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IMPLEMENTATION OF DEMAND SYSTEM RESTRICTIONS AND ACCURACY OF QUAIDS MODEL ESTIMATOR ON ANIMAL FOOD DEMAND IN INDONESIA

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Demonstration on restrictions and accuracy of an estimator is pivotal since the incomplete restrictions will make the estimator inaccurate that they cannot be used for the need of decision making. In this study, the demand system's three primary requirements-adding up, homogeneity, and symmetry – are examined. This current research was intended to demonstrate restrictions and accuracy of Quadratic Almost Ideal Demand System (QUAIDS) model estimator. The source of the data was referred to the results of National Socio-Economic Survey of Indonesia in 2016, involving 291,414 households in total. Iterated Nonlinear Seemingly Unrelated Regression method was used for the estimation procedure. Parameter estimation is used to calculate the elasticity of animal protein. The results have indicated that the three restrictions of the QUAIDS model estimator, i. e. adding up, homogeneity, and symmetry, have been completed. Further, the estimation made by the QUAIDS model is valid and efficient; therefore, the estimation is potentially used as a means of calculating own and cross price elasticity, either Marshallian or Hicksian. In addition, some other parameters, such as price, income, and income squared, are also employed to calculate income elasticity. The findings show that demand is elastic for all animal proteins, except for eggs, which are inelastic. Beef is most elastic. According to the income elasticity results, all animal proteins are considered luxury foods in Indonesia, except for eggs, which have an income elasticity of less than one. To fulfill Indonesian households' needs for animal protein, the income policy is more suited for beef, while the price strategy is more effective for animal proteins including chicken, milk, fresh fish, and eggs

Keywords: restrictions, food demand system, adding up, homogeneity, symmetry protein, QUAIDS, marshallian, hicksian, elasticity

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1. Introduction

A pattern of food consumption on animal protein serves to be one of several indicators to measure the degree of welfare amongst households [1]. The higher the incomes earned by households, the lower the expenditure for food consumption will be. Contrarily, the lower the incomes, the higher the expenditure for food consumption will be [2–6] also posits that a group of households with higher economic welfare will show up a trend of higher consumption of non-food than that of food, by assuming that food demand has been well fulfilled.

Law of demand refers to a relationship between demand of goods in specific amounts made by consumers and prices of the goods. The lower the prices of goods, the more increasing the demand of the goods will be, and in *vice versa*, the higher the prices of the goods, the more decreasing the demand of the goods [3]. Both of the assumptions are formulated on the basis of *ceteris paribus* law, which means that any factors, other than the prices of the goods, are considered constant in influencing the amounts of demand made by consumers. Demand over particular goods made by consumers can be dependent on many factors, such as income, price of other goods, personal preference, and expectation value [7, 8]. According to [9] there are three most dominant factors to influence household consumption, namely price, income, and preference. Further, the characteristics of preference amongst households must be different, like residential area, educational background of family members, the number of family members, shared custom, and culture.

It is known that studies on household consumption of the animal protein source food groups are still very rarely carried out. In general, the study conducted is a study of general food consumption expenditure. On the other hand, information about the consumption pattern of the animal protein source food group and how it responds to changes in prices and changes in income is needed to predict welfare, the effects of technological change, infrastructure development, or other economic policies.

Researches on food demand system by means of Almost Ideal Demand System (AIDS) or Quadratic AIDS (QUAIDS) model have been quite frequent in many countries, such as Italy [10]; Brazil [11], Nigeria [12], Kenya [13], Saudi Arabia [14], and Indonesia [15]. However, from those two models, the AIDS model has difficulty capturing the nonlinear effect of the Engel curve so it does not have the flexibility to represent the differentiation of income classes and regions. Therefore, to maintain the nature of the AIDS model and maintain consistency with the Engel curve and the relative price effect in the utility maximization framework, Quadratic AIDS (QUAIDS) was used. This QUAIDS model estimator is strongly required to meet the three restrictions so that the estimation can be applied to calculate elasticity, either price or income elasticity. Furthermore, some researches of demand system restrictions have been carried out many times in some countries, such as Canada [16], Japan [17] South Korea [18–21]. However, this sort of research is still of rarity in Indonesia.

Consumption expenditure on food in Indonesia is still divided into 14 food groups, namely: grains, tubers, fish, meat, eggs and milk, vegetables, nuts, fruits, oils and fats, beverage ingredients, spices, food and beverages, tobacco and betel, and other consumption. Based on available data, the largest consumption expenditure for food is allocated to prepared food and beverages, followed by the grains group, and the food group from animal protein sources such as fish, meat, eggs, and milk. Expenditures on household consumption of the animal protein source food group have tended to increase over the past few years.

Therefore, researches on testing the demand system restriction as a basis for estimating the parameters of price and income changes to the demand for animal protein as a source of households are relevant. The results of these researches are expected to be information and input for the governments as an illustration of the demand for animal protein in the community to meet food demand so that food security can be achieved properly. In addition, the results of these researches can be used as input for determining food price policies, especially regarding animal protein.

2. Literature review and problem statement

The demand function, in general, expresses the relationship between the quantity sought and the variables that affect it at a given location and time. [22] claims that there are two techniques for deriving the demand function. The first is to increase satisfaction while staying within financial and cost-related constraints. The Marshallian demand function is a demand function resulting from this theory [23]. The British economist first proposed this function in 1890, and made the assumption that consumer income is fixed. Using duality theory, it is possible to create another demand function that maximizes output while minimizing spending at a given level of spending. The amount of consumer happiness is an obstacle [24, 25]. In 1980, two researchers created a model of the AIDS demand function from this formulation (Almost Ideal Demand System). The AIDS model, first proposed by Muelbauer, is a model that is often used in system-based modeling of consumption behavior [24]. The budget share for the AIDS model is a linear function of the logarithm (income) of the overall budget. A linear indirect utility function in the log of total revenue is used to model the AIDS demand.

