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# Household Food Demand in Response to Earthquake: A Linear Approximate Almost Ideal Demand System Approach

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## Abstract

*Natural disasters are always associated with the disruption of local economies and hurting the local people. Households usually respond to those difficulties by cutting their consumption especially for non-necessity goods. Hence this paper discusses the pattern of food demand when the earthquake occurs. In addition, it also observes the price and expenditure elasticities of food demand by estimating a Linear Approximate Almost Ideal Demand System (LA-AIDS). This paper also examines the effect of earthquake on living standards of households. It finds that food demand estimations on rice and oil have price inelastic demand, while vegetable, meat, and fish are price elastic. Furthermore, poor households are more likely to have a greater negative impact than rich households although the effect is quite small.*

**Keywords** Earthquake, food demand, LA-AIDS

**JEL code** D12, I30, I31, I32

## 1. Introduction

As natural disasters increased in number and also in the intensity of the destruction in the last few years in Indonesia, it becomes very important to examine the impacts of disasters on human being and local economy in disasters region. There are several types of disasters that often occurred in Indonesia from the less harsh to the most destructive ones such as floods, earthquake, tsunami, landslides, wind storms, drought, and volcanic eruptions. Natural disasters always leave serious problems for the human beings in disaster regions, especially for a country like Indonesia which is highly populated. A lot of literatures have confirmed that disasters are negatively associated with any aspects of human beings such as human capital outcomes, consumptions, local economy, and other aspects.

Natural disasters are always associated with the disruption of local economies and hurting the local people. The destruction of property, assets, infrastructure, and also crop loss will affect the local economy and the well-being of households who are directly affected. All those direct impacts of disasters automatically disturb the flow of goods and services and also the production process as a result of scarce resources. Consequently, those conditions cause the price of goods and services to increase. Households usually respond to those difficulties by cutting their consumption especially for non-necessity goods. For necessity goods such as food, these households try to keep the same amount of consumption or only reduce consumption a bit although the price of food increases due to the scarcity of food because of the disasters. Considering all these conditions, studies of the impact of disasters, especially for Indonesia are needed and becomes very important in order to have a better response when disasters occur in the future.

During 2000-2011, more than 4000 disasters occurred and were recorded by the National Disaster Management Agency (BNPB) across various regions in Indonesia and some of them were very destructive and killed many people. The most destructive one was the earthquake and tsunami in Aceh on 26$^{th}$ December 2004 with a 9.1 - 9.3 moment magnitude scale, and the longest duration in history, of around 10 minutes. This disaster killed approximately 230,000 people in fourteen countries, and more than half of the people, 126,915, were from Indonesia. In addition, according to BNPB, 37,063 people were missing and 655,000 people were made homeless across Aceh province. The second destructive disaster was an earthquake on 26$^{th}$ May 2006 in Yogyakarta Province. More than 6,000 people were killed in a 6.3 magnitude earthquake and about 130,000 were left homeless. Another serious disaster was the floods in Jakarta in February 2007. Around 30 people were killed and approximately 340,000 left homeless. Another earthquake in West Sumatra that measured 5.8-6.4 on the Richter scale killed approximately 50 people on 6 March 2007.

This paper investigated the impact of earthquake in Yogyakarta in 2006 on food demand. Earthquake in Yogyakarta is chosen because this province has the second highest percentage for both dead and evacuated people in Indonesia after Aceh. Aceh did not consider in this research because not in the IFLS sample data. Hence, this paper tried to capture any response of the earthquake in Yogyakarta on household food demand and the pattern of food demand when the earthquake occurs. Furthermore, this paper has several objectives. First, this paper observes the price and expenditure elasticities of food demand by estimating a Linear Approximate Almost Ideal Demand System (LA-AIDS), as elasticity is a measure of demand response when there is a change in price because of earthquake. Elasticity can predict the amount of food which should be provided. Second, related with the change in food prices, this study also examined the effect of earthquake on living standards of households, whether there is any different impact for the poor and the rich.

This study contributes to the international literature in several aspects. First, this research investigated the net effect of earthquake on share expenditures of main foods such as rice, vegetable, fish and meat. Second, the consequences of earthquake on food demand can be observed in two ways: whether earthquake increase the price of goods and whether earthquake affect household spending independently of its effect on food prices. Lastly, this study also provided the impact of earthquake on living standard of different level of household expenditures.

This study employs Linear Approximate Almost Ideal Demand System (LA-AIDS) model. In LA-AIDS model this study looks at the impact of earthquake on food share expenditures controlling for prices. This study uses the parameter estimation from the LA-AIDS model to calculate the price and expenditure elasticities. According to Deaton and Meulbauer (1980), there are several reasons why LA-AIDS is preferred. First, LA-AIDS has a consistent functional form with known household-budget data. Second, it satisfies the axioms of choice. Third, LA-AIDS corresponds with a well-defined preference structure, since it is derived from a cost function, so that is very suitable for welfare analysis

The main findings are share expenditures on food in earthquake region (share expenditure on rice, vegetables, fish and oil) are negatively affected by earthquake. With regards to the elasticities, all own prices elasticities are negative as it expected. Moreover, all values of income elasticity for share expenditures are positive and less than 1. A positive income elasticity of demand is associated with normal goods and if income elasticity is less than 1, those goods are necessity goods. Furthermore, this paper is organized as follows. The next section presents about data sources and is followed by the methodology with Linear Approximates Almost Ideal Demand System (LA-AIDS) model and is followed by the discussion in research finding with LA-AIDS model. The last section concludes with some policy recommendations.

