

Long-term Impacts of Global Food Crisis on Production Decisions

Evidence from Farm Investments in Indonesia

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The World Bank
Multilateral Investment Guarantee Agency
Economics and Policy Group
May 2012



Abstract

Did the rise in food prices have a long-term impact on agricultural production? Using household-level panel data from seven provinces of Indonesia, this paper finds that the price shock created a forward-looking incentive to invest, which can dynamically enhance productivity in agriculture. It also finds that the impact of the price shock on investment behavior differs by initial wealth. In

response to price increases, wealthy farmers invested more in productive assets, while poor farmers increased their financial savings as well as consumption. Price spikes relax liquidity constraints, which increases investments among the richer while do so savings and consumptions among the poor, possibly leading to diverging income inequality in the long run.

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**Long-term Impacts of Global Food Crisis on Production Decisions:
Evidence from Farm Investments in Indonesia¹**

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JEL code: D22, O16, Q12

Key Words: Investment effect, Expectation, Anticipated shock, Liquidity constraint

Sector Boards: POV, SOCPT, ARD

¹ For collaboration, we are grateful to the Japan International Cooperation Agency for financial support and the Indonesian Center for Agriculture Socio Economic and Policy Studies (ICASEPS). We thank Sony Sumaryanto for sharing agricultural commodity price data. We thank Luc Christiaensen, Quy-Toan Do, Emanuela Galasso, Ivanic Maros, Owen Ozier, Rachel Heath, Reno Dewina, and the World Bank's DECRG. The findings, interpretations and conclusions expressed in this paper are entirely those of the authors, and do not necessarily represent the views of the World Bank, its Executive Directors, or the countries they represent.

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1. Introduction

Between 2007 and 2008, world prices of food commodities rose dramatically. The global food price inflation was transmitted to the domestic market of Indonesia, where the agricultural sector's share is about 19% of GDP and 41% of total employment. The rising food prices raised fears that the spike in food expenditures could worsen households' well-being, especially among the poor. Welfare impacts of food price inflation can be particularly large in Indonesia since the average family spends about a half of its income on food³. On the other hand, higher food prices increased agricultural profits and created large income gains to agricultural households compared to non-agricultural households (Ravallion, 1990; Yamauchi and Dewina, 2011). Interestingly, World Bank (2011) shows evidence that the positive impacts on producers seemed to outweigh the negative effects on consumers' welfare in Indonesia.

In the literature, a large number of papers have investigated the short-term impact of food price shock on poverty and welfare in different contexts (e.g. Ivanic and Martin (2008); Ravallion (1990) for Bangladesh; Ferreira, Fruttero, Leite, and Lucchetti (2011) for Brazil; Vu and Glewwe (2011) for Vietnam; Friedman, Hong, and Hou (2011) for Pakistan). However, its long-term effects on agricultural production are still yet to be explored and understood⁴. If the rise in food prices creates positive net gains to farmers, it is important to understand how farmers utilize the gains and change their agricultural production activities. If farmers perceive that the price change is rather permanent and/or if the income gain creates sufficient liquidity, it might give farmers an incentive to invest in production assets. On the other hand, if they perceive that the price shock is transitory, they will increase their savings for the future price fall, leaving

³ Paxson (1993) showed from Thailand that price changes significantly cause consumption fluctuation. Using the same sample from Indonesia, Yamauchi (2012) also recently showed that recurrent seasonality of rice prices fluctuates birth weight, resulting in variations in subsequent child growth and schooling investments.

⁴ In recent years, there is an emerging academic interest in examining the long-term impact of political or economic shocks (Collins and Margo (2007) for the impact of the 1960s riots in American cities on the property value; Hornbeck (2011) for the impact of the 1930's American Dust Bowl on the population and agricultural production also in the U.S). However, there is no research which investigates the long-term impact of food price crisis.

their investment unaffected (Paxson, 1992; Rosenzweig and Wolpin, 1993; Kazianga and Udry, 2006).

Which of the two effects dominates is ambiguous.

Did the positive food price shock increase investments in production capitals, creating a dynamic positive impact on agricultural productivity? Or, did farmers increase their savings (e.g., to cope with future negative income shocks) or production inputs (e.g., fertilizer and labor) to temporarily increase their outputs? In this paper, we aim to answer the questions of (a) whether farmers increased their investments or savings in response to the price spike and in both cases, and (b) whether any constraints bind farmers' optimal strategies.

We use two rounds of household panel surveys conducted in 2007 and 2010, which represent the main agro-climatic zones in Indonesia. Since the first round was prior to the 2007 food price crisis, followed after three years by the second round in 2010, we can examine the effect of the food price shock on investment decisions. Using (i) monthly provincial-level food price data and (ii) farm and plot-level data on farming activities, we construct a household-level price shock variable by weighting the commodity-specific price change by the household's production share. This measure captures farm-specific exposures to the food price crisis. First, we use the price shock variable to estimate the responsiveness of the producer's investment and saving decisions to the price increase. Since the future price level is uncertain and is highly unpredictable to households, we also examine whether the price shock is (perceived as) a permanent or transitory shock and the expectation formation affects their forward-looking investment behavior, by decomposing the price shock into anticipated and unanticipated components. Second, we test whether farmers' responses to the price shock were constrained by three factors: their land size, the initial wealth level (both proxies for productive and non-productive asset holdings), and the household's educational attainment level (as a proxy for their human capital).

In the empirical analysis, we found that farmers benefited from the positive price shock in general, but the anticipated components of the shock created an incentive to invest in productive assets. Their investment decision was, however, constrained by the initial wealth endowment, which shows a clear contrast between wealthier and poorer farmers in the presence of food price increase. That is, wealthier farmers tended to increase investments in productive assets, while poorer farmers increased their consumption. The response to price change was not statistically different between relatively more and less educated farmers. The result confirms that the investment decision depends on the conditional expectations of future price changes. Also, our analysis highlights the critical role of the initial wealth endowment in determining the trajectory of long-term agricultural development, i.e., divergence between those who invest in productive assets and increase production and those who increase financial savings and consumption, which may result in diverging income inequality and indicate the possibility of a poverty trap in a dynamic context.

This paper is organized as follows. Section 2 explains our survey and provides background information. Section 3 provides the theoretical model. Sections 4 to 6 carry out empirical analyses. Finally, Section 7 presents conclusions.

2. Data and context

2.1 Survey

The data come from two rounds of household surveys conducted in rural areas of Indonesia in 2007 and 2010 for 98 villages in seven provinces (Lampung, Central Java, East Java, West Nusa Tenggara (NTB), South Sulawesi, North Sulawesi, and South Kalimantan). The location of surveyed village is shown in the map. In 2010, we revisited all the 98 sample villages to re-interview sample households and their splits of the 2007 survey households. Out-migrants were also tracked through either direct or phone interviews. Since we are less concerned about attrition bias (attrition rate is only 1%), household members who could not be tracked in 2010 are excluded from our analysis.

In three years, some household members split from the 2007 original households and became an independent family head (for marriage or other reasons). In our sample, household division occurred in 204 original households (9% of our sample). We use the 2007-survey original household as the unit for analysis to avoid bias that may arise from household splits. For instance, a new household head, who split from his original household, might share and cultivate farm lands with his parents though the land still belong to his parents (vice versa). Also, a split household may have members who brought in new assets including farm lands, still cultivating their original lands with the original family. By aggregating original and split households in 2010, we minimize the split bias⁵.