In the past two decades, an AIDS (Almost Ideal Demand Systems) model developed by [24] has been commonly used as a method of demand analysis. The AIDS model is equipped with a number of demand properties, such as testing symmetry and homogeneity through linier restrictions amongst commodities. [26] generalized the AIDS model by demonstrating that the quadratic form could meet consumers' preferences, contrary to the linier form in the basic AIDS. According to [26], static model and dynamic model are two basic types of AIDS model. The analysis of the preference model in long-term equilibrium is carried out using a static model. In other words, the long-run or static balance determines how consumers or respondents will act. The dynamic AIDS model builds on the error correction method first introduced by Engle and Granger in 1987 to build econometric models. Long-term equilibrium that cannot be explained by the static AIDS model can be accommodated by the model.

Research conducted by [27] on AIDS on Korean millennial travel spending. This research is focused on domestic tourists in South Korea. The AIDS estimation results on data from 871 domestic tourists revealed significantly different travel spending patterns for the groups. In these data, it is possible that there are heterogeneous groups within the same generation group. In the AIDS model, the long-term balance between groups cannot be explained by the static AIDS model. This study also cannot show differences in income class and regional differences due to the AIDS model (or other models such as translog and linear expenditure systems) cannot accommodate and show these differences. Therefore, researchers want to do modeling with QUAIDS to overcome the problems that exist in research [22]. This research was conducted in Indonesia using data covering various regions in Indonesia. This is different from previous studies that have not been able to capture heterogeneous groups (weakness of the AIDS model). The way to overcome these difficulties can be used the QUAIDS model. This approach can be used to solve this problem. The QUAIDS model has affirmed the theory of consistency and demand properties of the AIDS model. The QUAIDS model can maintain the positive characteristics of the AIDS model, maintain consistency with the Engel curve, and maintain the relative price effect on utility maximization. In addition, this research was conducted in Indonesia and used data covering various regions in Indonesia. This is different from previous studies which have not been able to capture various heterogeneous groups. Researchers also consider price and demographics that can add useful information for Indonesia government.

As is often observed in empirical demand investigations, Engel's nonlinear curve is difficult to capture by the AIDS model. This is a shortcoming of the AIDS model. In addition, another shortcoming of the AIDS model is that information about income class differences and regional differences cannot be included in the AIDS model (or other models such as translogs and linear expenditure systems). Therefore, a way to overcome these difficulties can be to use a quadratic model of the income log which is added to the AIDS model so that it can produce Quadratic AIDS (QUAIDS). The QUAIDS model can maintain the positive characteristics of the AIDS model, maintain consistency with the Engel curve, and maintain the relative price effect on utility maximization [28]. The QUAIDS model can reproduce the Engel curve and has almost all of the same characteristics as AIDS. As a result, the demand model for the empirical estimation strategy has been decided to be QUAIDS. It is possible that the elasticity of expenditure for the consumption of these goods is constant at all income levels if the parameters presented in the estimation results are not significant goods or vice versa. Parameter values indicate this modification [29].

Based on the current situation in Indonesia, processed food and beverages make up the majority of food consumption expenditure, followed by the group of grains and foods derived from animal protein sources such as fish, meat, eggs, and milk. In recent years, household expenditures on foodstuffs from the animal protein source food group tend to increase. Therefore, it is necessary to conduct periodic studies on this matter as the basis for making government policies and strategies. By using the QUAIDS model, it can be seen how the socio-economic groups in urban areas differ from those in rural areas in the expenditure of animal protein food consumption. The results of modeling using QUAIDS are expected to be able to provide accurate information regarding price elasticity and consumption about household expenditures on foodstuffs from the animal protein.

3. The aim and objectives of the study

The aim of the study the effects of price changes on the demand for animal-based foods in Indonesia in 2016 as reflected by income and price elasticities. Include own and cross price elasticities generated by the parameter estimation of a demand system using QUAIDS in order to account for variations in consumption patterns as indicated in replacement and complement effects among food items.

To achieve this aim the following steps are carried out:

– to test restrictions on each share of animal protein expenditure;

– to find the accuracy of quadratic almost ideal demand system (QUAIDS) model estimator;

– to find parameter estimates for all research variables, namely price parameters for all animal proteins, income parameters, and income square parameters with the calculated elasticities are Marshallian and Hicksian self-esteem elasticity, Marshallian and Hicksian cross price elasticity, and income elasticity.

4. Materials and methods of research

4. 1. Object and hypothesis of the study

This current research was aimed to analyze demand system restrictions and accuracy of QUAIDS model estimator of animal protein demand in Indonesia that is relevant to this problem. The primary source of data was based on the data of animal protein consumption and outgo. Further, the data were collected from Central Bureau Statistics in the form of National Socio-Economic Survey in 2016, involving as many as 291,414 households. The model was chosen using Quadratic AIDS with the consideration that animal protein is a luxury food in several countries in the world, so it is necessary to include the quadratic income variable into the model. Iterative Nonlinear Seemingly Unrelated Regression (ITNL-SUR) was used to carry out the procedure of estimation. After restrictions and accuracy of the estimator remained valid, price and income elasticity was calculated. With reference to price elasticity, essential information would be obtained, whether animal protein appeared to be elastic, inelastic, or unitary elastic. Next, regarding income elasticity, it would be concluded if food animals typified normal, luxurious, or *giffen* goods.

To achieve this aim the following steps are carried out:

– theoretically, to find parameter estimates for all research variables, namely price parameters for all animal proteins, income parameters, and income square parameters with the calculated elasticities are Marshallian and Hicksian self-esteem elasticity, Marshallian and Hicksian cross price elasticity, and income elasticity;

– practically, this will allow it to serve as a basis for policy makers regarding food and animal protein consumption in Indonesia so that Indonesia can improve food security and food self-sufficiency.