## 2. Data Sources

The main data source for this research is the Indonesia Family Life Survey (IFLS). It is a longitudinal survey that was started in 1993. There are 4 waves: IFLS1 (first wave) in 1993, IFLS2 (second wave) in 1997, IFLS2+ in 1998 with a sub sample of 25% of IFLS households, IFLS3 (third wave) in 2000, and the latest wave IFLS4 in 2007. IFLS2+ was conducted to look at the impact of the Asian financial crisis in 1997-1998. The first and the second waves of IFLS were conducted by RAND in collaboration with Lembaga Demografi, University of Indonesia. The third and the fourth waves were conducted by RAND in collaboration with the Population Research Center, University of Gadjah Mada. This research only uses IFLS3 and IFLS4 for data completeness reason.

IFLS is a survey that has been conducted to provide economic, social and demographic information of the household and community facilities in Indonesia. The survey data was collected at individual and household levels and there is also information from the communities where households and individuals were located. Since IFLS is a longitudinal survey, data are available for the same individuals from multiple points in time, so it is possible to observe information of the dynamics of behaviour at the individual, household, family and community levels, for instance, changes in education, labour income, or health condition. At individual and household levels, the IFLS survey is about behaviours and outcomes related to wealth (consumption, income and assets); human capital (education, health, migration and labour market outcomes); marriage, fertility and contraceptive use; processes underlying household decision-making, such as the choice of food eaten at home, child education and other decisions on how they spend money; transfers among family members and inter-generational mobility; and participation in community activities. Moreover, the survey is also accompanied by information from the communities, such as physical and social environment, infrastructure, employment opportunities, food prices, access to health and educational facilities, and the quality and prices of services available at those facilities.

According to Neumayer and Plumper (2007), the strength of disasters is measured by using the number of people killed during the disasters divided by total population as a proxy of the strength of disaster. Since IFLS reports several types of natural disasters such as earthquake, tsunami, landslide, flood, volcanic eruption, and windstorm, this paper picked up earthquake in Yogyakarta as earthquake in Yogyakarta is the second strongest earthquake after Aceh. This study did not use Aceh because it is not in the IFLS data sample. In addition, IFLS defines households as being affected by earthquake if the earthquake was severe enough to cause death or major injuries to a household member, cause direct financial loss to the household, or cause household member to relocate. Thus, although households lived in Yogyakarta at the time of earthquake, they might not directly affected by earthquake.

Based on the information above, this study defines dummies ER (Earthquake region) and dummies A (being affected by earthquake). ER is equal to 1 if individuals are in earthquake region and in the time of the earthquake and A is equal to 1 if individuals are in earthquake region and were affected by earthquake. As explained above the individuals who suffered financial loss or one or more household member are dead or suffered major injuries are defined as affected by earthquake.

Besides earthquake variable, this study used share expenditures as the main variable. For share of expenditures on food can be seen from table 1 that the largest share of expenditures is on rice expenditures comprising around 11% of total household expenditures and followed by share expenditure on vegetable and meat comprising around 6% and 5%. For illustration, figure 1 presents the share of five foods expenditures. In general, expenditures on rice are the biggest proportion of food expenditure, and expenditures on oil are the smallest.

For prices of goods, this study used two different sources for prices of goods: prices of goods from households (household price) and prices of goods from market (market price). Since there is no direct information about prices of goods at household level in IFLS data, prices of goods from households are calculated from total expenditures on good $x$ divided by total quantity purchased of good $x$. On the other hand, price of goods from market level can be obtained directly from IFLS data. To avoid any measurement error from prices of goods in household level, prices of goods from households are instrumented by using prices of goods from market.

Table 2 illustrates the difference values of prices between household price which was collected from household level and market prices which was obtained from market level in each community.  There are variations of price information between these two types of prices in both years. Some are higher in household levels, and others are higher in market levels. Therefore, table 2 has strongly encouraged us to use prices at market level as instrument for prices at household levels.

To ensure that prices of foods at market level are good instruments, this study presents the correlation coefficient and scatter diagram between price at market level and household level. Table 3 presents the correlation coefficient of food prices at market level and household level. It seems the correlation of both prices for vegetables and fish are quite low, but if look at the scatter diagrams in figure 2, there is positive correlation between price of goods at market level and household level for each good.

## 3. Methodology

There are four important parts that are explained in this section: the concept of LA-AIDS model, elasticities, the procedure of LA-AIDS model, and measuring living standard.

