Estimating household price and income elasticities for animal derived sources of food using the QUAIDS model: the case of Jakarta, Indonesia

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Protein-rich animal sourced foods play a crucial role in improving the quality of human health in Indonesia. This study aims to investigate the impact of price increases on consumption patterns and demand for animal source foods as a source of protein among households in Jakarta, the capital of Indonesia. Data from the 2021 National Socio-Economic Survey were utilised, and the Quadratic Almost Ideal Demand Systems (QUAIDS) model approach was employed to analyse the data. A sample of 3,227 households was used for the analysis. The results reveal that all animal source foods except for eggs are elastic, with beef exhibiting the highest elasticity of demand at 1.71, followed by fish (1.61), poultry (1.39), milk (1.32), and eggs (0.67). Beef and milk were found to be substitute goods, while fish and milk are complementary goods with poultry. Moreover, all animal source foods are identified as luxury goods with income elasticity of beef at 2.20, followed by milk (1.84), poultry (1.44), and fish (1.07). In contrast, eggs are a normal good with an income elasticity of 0.38. These findings suggest that rising prices and income significantly influence the consumption patterns and demand for animal source foods in Jakarta. To make animal source foods a normal good rather than a luxury item, income policies may be more effective than price policies for beef, poultry, and milk. On the other hand, price policies may be more effective than income policies for fish and eggs. These findings can provide important insights into strategies for improving the consumption patterns and demand for animal source foods as a source of protein in Jakarta, Indonesia.

Keywords: Elasticities, food, household, Indonesia, QUAIDS

To achieve the targets of the Sustainable Development Goals (SDGs) in the field of human well-being, there is a growing global concern about the need to change the food systems (Godfray et al. 2010; Herrero et al. 2021; Swinnen and Vos 2021). This is in accordance with the first and second SDGs which are no poverty and no hunger (Ab Rahman et al. 2022; Singh et al. 2020). The SDGs also emphasise that, to meet future needs, we need to use land in a more sustainable manner, minimise negative impacts on the environment and look for opportunities to restore land that has lost nutrients and or biodiversity. Simultaneously, it is very important to provide food to everyone and the food systems of the future must provide a variety of affordable foods to allow everyone to have access to food of higher nutritional quality (Fanzo et al. 2022; Green et al. 2022; Matthias et al. 2022; Webb et al. 2020).

Data reported by FAOSTAT in 2018 noted that globally, over the 1990 – 2015 period, the average per capita food demand of all animal derived sources of foods increased by more than 40 kg/person/year. However, these figures hide substantial variation across regions and by commodity. For example, although there was an almost 35% increase in per capita demand for meat (11.27 kg/person/year) and total per capita meat demand increased for all regions between 1990 and 2015, this increase was driven by a large increase in demand for poultry and pigs, which experienced increases of 106% and 26%, respectively. In the context of a region encompassing East Asian countries, notably China, individualised reporting has been undertaken to accentuate significant patterns in the consumption of animal-based

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foods (Herrero et al. 2021). In these East Asian nations, there was an observable rise in the demand for animal-derived foods. This trend may have aligned with, exceeded, or differed from the global trajectory.

The global per capita demand for ruminant meat, encompassing beef and mutton, exhibited a consistent, but slight, downward trajectory from 1990-2023, with an average annual change of less than 1 kg per person on a global scale. However, in Indonesia, a striking disparity emerges in the demand trend for beef, marked by pronounced regional disparities; several of these regions have experienced a substantial decline in beef demand, in contrast to the slight decline observed in global figures. This trend in beef consumption sharply contrasts with the overall patterns of demand for all animal-derived foods within Indonesia. Per capita demand for poultry has increased at different rates in all regions of the world; the smallest increases occurred in East Africa and the United States, 27% and 32%, respectively. All other regions (including Indonesia within East Asia) saw the demand for poultry meat double per capita. Demand trends for pork are more variable, but more like poultry than beef.