The 2007 survey was designed to overlap with villages in the 1994/95 PATANAS survey conducted by ICASEPS to build household panel data. The 1994/95 PATANAS survey focused on agricultural production activities in 48 villages chosen from different agro-climatic zones in seven provinces. In 2007, we visited those villages to expand the scope of research as a general household survey under the IMDG survey. In the 2007 round, therefore, we added 51 new villages in the same seven provinces⁶.

In the revisited villages in 2007, we re-sampled 20 households per village from the 1994/95 sample and followed the split households. In the new villages, we sampled 24 households from two main hamlets in each village. Since one of the 48 villages in the 1994/95 PATANAS was not accessible for safety reasons in the 2007 survey (in NTB province), we have the total of 98 villages (in 39 kabupatens and 48 kecamatans).

⁵ First, we only report the results using the aggregated households. However, even when we use only households which did not experience split (excluding 204 split households), our empirical results in Table 4-9 (reported later) qualitatively remain the same. Second, it is possible that the 2007/2008 food price crisis affected household split decisions, which will potentially cause an additional bias if we omit split households or do not aggregate original and split households.

⁶ These new villages were selected with the following criteria. First we chose the same districts where PATANAS villages are located. We list villages that had received relatively large amounts of government infrastructure projects during the period of 1995 to 2005, funded by either the Japan Bank for International Cooperation or the World Bank. Finally, the new villages were randomly sampled from the list.

2.2 Descriptive evidence

Agricultural production

Using the survey data, summary statistics provide basic information on agricultural households producing rice, maize, cassava, and estate plantation crop in 2007 (N=1,083). The agricultural sector in Indonesia is characterized by smaller size of land (mean is 1.4 Ha in 2007) and multiple-crop farming. The distribution of average number of crops is shown in Figure 3. Many farmers cultivated three or four crops in Central and East Java. In this paper, we focus on the impact of three crops (rice, maize, and cassava) and estate plantation crops (such as coffee, coconut, cacao, and rubber).

There was a dramatic increase in agricultural production from 2007 to 2010 (see summary statistics), which seems to be accompanied by large investments in production capital (i.e. owning farm building; having machineries such as tractor, thresher, sprinkler, irrigation pump, sprayer, and dryer; buying agricultural tools; see Table 2 for a detailed breakdown of investments).

Table 3 shows the regional variation of the average agricultural production revenues in 2007 for rice, maize, cassava, vegetable crops, and estate plantation crops from IMDG 2007. Based on food crop statistics by the Badan Pusat Statisti (BPS), Java is the major producing area of rice, maize, and cassava; the place where multiple crops including vegetables are cultivated. In remote areas in South Kalimantan and NTB, farmers primarily produce rice, whereas farmers in Lampung, and North and South Sulawesi are specialized in estate plantation crops.

Household characteristics

Besides agricultural activity, the household module of the IMDG shows that average disposable income, durable asset holding, saving in financial assets, and consumption also increased from 2007 to 2010.

Disposable income, durable asset holding, financial saving, and non-food expenditure are adjusted for household size (i.e. real values per household member). Using the same nutrition scale as Dercon and Krishnan (1998), food expenditure is computed per adult equivalent. We use the provincial level consumer price index (2007=100) available online on the BPS website to calculate real values. Also, we use trimmed data to remove outliers throughout the analysis of this paper.

Durable assets are the ownership of non-production assets (such as residential house and land; consumer electrical appliances such as TV, radio, satellite antenna, and telephone) and the value has increased by 12.3% from 2007 to 2010. Financial savings is in liquid assets (mainly in cash-on-hand and bank saving) and the value has also doubled in three years. Food consumption per adult equivalent has increased by 27%, whereas non-food expenditures (such as expenditures for household items, transport and energy costs, health care, education, and insurance) have increased by 90.5%. The evidence suggests that a positive price shock seemed to provide income gains for agricultural households during this time period.

Local food price data

As discussed in Yamauchi and Dewina (2011), the wholesale price of agricultural products has started to rise since 2005 and the price grew substantially between 2007 and 2010. Figure 1 disaggregates the price dynamics into four crops based on the monthly price data available from the Indonesian Bureau of Logistics (Bulog) and BPS, which shows that prices of all crops increased at high rates between 2007 and 2010. For the monthly data of three seasonal crops, the Phillips-Perron test statistic (with time trend) does not reject the null hypothesis of unit root at any critical values, confirming that all three series are non-stationary. On the other hand, Table 1 shows that the first-order autocorrelations are more than 0.90 for three main crops (except estate plantation crops which are less persistent) and the autocorrelation remains high especially for maize and cassava even after twelve months. The high persistence implies that some parts of the price shocks might have been permanent.

In Figure 2, we also characterize the dynamics of local prices in each province. Three features catch our eye. First, the regional dispersion of rice price has widened since 2007. Second, the prices of maize and cassava were discontinuously raised step-by-step after 2007. Third, the price of estate plantation crop shows high volatility, and the provinces seemed to be divided into two groups: higher price provinces (Lampung, Central Java, North and South Sulawesi) vs. other low price provinces. The price level and volatility differs due to the different level of agricultural market integration.

3. A Simple Model

In this section, we describe our theoretical framework. Consider a producer using land and capital as factors of production. In the first period, the producer can decide the investment for the next period. For simplicity, we assume out capital depreciation. The producer can borrow and lend with an interest rate competitively determined in the credit market.

Let A denote landholding, and $f(k)$ represent land productivity. k is per-land capital stock. The producer has income from agricultural production $pAf(k)$ where p is the output price. The producer lives in 2 periods.

$$c_1 = p_1Af(k_1) - \Delta kA + b \quad (1)$$

$$c_2 = p_2Af(k_2) - (1 + r)b$$

Borrowing b is allowed with gross interest rate $1 + r$. If the producer saves ($b < 0$), there are positive returns in the next period ($(1 + r)b$). With investment $\Delta K = A\Delta k$, the next period capital stock is determined as

$$K_2 = Ak_2 = A(k_1 + \Delta k) \quad (2)$$

The producer maximizes the discounted sum of current and future utilities over Δk and b_{t+1} :

$$\max_{\{\Delta k, b\}} v(c_1) + \beta E v(c_2)$$

subject to Eq. (1) and Eq. (2), given the initial condition and the transversality condition. At this stage, we do not impose any constraints on b_{t+1} . The standard Euler equations are:

$$v'(c_1) = \beta f'(k_2) E[v'(c_2) p_2 | p_1] \quad (3)$$

$$v'(c_1) = \beta(1+r) E[v'(c_2) | p_1] \quad (4)$$

Since $E[v'(c_2) p_2 | p_1] = E[v'(c_2) | p_1] E[p_2 | p_1] + Cov(v'(c_2), p_2 | p_1)$, we obtain from Eq. (3) and Eq. (4):

$$\begin{aligned} 1+r &= f'(k_2) \left[E[p_2 | p_1] + \frac{Cov(v'(c_2), p_2 | p_1)}{E[v'(c_2) | p_1]} \right] \quad (5) \\ &\leq f'(k_2) E[p_2 | p_1], \end{aligned}$$

where the last inequality holds since

$$\frac{Cov(v'(c_2), p_2 | p_1)}{E[v'(c_2) | p_1]} \leq 0.$$

The equality holds when there is no uncertainty in p_2 or the producer is risk neutral. The covariance also captures the effect through which capital investment increases the variance of the future production value.