4. 2. Model Specification: quadratic almost ideal demand system (QUAIDS)

Formally, share equations of QUAIDS model [3, 27] is formulated as follows:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_1 \ln\left[\frac{m}{\alpha(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{\alpha(p)}\right]\right\}^2 + \varepsilon_i, \quad (1)$$

where w_i – a household's expenditure share for commodity i, which is formulated as:

$$w_i = \frac{p_i q_i}{m}, \text{ and } \sum_{i=1}^{n} w_i = 1. \quad (2)$$

On the other hand, the theory of demand requires the following restrictions:

– adding-up:

$$\sum_{i=1}^{n} \alpha_1 = 1, \sum_{i=1}^{n} \beta_1 = 1, \ \sum_{i=1}^{n} y_{ij} = 0, \sum_{i=1}^{n} \lambda_i = 0; \quad (3)$$

– homogenity:

$$\sum_{i=1}^{n} y_{ji} = 0; \quad (4)$$

– Slutsky symmetry:

$$\gamma_{ji} = \gamma_{ij}. \quad (5)$$

The QUAIDS model in this study was carried out to account for socio-demographic (z) effects on animal products' demand. Essentially, demographic factors can influence household behavior in terms of demand and expenditure allocated among goods [27, 30–34]. Further, a 'demographic scaling' method was used in this current research, which was referred to [35]. In this approach, the change effects on the demographics were close to the effects caused by a price change in animal products [36].

Considering z as a vector of S household characteristics, z is named as a scalar representing household size in the simplest case. Given $e^R(p,u)$, it is used to represent Roy's method is referred to expenditure function of household characteristics, without controlling any changes in consumption patterns. The second term is meant to control changes of relative prices and actual goods consumed. QUAIDS parameterizes $\underline{m_o}(z)$ is:

$$\overline{m_o}(z)=1+\rho z, \tag{6}$$

where ρ serves to be a vector of parameters to be estimated. The expenditure share equation takes a form of:

$$w_i=\alpha_i+\sum_{j=1}^{k}\gamma_{ij}\ln p_j+\left(\beta_1\eta_i^{/}z\right)+ +\ln\left[\frac{m}{\overline{m_o}(z)\alpha(p)}\right]+\frac{\lambda_i}{b(p)c(p,z)}\left\{\ln\left[\frac{m}{\overline{m_o}(z)\alpha(p)}\right]\right\}^2, \tag{7}$$

where

$$c(p,z)=\prod_{j=1}^{k}\rho^{n_{iz}}, \tag{8}$$

furthermore, the adding-up condition requires that:

$$\sum_{j=1}^{K}\eta_{rj}=0,\text{ for } r=1,\dots,s. \tag{9}$$

Meanwhile, the uncompensated (Marshallian) price elasticity of animal product group i with respect to price changes of animal product j is:

$$\varepsilon_{ij}=-\delta_{ij}+\frac{1}{w_i}\left(\begin{array}{l}\gamma_{ij}\left[\begin{array}{l}\beta_i+\eta_i^{/}z+\dfrac{2\lambda_i}{b(p)c(p,z)}\times\\ \times\ln\left\{\dfrac{m}{\overline{m_o}(z)\alpha(p)}\right\}\end{array}\right]\\ *\left(\alpha_j+\sum_1\gamma_{ij}\ln p_j\right)-\\ -\dfrac{\left(\beta_1\eta_i^{/}z\right)\lambda_i}{b(p)c(p,z)}\left[\ln\left\{\dfrac{m}{\overline{m_o}(z)\alpha(p)}\right\}\right]^2\end{array}\right). \tag{10}$$

The expenditure elasticity of the animal product group i is:

$$\mu_i=1+\frac{1}{w_i}\left[\beta_i+\eta_i^{/}z+\frac{2\lambda_i}{b(p)c(p,z)}\ln\left\{\frac{m}{\overline{m_o}(z)\alpha(p)}\right\}\right]. \tag{11}$$

Meanwhile, the compensated (Hicksian) price elasticity is derived from *Slutsky* equation:

$$\varepsilon_{ij}^{c}=\varepsilon_{ij}+\mu_i w_j. \tag{12}$$

The parameters are estimated by means of iterated feasible generalized non-linier least, equivalent to the multivariate normal maximum likelihood estimator for this class of problem assisted by Stata's 'NLSUR' command as suggested by [35]. After presenting the demand model, discussion on at least two major data issues is worth doing, by the inclusion of price measure and the treatment of outliers and missing values.

4. 3. Demand system restrictions: adding up, homogeneity, and symmetry

A demand function is a mathematical representative to demonstrate a connection between demand of goods and some related factors that determine or influence customers' decision making to purchase goods. The demand function, in addition, demonstrates a connection between dependent and independent variables. Moreover, the demand function encompasses two basic forms, Marshallian and Hicksian. The Marshallian Demand Function takes a form of:

$$X^M=f\left(P_x,P_y,I\right), \tag{13}$$

where X^M – number of demands over good X; P_x – price of good X; P_y – price of good Y; I – income.

Meanwhile, the Hicksian Demand Function is formulated as:

$$X^H=f\left(P_x,P_y,U\right), \tag{14}$$

X^H – number of demands over good; P_x – price of good X; P_y – price of good Y; U – utility.

Referring to the Marshallian Demand Function, the number of demands constitutes price and income function. This function is derived from utility maximization along with budget constraints. Meanwhile, the Hicksian Demand Function stems from the decrease of expenditure minimization with constant utility. Further, the Hicksian Demand Function demonstrates that the number of demands over goods signifies the function of price and price satisfaction level.

A specific commodity demand is simultaneously influenced by several factors. According to [25], to purchase some i commodities, consumers' decision making will be much affected by the price of the goods (p) and the total expenditure (x) as an income approach. There are several requirements that must be completed by the request function, namely:

4. 3. 1. Adding up

It demonstrates that a total expenditure, in a demand function, is equal to a total income. Mathematically, it is formulated as follows:

$$\sum p_i q_i=I, \tag{15}$$

with the descriptions of, p_i – price of the i^{th} commodity; q_i – quantity of the i^{th} commodity; I – income.