Animal derived sources of food are very important in household consumption patterns in Indonesia because there are essential proteins that only exist in animal source food, specifically beef (Akaichi and Revoredo-Giha 2014). Animal protein consumption is important compared to other sources of protein due to its high-quality protein content, complete amino acid profile, superior bioavailability, and richness in essential nutrients (Day et al. 2022; Rivero Meza et al. 2023). Animal proteins support muscle growth, immune function, and overall health, and their satiating effect aids in weight management. However, a balanced diet that includes both animal and plant-based proteins is advised to mitigate potential health risks associated with excessive animal protein intake. This study explicitly focuses on animal sourced protein since household consumption is already way below the recommended daily amount, especially in low-income households.

The pattern of household food consumption in Indonesia consists of a staple food, mainly rice, then there are additional side dishes like vegetables and fruits as well as complementary foods such as milk. In Indonesia, rice is the main source of carbohydrates. It is largely consumed by all income groups throughout the nation. However, lower income groups tend to consume more rice than higher income groups due to it being cheap. The share of household expenditure on staple foods such as rice and flour is almost 20%. However, in terms of animal food consumption, most households in Indonesia consume less than the National Protein Adequacy Rate (NPAR). If we look at the average national consumption, household consumption of animal food is sufficient, namely 57 g/person/day. However, the households at the three lowest poverty levels, very poor, vulnerable to poor and poor, consume less animal protein than the NPAR standard (Anindita et al. 2020; Nendissa et al. 2021; Khoiriyah et al. 2020).

Jakarta is Indonesia's capital city and the country's most modern city, serving as the centre of Indonesia's national economy. All households in Jakarta are classified as urban households. According to data from the National Socio-Economic Survey, Jakarta has the highest average monthly expenditure per capita in Indonesia, reaching IDR 2,388,129 (US$1 = IDR 15,300). Production and consumption of beef in Jakarta are the highest, with a consumption of 0.10 kg per month and an expenditure value of IDR 11,690 per capita per month. However, this consumption is still lower compared to other countries' protein consumption.

This study aimed to analyse the effect of prices and incomes on animal derived sources of food consumption patterns in Jakarta. The demand system model approach uses the Quadratic Almost Ideal Demand System (QUAIDS). QUAIDS is an approach that has quite high precision to date and is used in various studies involving demand analysis.

Materials and methods

The empirical demand model

Since Deaton and Muellbauer (1980) proposed the Almost Ideal Demand System (AIDS) model, researchers have widely favoured this over other functional forms due to the many favourable properties it yields. Barnett and Seck (2008) ascertain that the popularity of the AIDS model is due to the many attractive properties it possesses as it aggregates perfectly over consumers, has a functional form which is consistent with known data, satisfies the axiom of choice, is rather easy to estimate, and allows theoretical restrictions of homogeneity and symmetry to be imposed and tested. Although many of the existing functional forms in the literature possess many of the desirable properties noted above, only the AIDS model possess all of them at the same time (Barnett and Seck 2008; Deaton and Muellbauer 1980).

More recently, however, Banks et al. (1997) suggested a generalisation of the AIDS model by adding a quadratic variable to the specification which yields the Quadratic Almost Ideal Demand System (QUAIDS) model. According to Banks et al. (1997), some preferences are quadratic in nature, therefore, the QUAIDS specification is more appropriate. The QUAIDS model is also theoretically consistent and possesses all of the desirable properties of the traditional AIDS model. This specification is widely used in household demand analysis studies. The QUAIDS model is derived by assuming that household preferences over *n* consumption bundles are expressed by the indirect utility function as follows:

$$ln\,V = \left(\left[\frac{ln\,m - ln\,a(p)}{b(p)}\right]^{-1} + \lambda(p)\right)^{-1} \quad (1)$$

