocal relationship between per capita protein consumption and poverty rates. Both variables are treated as endogenous, as theoretical and empirical literature suggests a bidirectional linkage: poverty constrains households' ability to access nutritious food, while inadequate protein consumption adversely affects health, productivity, and long-term economic capacity, which in turn may reinforce poverty (Siddiqui *et al.*, 2020).

In this model, exclusion restrictions are not imposed, and all relevant socio-economic variables are allowed to enter both structural equations. This modelling choice is grounded in the argument that, in complex socio-economic systems, particularly those involving nutrition, income, inequality, education, and food prices, it is often theoretically implausible to identify variables that affect only one endogenous outcome while having no direct or indirect influence on the other. Methodological literature in applied economics and social sciences has increasingly emphasized that exclusion restrictions are frequently weak or difficult to justify

Table 1: *Operational definition of variables.*

No	*Variable*	*Code*	*Operational definition*	*Unit*	*Data source*
1	Per capita protein consumption	PCPC	Average daily protein intake per person at the provincial level is used as an indicator of nutritional outcomes	Grams/person/day	Statistics Indonesia (BPS)
2	Poverty rate	POV	Percentage of the population living below the official poverty line at the provincial level	Percent (%)	Statistics Indonesia (BPS)
3	GRDP per capita	GRDPpc	Gross regional domestic product (GRDP) per capita, calculated using current market prices, serves as a proxy for regional income and economic development	Rupiah	Statistics Indonesia (BPS)
4	Education	EDU	Mean years of schooling of the adult population, reflecting human capital quality	Years	Statistics Indonesia (BPS)
5	Chicken price	PCHICK	The average price of chicken paid by consumers at the provincial level	Rupiah/kg	Bank Indonesia
6	Beef price	PBEEF	The average price of beef paid by consumers at the provincial level	Rupiah/kg	Bank Indonesia
7	Gini index	GINI	Index measuring income inequality at the provincial level, with higher values indicating greater inequality	Index (0–1 scale)	Statistics Indonesia (BPS)

empirically, and that imposing them without strong theoretical support may introduce greater bias than it resolves (Babeshko *et al.*, 2019; Bollen *et al.*, 2022; Lal *et al.*, 2024).

Under this specification, income inequality, chicken prices, and beef prices are therefore treated as structural determinants rather than excluded instruments. From a theoretical perspective, income inequality directly shapes consumption patterns by influencing the distribution of purchasing power across households, independent of aggregate poverty levels. Deaton & Muellbauer (1980) demonstrate that income distribution can affect food demand and nutritional outcomes through non-poverty channels, as consumption behavior responds not only to average income but also to its dispersion. Similarly, food prices, particularly those of protein-rich commodities such as chicken and beef, have immediate effects on household consumption decisions by altering real purchasing power, especially among low-income groups that are more sensitive to price changes (Radwan & El Showeikh, 2021; Ansah *et al.*, 2025). At the same time, these variables may also influence poverty through cost-of-living effects, labour productivity, and welfare dynamics, making their exclusion from either equation theoretically restrictive.

Accordingly, identification in this study relies on the internal structure of the simultaneous system, where endogenous and exogenous variables jointly determine protein consumption and poverty. This approach aligns with the concept of internal instruments or model-implied instrumental variables, whereby identification is achieved through the covariance structure of the system rather than through externally imposed exclusion restrictions (Babeshko *et al.*, 2019; Bollen *et al.*, 2022). Such an approach is particularly suitable when the research objective is to capture structural interdependencies rather than isolate narrowly defined causal effects.

Estimation is conducted using Panel 2SLS, with each equation estimated separately within the simultaneous framework. In the first stage, endogenous variables are projected onto the full set of explanatory variables in the system to obtain predicted values, which are subsequently used in the second stage to estimate the structural equations. Instrument relevance is assessed using first-stage F-statistics, ensuring that the endogenous variation is sufficiently explained by the internal structure of the model (p-value < 10). All estimations are performed using EViews 12, employing panel data for 34 Indonesian provinces over the period 2015-2024.