4. 3. 2. Homogeneity

This requirement postulates that if income and price changes are found in an equal proportion, demand over commodities will remain stagnant. This remarks an implication of homogeneous demand function with a degree of zero (0) upon the price and demand. Such a requirement can be translated into the following mathematical equation:

$$\sum\nolimits_i\varepsilon_{ij}+\varepsilon_{il}=0, \tag{16}$$

with the descriptions of:

– ε_{ij} – cross price elasticity of the i^{th} commodity upon the price of the j^{th} commodity;

– ε_{il} – income elasticity of the i^{th} commodity.

4. 3. 3. Negativity requirement and Slutsky symmetry

This sort of requirement expounds that if income and price changes are in the same proportion, demand over commodities remains stagnant. This indicates the implication of homogeneous demand function with a degree of zero upon the price and demand. This symmetric condition can be mathematically formulated as follows:

$$w_i\left(\varepsilon_{ij}+w_j e_{il}\right)=w_j\left(\varepsilon_{ji}+e_{ji}\right), \quad (17)$$

with the descriptions of: w_i – expenditure proportion of the i^{th} commodity; w_j – expenditure proportion of the j^{th} commodity; ε_{ij} – cross price elasticity of the i^{th} commodity upon the price of the j^{th} commodity; e_{il} – income elasticity of the i^{th} commodity; e_{ij} – income elasticity of the j^{th} commodity.

4. 4. Data

The data used in the current research were the secondary data taken from National Socio-Economic Survey (March 2016). This data consists of consumption and household expenditure on animal protein in Indonesia. There are 300,000 households in the SUSENAS data sampling. It's a lot of people, this number. 294,414 households made up the sample that was finally ready for analysis after BPS had cleaned the data. The variables of this research are the price of eggs, the price of chicken meat, the price of beef, the price of fish and the price of powdered milk. The difference between the AIDS and QUAIDS models is in the quadratic income variable, so in this study the quadratic income variable is included in the model. There were a significant number of zero-consumption data for the intake and spending of animal protein, it was discovered. It takes a while to tabulate and analyze the data because this zero-consumption data is extremely tricky. With the help of Poi's technique, it is possible to overcome the issue of zero consumption, and calculation of QUAIDS parameters and findings from restriction testing are both highly promising. The analyzed data were household consumption, expenditure, and total expenditure. As for the animal proteins, some commodities were observed, such as eggs (for instance, chicken eggs, local chicken eggs, and duck eggs), chicken meat (local chicken meat and chicken meat), beef, fish (fresh fish and shrimp, or other products including fish, shrimp, squid, and shellfish), as well as milk (including milk powder and infant milk). In addition, the samples recruited for this current research were 291,414 households. For data analysis, Stata 14.3 software was used.

5. Research of Quadratic Almost Ideal Demand System Model on Animal Food

5. 1. The restriction of the quadratic almost ideal demand system (QUAIDS)

The completion of restrictions is the core of a demand system. In principle, a restriction includes three main components, namely adding up, homogeneity, and symmetry. Adding up refers to a specific condition in which household expenditure share is used up to purchase goods as stated in the equation, affirming that total expenditure in a demand function is equal to total income. In this research, the expenditure share was used to purchase five animal products, such as egg, chicken meat, beef, fish, and milk. Homogeneity avers that if price and income changes are in the same proportion, demand over commodities remains stagnant. This implies a homogeneous demand function with a degree of zero upon the price and demand, as shown in (16). Based on the analysis results, the value of gamma$_{ij}$ or gamma$_{ji}$ is equal to zero. Meanwhile, the symmetry confirms that if income and price changes are in the same proportion, demand over commodities will never change. This implies a homogeneous demand function with a degree of zero towards the price and demand, as stated in (17).

Tables 1–5 display the results of analysis on the restrictions for each equation of demand system share of expenditure on five major animal proteins, i. e. egg, chicken meat, beef, fresh fish, and milk. The results of analysis in Tables 1–5 indicate that the accumulation of (alpha)$_{eggs}$, $(\alpha)_{chicken}$, $(\alpha)_{beef}$, $(\alpha)_{fish}$, and $(\alpha)_{milk}$ was equal to 1. It can be inferred that the household income is in same level as animal protein demand. Accordingly, it has been proved that adding up restriction on animal protein in Indonesia has fulfilled all requirements needed for further analysis.

Table 1

Demand system restriction of expenditure share of egg group

SHARE_Eggs						
Description	Coef.	Std. Err.	z	$P>\|z\|$	[95 % Conf.]	[Interval]
Alpha						
alpha_1	0.566	0.017	33.160	0.000	0.533	0.600
Beta-(Expd-L)						
beta_1	0.045	0.003	15.690	0.000	0.039	0.051
Gamma-Price						
gamma_1_1	0.398	0.003	140.810	0.000	0.393	0.404
gamma_2_1	–0.259	0.005	–54.140	0.000	–0.268	–0.250
gamma_3_1	–0.006	0.002	–2.490	0.013	–0.010	–0.001
gamma_4_1	–0.039	0.001	–31.140	0.000	–0.041	–0.037
gamma_5_1	–0.095	0.004	–26.640	0.000	–0.102	–0.088
Lambda-(Expd-Q)						
lambda_1	0.015	0.000	150.640	0.000	0.015	0.016
eta						
eta_urb_rur_1	0.002	0.000	4.300	0.000	0.001	0.003
eta_hhsize_1	–0.001	0.000	–5.980	0.000	–0.001	0.000
rho						
rho_urb_rur	0.111	0.018	6.210	0.000	0.076	0.146
rho_hhsize	0.085	0.006	14.600	0.000	0.074	0.097