Where *m* is the total household expenditure and *p* represents a vector of commodity prices. Additionally, *ln a (p)* is the translog price index function given by

$$ln\,a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i\, ln(p_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln(p_i)\ln(p_j) \quad (2)$$

b(p) is a standard Cobb-Douglas aggregator which is given by

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad (3)$$

and $\lambda(p)$ is given by

$$\lambda(p) = \sum_{i=1}^{n} \lambda_i\, ln\, p_i \quad (4)$$

In order to ensure that the estimated model is consistent with utility maximisation (Attanasio et al. 2013), three theoretical restrictions are imposed on the estimated parameters – adding-up, homogeneity, and symmetry. The adding-up restriction ensures that total expenditure is equivalent to the sum of all individual expenditures on different commodity groups being studied, or that the budget shares all sum to one. The homogeneity restriction ensures that the demand functions are homogenous of degree zero in prices. The symmetry restriction is necessary to ensure that preferences are well-defined. In order to ensure that the adding-up restriction of the demand system holds, it is required that:

$$\sum_{i=1}^{n} \alpha_1 = 1, \sum_{i=1}^{n} \beta_1 = 0, \sum_{i=1}^{n} y_{ij} = 0, \sum_{i=1}^{n} \lambda_i = 0 \quad (5)$$

In order to ensure that the indirect utility function is homogeneous of degree zero in income and prices, the homogeneity restriction is imposed as:

$$\sum_{i=1}^{n} y_{ij} = 0 \quad \forall j \quad (6)$$

Finally, symmetry of the Slutsky matrix is imposed as follows:

$$\gamma_{ij} = \gamma_{ji} \quad (7)$$

The expenditure share equation can now be derived from the indirect utility function by applying Roy (1947) identity. The QUAIDS model expressed in terms of budget shares is

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} lnp_j + \beta_i ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{ln\left[\frac{m}{a(p)}\right]\right\}^2 \quad (8)$$

as follows:
In equation (8), w_i is the household expenditure share of the *ith* animal derived source of food group which is given as:

$$w_i \equiv \frac{p_i q_i}{m} and \sum_{i=1}^{n} w_i = 1 \quad (9)$$

The variable m represents total household expenditure. All other variables are defined prior. $\alpha_i, \gamma_{ij}, \beta_i$ and λ_i are all parameters to be estimated. In addition, the theoretical restrictions outlined in equations (5) - (7) are imposed on the parameters in equation (8) in order to ensure that they are consistent with economic theory. However, the model specified in equation (8) does not consider any of the socio-demographic factors that might have an impact on household demand for animal derived sources of food in Jakarta, Indonesia. Socio-demographic factors can effect household behaviour in terms of demand and allocation of expenditure among goods (Alboghdady and Alashry 2010; Tefera et al. 2012). Therefore, they should be included and accounted for in the specified QUAIDS model shown in equation (8).

The demographic scaling method was used to take into account the effect of socio-demographic factors that might possibly affect household demand for animal derived sources of food in this study (Poi 2012). In this approach, the effects of a change on the demographics are closed to the effect of the price changing of animal sourced foods. Considering z as a vector of household characteristics; z is a scalar representing the household size in the simplest case. Let $e^R(p,u)$ represent the expenditure function of a reference household with just single adult. For each household, Ray (1983) uses an expenditure function of household characteristics, without controlling for any changes in consumption patterns. The second term control for a change in relative prices and actual goods consumed. Following Ray (1983) and Poi (2012), the QUAIDS model is parameterised as follow:

$$\overline{m_o}(z) \text{ as } \overline{m_o}(z) = 1 + \rho z \quad (10)$$

Where $\boldsymbol{\rho}$ is a vector of parameters to be estimated. The share expenditure equation highlighted in equation (1) now takes the following form:

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{ij} lnp_j + (\beta_i + \eta_i' z) ln\left\{\frac{m}{\overline{m_o}(z)a(p)}\right\} + \frac{\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{m}{\overline{m_o}(z)a(p)}\right\}\right]^2 \quad (11)$$

Where

$$c(p,z) = \prod_{j=1}^{k} p_j^{\eta_i' z} \quad (12)$$

and $\boldsymbol{\eta_i}$ represents the *j*th column of *s x k* parameter matrix η (Poi 2012). The adding-up condition requires that:

$$\sum_{j=1}^{K} \eta_{rj} = 0 \quad \text{for } r = 1, \ldots, s. \quad (13)$$

The parameters of the QUAIDS model are estimated by iterated nonlinearly seemingly unrelated regression (ITNL-SUR) technique. Finally, to ensure that the variance-covariance matrix is not singular, one of the share equation is dropped during estimation, then recovered using the additivity restriction.