2.3 *Model specification*

This model formulates two structural equations that are estimated simultaneously within a single system. All variables are expressed in natural logarithms to reduce scale differences, mitigate heteroskedasticity, and allow elasticity-based interpretation of the estimated coefficients. The first equation models protein consumption as a function of poverty rates, GRDP per capita, education, chicken price, beef price, and income inequality. The second equation models poverty rates as a function of protein consumption, income, education, chicken price, beef price, and income inequality. Based on this framework, the protein consumption equation can be formulated as follows:

$$\ln PCPC_{it} = \alpha_0 + \alpha_1 \ln POV_{it} + \alpha_2 \ln GRDPpc_{it} + \alpha_3 \ln EDU_{it} + \alpha_4 \ln PCHICK_{it} + \alpha_5 \ln PBEEF_{it} + \alpha_6 \ln GINI_{it} + u_{it}$$

The poverty equation is formulated as follows:

$$\ln POV_{it} = \beta_0 + \beta_1 \ln PCPC_{it} + \beta_2 \ln GRDPpc_{it} + \beta_3 \ln EDU_{it} + \beta_4 \ln PCHICK_{it} + \beta_5 \ln PBEEF_{it} + \beta_6 \ln PGINI_{it} + v_{it}$$

Where:
$PCPC_{it}$ = per capita protein consumption; POV_{it} = poverty rate; $GRDPpc_{it}$ = GRDP per capita; EDU_{it} = education; $PCHICK_{it}$ = chicken price; $PBEEF_{it}$ = beef price; $GINI_{it}$ = Gini index; u_{it} = Error term in the first equation for province i in year t; v_{it} = Error term in the second equation for province i in year t; i = Province; t = Year.

2.4 Model evaluation and estimation validity

To ensure the validity of the estimates, the model was subjected to several diagnostic tests. Multicollinearity is assessed using the Variance Inflation Factor (VIF); as a rule of thumb, VIF values below 10 suggest that multicollinearity is not severe, whereas values above 10 may indicate problematic collinearity among the regressors. Autocorrelation is examined using the Durbin-Watson statistic, where values close to 2 are consistent with little to no first-order autocorrelation in the residuals. Heteroscedasticity is tested using the Breusch-Pagan procedure; a p-value greater than 0.05 implies that the null hypothesis of homoscedasticity cannot be rejected. Overall, these diagnostics support the adequacy of the model specification and the reliability of the ensuing estimates (Gujarati & Porter, 2009).

3 Results

Based on Table 2, the descriptive statistics indicated clear variation across provinces and over time in the key economic and social variables. All variables were expressed in natural logarithmic form, consistent with the model specification. Protein consumption exhibited relatively limited dispersion compared to poverty and income variables. Poverty and GRDP per capita showed wider variation across provinces. Education also displayed notable cross-regional differences. Chicken and beef prices appeared comparatively stable within the observed period, while income inequality showed moderate variation. Overall, the presence of cross-sectional and temporal variation supported the suitability of the panel-data framework for the subsequent analysis. The empirical model treats each province as the unit of analysis, and the variation exploited in the estimation reflects both differences across provinces and changes within provinces over time.

Table 2: *Descriptive statistics of variables (N=340).*

Variable	*Min.*	*Max.*	*Mean*	*Std. Deviation*
lnPCPC	8.25	8.95	8.69	0.10
lnPOV	5.85	7.95	6.84	0.49
lnGRDPpc	9.61	12.95	10.88	0.58
lnEDU	2.08	7.05	6.56	0.73
lnPCHICK	9.85	10.86	10.49	0.17
lnPBEEF	11.41	12.03	11.76	0.12
lnGINI	3.30	5.83	3.82	0.30

Source: Data processed using EViews 12 (2026).
Note: *lnPCPC* = natural log of per capita protein consumption; *lnPOV* = natural log of poverty rate; *lnGRDPpc* = natural log of gross regional domestic product per capita; *lnEDU* = natural log of mean years of schooling; *lnPCHICK* = natural log of chicken price; *lnPBEEF* = natural log of beef price; *lnGINI* = natural log of Gini index.

Given the cross-sectional and temporal variation documented in Table 2, the empirical analysis proceeds with the estimation of a simultaneous-equations model using Two-Stage Least Squares (2SLS). The panel structure allows the model to exploit both between-province differences and within-province changes over time, thereby capturing regional heterogeneity as well as dynamic adjustments across years. Prior to this, to ensure the validity of the estimates, the model was tested using several diagnostic tests. The results of the multicollinearity test show that the Variance Inflation Factor (VIF) is less than 10, indicating that there are no significant multicollinearity issues in the model. Autocorrelation was examined through the Durbin-Watson test, with a value approaching 2, indicating no autocorrelation in the model's residuals. Additionally, heteroscedasticity was tested using the Breusch-Pagan test, where a p-value greater than 0.05 indicates no heteroscedasticity issues in the model (Gujarati & Porter, 2009). Next, a first-stage regression was conducted for each endogenous variable, namely, per capita protein consumption and poverty (Table 3).