*Note: *Restriction: 0.00 or 1.00 (alpha)*

Table 2

Demand system restriction of expenditure share of chicken meat group

SHARE_Chicken meat						
Description	Coef.	Std. Err.	z	P>|z|	[95 % Conf.]	[Interval]
alpha						
alpha_2	–1.341	0.022	–62.030	0.000	–1.383	–1.298
Beta-(Expd-L)						
beta_2	–0.318	0.003	–96.000	0.000	–0.324	–0.311
Gamma-Price						
gamma_1_2	–0.259	0.005	–54.140	0.000	–0.268	–0.250
gamma_2_2	0.568	0.011	51.200	0.000	0.547	0.590
gamma_3_2	–0.192	0.005	–38.260	0.000	–0.202	–0.182
gamma_4_2	0.070	0.005	15.180	0.000	0.061	0.079
gamma_5_2	–0.187	0.007	–26.210	0.000	–0.201	–0.173
Lambda-(Expd-Q)						
lambda_2	–0.021	0.000	–120.620	0.000	–0.022	–0.021
eta						
eta_urb_rur_2	–0.004	0.000	–9.910	0.000	–0.005	–0.003
eta_hhsize_2	0.001	0.000	9.910	0.000	0.001	0.001
rho						
rho_urb_rur	0.111	0.018	6.210	0.000	0.076	0.146
rho_hhsize	0.085	0.006	14.600	0.000	0.074	0.097

*Note: *Restriction: 0.00 or 1.00 (alpha)*

Table 3

Demand system restriction of expenditure share of beef group

SHARE_Beef						
Description	Coef.	Std. Err.	z	P>|z|	[95 % Conf.]	[Interval]
alpha						
alpha_3	0.728	0.011	66.87	0	0.707	0.75
Beta-(Expd-L)						
beta_3	0.122	0.002	57.63	0	0.118	0.126
Gamma-Price						
gamma_1_3	–0.006	0.002	–2.49	0.013	–0.01	–0.001
gamma_2_3	–0.192	0.005	–38.26	0	–0.202	–0.182
gamma_3_3	0.06	0.003	17.31	0	0.053	0.066
gamma_4_3	0.012	0.002	6.05	0	0.008	0.015
gamma_5_3	0.127	0.003	44.31	0	0.121	0.132
Lambda-(Expd-Q)						
lambda_3	0.005	0	40.89	0	0.004	0.005
eta						
eta_urb_rur_3	0.001	0	9.46	0	0	0.001
eta_hhsize_3	0	0	14.06	0	0	0
rho						
rho_urb_rur	0.111	0.018	6.21	0	0.076	0.146
rho_hhsize	0.085	0.006	14.6	0	0.074	0.097

*Note: *Restriction: 0.00 or 1.00 (alpha)*

Table 4

Demand system restriction of expenditure share of fresh fish group

SHARE_Fresh Fish						
Description	Coef.	Std. Err.	z	P>|z|	[95 % Conf.]	[Interval]
alpha						
alpha_4	0.018	0.013	1.42	0.157	–0.007	0.042
Beta-(Expd-L)						
beta_4	–0.012	0.002	–4.81	0	–0.016	–0.007
Gamma–Price						
gamma_1_4	–0.039	0.001	–31.14	0	–0.041	–0.037
gamma_2_4	0.07	0.005	15.18	0	0.061	0.079
gamma_3_4	0.012	0.002	6.05	0	0.008	0.015
gamma_4_4	–0.052	0.001	–59.28	0	–0.053	–0.05
gamma_5_4	0.009	0.002	3.71	0	0.004	0.014
Lambda-(Expd-Q)						
lambda_4	–0.002	0	–15.02	0	–0.002	–0.002
eta						
eta_urb_rur_4	0.001	0	15.24	0	0.001	0.001
eta_hhsize_4	0	0	4.51	0	0	0
rho						
rho_urb_rur	0.111	0.018	6.21	0	0.076	0.146
rho_hhsize	0.085	0.006	14.6	0	0.074	0.097

*Note: *Restriction: 0.00 or 1.00 (alpha)*

Table 5

Demand system restriction of expenditure share of milk group

SHARE_Milk						
Description	Coef.	Std. Err.	z	P>|z|	[95 % Conf.]	[Interval]
alpha						
alpha_5	1.028	0.014	70.990	0.000	1.000	1.057
Beta-Expd-L						
beta_5	0.162	0.003	58.290	0.000	0.157	0.168
Price–Gamma						
gamma_1_5	–0.095	0.004	–26.640	0.000	–0.102	–0.088
gamma_2_5	–0.187	0.007	–26.210	0.000	–0.201	–0.173
gamma_3_5	0.127	0.003	44.310	0.000	0.121	0.132
gamma_4_5	0.009	0.002	3.710	0.000	0.004	0.014
gamma_5_5	0.146	0.006	24.760	0.000	0.135	0.158
Lambda-(Expd-Q)						
lambda_5	0.003	0.000	22.950	0.000	0.003	0.004
eta						
eta_urb_rur_5	0.000	0.000	4.280	0.000	0.000	0.001
eta_hhsize_5	–0.001	0.000	–31.140	0.000	–0.001	–0.001
rho						
rho_urb_rur	0.111	0.018	6.210	0.000	0.076	0.146
rho_hhsize	0.085	0.006	14.600	0.000	0.074	0.097

*Note: *Restriction: 0.00 or 1.00 (alpha). Source: Author's computation, 2022*

5. 2. The results of the accuracy of quadratic almost ideal demand system (QUAIDS) model estimator

The model satisfies three constraints in the AIDS demand system, namely summation, homogeneity, and symmetry. The results of QUAIDS analysis on the prices of eggs, chicken meat, beef, fresh fish, and milk will be shown in Table 6.