Deriving income and price elasticities

In the previous section, a theoretically consistent model to study household demand for animal derived sources of food was specified. However, according to Poi (2012) and Lewbel (1991), the estimated parameters are difficult to interpret directly, but they are useful in deriving income and prices elasticities. Elasticities measure the degree of responsiveness of demand brought about by changes in one of the factors that affect demand. Elasticities are useful tools in that they can help to better understand consumption behaviour of households so that effective policies can be developed to help improve welfare and overall well-being. In addition, elasticities can be used to obtain more comprehensive insights into the relationship between commodities, prices, and income which is essential for production activities and decision making (Singh et al. 2011).

From the QUAIDS model, income elasticities can be derived using the formula:

$$\xi_i = 1 + \frac{1}{w_i}\left[\beta_i + \eta_i z + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{m}{\overline{m_o}(z)\alpha(p)}\right\}\right] \qquad (14)$$

Income elasticity of demand measures the changes in demand brought about by changes in income. Marshallian price elasticities for each animal derived source of food group are calculated using the formula:

$$\varepsilon_{ii}^{M} = -\delta_{ii} + \frac{1}{w_i}\left(\gamma_{ij}\left[\beta_i + \eta_i z + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{m}{\overline{m_o}(z)\alpha(p)}\right\}\right] * \left(\alpha_j + \sum_1 \gamma_{ij} ln p_j\right) - \frac{(\beta_i + \eta_i z)\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{m}{\overline{m_o}(z)\alpha(p)}\right\}\right]^2\right) \qquad (15)$$

All of the parameters in equation (15) are previously defined except delta (δ) which is the Kronecker delta which takes the value of 1 for own-price elasticities and 0 otherwise. Marshallian own-price elasticities generally measure changes in the quantity demanded as a result of changes in prices. Finally, Hicksian own- and cross-price elasticities are derived from the Slutsky equation using the formula below:

$$\varepsilon_{ii}^{H} = \varepsilon_{ii} + \xi_i w_i \qquad (16)$$

Data and source

This analysis utilises secondary data collected by the Central Bureau of Statistics in the form of household surveys, known as the SUSENAS, for March 2023 which included 3,227 households. The data comprises socio-demographic information, household size, consumption, and expenditure. The study includes variables for the prices of five animal derived food sources: eggs, poultry, beef, fish, and milk, approximated by dividing each food's expenditure by the quantity consumed. In addition to price, the study also considers the consumption of these five animal derived sources of food groups. For each group, items aggregated were eggs (chicken and duck), poultry (local and imported and chicken meat), beef (fresh, frozen, and chilled), fish (fish, shrimp, squid, and shellfish), and milk (milk powder and infant milk).

Results and discussion

Factors affecting animal derived sources of food demand

The results of the QUAIDS model incorporating socio-demographic variables and theoretical restrictions imposed for the five animal derived food categories, which were computed using equation (11), are presented in Table 1. The majority of the estimated parameters are highly significant. The effect of own-price variables (γ_i) on each share equation is positive and highly significant except for fish, which has a negative effect. The study suggests that an increase in the prices of eggs, poultry, beef, and milk causes an increase in the budget share expenditure. This finding is similar to Kharisma et al. (2020), who indicated that there is a direct relationship between own-price and expenditure share. Conversely, for fish, a price hike leads to a decrease in the budget share expenditure. Comparable outcomes for fish were also discovered by Nendissa et al. (2021). Poultry has the most response to price changes with regards to expenditure share, while fish has the least response, followed by milk.

Table 1 also presents the income variable for each of the animal derived source of food share equations. The parameters related to income (β_i) in all share equations, except for fish, were highly significant. It was observed that an increase in household income leads to an increase in the expenditure shares of eggs, beef, and milk, but a decrease in the expenditure shares of poultry and fish. This finding is consistent with the research of Hayat et al. (2016), which suggests that higher household income leads to an increase in demand for meat and dairy products. Kharisma et al. (2020) also found similar results regarding the negative relationship between income and the consumption of poultry and fish; they suggested that as household income rises, there is a shift towards more expensive animal derived food products such as meat and milk. Additionally, the results for poultry and fish align with Bennett's Law (Bennett 1941) in Jakarta, Indonesia, which indicates that higher household income tends to result in a shift towards consuming better-quality foods.

