Demand for animal source of food in Central Java, Indonesia

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Abstract. Consumption of protein was often used as an indicator of household welfare. This study analyzed the impact of price and income change on demand for animal food in rural households in Central Java, using the Quadratic Almost Ideal Demand System model approach. The research data used data from the National Socio-Economic Survey, totalling 13,872 households. The output appeared that a one percent increase in animal food prices reduced the demand for eggs, chicken, beef, fish, and milk by 0.505%, 1.281%, 4.099%, 3.424%, and 1.915%, respectively. The most elastic animal food group is beef, followed by milk, fish, chicken, and eggs with income elasticities of 3.278%, 2.339%, 2.156%, 1.411%, and 0.556%. All animal food is a luxury item except eggs, which are normal goods. Beef is a substitute for fish, chicken, and eggs, while milk is complementary. The price policy is more effective compared to the income policy for rural Central Java. Rural households in Central Java very responsive to changes in price.

1. Introduction

Food security can be seen from three aspects: food availability, access to food, and food absorption[1,2,3,4]. The aspect of food absorption is related to nutritional status, which can be seen from the adequacy level of energy and protein consumption. Nutritional status is an important thing that is one of the Sustainable Development Goals (SDGs) goals, namely ending hunger, achieving food security, and proper nutrition[5,6]. A person's nutritional status is influenced by the quantity and quality of food consumed. Even though an area has food availability, it does not mean that it can properly meet energy and protein consumption. This is because people's purchasing power influences the level of public consumption. The people's purchasing power cannot be separated from the price of the goods consumed and the income of the people[7,8,9].

The March 2019 National Socio-Economic Survey shows that the average daily per capita calorie consumption in Central Java Province is 2,045.63 kcal and protein consumption of 62.34 grams/cap/day. This figure is below the national calorie adequacy rate of 2,150 kcal and the protein adequacy rate of 57 grams/cap/day. Based on the area of residence, the average calorie consumption in rural areas is 2,062.67 kcal, higher than that of urban areas, which is 2,029.63 kcal. The average per capita protein consumption for Central Java Province in 2018 was 60.61 grams. This value is lower when compared to other provinces such as DKI Jakarta Province (72.49 grams), Yogyakarta Province (70.18 grams), South Kalimantan Province (67.83 grams) and West Java Province (64.82 grams). The level of protein consumption per capita in Central Java is lower when compared to several other provinces. On the other hand, the amount of food availability in Central Java is higher. Based on the
data, the number of cattle slaughtered at the Slaughterhouse for 2017 is 111,737 heads. This is higher when compared to DKI Jakarta Province, with 32,405 heads and Yogyakarta Province 12,962 heads.

Research on-demand systems using the Quadratic Almost Ideal Demand System (QUAIDS) model approach has been carried out in various countries, including in South Africa [10,11,12], in Nigeria [13,14,15], in India [16], and in Ethiopia[17,18], in Italy [19], and also in Indonesia[20,21,22]. Therefore, this research was important to analyze the impact of changes in the animal source of food prices on demand in rural Central Java. Through the QUAIDS analysis results, the price and income parameters for each animal source of food commodity obtained. These parameters were used to calculate price and income elasticity. With price and income elasticity, valuable information can be obtained about the purchasing power and household consumption patterns of animal source of foods. Through price elasticity, it will be known whether animal source food is elastic, inelastic, and unitary elastic. Through income elasticity, it is obtained whether animal source food is a luxury, normal or inferior. The research results are expected to be used to formulate policies on how reasonable animal source of food prices are so that prices are stable so that animal protein consumption can be fulfilled immediately.

2. Materials and Methods

2.1 Modelspecification: quadratic almost ideal demand system (QUAIDS)

The foremost common method in demand analysis within two decades is the AIDS model[22,23]. The AIDS model shows a number of few demand properties such as testing for symmetry and homogeneity through linear restriction among the goods[24,25] generalized the AIDS model show by demonstrating the fitting frame for some consumer inclinations is quadratic contradictory to the linear frame within the fundamental AIDS. Furthermore, the QUAIDS demonstrates keep up the hypothesis consis tency and the demand properties of the AIDS model. Formally, the share condition of QUAIDS model[26,27,28] is:

\[ w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} 1n p_j + \beta_1 1n m + \lambda_i \frac{m}{a(p)} + \varepsilon_i \] (1)

Where \( w_i \) is a household’s expenditure share for goods i, \( \alpha \) is constant, \( \gamma \) is expenditure parameter coefficient, \( \beta \) is price parameter coefficient, m is total expenditure, \( \lambda \) is quadratic parameter coefficient of animal foods, and it is defined as

\[ w_i \equiv \frac{p_i q_i}{m} \text{ and } \sum_{i=1}^{n} w_i = 1 \] (2)