The results in Table 3, specifically the first-stage regression, show that the F-statistics for PCPC (43.7670) and POV (62.1777) exceed the accepted threshold (>10), indicating that the internal instruments derived from the simultaneous system meet the relevance criteria. Therefore, the selected instruments are both valid and relevant (Gujarati & Porter,

Table 3: *Results of first-stage regression.*

Variable	*Instrument*	*F-statistic*
lnPCPC	*lnGINI*, *lnPCHICK*, *lnPBEEF*	43.7670
lnPOV	*lnGINI*, *lnPCHICK*, *lnPBEEF*	62.1777

Source: Data processed using EViews 12 (2026). Note: see table 2 for variable explication.

2009). With these results, it can be assured that the estimates obtained are consistent and free from diagnostic issues that could affect the research outcomes. The 2SLS estimation was conducted using panel data from 34 provinces in Indonesia for the period 2015-2024, as follows.

Table 4: *Results of the simultaneous equation model (2SLS) – protein consumption equation.*

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	9.8222	0.4938	19.8879	0.0000
lnPOV	−0.1135***	0.0108	−10.4391	0.0000
lnGRDPpc	−0.0136	0.0093	−1.4679	0.1431
lnEDU	0.1385***	0.0475	2.9142	0.0038
lnPCHICK	−0.0017	0.0252	−0.0675	0.9462
lnPBEEF	−0.0735**	0.0364	−2.0218	0.0440
lnGINI	0.1723***	0.0217	7.9284	0.0000

Source: Data processed using EViews 12 (2026).
Note: *** $p < 0.01$, ** $p < 0.05$. See table 2 for variable explication.

The estimation results in Table 4 show that per capita protein consumption was significantly associated with several structural variables. Poverty was negatively and statistically significantly associated with protein consumption at the provincial level. GRDP did not exhibit a statistically significant direct effect on protein consumption once other covariates were controlled for. Education was positively and statistically significantly associated with protein consumption. The price of beef exhibited a statistically significant association with protein consumption, while the price of chicken did not show a statistically significant effect. GINI was positively and statistically significantly associated with protein consumption, controlling for GRDP per capita and other covariates. Overall, the results indicated that protein consumption was systematically correlated with poverty, education, inequality, and selected food prices within the estimated simultaneous-equations framework. The estimation results for the poverty equation are presented in Table 5.

Based on Table 5, per capita protein consumption was negatively associated with poverty, although the magnitude of the coefficient was smaller relative to GRDP per capita and GINI. GRDP per capita was negatively and statistically significantly related to poverty, indicating that higher provincial income levels were associated with lower poverty rates. Education was negatively and statistically significantly associated with poverty. The price of chicken was negatively and statistically significantly related to poverty, while the price of beef did not show a statistically significant effect in the poverty equation. GINI was positively and statistically significantly associated with poverty, suggesting that higher income inequality was correlated with higher poverty levels within provinces. Overall, the poverty equation indicated that income levels, income distribution, education, and selected food prices were systematically associated with provincial poverty outcomes within the simultaneous-equations framework.

Table 5: *Results of the simultaneous equation model (2SLS) – poverty equation.*

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	31.3835	2.6932	11.6524	0.0000
lnPCPC	−2.1721***	0.2080	−10.4391	0.0000
lnGRDPpc	−0.2393***	0.0387	−6.1749	0.0000
lnEDU	−0.8562***	0.2052	−4.1715	0.0000
lnPCHICK	−0.3028***	0.1091	−2.7751	0.0058
lnPBEEF	−0.1721	0.1600	−1.0755	0.2829
lnGINI	0.7696***	0.2293	8.1257	0.0000

Source: Data processed using EViews 12 (2026).
Note: *** $p < 0.01$, ** $p < 0.05$. See table 2 for variable explication.