Next we consider the expectation formation. Our main interest is to clarify theoretical insights of the potential effects of a price spike on the investment, financial savings and consumption.

Proposition 1 (Effect of unanticipated price shock):

If the price dynamics is i.i.d., then $E[p_2|p_1] = E[p_2] = p^*$ and $1 + r = p^* f'(k_2)$. That is, a temporary price shock in p_2 (if the producer believes so) does not induce investments since it does not raise the expected marginal productivity of capital in the next period (as the producer thinks p_2 moves back to normal). It only has an income effect for the producer to increase financial savings and consumption.

Proposition 2 (Effect of anticipated price shock):

If $E[p_2|p_1]$ increases in response to an increase of p_1 (i.e., $E[p_2|p_1] > p^*$), there are two effects through:

(i) $E[p_2|p_1]$ and (ii) $\frac{Cov(v'(c_2), p_2|p_1)}{E[v'(c_2)|p_1]}$. The effect (i) is positive to investments, but the effect (ii) is negative to investments (i.e., due to risk aversion). When the first effect dominates, the investment will increase.

3.1 Liquidity constraint

There are two modifications we consider. First, we incorporate a liquidity constraint (imperfect credit market) in the above model by assuming that the interest rate depends on A . Suppose that r is constant if $b < 0$ but $r(A)$ if $b > 0$ where $r'(A) \leq 0$. That is, they face the same interest rate when they save, but small farmers have to pay a higher interest rate than large farmers when they borrow. When they borrow, it is often the case that they offer collateral (e.g., land). If so, since the left-hand side of Eq. (5) increases for small farmers, the marginal effect of $E[p_2|p_1]$ on investments weakly decreases for them. Therefore, small farmers tend to absorb a positive income shock by increasing financial savings and consumption.

Another way to incorporate liquidity constraint is to impose the condition that $b \leq 0$. The modified Euler equation for b is given as:

$$u'_t = \beta(1 + r)E[v'(c_2)|p_1] + \lambda, \quad (4)'$$

$$\lambda \geq 0.$$

where λ is the Lagrangian multiplier associated with $b \leq 0$. Then, the condition (5) becomes

$$(1 + r) + \frac{\lambda}{\beta E[v'(c_2)|p_1]} = f'(k_2) \left[E[p_2|p_1] + \frac{Cov(v'(c_2), p_2|p_1)}{E[v'(c_2)|p_1]} \right] \quad (5)'$$

Even in Eq. (5)', our intuition remains the same: it potentially reduces the impact of $E[p_2|p_1]$ on the investment, but we also observe asymmetry of the liquidity effect since the likelihood of facing the constraint ($\lambda > 0$ or $\lambda = 0$) depends on the realization of p_1 .

Proposition 3 (Effect of liquidity constraint)

$$\frac{\partial k_2}{\partial r} < 0 \quad (\text{borrowing constraint for small farmers})$$

$$\frac{\partial k_2}{\partial \lambda} < 0 \quad (\text{liquidity constraint for poor farmers})$$

3.2 Education effect

The second modification is directly related to $E[p_2|p_1]$. Suppose that the regime of price dynamics has changed at the initial period (but also knowing the new distribution), so that the producer has to learn about the new price distribution (i.e., the producer uses the updated distribution in each period to form the expectations). We assume that there are price realizations between times 1 and 2 (e.g., observing international prices), so that the producer can learn price distributions and form the expectations of p_2 . Signals are given as $p_s = \theta + \varepsilon_s$ where θ is the unknown mean in the new regime ($\theta \neq p^*$) and ε_s is an i.i.d. price shock, both following normal distributions. The producer knows that the mean price in the new/current region differs from that of the previous regime. In the above setting, rational learning (Bayesian) gives

$$E[p_2|p_1] = \phi_s p_s + (1 - \phi_s) \mu_1$$

and $\phi_s = \frac{\sigma_s^2(h)}{\sigma_s^2(h) + \sigma_\varepsilon^2(h)}$ where μ_1 is the prior mean right after time 1, $\sigma_s^2(h)$ is the prior variance, and $\sigma_\varepsilon^2(h)$ is the noise variance. Here we assume that human capital (education) h changes both $\sigma_s^2(h)$ and $\sigma_\varepsilon^2(h)$. When h increases $\sigma_s^2(h)$ or decreases $\sigma_\varepsilon^2(h)$, the educated farmers adjust $E[p_2|p_1]$ fast.

Proposition 4 Positive effect of human capital on investments

If higher education helps farms to learn the price dynamics, $\frac{\partial E[p_2|p_1]}{\partial h} = \frac{\partial E[p_2|p_1]}{\partial \phi_s} \frac{\partial \phi_s}{\partial h} > 0$. Farmer will invest more in this case. If education does not augment learning, $\frac{\partial E[p_2|p_1]}{\partial h} = 0$. Farmers will not change their investment decisions in this case.

4. Empirical analysis

We now use the IMDG data to test the implication of our theoretical model about the expectation formation (Proposition 1 and 2), liquidity constraints (Proposition 3), and the human capital effect (Proposition 4). In our empirical model, we assume that households are price takers. Using the exogenous variations of food price shocks to households, we estimate the relationship between agricultural investment and food price using a first-differencing (FD) model.

We define food price variable ΔP as a log difference of food prices between 2007 and 2010. The price index is constructed as follows. We start from the provincial capital producer prices of four main food items: rice ($c=1$), maize ($c=2$), cassava ($c=3$), and estate plantation crops ($c=4$). We use aggregated measure of estate plantation crops which include major crops such as coffee, cocoa, and coconuts. Since many farmers produce multiple crops in our sample, the prices of each food item are weighted by the revenue shares of

each main crop among total revenues in 2007 (ϕ_{2007})⁷. This creates household-level variations in the exposure to food price shocks (see Figure 5), which helps our identification of food price shock⁸.

$$\Delta P_{ij} = \sum_{c=1}^4 \phi_{ijc,2007} (\ln p_{c,j,2010} - \ln p_{c,j,2007}) \quad (6)$$

For a household i in province j , we estimate:

$$\Delta \ln k_{ij} = \beta \Delta P_{ij} + D_j + \Delta \varepsilon_{ij} \quad (7)$$

where $\Delta \ln k$ is the log of gross investments in agricultural assets (in real term) between 2007 and 2010.

Depreciation of agricultural assets is not captured. The standard error is clustered at village level.

In order to obtain causal effects of food price on investment, we use two-year panel data and difference out household-level fixed effect to account for time-invariant unobserved heterogeneity. We can difference out the risk aversion, which is the covariance term in the RHS of Eq. (5), and farmer's abilities and tastes which could affect their crop choice. These unobserved factors may be correlated with the price weights of each crop in 2007 (ϕ_{2007}), which may bias our estimate of the effect of food price on investment decision.