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

- Adding-up: \( \sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} y_{ij} = 0, \sum_{i=1}^{n} \lambda_i = 0 \) , (3)
- Homogeneity: \( \sum_{i=1}^{n} y_{ij} = 0 \) (4)
- Slutsky symmetry: \( y_{ij} = y_{ij}(5) \)

The QUAIDS model in this consider was carried out to account socio-demographic (z) impact to the animal food consumption demand. Statistic components can impact household behaviour in terms of demand and allocation of expenditure among goods[29,30]. The ‘demographic scaling’ method was used to take into account in this study[33]. In this approach, the impact of a altering the socioeconomic is closed to the impact of the price changing of animal nourishment[34].

Considering z as a vector of household characteristics z may be a scalar reflected the household measurement in the simplest case. Let \( e^R (p, u) \) reflected the consumption function of a reference household with just a single grown-up. For each household, the use of Roy’s strategy on expense function of household characteristics, without controlling for any changes in expense designs. The second term control for a replacement in relative prices and actual products consumed.
Following Roy’s method, QUAIDS parameterized $\bar{m}_o(z)$ as $\bar{m}_o(z) = 1 + pz$ 

Where $\rho$ is a vector of parameters of assessment. The expenditure share expenditure equation takes the following form:

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{ij} 1n p_j + (\beta_i + \eta_i z) 1n \left( \frac{m}{\bar{m}_o(z) \alpha(p)} \right) + \frac{\lambda_i}{b(p) c(p) z} \left[ 1n \left( \frac{m}{\bar{m}_o(z) \alpha(p)} \right) \right]$$

(7)

Where $c(p, z) = \prod_{j=1}^{K} p_j^{\eta_j}$

(8)

In equation 6, $m_o$ is a total expenditure, $z$ is utility.

The adding-up condition requires that $\sum_{j=1}^{K} \eta_j = 0$ for $r = 1, ..., s$.

(9)

The uncompensated (Marshallian) price elasticity ($\varepsilon_{ij}$) for the animal source of protein group $i$ with respect to changes in the price of animal product group good $j$ is:

$$\varepsilon_{ij} = -\delta_{ij} + \frac{1}{w_i} \left( \gamma_{ij} [\beta_i + \eta_i z] + \frac{2z}{b(p)c(p)z} 1n \left( \frac{m}{\bar{m}_o(z) \alpha(p)} \right) \right) + \left( \alpha_i - \sum_{j=1}^{K} \gamma_{ij} 1n p_j \right) - \frac{\lambda_i}{b(p) c(p) z} \left[ 1n \left( \frac{m}{\bar{m}_o(z) \alpha(p)} \right) \right]$$

(10)

The expenditure (income) elasticity ($\mu_i$) for the animal product group $i$ is:

$$\mu_i = 1 + \frac{1}{w_i} \left( \beta_i + \eta_i z \right) + \frac{2z}{b(p)c(p)z} 1n \left( \frac{m}{\bar{m}_o(z) \alpha(p)} \right)$$

(11)

The compensated (Hicksian) price elasticity ($\varepsilon_{ij}^c$) are derived from the Slutsky equation:

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

(12)

Where $w_i$ is a budget share of the animal source of protein, $p$ is a price, $\alpha$, $\gamma$, $\beta$, $\eta$ are parameter coefficient of the constant, animal food prices, income/expenditure, and income square. All the lowercase Greek letters other than $\alpha_i$ are the parameters to be estimated. The demographic variable was finally used in this research, namely rural. The parameters are estimated by iterated feasible generalized non-linear least which are equivalent to the multivariate normal maximum likelihood estimator for this class of problem via Stata’s ‘nlsur’ command as suggested by [33]. After the presentation of the demand model, it is worth discussing at least two major data issues, namely the price measure and the treatment of outliers and missing values.

2.2 Data

The data utilized in this study is secondary data of National Socio-economics Survey(Survei Sosial Ekonomi Nasional/SUSENAS) data(March 2016). The data analyzed were socio-demographic data (household residence status, household consumption and expenditure of all animal foods, and total expenditure). The animal foods watched in this consider were five animal food groups, i.e. eggs (broiler chicken eggs, local chicken eggs, and duck eggs), chicken (local chicken meat and broiler chicken meat), beef, fish (fresh fish and shrimp including fish, shrimp, squid, and shellfish), and milk (milk powder and infant milk). This research is specifically for rural households. The sample of this research was 13,872 households.