### 3.1. The concept of LA-AIDS model

This study employs demand function model which was proposed by Deaton and Muellbauer (1980) that was called the Almost Ideal Demand System (The AIDS) model. Deaton and Muellbauer defined the preferences as representation of the cost or expenditure function. The expenditure was defined as the minimum expenditure to attain a specific utility level at given prices.  According to Poi (2002), in budget share AIDS model equation, household share expenditure for good $i$ can be written as:

$$w_i = \frac{p_i q_i}{X} \quad \dots (1)$$

Where $p_i$ is price for good $i$, $q_i$ is quantity for good $i$ , and $X$ is the total expenditure on all goods in demand system. The equation of budget share form usually can be written as:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \, lnP_j + \beta_i \ln\left(\frac{X}{P}\right)$$

… (2)

Where $w_i$ is the share of total expenditure allocated to the $i^{th}$ good, $P_j$ is the price of the $j^{th}$ good within the group, $X$ is total expenditure on the group of goods being analysed, $P$ is the price index, and $\alpha, \beta, \gamma$ are parameters, and the subscripts $i$ and $j$ denote goods ($i$, $j$=1,…, n).

Price index (P) is defined as:

$$lnP = \alpha_0 + \sum_k \alpha_k \, lnP_k + \frac{1}{2}\sum_j \sum_k \gamma_{kj} \, lnP_k lnP_j$$

… (3)

Due to the difficulties as well as technical problem in estimating the price index (P) in the share equation, Deaton and Muellbauer (1980) suggest using a linear approximation to the price index using Stone's price index. Stone's price index (P*) that is used as a linear approximation can be written as:

$$lnP^* = \sum w_k lnP_k$$

… (4)

Where $w_k$is share expenditure, little $k$ is an index and will be equal 1 if each household had the same tastes, so $k$ will be an index of the equality distribution of household budget. However this price index may cause a simultaneity problem when this paper uses share expenditure as measurement of $w_k$. To avoid those problem, following Haden(1990), this paper uses mean of share expenditure across all households instead of share expenditure for $w_k$.

$$lnP^* = \sum \overline{w}_k lnP_k$$

… (5)

Where P* is Stone's price index, $\overline{w}_k$ is the mean of share expenditure, $P_k$ is the price of good. Therefore, the approximation of the AIDS demand function in budget share is:

$$w_i = \alpha_i^* + \sum_j \gamma_{ij}\, lnP_j + \beta_i \ln\left(\frac{X}{P^*}\right)$$

… (6)

This model started to be known as LA-AIDS, when Blanciforti, Green and King (1986) named this model as "Linear Approximation of the Almost Ideal Demand System" (LA-AIDS).

Economic theory imposes three sets of restrictions on the parameters of the AIDS model.

1. Adding up:
   $\sum_{i=1}^{n} \alpha_i = 1 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \sum_{i=1}^{n} \beta_i = 0$

   ... (7)
2. Homogeneity:
   $\sum_{j=1}^{n} \gamma_{ij} = 0$

   ... (8)
3. Symmetry:
   $\gamma_{ij} = \gamma_{ji}$

   ... (9)

Where, the coefficient of $\gamma_{ij}$represents the changes in relative prices, while $\beta_i$ coefficient represents the changes in real expenditure. The $\beta_i$ coefficient sums to zero and $\beta_i$ are positive and less than 1 for necessities, more than 1 for luxury goods and negative for inferior goods. If restrictions 1,2 and 3 hold, then the LA-AIDS share expenditure equation above represents a system of demand functions with the adding-up condition that the total share expenditure is equal to one ($\sum w_i = 1$ ). Moreover, homogeneity and symmetry imply that the demand functions are homogeneous of degree zero in prices and total expenditure, and must satisfy Slutsky symmetry. Deaton and Muellbauer (1980) said that AIDS model can be used as the natural starting point for predictions. According to Poi (2002), error term $\epsilon_i$ is added to the budget share equation for estimation purposes. In addition, matrix of $\epsilon_i$ assumes that covariance matrix of budget share equation in AIDS demand system is singular with zero determinant. Therefore, the adding up condition implies that one of the demand equations is dropped from the system, so the estimation is performed on the remaining demand equations (n-1).

### 3.2. Elasticities

For analysis of the impact of disasters on food demand by households, this study can observe the response of food demand by looking at the values of elasticity. Following Green and Alston (1991), income (expenditure) elasticity of LA-AIDS model can be written as:

$$\eta_{i,x} = \frac{dlnQ_i}{dlnX} = 1 + (\frac{dw_i}{dlnX})/w_i \qquad \ldots (10)$$

By using Stone's price index (P*), $\frac{dw_i}{dlnX} = \beta_i$ , so expenditure elasticity can be expressed as:

$$\eta_{i,x} = 1 + \beta_i/w_i \qquad \ldots (11)$$

Following Green and Alston (1990), uncompensated demand elasticity of AIDS and LA-AIDS ($\eta_{ij}$) can be written as:

$$\epsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{w_j}{w_i}\beta_i \qquad \ldots (12)$$

With $\delta_{ij}$ is the Kronecker delta where $\delta_{ij} = 1$ for $i = j$ and $\delta_{ij} = 0$ for $i \neq j$.