⁷ Revenue shares are the proportions of production revenues of rice, maize, cassava, vegetables, and estate crops. We exclude vegetables when constructing the price shock measure since vegetables are perishable and is unlikely to affect farmers' long-term investment decisions. For this reason, we exclude farmers who cultivated vegetables from our regression. If farmers do not market the crops and thus only report the volume of crop production, we imputed the production revenue using the median price of each crop at the village level.

⁸ We started from 1,578 agricultural households who were producers of some kinds of crops. In our regression, we do not include farmers who produced vegetable crops, which restricts our sample to 1,083 households as we do not have a price data of vegetable crops. Including vegetable farmers will bias our price shock variable (defined in equation (6)) to zero which will attenuate our estimates. Even in our restricted sample, there are sufficient household-level variations for the price shock variable as shown in Figure 5.

We have a concern that unobserved time-varying provincial factors, which affect the rise in food price, could also affect households' production decision. Different provinces have different natural endowments of land and resource, and the agro-climatic characteristics (e.g. soil quality) are also different. For example, Java and other provinces have very different levels of natural endowments, agricultural technologies, and market integration. With different comparative advantage in agriculture, we expect that actual realization of the food price changes would depend on adjustments of supply and demand, which depend on local productive endowment and market structures specific to each province. We also expect that each province might have taken different policies in response to rising food price. To account for the bias from the time-varying unobserved provincial attributes, we include provincial dummies (D_j) in Eq. (7).

If the food price had a dynamic impact on agricultural investments, we expect to see $\beta > 0$ in Eq. (7). On the other hand, if the price effect only had short-term impact on the production level, we expect that the price variable does not have significant effect on investment but will increase agricultural inputs.

4.1 Results

4.1.1 Capital investment, saving, and consumption decisions

Table 4 reports the FD estimates of Eq. (7) for the sample of 1,083 agricultural households. The result in the first column shows that food price shock had a positive effect on households' investment decision, but the impact is not significant. This preliminary finding suggests that higher food price did not significantly alter production frontier by changing the productive investments.

Agricultural households face the increase in their farm profits. As a consumer, however, farmers also concern about the volatility of future food price and may try to smooth their consumptions for future price falls by restructuring their portfolios. The optimal amount of expenditures on food and non-food items depends on relative price of two consumption goods. If they are risk-averse, they will increase cash-on-hand, save in financial assets (e.g. bank saving), or accumulate storage in other forms (such as jewelry

holding) as a consumption smoothing device. Households might prefer cash-on-hand or financial savings to preserve their liquidity since durable assets are indivisible. To examine consumption and saving behaviors, we replace the outcome variable in Eq. (7) with the log of households' financial savings, food and non-food expenditures. Our findings in Table 4 suggest that farmers reduced their saving but increased their consumption, but none of them are statistically significant.

The above results indicate that food price shock did not have a significant investment effect, which seems to suggest that higher food price did not have any dynamic impacts on agricultural production. However, Proposition 1 and 2 in Section 3 predict that production decisions to the price shock might differ by the nature of shock (anticipated or unanticipated) if household's expectation on price dynamics matters. If households perceived that the price shock is temporary (i.e. unanticipated shock), it will not have investment effect (from Proposition 1). On the other hand, if households changed their price expectation based on the permanent shift in price regime (i.e. anticipated shock), it will affect their investment decision. In the next sub-section, we try to distinguish whether farmers expectation formation matter by disentangling anticipated and unanticipated price shocks.

4.1.2 Anticipated and unanticipated price shocks

To test Predictions 1 and 2 on the expectation formation, we use a similar empirical strategy as Paxon (1992) and Jacoby and Skoufias (1997) to distinguish anticipated and unanticipated components of the price shock. In the first stage, we regress ΔP_t on initial crop shares in 2007 (rice, maize, cassava, and estate crops), X_{2007} (a vector of household characteristics in 2007 such as the age of the household head and the household's average years of schooling), and regional dummies (capturing region specific factors). We assume that households have rational expectations concerning the future distribution of food prices. The initial crop shares summarize households' anticipation and risk aversion on price dynamics based on the past price levels and volatilities up to 2007. We include the interaction terms between initial crop shares in

2007 and average years of schooling (H) to allow the heterogeneity in price expectation formation depending on households' human capital.

The anticipated component is the projection of the price change based on information available to households in 2007, which is \widehat{P}^P . We use the residual of the price shock $\widehat{P}^{UP} = P - \widehat{P}^P$ to represent the unanticipated component of the price shock.

$$\begin{aligned}\Delta\widehat{P}_{ijt}^P &= \widehat{\alpha}_1\Delta P_{ijt-1} + \widehat{\alpha}_2X_{ij,2007} + \widehat{\alpha}_3\Delta P_{ijt-1}H_{ij,2007} + D_j \\ \Delta\widehat{P}_{ij}^{UP} &= P_{ij} - \Delta\widehat{P}_{ij}^P\end{aligned}\quad (8)$$

Using Eq. (7) and Eq. (8), we estimate β_1 and β_2 in the following regression. Since the second stage estimator $\widehat{\beta}$ depends in part on the first-stage estimator $\widehat{\alpha}$, we use the bootstrap to estimate the adjusted standard errors for generated regressors.

$$\Delta\ln k_{ij} = \beta_1\Delta\widehat{P}_{ij}^P + \beta_2\Delta\widehat{P}_{ij}^{UP} + D_j + \Delta\varepsilon_{ij} \quad (9)$$

To estimate Eq. (9), we consider the possibility that farmers' expectation on future price may differ depending on the marketing system of the products in 2007. In Indonesia, there exists special arrangement (i.e. *Tebasan* and *Ijon* systems⁹) between farmers and traders in which purchasing price of crops differs from normal market rates. With fixed price determined by an informal contract with traders, farmers may expect future prices differently. In this regard, we exclude households who used either *Tebasan* or *Ijon* system in this regression.

⁹ *Tebasan* is a harvesting practice in which standing crops, mainly paddy and maize, are sold on area basis just before harvesting at prices close to normal market rates. In this way, farmers and traders avoid transaction costs. While *Ijon* is purchase of crops prior to the harvest at lower price, so that farmers can avoid harvest risks by paying risk premium to traders.

In Table 5, the top table shows the first-stage estimates of Eq. (8) and the bottom table shows the two-step bootstrap estimates of anticipated and unanticipated price shocks in Eq. (9). In comparison with the aggregate price shock reported in Tables 1 and 2, column (1) of the bottom table shows that the anticipated component of the price shock has a significant positive effect on productive investment when we include provincial dummies. The significant effect of anticipated shock on investment disappears when we replace with village dummies. This implies that expectations do not vary much within a village¹⁰. In both specifications, the unanticipated component is not significantly different from zero. Farmers decided to invest in productive assets in response to the predictable component of the price change, given the current realization of the positive price shock.

In columns (2)-(4), we find that anticipated food price shock increases food consumption. Although this paper does not isolate two effects coming from higher food price, this implies that positive *income effect* of higher food price dominates negative *substitution effect* for agricultural households. We find evidence of little consumption smoothing in response to the transitory spike of food price. Besides, the estimate in column (2) shows that households did not significantly increase their financial saving as a buffer stock to stabilize their life-time consumption, suggesting that they had a relatively short time horizon to smooth their consumption against the price uncertainty, or their consumption has been constrained at a very low level (so the marginal utility of increasing consumption is exceedingly large).