3. Results and Discussion

3.1 Marshallian (uncompensated) own and cross-price elasticities

Table 1 shows the Marshallian own and cross-price elasticities. Marshallian own-price elasticity was negative. This is by the economic theory that an increase in prices reduces demand. In rural Central Java, beef is the most elastic with a demand elasticity of 4.142%. Other animal foods have the following elasticities: fish (3.474%), milk (2.079%), chicken (1.687%), and eggs (0.842%). This shows that households in rural areas are more sensitive to changes in the price of beef. These results are consistent with research [34].
Cross price elasticity shows the relationship between animal foods, whether they are substitution or complementary. If positive, it means that there is a substitution relationship between animal food. Conversely, if it is negative, it means that there is a complementary relationship between animal foods. Central Java rural communities have cross-price elasticities that are mostly positive. This means, in general, there is a substitution relationship between animal foods, only eggs are complementary. In other words, households in rural Central Java consume only one animal food group, and only eggs are consumed together with other animal foods. In rural areas, a 1% increase in the price of chicken meat will increase beef consumption by 1.89% and fish by 1.05%.

Meanwhile, when there is a 1% increase in beef prices, it causes an increase in fish consumption by 0.556%, chicken meat by 0.11%, or eggs by 0.02% and decreasing milk consumption by 0.225%. This means that beef is a substitute for fish, chicken, and eggs, complementary to milk. It can be concluded that household preference in rural Central Java increases in animal food such as chicken or beef, and households will switch to consumption of other animal food groups, namely eggs and fish groups.

Table 1. Marshallian own and cross-price elasticities in rural Central Java.

|       | Eggs  | Chicken | Beef    | Fish    | Milk    |
|-------|-------|---------|---------|---------|---------|
| Eggs  | -0.842| 0.180   | 0.020   | 0.031   | 0.056   |
|       | (0.003)| (0.003) | (0.001) | (0.001) | (0.002) |
| Chicken| -0.136| -1.687  | 0.113   | 0.097   | 0.202   |
|       | (0.007)| (0.009) | (0.003) | (0.004) | (0.005) |
| Beef  | -0.689| 1.896   | -4.142  | 0.925   | -1.269  |
|       | (0.066)| (0.070) | (0.076) | (0.047) | (0.060) |
| Fish  | -0.316| 1.054   | 0.559   | -3.474  | 0.021   |
|       | (0.040)| (0.042) | (0.027) | (0.036) | (0.034) |
| Milk  | -0.572| 0.554   | -0.225  | -0.017  | -2.079  |
|       | (0.018)| (0.020) | (0.011) | (0.011) | (0.021) |

Source: March 2018 Susenas, STATA data analysis, standard error of mean in parentheses

3.2 Hicksian own and cross-price elasticities
Hicksian (compensated) price elasticity is the price elasticity when there is only a price change effect. Table 2 presents the Hicksian price elasticities, both own and cross elasticities. The most elastic Hicksian own-price elasticity was beef with an elasticity of 4.099%, followed by fish (3.424%), powdered milk (1.915%), chicken (1.281%), and eggs (0.505%). A 1% increase in beef prices reduced demand by 4.099%. This decrease is much more significant than the increase in prices. This means that the increase in prices has a more significant effect on decreasing demand. Among these five food groups, the most sensitive to price changes is beef. It can be interpreted that when there is a price increase, rural Central Java households respond quickly in reducing beef consumption.

All cross-price elasticities of the Hicksian cross are positive except for milk with beef. It can be interpreted that the animal source of food is a substitution. In other words, an increase in the price of one animal source food increases the demand for other animal sources of food. Meanwhile, beef and milk have a complementary relationship. This finding is interesting because there was only one complementary commodity. Beef is the most elastic among all animal sources of foods. At the same time, milk was also elastic but had the third elasticity after beef and fish. The increase in the price of milk reduced the demand for milk by 1.915% and reduced the demand for beef by 1.039%. An increase followed this decrease in demand in demand for chicken meat by 0.301%. The increase in milk prices in addition to reducing milk consumption, but also reduces the consumption of beef, and
the two commodities were replaced by chicken. It can be concluded that households in rural areas of Central Java consume chicken if there is an increase in the price of milk and beef.