### 3.3. LA-AIDS estimation procedures

In estimating LA-AIDS model, there are 6 equations of budget share expenditures on rice, vegetables, meat, fish, oil and all other goods (everything else) with their respective prices and real expenditures. The LA-AIDS demand system can be written as:

$$w_{rice} = \alpha_1 + \gamma_{11} ln\widehat{P_{rice}} + \gamma_{12} ln\widehat{P_{veg}} + \gamma_{13} ln\widehat{P_{meat}} + \gamma_{14} ln\widehat{P_{fish}} + \gamma_{15} ln\widehat{P_{oil}} + \gamma_{16} ln\widehat{P_{others}} + \beta_1 ln\left(\frac{X}{P^*}\right) + \theta_1 ER_{hrt} + \rho_1 A_{hrt} + \sigma_1 Urban_{hrt} + \mu_1 \qquad \ldots (13)$$

$$w_{veg} = \alpha_2 + \gamma_{21} ln\widehat{P_{rice}} + \gamma_{22} ln\widehat{P_{veg}} + \gamma_{23} ln\widehat{P_{meat}} + \gamma_{24} ln\widehat{P_{fish}} + \gamma_{25} ln\widehat{P_{oil}} + \gamma_{26} ln\widehat{P_{others}} + \beta_2 ln\left(\frac{X}{P^*}\right) + \theta_2 ER_{hrt} + \rho_2 A_{hrt} + \sigma_2 Urban_{hrt} + \mu_2$$

… (14)

$$w_{meat} = \alpha_3 + \gamma_{31} ln\widehat{P_{rice}} + \gamma_{32} ln\widehat{P_{veg}} + \gamma_{33} ln\widehat{P_{meat}} + \gamma_{34} ln\widehat{P_{fish}} + \gamma_{35} ln\widehat{P_{oil}} + \gamma_{36} ln\widehat{P_{others}} + \beta_3 ln\left(\frac{X}{P^*}\right) + \theta_3 ER_{hrt} + \rho_3 A_{hrt} + \sigma_3 Urban_{hrt} + \mu_3$$

… (15)

$$w_{fish} = \alpha_4 + \gamma_{41} ln\widehat{P_{rice}} + \gamma_{42} ln\widehat{P_{veg}} + \gamma_{43} ln\widehat{P_{meat}} + \gamma_{44} ln\widehat{P_{fish}} + \gamma_{45} ln\widehat{P_{oil}} + \gamma_{46} ln\widehat{P_{others}} + \beta_4 ln\left(\frac{X}{P^*}\right) + \theta_4 ER_{hrt} + \rho_4 A_{hrt} + \sigma_4 Urban_{hrt} + \mu_4$$

… (16)

$$w_{oil} = \alpha_5 + \gamma_{51} ln\widehat{P_{rice}} + \gamma_{52} ln\widehat{P_{veg}} + \gamma_{53} ln\widehat{P_{meat}} + \gamma_{54} ln\widehat{P_{fish}} + \gamma_{55} ln\widehat{P_{oil}} + \gamma_{56} ln\widehat{P_{others}} + \beta_5 ln\left(\frac{X}{P^*}\right) + \theta_5 ER_{hrt} + \rho_5 A_{hrt} + \sigma_5 Urban_{hrt} + \mu_5$$

… (17)

$$w_{others} = \alpha_6 + \gamma_{61} ln\widehat{P_{rice}} + \gamma_{62} ln\widehat{P_{veg}} + \gamma_{63} ln\widehat{P_{meat}} + \gamma_{64} ln\widehat{P_{fish}} + \gamma_{65} ln\widehat{P_{oil}} + \gamma_{66} ln\widehat{P_{others}} + \beta_6 ln\left(\frac{X}{P^*}\right) + \theta_6 ER_{hrt} + \rho_6 A_{hrt} + \sigma_6 Urban_{hrt} + \mu_6$$

… (18)

Where $\alpha_i, \beta_i, \gamma_{ij}, \theta_i, \rho_i, \sigma_i$ are parameters to be estimated, $\mu_i$ are error terms, $ER_{hrt}$ is dummy earthquake region, $A_{hrt}$ is dummy affected by earthquake, $Urban_{hrt}$ is urban dummy. For share expenditures, there are: $w_{rice}$ is share expenditure on rice, $w_{veg}$ is share expenditure on vegetables, $w_{meat}$ is share expenditure on meat, $w_{fish}$ is share expenditure on fish, $w_{oil}$ is share expenditure on cooking oil, and $w_{others}$ is share expenditure for everything else (all other goods). For price of goods, this study used log of price from linear prediction (log price hat). In IFLS data, this study generated price of goods at household level by dividing expenditures of certain goods with its quantity purchased. Since this study used this price of goods from household levels, this study worries about measurement error and endogeneity of the price, so this study instrumented the price of goods at HH level by using price of goods at market level. Here, this study estimated price for LA-AIDS model by using he following equation:

$$lnHHP_i = \delta_0 + \delta_1 lnMP_i + \theta_i ER_{hrt} + \rho_i A_{hrt} + \sigma_i Urban_{hrt} + \gamma_r + \nu_t + \mu_i \quad \ldots (19)$$

Where $lnHHP_i$ is log price of good i at HH level, $lnMP_i$ is log price of good i at market level. In addition, this study also adds other explanatory variables in the model including dummy earthquake region ( $ER_{hrt}$ ), and dummy affected by earthquake ( $A_{hrt}$). Urban dummy is also included on the model, and variables $\gamma_r$ and $\nu_t$ are used to control for regions and year fixed effects respectively. Once the study gets the result from the regression, then it can obtain the linear prediction of the log price of goods for LA-AIDS model. Therefore, this study has $\widehat{lnP_{rice}}$ for price of rice, $\widehat{lnP_{veg}}$ for price of vegetables, $\widehat{lnP_{meat}}$ for price of meat, $\widehat{lnP_{fish}}$ for price of fish, $\widehat{lnP_{oil}}$ for price of oil, and $\widehat{lnP_{others}}$ for price for other goods. It assumed that other goods are the numeraire good, so $\widehat{P_{others}}$=1 and the prices of other goods are defined relative to $\widehat{P_{others}}$. When it estimated LA-AIDS model, $\widehat{P_{others}}$ will be omitted since log of 1 is zero.