The results of the QUAIDS analysis have shown that egg, chicken meat, beef, fresh fish, and milk prices are nearly perfect in significance, at the range of 1 % to 5 % alpha values. Additionally, variables other than the prices, such as expenditure, quadratics of the expenditure, and demographic factors (e. g. household size) have shown the equivalent results to the prices (Table 6).

Table 6

QUAIDS model estimator of animal protein demand

Parameter	Coef.	Std. Err.	z	$P>\|z\|$	[95 % Conf.]	[Interval]	Animal food groups
alpha							Constanta
alpha_1	0.566	0.017	33.160	0.000	0.533	0.600	Eggs
alpha_2	–1.341	0.022	–62.030	0.000	–1.383	–1.298	Chicken meat
alpha_3	0.728	0.011	66.870	0.000	0.707	0.750	Beef
alpha_4	0.018	0.013	1.420	0.157	–0.007	0.042	Fresh fish
alpha_5	1.028	0.014	70.990	0.000	1.000	1.057	Milk
Beta-1.00							Expenditure
beta_1	0.045	0.003	15.690	0.000	0.039	0.051	Eggs
beta_2	–0.318	0.003	–96.000	0.000	–0.324	–0.311	Chicken meat
beta_3	0.122	0.002	57.630	0.000	0.118	0.126	Beef
beta_4	–0.012	0.002	–4.810	0.000	–0.016	–0.007	Fresh fish
beta_5	0.162	0.003	58.290	0.000	0.157	0.168	Milk
Gamma-0.00							Price
gamma_1_1	0.398	0.003	140.810	0.000	0.393	0.404	Eggs
gamma_2_1	–0.259	0.005	–54.140	0.000	–0.268	–0.250	Chicken meat
gamma_3_1	–0.006	0.002	–2.490	0.013	–0.010	–0.001	Beef
gamma_4_1	–0.039	0.001	–31.140	0.000	–0.041	–0.037	Fresh fish
gamma_5_1	–0.095	0.004	–26.640	0.000	–0.102	–0.088	Milk
gamma_2_2	0.568	0.011	51.200	0.000	0.547	0.590	Chicken meat
gamma_3_2	–0.192	0.005	–38.260	0.000	–0.202	–0.182	Beef
gamma_4_2	0.070	0.005	15.180	0.000	0.061	0.079	Fresh fish
gamma_5_2	–0.187	0.007	–26.210	0.000	–0.201	–0.173	Milk
gamma_3_3	0.060	0.003	17.310	0.000	0.053	0.066	Beef
gamma_4_3	0.012	0.002	6.050	0.000	0.008	0.015	Fresh fish
gamma_5_3	0.127	0.003	44.310	0.000	0.121	0.132	Milk
gamma_4_4	–0.052	0.001	–59.280	0.000	–0.053	–0.050	Fresh fish
gamma_5_4	0.009	0.002	3.710	0.000	0.004	0.014	Milk
gamma_5_5	0.146	0.006	24.760	0.000	0.135	0.158	Milk
lambda							Quadratics
lambda_1	0.015	0.000	150.640	0.000	0.015	0.016	Eggs
lambda_2	–0.021	0.000	–120.620	0.000	–0.022	–0.021	Chicken meat
lambda_3	0.005	0.000	40.890	0.000	0.004	0.005	Beef
lambda_4	–0.002	0.000	–15.020	0.000	–0.002	–0.002	Fresh fish
lambda_5	0.003	0.000	22.950	0.000	0.003	0.004	Milk
Eta-0.00							Demography
eta_urb_rur_1	0.002	0.000	4.300	0.000	0.001	0.003	Eggs
eta_urb_rur_2	–0.004	0.000	–9.910	0.000	–0.005	–0.003	Chicken meat
eta_urb_rur_3	0.001	0.000	9.460	0.000	0.000	0.001	Beef
eta_urb_rur_4	0.001	0.000	15.240	0.000	0.001	0.001	Fresh fish
eta_urb_rur_5	0.000	0.000	4.280	0.000	0.000	0.001	Milk
eta_hhsize_1	–0.001	0.000	–5.980	0.000	–0.001	0.000	Eggs
eta_hhsize_2	0.001	0.000	9.910	0.000	0.001	0.001	Chicken meat
eta_hhsize_3	0.000	0.000	14.060	0.000	0.000	0.000	Beef
eta_hhsize_4	0.000	0.000	4.510	0.000	0.000	0.000	Fresh fish
eta_hhsize_5	–0.001	0.000	–31.140	0.000	–0.001	–0.001	Milk
rho							
rho_urb_rur	0.111	0.018	6.210	0.000	0.076	0.146	Urban-rural
rho_hhsize	0.085	0.006	14.600	0.000	0.074	0.097	Household Size

*Note: *Restriction: 0.00 or 1.00 (alpha). Source: Author's computation, 2022*

Therefore, it can be simply interpreted that all the variables have affected the demand of animal protein products. In addition, quadratic of the expenditure variable is shown strongly significant at the alpha value of 1 %. This indicates that the quadratic of the expenditure is significantly influential in animal protein demand. The QUAIDS coefficient essentially indicates whether animal protein products typify normal goods that appear to be luxurious, or luxurious that appear to be normal [16]. The results of data analysis have shown that eggs belong to normal goods that tend to be luxurious, marked by positive signs on the income variable and the square of income. On the other hand, chicken meat, beef, fresh fish, and milk powder are categorized luxurious goods, referring to the sign of negative income coefficient. In addition, demography variable is found very significant for animal protein demand [3, 37–39].