These results are consistent with our theoretical predictions in Propositions 1 and 2, i.e., the expectation formations (at provincial level) matter.

¹⁰ It should also be noted that the point estimates of generated regressors become less precise with 97 village dummies included in the regression as standard error cannot be computed in many bootstrapping replications. Given that expectations do not vary much within village, we use provincial dummies in our main regressions in sub-section 5.3.

5 Distributional effect of food price (by land size and liquidity constraint)

In this section, we examine whether the production decision to the price shock was constrained by production scale (landholding size) and the initial wealth endowment, which tests our Proposition 3. We also try to decompose the effects through three channels: expectation effect, land size, and liquidity constraint.

5.1 Land size

If land is used as collateral, small farmers will face borrowing constraint as we saw in Proposition 3 and small farmers invest less. It is also possible that large agricultural land owners have higher profitability per acre (scale economy) and the return to investment is scale-dependent¹¹.

Although we cannot perfectly separate the effect of borrowing constraint from the scale effect since land is a collateral as well as the most important factor determining the scale of production (thus, the efficiency of investments), we can test whether the size of land affected the effect of price shock on investment decision. We examine the above issue by including the interaction term between the food price change and the size of agricultural land owned in 2007 (L_0), in addition to the linear term of land size in Eq. (7).

$$\Delta \ln k_{ij} = \beta_1 \Delta P_{ij} + \beta_2 \Delta P_{ij} \times L_{0,ij} + \beta_3 L_{0,ij} + D_j + \Delta \varepsilon_{ij} \quad (10)$$

In Table 6, the marginal effect of the price shock on investment is $\frac{\partial \Delta k}{\partial \Delta P} = 0.281$. The interaction term with land size is also insignificant, suggesting that the effect of price shock on investment does not depend on land size. However, the main effect of land size on investment is 24.6% which is statistically significant at 5%. This suggests that there exists a scale economy regardless of the price shock.

¹¹ Foster and Rosenzweig (2011) found the positive relationship between farm size and productivity using panel data in India.

In the saving and consumption decision equations (in column (2)-(4)), we found that small farmers tended to make a temporary response to the food price shock by increasing their consumption in the short run from the extra profits although the result is weak.

5.2 Liquidity constraint

Proposition 3 is about the effect of liquidity constraint on households' investment and saving decisions in response to price shocks. The theory predicts that rich farmers invest more than poor farmers since their borrowing cost is lower. On the one hand, if this prediction is true, poor households will absorb the positive income shock by increasing savings and consumption. However, it could also be the case that poor farmers have a stronger incentive to invest since the marginal return to capital is higher than for rich farmers. It all depends on which activity – investment or consumption (current or future) – was constrained. With higher agricultural profit caused by the positive price shock, poor households might be able to invest easily since they do not have to borrow funds externally (which usually imposes a higher unit cost for poor farmers). If this conjecture holds, the poor will invest and the rich will use the income gains for savings or consumption.

To test which hypothesis holds in our context, we added interaction terms between the price change and two measures of the initial wealth level; durable assets and disposable income in 2007 (A_0).

$$\Delta \ln k_{ij} = \beta_1 \Delta P_{ij} + \beta_2 \Delta P_{ij} \times A_{0,ij} + \beta_3 A_{0,ij} + D_j + \Delta \varepsilon_{ij} \quad (11)$$

In Table 7, the upper panel uses durable asset holding as a measure of the initial wealth, whereas the lower panel uses disposable income as an initial wealth measure. The first measure captures general wealthiness of the households (total value of non-liquid wealth ownership), while the second measure captures the liquidity position in 2007. Collins, Morduch et al (2009) studies the day-to-day financial practices of the poor in three countries (Bangladesh, India, and South Africa), reporting a large vulnerability of their cash

flow to various shocks (e.g. health, weather, and employment risks) which make their long-term investment decisions difficult. If Indonesian farmers similarly face cash flow problems as the poor in other low income countries, we expect that disposable income will be a binding constraint for farmers to take optimal strategies.

In column (1), the positive coefficient of the interaction term between price change and wealth measures imply that wealthier farmers made more productive investments in response to price shock. In the upper panel, the interaction term is 0.173 (significant at 10%). Similarly, in the lower panel, the interaction term is 0.177 (not significant). The marginal effect of the price shock on investment is $\frac{\partial \Delta k}{\partial \Delta P} = -0.920 + 0.173A_0$ for durable asset. For 602 agricultural households which made productive investment, the mean of their durable asset was 7.68 (the unit is re-scaled to 10^6 Rp). This means that the marginal effect for the average income farmers is 40.8%, which increases for wealthier farmers. The large positive marginal effect is consistent with our theoretical prediction that richer farmers invested more since their borrowing cost is lower.

On the other hand, as shown in column (2)-(4) in both upper and lower tables, poor households tended to increase the non-food consumption. This is in line with the Deaton (1989)'s finding that consumption is a non-linear function of cash-on-hand and the propensity to consume is higher when the wealth holding is lower than a threshold level.

5.3 Anticipated and unanticipated price changes

To decompose the effect of land size and liquidity constraint (Z) from expectation effect ($\widehat{\Delta P_{ij}^P}, \widehat{\Delta P_{ij}^{UP}}$), we added the interaction term between two variables and the main effect of Z as specified in Eq. (12).

$$\Delta \ln k_{ij} = \beta_1 \widehat{\Delta P_{ij}^P} + \beta_2 \widehat{\Delta P_{ij}^P} \times Z_{ij} + \beta_3 \widehat{\Delta P_{ij}^{UP}} + \beta_4 \widehat{\Delta P_{ij}^{UP}} \times Z_{ij} + \beta_5 Z_{ij} + D_j + \Delta \varepsilon_{ij} \quad (12)$$

We use the same sample as in sub-section 4.2 (excluding households which used either *Tebasan* or *Ijon* system) with two-step bootstrap estimators. Even after we decompose the price shock into anticipated and unanticipated components, our findings in sub-section 5.1 and 5.2 are robust.

Table 8 shows that (a) anticipated price shock had greater positive effect on investment, while unanticipated shock had no significant effect and (b) the marginal effect of anticipated price shock does not significantly differ by land size.

As shown in column (2) and (3) of Table 8, we also find that richer farmers have stronger incentives to invest in response to price shock (interaction terms is significant at 5% when using durable asset and marginally significant when using disposable income). The marginal effect of the anticipated price shock on investment is $\frac{\partial \Delta k}{\partial \Delta P^P} = -0.652 + 0.258A_0$ for durable asset and $\frac{\partial \Delta k}{\partial \Delta P^P} = 0.246 + 0.284A_0$ for disposable income. For average farmers with the mean level of durable asset (disposable income), the marginal effect of anticipated price shock on investment is computed to be 125% (162%) which increases for wealthier farmers. This shows that both general wealth level (i.e. ownership of non-liquid wealth) and liquidity position are crucial for stronger investment effects.

This finding reinforces our arguments that (a) not all farmers with anticipated shock invested in agricultural productive assets, but (b) only richer farmers, who anticipated a rather permanent upward shift of the food price level, increased investments.