By imposing homogeneity, adding-up, and symmetry, the equation for $w_{others}$ is dropped to avoid singularity due to the adding up condition. All equations above are estimated jointly using Zellner's Semingly Unrelated Regressions (SUR).

### 3.4. Measuring Living Standard

According to Deaton and Muellbaur (1980), demand system can be derived from the expenditure function which shows the minimum income required to yield a particular utility, taking prices as given:

$$\log E(p, U) = A(p) + B(p)U \quad \ldots (20)$$

Where:

$A(p) = \sum_i \sum_j \gamma_{ij} logP_i \, logP_j + \sum_i \alpha_i logP_j$

… (21)

$B(p) = \prod_{i=1}^{n} P_i^{\beta_i}$

… (22)

Symons and Walker (1989) said that E(p,U) represents the minimum income needed for standard living of U in the price of goods p. So in order to measure living standard the equation can be rewritten to:

$U = \frac{logE - A(p)}{B(p)}$

… (23)

U is indirect utility of LA-AIDS model or living standard, can be poor or rich and can be measured by using money metric of utility, $p$ is price of foods, E is total expenditure. It has two conditions before earthquake and after earthquake which influence the value of price, and assume that before earthquake the price is equal to 1, and after earthquake the price is equal to 1 plus the change of price that it can measure from price estimation without controlling for price at market level. According to the above condition, before earthquake can be written as: $A(P_0)$ = 0, $B(P_0)$ =1, then $U = logE$, and after earthquake as: $A(P_1)$ = certain values, $B(P_1)$=certain values, then the value of $U$ depends on the category of $U$ as poor or rich. For poor, this study used the income definition from Central Bureau Statistics of Indonesia of 250,000 rupiahs per month and also calculated for the poorest which is obtained from the lowest income of income distribution at 15,000 rupiahs per months. For rich, this study used the income of 5 million rupiahs, then calculated for the welfare effect of earthquake as:

$$Disaster\ effect = E(P_1, U) - E(P_0, U) = A(P_1) - A(P_0) + [B(P_1) - B(P_0)]U.$$

## 4. Empirical Results

The LA-AIDS model was estimated using Seemingly Unrelated Regression (SUR). The purpose of estimating using this model is to find out whether there is any different outcome if it controls for prices of goods in estimating the impact of earthquake on expenditures. This study considered that prices are also important variables that should be controlled for in the impact of earthquake.

### 4.1. First Stage Regressions: Predicting Household Prices

According to the previous research by Alboghdady and Alastry (2010) in estimating LA-AIDS, all the restrictions in the model cause a singular/covariance matrix of the errors. Therefore, one of the equations from the system, share equation of other goods was dropped from the system to avoid the singularity problem. Before estimating LA-AIDS model, this study obtained the predicted price of goods that are used on LA-AIDS system from the regression between price of goods at household level with price of goods at market level and several other explanatory variables such as ER and A variables.

Table 4 presents the first stage least square regression for price of goods. The table shows the regression of price of good at market level, ER and A variables on price of goods at household level. The predicted values of household prices from this regression are used in the second stage regression of the LA-AIDS model. Almost all prices of goods at market level are significant and positively correlated with price of goods at household level, only fish has no significant value but still positively associated with price at household level. ER is positively correlated with price of goods at household level for rice, vegetable, fish and oil. It indicates that price of goods tend to increase when disasters occur. On the other hand, there are negatively correlated of A on price of rice and fish, and positively correlated of A on price of vegetables, meat, and oil. This indicates that especially for rice, all aid agencies have done a good job by bringing enough staple foods to disaster regions for all victims, so the price would be more stable, but for non-staple foods the price would be more expensive.

Table 5 shows the results of price regression without controlling price at market level. This is to investigate the transmission mechanism of the earthquake effect on price of goods. By controlling for market prices, as in table 4, this study is only able to identify the additional effect of earthquake on household prices beyond their impact on market prices. Here, this study wants to observe the total effect of earthquake on the prices which households pay. This will be used later in evaluating the welfare impact of earthquake. The results show that only price of vegetable, meat and fish that are positively associated with earthquake.

### 4.2. Parameters of the LA-AIDS model

Table 6 shows the parameters of LA-AIDS model with homogeneity and symmetry restriction. Generally, the results indicate that the model is well constructed. It can be seen from the level of significance of each parameter, almost all parameters are significant at 1% and few are at 5%. Additionally, for the interpretation, it is only about the relationship of the parameters and share expenditure. For variable of interest ER, almost all share expenditures are negatively correlated with ER and highly significant. Only share expenditure on meat is positively correlated with ER but only significant at 10%, For variable of interest A, only share expenditures on meat and fish are negatively associated with A. It seems that households reduced their expenditures on meat and fish when the disasters occur, as those two goods were not staple-food. For urban, almost all values show that urban has negative correlation with the share of all food expenditures. It means that all household food expenditures in urban area are lower than in rural areas. Furthermore, an important meaning in economic interpretation is on the next table with the results in elasticities.