4 Discussion

This study places per capita protein consumption and poverty levels within a simultaneous equations framework to capture the reciprocal relationship between nutritional outcomes and economic well-being. This approach is relevant as the relationship between protein consumption and poverty does not stand alone, but is shaped by structural factors such as income, human resource quality, and income distribution (Berkowitz *et al.*, 2025; Harrison *et al.*, 2019). The findings of this study indicated a negative and statistically significant relationship between poverty levels and per capita protein consumption, confirming that higher levels of poverty were generally associated with lower average protein intake across Indonesian provinces. Consistent with the empirical results reported in Table 5, PCPC was negatively associated with poverty, while GRDPpc and EDU were negatively related to poverty and GINI was positively related to poverty within the simultaneous-equations framework. This result is consistent with standard economic theory, which suggests that poverty constrains household purchasing power and limits access to nutritionally adequate food (Amrullah *et al.*, 2023). However, this relationship is not purely linear, as social protection programmes and access to affordable protein sources can partially mitigate the adverse effects of poverty. In Indonesia, social protection programmes, such as the Conditional Cash Transfer (CCT) and food assistance schemes, play an important role in supporting minimum food consumption among low-income households. These programmes can partially buffer the adverse impact of poverty by improving access to relatively affordable protein sources, particularly chicken, which remains the most commonly consumed animal-based protein due to its lower price compared with beef (Hudang & Setyarini, 2024). These mechanisms do not eliminate the negative effect of poverty on protein consumption; rather, they reduce its severity, resulting in observed variations in protein intake across provinces with differing levels of policy support and food market accessibility (Rammohan & Tohari, 2024).

Food price dynamics further reinforce this mechanism in a more consolidated way. Chicken remains the most widely consumed animal protein due to its affordability and stable supply, whereas beef is relatively expensive and more sensitive to supply shocks. As a result, fluctuations in beef prices have limited influence on aggregate protein consumption, since lower-income households adjust by relying on cheaper protein sources. This highlights that protein consumption in developing contexts is shaped more by relative prices and market access than by income alone (Firmansyah & Harahap, 2024; Khoiriyah *et al.*, 2020). In provinces characterised by relatively lower chicken prices and stronger market integration, the negative association between poverty and protein consumption may have been partially mitigated. These findings are consistent with the research by Andreoli *et al.* (2021) which suggests that in many developing countries, protein consumption is more influenced by market access and food prices than by household income alone. Thus, the relationship between poverty and protein consumption may change depending on the presence of social policies or local food market conditions.

The methodological contribution of this study lies in the identification strategy that does not use exclusion restrictions, where all variables in the model are used as direct explanations. Instead of relying on external instruments that may be weak or difficult to justify, such as geographic, historical, or policy proxies that are only indirectly related to current protein consumption, this study estimates the system jointly within a simultaneous-equations framework. This approach prioritises structural interdependence over strict causal identification, which may bias 2SLS estimates (Bollen *et al.*, 2022; Lal *et al.*, 2024). The direct inclusion of income inequality in the protein consumption equation shows that inequality can affect the distribution of protein consumption without going through aggregate poverty. Deaton & Muellbauer (1980) demonstrate that income inequality directly impacts consumption patterns, including access to nutritious food sources. On the other hand, the prices of chicken and beef serve as direct determinants for protein consumption, and food prices indeed have a significant impact on poverty, especially in developing countries where poverty lines are highly sensitive to food price fluctuations (Birhanu *et al.*, 2023; Khoiriyah *et al.*, 2020; Rahbarinejad *et al.*, 2025). By using this simultaneous approach, this study captures the direct interdependencies between socio-economic factors, food prices, and protein consumption without depending on externally imposed identifying variables.

A key structural factor linking both poverty and nutritional outcomes is income inequality, which operates through both income distribution and access channels. Recent development economics literature shows that high income inequality weakens the poverty reducing impact of economic growth, as gains from growth are disproportionately captured by higher income groups (Ali *et al.*, 2022; Bergstrom, 2020). Consistent with this, the results showed that income inequality was positively associated with poverty even after controlling for income, education, and food prices, indicating that non inclusive growth limits both poverty reduction and equitable access to nutritious food. Moreover, inequality also affects consumption patterns directly, as access to animal source protein is typically more income elastic and unevenly distributed across socio economic groups (Headey & Alderman, 2019; Laborde *et al.*, 2020).