6. Education effect

Finally, farmers, who observed the food price shock between 2007 and 2010, might form their heterogeneous expectations of the price dynamics, and such a learning process can differ across farmers. From Proposition 4, we hypothesize that the learning speed of new information may differ by farmers?

education level. Rosenzweig (1995) empirically examined whether schooling improved abilities to learn new technology in India. In the similar spirit, we investigate whether educated farmers learned faster (either for better learning opportunities or better ability to decipher the information more efficiently) and were more responsive to food price shocks than uneducated farmers. If $\emptyset'(h) = 0$ in our model, the learning speed will not be significantly different between educated and uneducated farmers. On the other hand, if their prior variance is larger, uneducated farmers will be more responsive to the price shocks.

To test this hypothesis, we added interaction term between the price shock variable and the average year of schooling of age 20-55 adults in each household (H) in 2007. We also include the main effect of education variable.

$$\Delta \ln k_{ij} = \beta_1 \Delta P_{ij} + \beta_2 \Delta P_{ij} \times H_{ij} + \beta_3 H_{ij} + D_j + \Delta \varepsilon_{ij} \quad (13)$$

Table 9 shows that educated farmers were not significantly more likely to invest in agricultural assets than uneducated farmers, whereas the main effect is positive and significant at 10%. Unlike the return to learning of new technology as in Rosenzweig (1995), this implies that there was no enhanced learning effect of schooling during food crisis in Indonesia since food price can be almost commonly known to all farmers in our sample.

7. Conclusion

In this paper, we have examined investment and saving decisions during the food crisis period in Indonesia using recent household panel data. The empirical analysis showed the positive price effect on farmers' investment decisions in response to the food price increase experienced in the period from 2007 to 2010. Unlike the negative welfare impacts of higher food prices for consumers, studied in the previous literature, we found that the anticipated component of the price shock created a forward-looking incentive for Indonesian farmers to invest in productive assets. We also show that initial wealth is an important

constraint significantly influencing the investment decisions in response to the anticipated price shock. This implies the possibility of diverging long-term agricultural development between rich and poor farmers, suggesting that mitigating the liquidity constraint by improving farmers' *access to capital* could have a large benefit on inclusive growth (enhancing agricultural productivity and reducing income inequality) immediately after a food price crisis. Though the analysis further disentangled the investment behavior by educational attainment level, we found little evidence to support the role of human capital in determining the investment response.

Although the paper contributes to establishing a new perspective in the food price crisis literature by disentangling the production responses to the food price shocks, a clear research agenda awaits. It is important to analyze whether the investment indeed had a dynamic positive impact on agricultural productivity. Our preliminary result in the appendix suggests that investments undertaken between 2007 and 2010 have already created substantial productivity gains amid the global food price crisis. This suggests that the food price spike might have brought long-term productivity gains and induced upward shifts in the production frontier for the agricultural households in Indonesia.

Also, for future research using our sample, it is important to understand (a) whether income inequality between rich and poor farmers has actually diverged since the food price crisis, and (b) whether the poor farmers were trapped into lower production technologies, which suggests the necessity of designing public policy specifically targeted toward poor farmers to address the poverty trap in the context of a global food price crisis (a similar idea was suggested by Carter et al. (2007) in the case of natural disasters in Ethiopia and Honduras).

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Summary statistics

	Unit	2007					
		N	Mean	SD	P50	Min	Max
Land	Ha	950	1.42	1.75	1	0.0035	20
Agricultural production	1000Rp	1,003	5,470.31	6,118.9	3,190	0.01	28,400
Agricultural productivity	1000Rp/Ha	836	6,335.34	7,169.19	3,743.33	0.02	34,137.93
Disposable income*	1000Rp	982	2,068.13	2,319.32	1,244.44	0.06	11,994.18
Durable asset holding*	1000Rp	1,045	7,227.63	6,653.56	5,200	0	31,656.25
Financial saving*	1000Rp	676	186.67	413.71	25.86	0	2,510
Food expenditure**	1000Rp	1,031	4.53	2.56	4.17	0	11.25
Non-food expenditure*	1000Rp	1,035	567.65	568.55	373.33	7.79	3,226.8
Household size		1,083	5.11	2.14	5	0	17
Age of household head		1,049	50.09	13.18	49	22	90
Years of schooling		1,008	7.61	3.03	7.5	0	16

	Unit	2010					
		N	Mean	SD	P50	Min	Max
Inv (2007-2010)	1000Rp	610	12.46	1.64	12.42	6.26	19.42
Land	Ha	972	1.52	1.98	1	0.002	20
Agricultural production	1000Rp	1,019	7,324.71	7,621.67	5,119.21	0	33,866.02
Agricultural productivity	1000Rp/Ha	896	8,725.80	10,015.04	5,530.83	0	53,930.41
Disposable income*	1000Rp	962	2,031.19	1,911.02	1,436.52	-29.08	9,309.30
Durable asset holding*	1000Rp	1,022	8,118.82	7,302.42	5,999.14	34.63	38,694.5
Financial saving*	1000Rp	1,008	371.38	695.76	73.30	0	4,169.06
Food expenditure **	1000Rp	1,007	5.74	2.88	5.37	0	14.27
Non-food expenditure*	1000Rp	1,011	1,081.33	1,101.95	666.38	14.13	5,628.72
Household size		1,067	5.31	2.19	5	0	16

(Note) Agricultural production, disposable income, durable asset holding, financial saving, food expenditure, non-food expenditure are all converted to real term, which are deflated by CPI index.

*Disposable income, durable asset holding, financial saving, and non-food expenditure are adjusted for household size.

** Food expenditure is per adult equivalent.

Variable definition

Variable name	Definitions	Source
d_price shock	Sum of the changes of log prices for four crops (rice, maize, cassava, and estate plantation crops) from 2007 to 2010 weighted by shares of each production revenue	IMDG 2007, Bulog, BPS
Inv	Log of gross investment on agricultural assets taken place from 2007 to 2010; values in real term	IMDG 2010, BPS
d_finasset	Log differences of financial savings (mostly cash-on-hand and savings); adjusted per household member; values in real term	IMDG 2007 and 2010, BPS
d_foodexp	Log differences of market purchases of staple food (rice, maize, cassava, flour, potato), vegetable and fruits, meat and fish, milk and eggs, oil, spice, and beverages; adjusted per adult equivalent using nutrition scales; values in real term	IMDG 2007 and 2010, BPS, Dercon and Krishnan (1998)
d_nonfoodexp	Log differences of non-food expenditures on household items (e.g. kitchen equipment, furniture), clothing and shoes, health care, personal items, schooling fees, and insurance and taxes; adjusted per household member; values in real term	IMDG 2007 and 2010, BPS
Land	Size of agricultural land (in Ha) owned in 2007	IMDG 2007
Asset	Log of sum of household's durable asset holding in 2007 such as residential land, TV, radio, satellite antenna, phone, electronic machines, motorbike; adjusted per household member; values in real term	IMDG 2007, BPS
Income	Log of household's disposable income in 2007; adjusted per household member; values in real term	IMDG 2007, BPS
Years of schooling	Average years of schooling of household members aged 20-55 in 2007	IMDG 2007

Table 1: Monthly Commodity Prices (2006-2010) Summary Statistics

Commodity	Coefficient of variation	Autocorrelation		Persistence measure
		1 month	12 month	
Rice	0.16	0.91	0.28	0.16
Maize	0.20	0.96	0.45	0.18
Cassava	0.19	0.95	0.38	0.15

(Source) Bulog

(Note) Following the method in Deaton (1990), the persistence measure is computed as the weighted average of autocorrelations between 2006 and 2010 with weights declining linearly with the length of the lag. We do not report estate plantation crop since the price index is not fully comparable with other crop items.