Moreover, table 6 also presents the results of test excluded instrument in F statistics from instrumental variable regression. The value of F statistics are the same for all share expenditure equation since it used exactly the same endogenous variables and other covariates in the right hand side equation of share expenditure. This study runs instrumental variable regression on share equations (13 to 17 equations) with 5 endogenous variables since it assumed that all price of goods at household level are endogenous.

### 4.3. Price and Expenditure Elasticities

Table 7 shows price and expenditure elasticities obtained from the LA-AIDS estimation in table 6. For price elasticities, all values in bold are own price elasticities and others coefficient in the matrix of commodities are cross price elasticities. All own price elasticities are negative as it expected from the theory of demand.

Rice has inelastic own price elasticity and significant. The possible explanation for this phenomenon is presumably because rice as staple food so the response of demand when the price increased is low. Fish also has inelastic own price elasticity. Furthermore, vegetable, and meat have highly elastic own price elasticities, so when the price of these foods increase, there will be a greater response in reducing consumption. On the other hand, oil has inelastic own price elasticity. It indicates that although the price of oil increase but the response on demand is quite low. It is true, since most households need cooking oil for cooking.

For cross price elasticities, negative values show that both commodities are complements, while positive values indicate that both commodities are substitutes. For instance, rice has a complement relationship with fish (-0.620), and meat has a substitution relationship with fish (0.073). In expenditure elasticities, for rice, when incomes increase by 10% households would like to increase expenditure on rice by approximately 8%. In addition to rice, when income increase by 10%, households would like to spend more on vegetable, meat and oil by around 9% . Fish has unitary expenditure elastic. When there is an increasing in income by 10% household would like to spend more on fish by 10%. By comparing expenditure and price elasticity, this study can suggest the income and price policies regarding to the food consumption.

For the effect of earthquake on household's standard living, it used the information of price estimation from table 5 without controlling for market price to get the total effect of an earthquake on the price that households pay for their foods. This study used equation 20 for estimating the impact of earthquake on standard of living. By assuming that prices before earthquake are 1, and prices after earthquake are 1 plus the change in price that it obtained from price estimation, then this study can calculate the effect of earthquake on standard of living. This paper classified standard of living into three: poorest, poor and rich. For poor standard of living, as an extreme expenditure value of the poorest, it picks the minimum value of household expenditure at approximately Rp 15,000 per month. Another expenditure value for comparison is information of poverty line from Central Bureau of Statistics with Rp 250,000 per month. For rich standard of living, it used the expenditure measure of Rp 5 million per month. The effect of disasters on household's standard of living is on table 8. For the poorest households, their living standard is lower by 2.42% and for the poor households is lower by 2.22% than their living standard before earthquake. On the other hand, for the rich households, their standard living is lower by 2% than before earthquake. As it expected poor households suffered more than rich households although the percentage is only slightly different with the rich, but overall effects are small compared to average annual change in incomes.

## 5. Conclusion

This paper finds that there are significant net effects of earthquake on household share expenditures by controlling for prices. There is also an impact of earthquake on prices of food. For food demand estimations, the results show that rice and oil have price inelastic demand, while vegetable, meat, and fish are price elastic. In addition, expenditure elasticity of demand for rice is less elastic than other foods at approximately 0.8. For expenditure elasticity of demand for vegetable, meat and oil are about 0.9, while for expenditure elasticity for fish are unit elastic, as an indication that fish is luxury goods. By comparing expenditure and price elasticity, it can suggest the income and price policies regarding to the food consumption. For food with expenditure elasticity exceed the price elasticity, income policy for food consumption is more effective such as income transfer, and for food with expenditure elasticity fall behind price elasticity, price policy for food is more efficient such as intervene the price of goods in the market by using market operation for rice and cooking oil. Furthermore, looking at the impact of earthquake on living standard, poor households are more likely to have a greater negative impact than rich households although the effect is quite small.

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Appendix

Table 1: Share of household expenditures on food in 2000 and 2007

| **Types of share expenditures** | **2000** | **2007** |
|---|---|---|
| Share expenditure of rice | 0.109 | 0.109 |
| Share expenditure of vegetable | 0.066 | 0.051 |
| Share expenditure of meat | 0.055 | 0.048 |
| Share expenditure of fish | 0.044 | 0.035 |
| Share expenditure of oil | 0.021 | 0.026 |

Note: only for 5 foods categories of share expenditures

Table 2: The average of household and market prices in 2000 and 2007 (Rupiah)

| | 2000 | | 2007 | |
|---|---|---|---|---|
| | household | market | household | market |
| price of rice (per kg) | 2,153.56 | 2,697.73 | 4,876.31 | 4,958.76 |
| price of meat (per kg) | 22,744.57 | 27,741.94 | 48,859.69 | 51,995.15 |
| price of fish (per kg) | 11,657.19 | 10,431.11 | 13,756.76 | 13,088.82 |
| price of oil (per kg) | 3,935.46 | 3,235.83 | 11,220.06 | 11,315.14 |
| price of vegetable (per bunch) | 594.81 | 354.91 | 1192.66 | 975.22 |

Note: market price is retail price, household price is price that HH actually pay