Table 1: Parameter estimates of QUAIDS models for animal derived sources of food in Jakarta, Indonesia

Parameter	Eggs	Poultry	Beef	Fish	Milk
α_i	**1.611***** (0.080)	**-2.640***** (0.110)	**1.454***** (0.096)	**0.027** (0.081)	**0.548***** (0.094)
Price 1 (γ_1)	**0.496***** (0.016)	**-0.501***** (0.032)	**0.135**** (0.021)	**-0.043***** (0.015)	**-0.088***** (0.018)
Price 2 (γ_2)	**-0.501***** (0.032)	**1.131***** (0.089)	**-0.537***** (0.057)	**0.114***** (0.036)	**-0.208***** (0.046)
Price 3 (γ_3)	**0.135**** (0.021)	**-0.537***** (0.057)	**0.233***** (0.045)	**-0.009** (0.019)	**0.177***** (0.020)
Price 4 (γ_4)	**-0.043***** (0.015)	**0.114***** (0.036)	**-0.009** (0.019)	**-0.078***** (0.009)	**0.016*** (0.009)
Price 5 (γ_5)	**-0.088***** (0.018)	**-0.208***** (0.046)	**0.177***** (0.020)	**0.016*** (0.009)	**0.102***** (0.021)
Income (β_i)	**0.192***** (0.012)	**-0.544***** (0.017)	**0.261***** (0.017)	**-0.006** (0.015)	**0.097***** (0.018)
Income^2 (λ_i)	**0.022***** (0.000)	**-0.028***** (0.001)	**0.009***** (0.001)	**-0.001**** (0.001)	**-0.002**** (0.001)
HHS (η_i)	**0.001** (0.001)	**-0.002**** (0.001)	**0.001**** (0.000)	**0.000** (0.000)	**0.000** (0.000)

*** P ≤ 0.01, ** P ≤ 0.05, * P ≤ 0.1. Standard errors in parentheses. Parameter symbols are defined Materials and methods. HHS represents household size.

The investigation conducted in this study examined how the number of individuals in a household (η_i) affects the percentage of money spent on different animal-based food products. The findings are displayed in Table 1. Previous studies by Khoiriyah et al. (2020), Abdulai and Aubert (2004), Armagan and Akbay (2008) and Cornelsen et al. (2016) established a correlation between household size and demand for animal-based foods. The results indicated that the size of the household had a statistically significant impact on the expenditure share of poultry and beef for Jakarta households, but the effect was relatively minor. Moreover, the research revealed that the expenditure share of poultry decreases as the size of the household increases. Deaton and Paxson (1998) observed that households with more members tend to consume less food on a per capita basis, while Abdulai (2002) found that larger households tend to purchase less expensive food items due to financial constraints. This could imply that households with more members have a more varied diet and may allocate their income to purchasing other preferred or affordable food products instead of poultry meat.

Income elasticities

The demand for goods and services is significantly influenced by household income, and the extent of this impact can be measured through income elasticity, which reflects the percentage change in demand caused by a percentage change in income. Table 2 presents the income elasticities for the five animal derived food groups for Jakarta, Indonesia. The findings reveal that beef is the most income elastic of all animal derived sources of food, with an income elasticity of 2.20. This implies that a 1% increase in income leads to a 2.20% increase in the demand for beef. These findings align with research that has found beef to be a luxury good (Khoiriyah et al. 2019; Anindita et al. 2020). Poultry, fish, and milk are also income elastic, with income values of 1.44, 1.07, and 1.84, respectively. Since the income elasticities of these four animal derived food groups are greater than unity, they are considered luxury commodities. Conversely, eggs are considered normal goods since changes in their demand due to income increases are less than unity, specifically 0.38%.

Table 2 also presents the marginal expenditure shares (MES) analysis, which refers to the additional changes in the amount requested as a result of changes in income in the long run (Sa'diyah et al. 2019). The analysis of MES is crucial as it can aid in the development of price or income policy scenarios to achieve the recommended dietary allowance (RDA) which is around 57 g/capita/day in Indonesia. The results indicate that MES for beef is the highest, implying that households in Jakarta tend to increase their beef consumption with an increase in income more than proportionally in the long run.