**Table 2.** Hickisan own and cross-price elasticities in rural Central Java.

|          | Eggs  | Chicken | Beef  | Fish  | Milk  |
|----------|-------|---------|-------|-------|-------|
| Eggs     | -0.505| 0.340   | 0.027 | 0.044 | 0.095 |
| (0.003)  | (0.003)| (0.001) | (0.001)| (0.002)|       |
| Chicken  | 0.718 | -1.281  | 0.131 | 0.130 | 0.301 |
| (0.007)  | (0.009)| (0.003) | (0.004)| (0.005)|       |
| Beef     | 1.297 | 2.839   | -4.099| 1.002 | -1.039|
| (0.066)  | (0.070)| (0.076) | (0.047)| (0.060)|       |
| Fish     | 0.990 | 1.674   | 0.587 | -3.424| 0.173 |
| (0.039)  | (0.043)| (0.027) | (0.035)| (0.034)|       |
| Milk     | 0.845 | 1.227   | -0.194| 0.037 | -1.915|
| (0.017)  | (0.020)| (0.011) | (0.011)| (0.021)|       |

Source: March 2016 Susenas, STATA data analysis, standard error of mean in parentheses

The 1% increase in the price of beef increased the demand for fish, chicken, and eggs by 0.587%, 0.131%, and 0.027%. The beef was a substitute for fish, chicken, and eggs, while with milk, beef is complementary. The increase in the price of chicken increased the demand for fish by 1.674%, powdered milk by 1.227%, and eggs by 0.340%. Almost all animal foods are substitutes. This can be interpreted that almost all households in rural Central Java consume only one group of animal foods, not simultaneously because of all other animal foods. This result implies that animal food price policies are needed to stabilize prices and not experience significant increases. This was because the price increase caused a decrease in the consumption of animal food as a protein source.

### 3.3 Expenditure elasticity

Expenditure (income) is an important factor in the demand for goods and services. Community income is not only used to meet food needs but also non-food. The average consumption expenditure of each resident in Central Java in 2016 was IDR 756,720/month. With a food consumption rate of 49.73% and non-food as much as 50.27%. Based on the area of residence, the level of consumption in urban and rural communities is presented in Table 3. The average per capita expenditure in urban Central Java was recorded to be lower than in urban areas where the average per capita expenditure in urban areas was IDR 937,525, while in rural areas, it was only IDR 720,034. The rural community spent more on food consumption (53.17%), while the rural community expenditure for non-food consumption was 46.83%.

**Table 3.** Average monthly per capita expenditure by settlement type 2016.

| Type of expenditure | Urban+rural | Urban | Rural |
|---------------------|-------------|-------|-------|
| Food                | 371,605     | 409,810| 337,788|
| (49.73%)            | (45.84%)    | (53.17%) |       |
| Non food            | 385,115     | 484,097| 297,504|
| (50.27%)            | (54.16%)    | (46.83%) |       |
| Total               | 756,720     | 893,907| 635,292|
| (100%)              | (100%)      | (100%) |       |

Source: the Bureau of Central Statistics of Central Java Province, 2018
After knowing the proportion of people's food consumption, an important factor is how the demand for animal food occurs when income changes. Table 4 shows the income elasticity of eggs, chicken, beef, fish and milk for rural households in Central Java Province. All income elasticities are positive, it means that the increase in income increases the demand for animal food for rural communities. The highest income elasticity of beef was with an elasticity of 3.279%. This means that the increase in household income of rural communities causes people to tend to consume beef compared to other animal foods.

Eggs are inelastic with a low-income elasticity of 0.556% in rural Central Java. The results of the analysis show that eggs are a normal item and are a basic necessity for rural people in Central Java. Chicken, beef, fish and milk were luxury items. In rural areas of Central Java, the most elastic animal food was beef at 3.278% followed by milk, fish and chicken with elasticities of 2.339%, 2.156% and 1.411%, respectively. Seeing that animal food is very elastic in rural Central Java, this means that an increase in income causes the demand for animal food in rural communities to increase.

### Table 4. Expenditure elasticity.

| Animal food group | Eggs   | Chicken | Beef   | Fish   | Milk   |
|-------------------|--------|---------|--------|--------|--------|
| Rural             | 0.556  | 1.411   | 3.278  | 2.156  | 2.339  |
|                   | (0.001)| (0.002)| (0.018)| (0.012)| (0.006)|

Source: March 2016 Susenas, STATA data analysis

### 4. Conclusions
This paper focuses on analyzing the impact of price and income changes on demand for animal food in rural Central Java. The demand system approach uses the QUAIDS model with parameter estimation using Iterated non-linear SUR. The results showed that the Marshallian and Hicksian demand for beef and fish were the most elastic for rural households in Central Java. The one percent increase in animal food prices reduced the demand for eggs, chicken, beef, fish, and milk by 0.505%, 1.281%, 4.099%, 3.424%, and 1.915%, respectively. For rural communities, beef is a substitute for fish, chicken, and eggs. The income elasticity of rural households in Central Java shows that the most elastic food group is beef, followed by fish, milk, and chicken with elasticities of 3.278%, 2.156%, 2.339%, and 1.411%, respectively. Beef, chicken, fish, and milk are luxury goods, and only eggs are a normal good. For rural households in Central Java, the price policy is more effective than the income policy.

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