5. 3. Implementation of quadratic almost ideal demand system (QUAIDS) parameter estimation

5. 3. 1. Marshallian (uncompensated) own and cross-price elasticity

The results of the estimator as shown in Table 6 were used to calculate price and income elasticity. Own and cross-price elasticity comprise two forms, Marshallian and Hicksian. The former is regularly termed as demand elasticity. Further, with reference to the Marshallian price elasticity, not only does it contain price effect, but also income effect so as to make the price elasticity greater than that of Hicksian. Table 7 has shown Marshallian own and cross-price elasticity. In fact, in all over Indonesia, beef has been found to be the most elastic animal protein, followed by fresh fish, milk powder, chicken meat, and egg, with the demand elasticity of 2.41 %, 2.19 %, 1.70 %, 1.57 %, and 0.80 % respectively. Beef remains the priciest amongst animal protein products. Households in Indonesia have consumed beef 56 Kcal/capita/day or in the estimation of 2.7 % on the total of Kcal/capita/day [3]. In fact, it is the lowest level of consumption among Asian countries. In addition to own-price elasticity, the estimator has also been used to seek cross-price elasticity. In accordance with the cross-price elasticity, the animal protein products typify substitutiary or complementary goods [25, 34, 35, 40]. Table 7 shows the results of cross-price elasticity with Marshallian (uncompensated).

5. 3. 2. Hicksian own and cross-price elasticity

Hicksian (compensated) price elasticity refers to price elasticity that is only equipped with price-change effects. Table 8 presents the Hicksian own and cross-price elasticity.

5. 3. 3. Income elasticity

Income is an essential factor regarding the demand of goods and services. Tables 7, 8 show income elasticity of the five animal protein groups, i. e., egg, chicken meat, beef, fresh fish, and milk powder. The income elasticity has shown a positive trend, which means that the animal protein products are all typified normal and luxurious goods. Further, beef is the most luxurious amongst other animal protein products with the highest income elasticity value of 2.18 %, followed by milk powder (1.96 %), fresh fish (1.54 %), chicken meat (1.43 %), and egg (0.53 %). Additionally, beef, milk powder, fresh fish, and chicken meat belong to luxurious goods due to their income elasticity value that is greater than 1. Meanwhile, egg is considered normal goods since its income elasticity is positive, greater than zero (0), but lower than 1. Beef is evident to be the most elastic product. In every price increase of 1 %, the demand of egg decreases with the maximum portion of 2.18 %.

Table 7

Marshallian (uncompensated) own and cross-price elasticity

Animal food groups	Animal-source Foods										Expenditure Elasticity
	Eggs		Chicken Meat		Beef		Fishes		Powdered Milk		
	Uncompensated Cross-price Elasticity (Marshallian)										
Egg	–0.8015	(0.0035)	0.1421	(0.0030)	0.0296	(0.0015)	0.0325	(0.0016)	0.0658	(0.0021)	0.5315
Chicken Meat	–0.2145	(0.0069)	–1.5670	(0.0087)	0.0716	(0.0033)	0.1107	(0.0037)	0.1626	(0.0050)	1.4367
Beef	–0.2512	(0.0323)	0.4730	(0.0324)	–2.4090	(0.0372)	0.4482	(0.0232)	–0.4389	(0.0289)	2.1779
Fish	–0.1989	(0.0192)	0.5676	(0.0196)	0.2675	(0.0127)	–2.1925	(0.0172)	0.0182	(0.0163)	1.5380
Powdered Milk	–0.4108	(0.0124)	0.2744	(0.0133)	–0.1107	(0.0078)	–0.0153	(0.0080)	–1.7000	(0.0142)	1.9624

Source: Author's computation, 2022; the standard errors of means in parentheses

Table 8

Hicksian (uncompensated) own and cross-price elasticity

Animal food groups	Animal-source Foods										Expenditure Elasticity
	Eggs		Chicken Meat		Beef		Fishes		Powdered Milk		
	Uncompensated Cross-price Elasticity (Marshallian)										
Egg	–0.8015	(0.0035)	0.1421	(0.0030)	0.0296	(0.0015)	0.0325	(0.0016)	0.0658	(0.0021)	0.5315
Chicken Meat	–0.2145	(0.0069)	–1.5670	(0.0087)	0.0716	(0.0033)	0.1107	(0.0037)	0.1626	(0.0050)	1.4367
Beef	–0.2512	(0.0323)	0.4730	(0.0324)	–2.4090	(0.0372)	0.4482	(0.0232)	–0.4389	(0.0289)	2.1779
Fish	–0.1989	(0.0192)	0.5676	(0.0196)	0.2675	(0.0127)	–2.1925	(0.0172)	0.0182	(0.0163)	1.5380
Powdered Milk	–0.4108	(0.0124)	0.2744	(0.0133)	–0.1107	(0.0078)	–0.0153	(0.0080)	–1.7000	(0.0142)	1.9624

Source: Author's computation, 2022; the standard errors of means in parentheses

6. Discussion of the restriction, accuracy, parameter of the quadratic almost ideal demand system (QUAIDS) animal protein demand model

Research findings through testing the restriction system on demand for animal protein with the QUAIDS approach which consists of adding-up, homogeneity and symmetry produces a value between zero and one. This explains that the animal protein demand model is valid. The availability of the QUAIDS model is a useful model for overcoming the primary issues that are frequently encountered in household consumption surveys when specific commodities are not used, also known as zero consumption or zero expenditure [25]. According to [41], various variables explain the phenomena of zero consumption or zero expenditure, including differences in consumer/household choices, relatively high commodity prices, limited budget, or reporting inaccuracies. If the conditions of normality, freedom, and variance homogeneity are met, the standard regression model employing the Ordinary Least Square (OLS) method will be pretty well addressed. Observations with a value of zero on the acquired data will result in heteroscedasticity issues. Because the underlying assumptions are not met, the OLS approach produces skewed and inconsistent estimates. Meanwhile, removing zero consumption data reduces the sample size and does not reflect the actual situation because homes with zero consumption are still part of the population and zero consumption is a decision made by the household in question. All QUAIDS parameter different from zero. Since the parameters are difficult to interpret, let's continue with the calculation of income elasticities, and the discussion will be presented in next section. Statistical significance of the log-price coefficients has interesting pattern. Coefficients near real expenditures squared are naturally lower in magnitude than those of linear expenditure terms.