Table 2: Income elasticities and marginal expenditure shares for Jakarta, Indonesia

Food group	Income elasticity	Marginal expenditure share
Eggs	**0.382**	**0.073**
	(0.008)	(0.032)
Poultry	**1.073**	**0.384**
	(0.013)	(0.035)
Beef	**2.196**	**1.376**
	(0.040)	(0.018)
Fish	**1.444**	**0.378**
	(0.039)	(0.028)
Milk	**1.838**	**0.331**
	(0.024)	(0.054)

Standard errors in parentheses

Marshallian price elasticities

The estimated QUAIDS parameters were used to calculate price elasticities of demand for various animal derived sources of food for urban households in Jakarta, Indonesia. Prices elasticities of demand are all calculated at means. Price elasticity is comprised of both own- and cross-price elasticities. Own-price elasticity of demand is a measure of the responsiveness of the quantity demanded of a commodity to a change in its own price, while holding all other factors that may affect demand constant. If the elasticity is greater than one, demand is considered elastic, indicating that a small change in price results in a larger change in the quantity demanded. Conversely, if the elasticity is less than one, demand is considered inelastic, meaning that a change in price has a relatively smaller effect on the quantity demanded. If the elasticity is exactly one, demand is unitary elastic, indicating that the percentage change in quantity demanded is equal to the percentage change in price.

Table 3 presents Marshallian own-price elasticities for the five animal derived sources of food. All Marshallian own-price elasticities exhibit negative values, which align with the well-established economic theory that posits that an increase in animal derived sources of food prices results in a decreased demand for quantity demanded. Put simply, when the prices of eggs, poultry, beef, fish, and milk increase, households tend to reduce their consumption. Thus, animal derived sources of food consumption are inversely related to prices. The findings reveal that beef is the most elastic food group, followed by fish, poultry, eggs, and milk, with successive elasticities of 1.71, 1.61, 1.39, 1.32, and 0.67. Significantly, all animal derived sources of food exhibit elastic demand, except for eggs, implying that an increase in prices results in a more substantial decrease in demand than an increase in price. This trend can be explained by the fact that urban households, in general, tend to be consumers rather than producers of animal derived sources of food, thereby making them more susceptible to price increases than producer households. In addition, eggs were found to be the least responsive to changes in prices since they are a relatively cheap source of protein compared to other sources of animal proteins.

Table 3: Marshallian price elasticities for households in Jakarta, Indonesia

Food group	Eggs	Poultry	Beef	Fish	Milk
Eggs	**-0.669**	0.207	-0.005	0.008	-0.048
	(0.039)	(0.026)	(0.019)	(0.012)	(0.021)
Poultry	-0.240	**-1.386**	-0.168	-0.011	-0.057
	(0.065)	**(0.071)**	(0.045)	(0.028)	(0.048)
Beef	0.229	-0.709	**-1.705**	-0.221	0.574
	(0.211)	(0.198)	**(0.267)**	(0.113)	(0.168)
Fish	1.039	0.066	-0.405	**-1.605**	-0.335
	(0.272)	(0.245)	(0.224)	**(0.202)**	(0.217)
Milk	-0.394	0.091	0.224	-0.061	**-1.323**
	(0.081)	(0.072)	(0.056)	(0.036)	**(0.086)**

Note: Standard errors in parentheses

Table 3 also presents cross-price elasticities for animal derived sources of food that reveal the relationship between different groups. A positive cross-price elasticity implies a substitution relationship, while a negative value indicates a complementary relationship. The results indicate that most cross-price elasticities are positive, indicating that animal derived sources of food are substitutes for one another. Fish is found to substitute with eggs and poultry, but complementary with beef and milk. For instance, a 1% increase in the price fish is expected to increase demand of eggs and poultry by around 1.04% and 0.07%, respectively. Furthermore, an increase in fish prices most positively affects household consumption of eggs in urban Jakarta.