Table 2: Type of investment in agricultural asset (N=1,292)

	N	Mean (1000Rp)	Min	Max
Farm equipments*	1,110	990.8	2.5	320,000
Sprayer	404	707.8	0	100,000
Farm building	223	3,294.3	50	120,000
Barn	43	482	0	9,900
Plow/Harrow	30	538	30	3,000
Tractor	21	8,561.9	100	20,000
Dryer	20	141.3	0	2,600
Machinery**	19	7,744.7	250	30,000
Thresher	17	9,700	0	70,000

*Farm equipments include agricultural tools such as shovel, hoe, sickle, jackknife, machete, crowbar and so on.

**Milling, feed processor, crumb rubber processor etc.

Table 3: Average share of production revenues (by provinces)

	All provinces	Each provinces						
		Central Java	East Java	Lampung	North Sulawesi	South Sulawesi	South Kalimantan	NTB
Rice	0.43	0.28	0.43	0.27	0.26	0.38	0.64	0.80
Maize	0.10	0.25	0.50	0.01	0.13	0.07	0.02	0.05
Cassava	0.04	0.16	0	0.10	0	0.01	0.01	0
Estate plantation crops	0.43	0.31	0.07	0.62	0.61	0.54	0.33	0.15

Table 4: Positive price shock and productions, consumption, and saving decisions

VARIABLES	(1) Inv	(2) d_finasset	(3) d_foodexp	(4) d_nonfoodexp
d_price shock	0.214 (0.580)	-0.788 (0.681)	0.0631 (0.114)	0.118 (0.240)
Provincial dummies included but not reported	YES	YES	YES	YES
Observations	610	551	959	974
R-squared	0.092	0.020	0.039	0.025

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.; Food expenditure is per adult equivalent.

Table 5: Impact of anticipated vs. unanticipated price shocks

First-stage regression on price expectation

VARIABLES	dprice	dprice
Share of rice in 2007	0.555*** (0.0439)	0.391*** (0.0688)
Share of maize in 2007	0.765*** (0.198)	0.886*** (0.260)
Share of estate crops in 2007	0.469*** (0.0376)	0.399*** (0.0717)
Age of HH in 2007	-0.000271 (0.000281)	-7.54e-05 (0.000185)
Avg. years of schooling	0.00527 (0.00428)	-0.00337 (0.00450)
Constant	-0.252*** (0.0706)	-0.0955* (0.0565)
Interaction term between initial crop shares in 2007 and average years of schooling included	YES	YES
Regional dummies included	Prov	Village
Observations	537	537
R-squared	0.620	0.852

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.

Main regressions on investment and saving decisions

VARIABLES	(1) Inv		(2) d_finasset		(3) d_foodexp		(4) d_nonfoodexp	
Anticipated shock	0.904* (0.526)	-0.135 (1.902)	-1.610 (1.922)	-4.991 (5.273)	0.265 (0.273)	0.302*** (0.113)	-0.155 (0.529)	0.0787 (1.331)
Unanticipated shock	-0.678 (0.832)	-0.298 (1.394)	-0.600 (1.568)	-0.0936 (4.789)	0.0237 (0.310)	-0.639 (0.705)	0.358 (0.588)	0.324 (1.382)
Regional dummies included	Prov	Village	Prov	Village	Prov	Village	Prov	Village

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses. Standard errors are corrected by two-step bootstrap estimator with 2,000 replications.

Table 6: Scale economies

Heterogeneity by land level

VARIABLES	(1) Inv	(2) d_finasset	(3) d_foodexp	(4) d_nonfoodexp
d_price shock	0.281 (0.664)	-0.581 (0.654)	0.0796 (0.181)	0.0605 (0.299)
d_price shock x Land	-0.127 (0.328)	-0.146 (0.256)	-0.0141 (0.0938)	0.0562 (0.131)
Land	0.246** (0.0939)	0.0671 (0.0888)	-1.37e-05 (0.0284)	-0.0340 (0.0409)
Provincial dummies included but not reported	YES	YES	YES	YES
Observations	610	551	959	974
R-squared	0.150	0.021	0.039	0.026

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.;
Food expenditure is per adult equivalent.

Table 7: Liquidity constraint
Heterogeneity by initial wealth

Using durable asset in 2007

VARIABLES	(1) Inv	(2) d_finasset	(3) d_foodexp	(4) d_nonfoodexp
d_price shock	-0.920 (0.764)	-0.637 (0.901)	0.007 (0.175)	0.695*** (0.263)
d_price shock x Asset	0.173* (0.0932)	-0.00918 (0.0785)	0.0048 (0.0129)	-0.0725** (0.0285)
Asset	-0.0351 (0.0251)	-0.0358 (0.0265)	-0.004 (0.0049)	0.0200** (0.0085)
Provincial dummies included but not reported	YES	YES	YES	YES
Observations	602	549	952	968
R-squared	0.108	0.039	0.039	0.029

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.; Food expenditure is per adult equivalent.

Using disposable income in 2007

VARIABLES	(1) Inv	(2) d_finasset	(3) d_foodexp	(4) d_nonfoodexp
d_price shock	-0.0602 (0.586)	-0.809 (0.682)	0.0444 (0.117)	0.112 (0.245)
d_price shock x Income	0.177 (0.114)	-0.0165 (0.0645)	0.00611** (0.00291)	-0.00423 (0.00351)
Income	-0.0256 (0.0162)	0.00264 (0.00933)	-0.00120** (0.000603)	0.000754 (0.000872)
Provincial dummies included but not reported	YES	YES	YES	YES
Observations	608	549	955	970
R-squared	0.107	0.021	0.041	0.027

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.; Food expenditure is per adult equivalent.