The model has met the three restrictions included in the AIDS demand system, namely adding up, homogeneity, and symmetry. Adding up is referred to an accumulation of the whole goods, i. e. egg, chicken meat, beef, fresh fish, and milk powder, which is equal to 1 and zero (0), as stated in (3). Table 6 shows that the alpha (α) value constitutes 1. This value indicates that adding up restriction has been completed. The same thing applies to beta (β), gamma (γ), and lambda (λ) calculations, indicated by zero (0) value. Alpha indicates Constanta coefficient, beta for expenditure coefficient, gamma for animal protein price coefficient, and lambda for quadratic of expenditure coefficient, eta for region coefficient (urban-rural), and rho for household size coefficient (HH). Additionally, the accumulation of beta, gamma, lambda, eta, and rho signifies zero (0). It can be concluded that the adding up restriction has been completed.

This finding also explains that the animal protein demand model estimation of all parameters of the animal protein demand model is also significant so that it can be used to calculate the elasticity of animal demand and income elasticity. This finding is supported by [42–45] confirming that when compared to the linear, log-linear and double-log models commonly used in estimation, QUAIDS appears to result in a better overall fit and a better fit with the true asymmetric shape. Thus the functional specifications of QUAIDS are expected to be more consistent with the observed consumer behavior.

Based on Table 7, almost all animal protein products in Indonesia are categorized substitute goods. This is indicated by positive marking shown in the cross elasticity, excluding egg that has been found to be complementary among its counterparts based on the indication of negative marking of its price elasticity. Beef is substitute to all animal protein products, which implies that the increase of beef's price is followed by the decrease of beef's demand and by the increase of other animal products' demand. With 1 % increase of beef's price, there is a demand increase of 0.27 % for fresh fish, 0.11 % for milk, 0.07 % for chicken meat, and 0.002 % for egg. Further, the increase of beef's price has influenced the households to alternate their consumption to the cheaper products such as: fresh fish, milk, chicken meat, and egg. On the other hand, egg has been found complementary to all animal protein products, which means that along with 1 % increase of egg's price, there is a demand decrease with the portion of 0.25 % for beef, 0.21 % for chicken meat, 0.41 % for milk powder, and 0.19 % for fresh fish.

Based on table 8, all of the price elasticity coefficients are negative, which is in line with the law of demand – when price increases, demand decreases. The Hicksian price elasticity merely focuses on the influence of price change upon demand. With price increase of 1 %, there is demand decrease of 2.35 % for beef. The same scenarios apply to other animal protein products, namely fresh fish (2.12 %), milk powder (1.51 %), chicken meat (1.19 %), and egg (0.50 %). In addition, beef is the most sensitive product in term of price, and thus it becomes strongly elastic, followed by fresh fish, milk powder, chicken meat, and egg. In contrast, egg is inelastic (the elasticity price <1), implying that egg remains the most consumed animal protein product amongst households in Indonesia.

Unlike the Marshallian cross-price elasticity, the Hicksian cross-price elasticity of animal protein products are all positively marked; even egg is shown to be positive to the other animal protein products. In general, the increasing trend of animal protein product price has made the households in Indonesia only consume single type of animal protein product. It is since all animal protein products are substitute, except beef that is proved to be complementary to milk powder. The increase of beef's price triggers the increase of fresh fish demand at 0.31 %, chicken meat at 0.11 %, or egg at 0.04 %. In addition, such increase could lower the demand of milk powder. Accordingly, it could be concluded that the increase of beef's price has resulted in consumption alternation from beef to fresh fish, chicken meat, or egg. As for milk powder, the increase of beef's price is followed by the decrease of household consumption over milk powder. In other words, the beef's price increase is replaced by the consumption of cheaper animal protein products, such as fresh fish, chicken meat, and egg.

This study's limitation is that it only considers animal proteins because its goal is to examine each one's elasticity in detail. To avoid zero data consumption, future study may be more thorough if it considers all foods, including carbohydrates, fats, food, and beverages. It is well known that in Indonesia, the percentage of poor households is relatively high. Since animal protein is typically expensive, there isn't a lot of data consumption. Data processing and tabulation are extremely challenging. As a result, incorporating all items into the model will lessen the data on zero consumption.

7. Conclusions

1. This paper focuses on the analysis of demand system restrictions and accuracy of QUAIDS model estimator – an empirical study of animal protein demand in Indonesia.

After the restriction is completed and the estimator remains valid and significant, the further procedure to carry out is an analysis on the impact of changes in prices, incomes, and demographic factors on animal protein demand in Indonesia. The results have indicated that adding up comprises the accumulation of Constanta (alpha/) equal to 1. In addition, it also includes the accumulation of price parameters of the whole animal protein groups (beta/), income squared (gamma/), urban-rural region (rho/), and household size (eta/); all of which are equal to zero (0). In sum, adding up has been completed, and so have homogeneity and symmetry.

2. Estimates made using Iterative Non-linear Seemingly Unrelated Regression (ITNL-SUR) are considered accurate and can be applied to determine price and income elasticity.

3. All animal protein products are categorized substitute, by leaving out egg as the complementary product to the other animal protein products. On top of that, beef is the most luxurious goods amongst animal protein products with the highest income elasticity of 2.18 %, followed by milk powder (1.96 %), fresh fish (1.54 %), chicken meat (1.43 %), and egg (0.53 %). Additionally, beef, milk powder, fresh fish, and chicken meat are categorized luxurious goods due to their income elasticity that is greater than 1. Contrarily, egg typifies normal goods due to positively-marked income elasticity, greater than zero (0), but lower than 1. At last, beef is the most elastic product, implying that in every price increase of 1 %, the demand of egg decreases with the maximum portion of 2.18 %.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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