Table 3: Correlation coefficient

| **Price of foods** | **R** |
|---|---|
| price of rice | 0.65 |
| price of vegetable | 0.27 |
| price of meat | 0.53 |
| price of fish | 0.07 |
| price of oil | 0.76 |

Table 4: First stage least square regression for price of goods

| Dept var:<br>Log of household price | Rice | vegetable | meat | fish | Oil |
|---|---|---|---|---|---|
| log market price | 0.03***<br>(0.00) | 0.07***<br>(0.00) | 0.04*<br>(0.02) | 0.00<br>(0.00) | 0.03***<br>(0.01) |
| ER | 0.00<br>(0.00) | 0.22***<br>(0.02) | -0.12***<br>(0.01) | 0.20***<br>(0.01) | 0.00<br>(0.01) |
| A | -0.03***<br>(0.01) | 0.06**<br>(0.03) | 0.03*<br>(0.01) | -0.03*<br>(0.02) | 0.05***<br>(0.01) |
| Urban | 0.08***<br>(0.00) | 0.01**<br>(0.00) | 0.06***<br>(0.00) | 0.03***<br>(0.00) | 0.01***<br>(0.00) |
| time dummies | Yes | yes | yes | yes | Yes |
| regional dummies | Yes | yes | yes | yes | Yes |
| Observation | 19,574 | 19,574 | 19,574 | 19,574 | 19,574 |

Note: Robust standard errors in parentheses and asterisk denote statistical significance: *** 1%, ** 5%, * 10%

Table 5: The effect of disasters on Price without controlling market price

| Dept var: Log of household price | rice | vegetable | meat | fish | Oil |
|---|---|---|---|---|---|
| ER | 0.00 | 0.23*** | -0.12*** | 0.20*** | 0.01 |
| | (0.01) | (0.02) | (0.01) | (0.01) | (0.01) |
| A | -0.04*** | 0.06** | 0.03* | -0.04* | 0.041*** |
| | (0.01) | (0.03) | (0.02) | (0.02) | (0.01) |
| Urban | 0.09*** | 0.02*** | 0.07*** | 0.04*** | 0.01*** |
| | (0.00) | (0.01) | (0.00) | (0.00) | (0.00) |
| time dummies | yes | yes | yes | yes | Yes |
| regional dummies | yes | yes | yes | yes | Yes |
| Observation | 20,079 | 20,085 | 20,015 | 20,089 | 20,086 |

Note: Robust standard errors in parentheses and asterisk denote statistical significance: *** 1%, ** 5%, * 10%

Table 6: Parameters of LA-AIDS Demand System with Homogeneity and Symmetry Restriction

| | share equations of total expenditures | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Parameters | rice | veg | Meat | fish | oil |
| $\gamma_{i1}$ | 0.03*** | -0.01*** | -0.003*** | -0.02*** | 0.004*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\gamma_{i2}$ | -0.01*** | -0.01*** | -0.001*** | 0.03*** | 0.002** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\gamma_{i3}$ | -0.003*** | -0.001*** | -0.0005 | 0.003*** | 0.003*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\gamma_{i4}$ | -0.02*** | 0.02*** | 0.003*** | 0.005*** | -0.01*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\gamma_{i5}$ | 0.004*** | 0.001** | 0.003*** | -0.01*** | 0.00 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\beta_i$ | -0.04*** | -0.003*** | 0.001*** | -0.002*** | -0.005*** |
| | (0.00) | (0.00) | (8.96e-05) | (0.00) | (0.00) |
| $\theta_i$ | -0.01*** | -0.005*** | 0.0005* | -0.01*** | -0.001*** |
| (ER) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\rho_i$ | 0.008* | 0.01*** | -0.001*** | -0.006*** | 0.004*** |
| (A) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| $\sigma_i$ | -0.04*** | -0.01*** | 2.06e-05 | -0.01*** | -0.007*** |
| (urban) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| F statistics market price: | | | | | |
| Price of rice | 6558.29 | | | | |
| Price of vegetable | 1291.69 | | | | |
| Price of meat | 3282.58 | | | | |
| Price of fish | 32.67 | | | | |
| Price of oil | 10364.23 | | | | |
| Observation | 19,574 | | | | |

Note: Standard errors in parentheses and asterisk denote statistical significance: *** 1%, ** 5%, * 10%

Table 7: Price and expenditure demand elasticities

| Price elasticities | Rice | vegetable | Meat | Fish | oil | other |
|---|---|---|---|---|---|---|
| Rice | **-0.65*** ** | -0.07*** | -0.03*** | -0.21*** | 0.04*** | -0.08** |
| | **(0.02)** | (0.01) | (0.00) | (0.01) | (0.01) | (0.03) |
| Vegetable | -0.16*** | **-1.30*** ** | -0.03*** | 0.48*** | 0.03** | -0.01 |
| | (0.02) | **(0.02)** | (0.00) | (0.01) | (0.01) | (0.03) |
| Meat | -1.73*** | -0.79*** | **-1.23*** ** | 1.23*** | 1.39*** | 0.13 |
| | (0.29) | (0.14) | **(0.28)** | (0.12) | (0.25) | (0.50) |
| Fish | -0.62*** | 0.72*** | 0.07*** | **-0.87*** ** | -0.28*** | -0.01 |
| | (0.03) | (0.01) | (0.00) | **(0.02)** | (0.01) | (0.04) |
| Oil | 0.19*** | 0.09*** | 0.13*** | -0.46*** | **-0.90*** ** | -0.05 |
| | (0.06) | (0.03) | (0.02) | (0.02) | **(0.05)** | (0.09) |
| Other | 1.97*** | 0.37** | 0.08 | -1.17*** | -1.28*** | **-0.97* ** |
| | (0.30) | (0.15) | (0.28) | (0.12) | (0.25) | **(0.52)** |
| Expenditure Elasticities | 0.82*** | 0.89*** | 0.94*** | 1.03*** | 0.91*** | 1.04*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.02) |
| Budget shares | 0.10 | 0.06 | 0.05 | 0.04 | 0.02 | 0.72 |