In the protein consumption equation, the results showed that structural factors were more significant than short-term transactional impulses. Per capita income did not show a statistically significant direct effect on protein consumption once poverty, education, and income inequality were controlled for, suggesting that income influences protein intake mainly through structural and distributional channels (Knap, 2022; Li *et al.*, 2025; Milford *et al.*, 2019; Wibowo *et al.*, 2025). Education, however, emerges as a central and consistent determinant of protein consumption, reflecting its dual role in improving economic capacity and nutrition literacy, which enables households to make more informed and efficient dietary choices. This reflects the role of human capital in improving both economic capacity and nutrition literacy (Azizi *et al.*, 2021; Li *et al.*, 2025). Thus, rather than being treated as a repeated supporting factor, education can be understood as a key structural driver influencing both consumption behaviour and food quality outcomes.

In the poverty equation, per capita income was negatively related to poverty and served as the most direct welfare channel, while income inequality was positively related to poverty. The positive and statistically significant coefficient on GINI indicated that inequality remained strongly associated with poverty, even after controlling for income levels, education, and food prices. This combination underscores that non-inclusive growth tends to limit poverty reduction, as the benefits of development are not spread evenly (Ali *et al.*, 2022; Bergstrom, 2020; Hanandita & Tampubolon, 2015; Jamil, 2022). Education also showed a direct and significant role in reducing poverty, indicating that human capital improves labour market access and strengthens household economic resilience beyond income effects alone. According to Hanushek & Woessmann (2020) and Oktaviani & Hartono (2022), education helps improve individual skills and abilities, enabling them to secure higher-paying jobs, improve job access, and enhance household economic capacity.

Overall, the findings supported broader empirical evidence from developing countries showing that protein consumption and poverty interact through structural channels rather than simple income effects. Cross country studies confirm that access to nutritious food depends on income distribution, food prices, and market conditions, not solely on average income levels (Andreoli *et al.*, 2021; Carrillo-Alvarez *et al.*, 2025). This also explains why protein consumption may remain relatively stable in some high poverty regions, as the combined effects of affordable food markets and social protection policies help sustain minimum nutritional intake.

The policy implications of these findings point towards an integrated approach. To maintain access to animal protein for a wide range of groups, relevant interventions include strengthening supply stability and mitigating price volatility, particularly for beef. However, sustainable poverty reduction cannot rely solely on price stabilisation, as the main drivers are still related to income capacity and more equitable distribution. Therefore, policies need to focus on creating broader income opportunities, strengthening human capital, and controlling inequality to make growth more inclusive and extend its benefits to vulnerable groups (Christy & Sudarsana, 2025; Geubrina *et al.*, 2025). Therefore, nutrition and poverty policies should be framed as complementary strategies, integrating food access interventions with broader structural policies aimed at enhancing income distribution and human capital development.

5 Conclusion

This study shows that the two-way relationship between per capita protein consumption and poverty across Indonesian provinces is shaped mainly by structural conditions rather than short-term income changes alone. The results point to a structural account of nutritional outcomes: differences in education and income inequality appear more consequential for provincial variation in protein consumption than short-run income movements or broad food-price changes. Importantly, the findings reinforce the idea that nutrition and poverty should be treated as jointly determined outcomes, implying that policy aimed at one domain is likely to feed back into the other. The paper contributes to the literature by modelling nutrition and poverty as an interdependent system in a provincial panel setting, rather than as a one-directional relationship, and by demonstrating the central role of human capital and distributional conditions in shaping aggregate nutritional outcomes. From a policy perspective, the findings support a complementary policy package that combines measures to protect food affordability and supply stability for key protein commodities, longer-term investments in education, and interventions to reduce inequality in access to nutritious diets among lower-income groups. Several limitations should be acknowledged. First, the analysis relies on provincial aggregates, which may mask within-province disparities and household-level substitution behaviour. Second, because identification relies on the structure of the simultaneous system and available covariates, the estimates should be interpreted as structural associations within the model rather than isolated causal effects. Unobserved factors, such as local programme intensity, market integration, and dietary preferences, may still influence the estimates. Future research could therefore use household microdata and richer policy indicators, explore heterogeneous effects across regions and income groups, and test alternative identification strategies, including dynamic or spatial specifications, to strengthen interpretation and refine policy targeting.

Conflict of interest

The authors declare that no conflict of interest exists in relation to this study.

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