Hicksian price elasticities

The Hicksian or compensated price elasticity measures the degree of responsiveness of the quantity demanded when there is a price change, completely ignoring the income effect associated. Table 4 presents Hicksian own- and cross-price elasticities for the various animal derived sources of protein which were all negative as expected. The highest elasticity of demand is beef with a price elasticity of 1.61. Fish and milk were also found to have an elastic demand. It was found that 1% increases in the prices of fish and milk lead to 1.57% and 1.10% decreases in demand, respectively. Hence, for beef, fish and milk, price increase would negatively affect household consumption patterns and lead to protein deficiencies as these items respond more than proportionally to changes in prices. Eggs were found to be the least responsive to changes in prices. A 1% increase in the price of eggs is expected to bring about on average a 0.62% decrease in egg consumption. Eggs and poultry were found to have inelastic demand, this means that they are less responsive to changes in prices. Based on the elasticities of other animal protein sources, egg consumption is expected to increase when the prices of other items increase as they are a relatively cheaper source of protein.

Table 4: Hicksian price elasticities for households in Jakarta, Indonesia

Food group	Eggs	Poultry	Beef	Fish	Milk
Eggs	**-0.624**	0.292	0.112	0.080	0.140
	(0.038)	(0.026)	(0.019)	(0.012)	(0.021)
Poultry	0.784	**-0.969**	-0.075	0.037	0.224
	(0.062)	**(0.071)**	(0.045)	(0.028)	(0.048)
Beef	1.236	-0.299	**-1.613**	-0.174	0.850
	(0.208)	(0.199)	**(0.267)**	(0.113)	(0.167)
Fish	1.721	0.343	-0.343	**-1.573**	-0.148
	(0.268)	(0.247)	(0.224)	**(0.202)**	**(0.217)**
Milk	0.410	0.418	0.298	-0.024	**-1.103**
	(0.081)	(0.072)	(0.056)	(0.036)	(0.086)

Standard errors in parentheses

The study also calculated Hicksian cross-price elasticities which are also presented in Table 4. Generally, it was found that mostly substitution relationships existed among various animal-sources of protein food groups when only the price effect was analysed. Beef, for example, is a substitute for milk and eggs with cross-price elasticities of 0.29 and 0.11. In other words, if the price of beef rises by 1%, households in Jakarta will replace their consumption of beef with milk or eggs. Whereas with fish and poultry, beef is complementary. The research results shown that the Hicksian cross-price elasticities of beef to fish and poultry are -0.34 and -0.08. It can be concluded that if the price of beef increases, households in Jakarta are expected to consume fish and poultry more. Fish is a substitute for eggs and poultry with cross-price elasticities of 0.08 and 0.04. Fish is complementary to beef and milk with cross-price elasticities of 0.17 and 0.02. The increase in fish prices not only reduced the demand for fish, but also decreased the demand for beef and milk simultaneously. Milk was found to have substitution relationships with beef, poultry, and egg with cross-price elasticities of 0.85, 0.22 and 0.14, respectively.

Conclusion

This study examined the effects of rising prices and incomes on the demand for animal derived sources of food in urban households in Jakarta, Indonesia. The research used secondary data from the SUSENAS for March 2021 utilising a total of 3,227 households. Data analysis used the QUAIDS model approach. The results of the study show that even though all households in the capital city of Indonesia are urban households, all animal source foods are elastic except for eggs which are inelastic. The most elastic animal food is beef with a demand elasticity of 1.71, followed by fish, chicken, eggs and milk with a demand elasticity of 1.61, 1.39, 1.32 and 0.67, respectively. Various substitution and complementary relationships were found to exist between pairs of animal foods. Income elasticities concluded that all animal food in Jakarta are a luxury item except for eggs which are normal goods with an income elasticity of 2.20 for beef, followed by milk (1.84), poultry (1.44), and fish (1.07). While the income elasticity of eggs is 0.38. These findings confirm that prices and incomes greatly affect consumption patterns of animal derived sources of foods in urban households in Jakarta. Therefore, it is deemed necessary to provide a price or income policy to stabilise prices so that protein consumption can be met, especially beef. For households in Jakarta, income policies are more effective than price policies. It is hoped that the results of the research will be valuable information to meet consumption of animal protein foods in Jakarta so that the household protein food and nutrition security can be achieved.

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