Note: Standard errors in parentheses and asterisk denote statistical significance: *** 1%, ** 5%, * 10%
All values on bold are own price elasticities; $\sum_{i=1}^{n} w_i = 1; \sum_{i=1}^{n} w_i \eta_i = 1; -w_j = \sum_{i=1}^{n} w_i \in_{ij}$

Table 8: The effect of earthquake on living standard

| | Monthly expenditure (RP) | Effect of Disasters |
|---|---|---|
| Poorest | 15,000 | -2.42% |
| Poor | 250,000* | -2.22% |
| Rich | 5,000,000 | -2.00% |

Note: Note: 1 US$ = RP 10,000; * Indonesian poverty line on July 2012

Figure 1: Share of household expenditures in 2000 and 2007

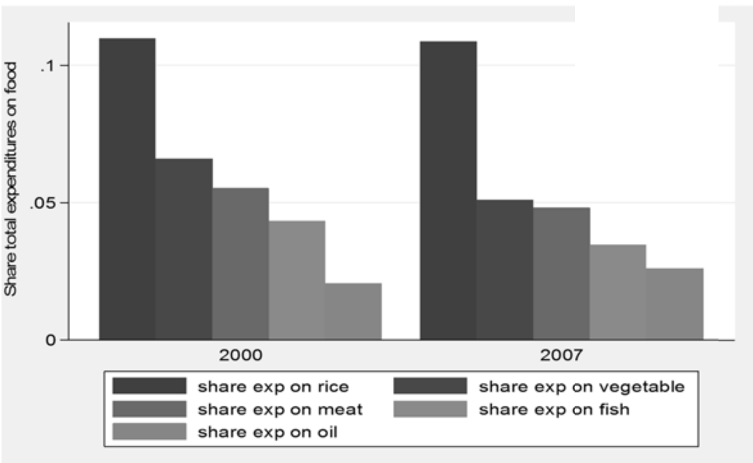
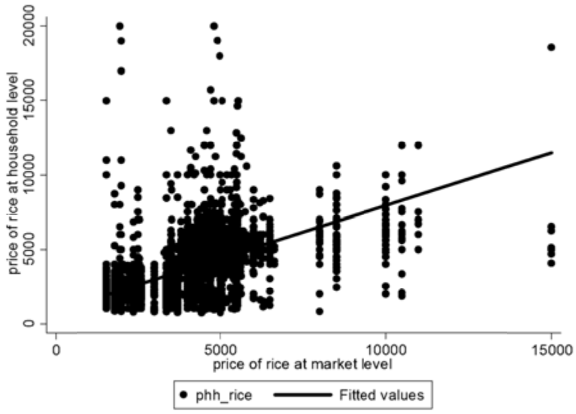
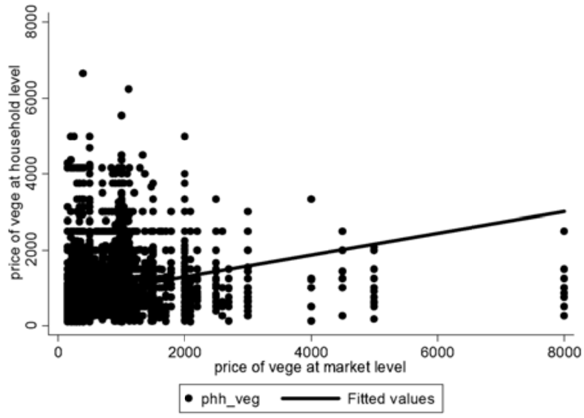


Figure 2: Scatter diagrams of food prices at market level and household level

a. Price of Rice

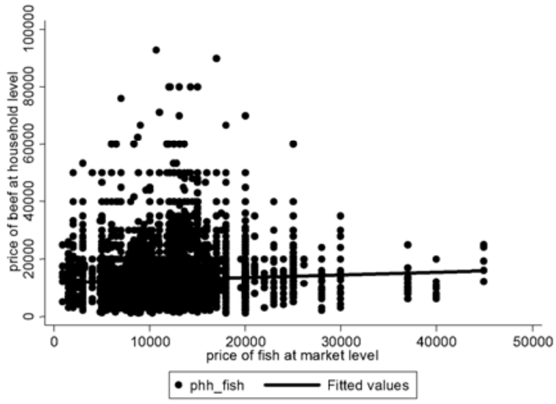



b. Price of Vegetable




c. Price of Meat


d. Price of Fish




e. Price of Oil