Table 8: Decomposition of expectation from other variables

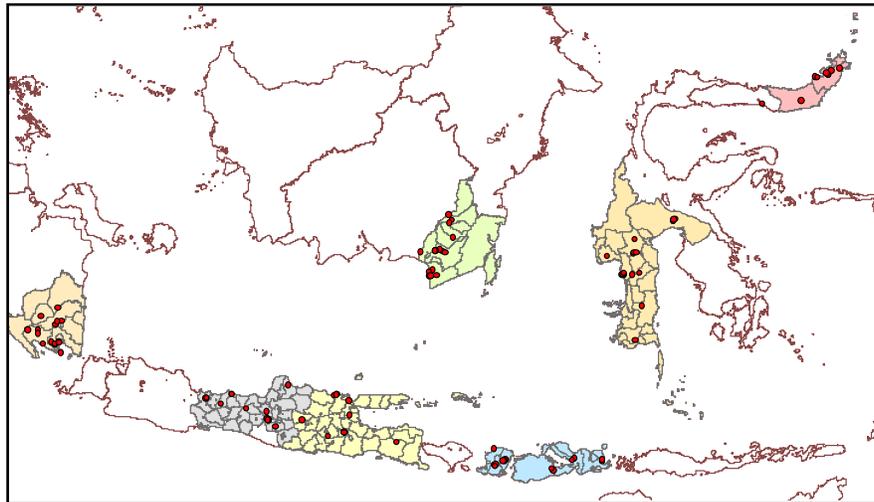
VARIABLES	(1) Inv	(2) Inv	(3) Inv
<u>A. Land</u>			
Anticipated shock	1.001 (0.644)		
Anticipated shock x Land	-0.120 (0.466)		
Unanticipated shock	-0.629 (0.945)		
Unanticipated shock x Land	-0.110 (0.594)		
Land	0.249* (0.142)		
<u>B. Initial wealth (using durable asset in 2007)</u>			
Anticipated shock		-0.652 (0.861)	
Anticipated shock x Asset		0.258** (0.124)	
Unanticipated shock		-1.238 (1.178)	
Unanticipated shock x Asset		0.0839 (0.157)	
Asset		-0.0594* (0.0357)	
<u>C. Initial wealth (using disposable income in 2007)</u>			
Anticipated shock			0.246 (0.687)
Anticipated shock x Income			0.284 (0.185)
Unanticipated shock			-1.580* (0.907)
Unanticipated shock x Income			0.408* (0.241)
Income			-0.0343 (0.0463)
Provincial dummies included but not reported	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses. Standard errors are corrected by two-step bootstrap estimator with 2,000 replications.; Panels A-C show separate regressions with same generated regressors interacted with land size and two initial wealth measures.

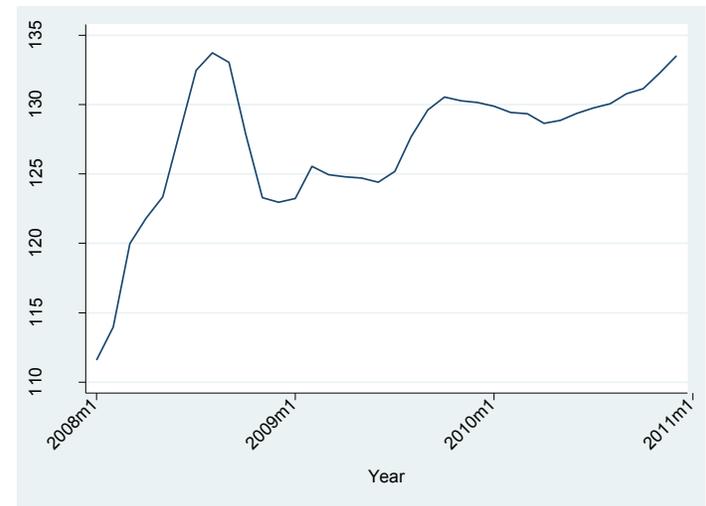
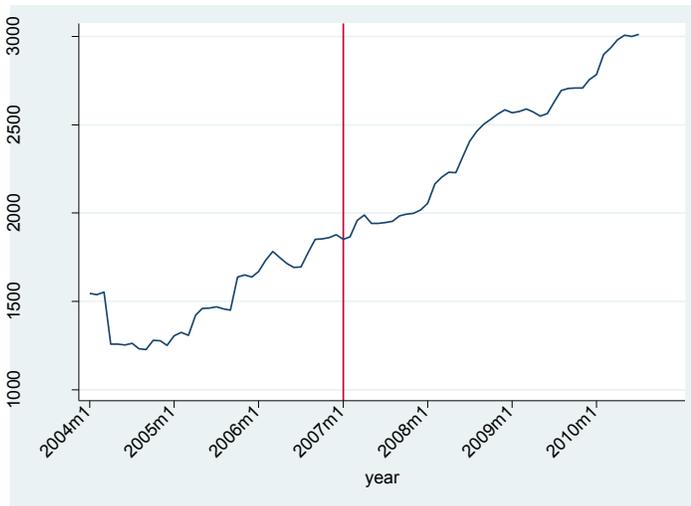
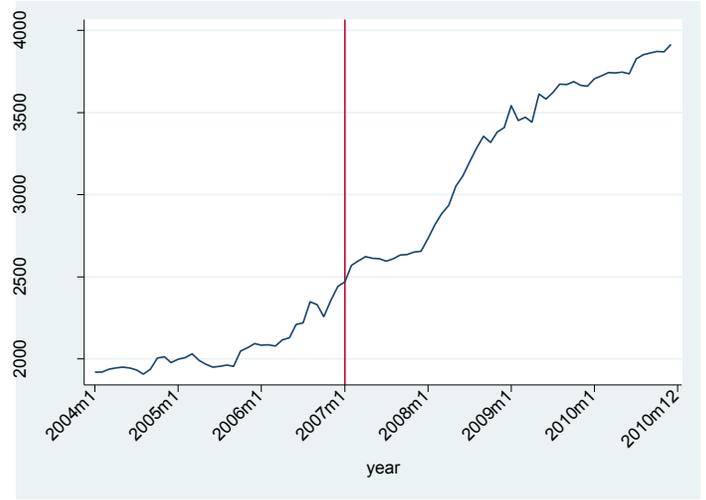
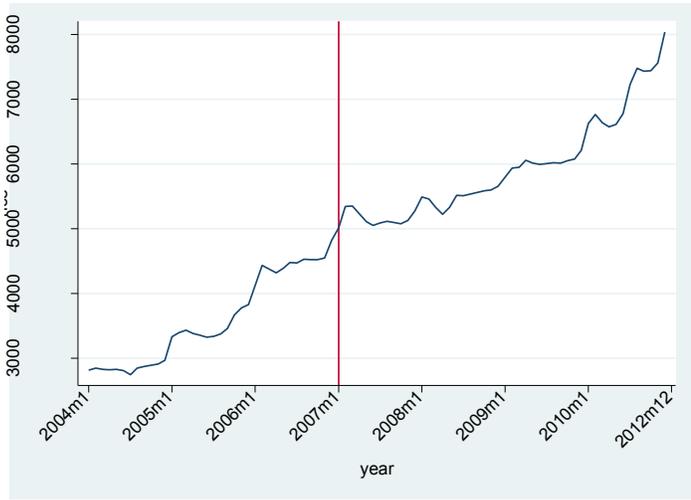
Table 9: Education effect

VARIABLES	(1) Inv	(2) d_finasset	(3) d_foodexp	(4) d_nonfoodexp
d_price shock	1.737 (1.414)	-0.250 (1.352)	0.0418 (0.227)	0.341 (0.539)
d_price shock x Years of schooling	-0.244 (0.204)	-0.0781 (0.180)	0.0009 (0.0325)	-0.0308 (0.0609)
Years of schooling	0.112* (0.0635)	-0.00631 (0.0730)	0.00288 (0.0131)	0.00586 (0.0228)
Provincial dummies included but not reported	YES	YES	YES	YES
Observations	578	520	892	908
R-squared	0.091	0.021	0.042	0.029

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.; Food expenditure is per adult equivalent.



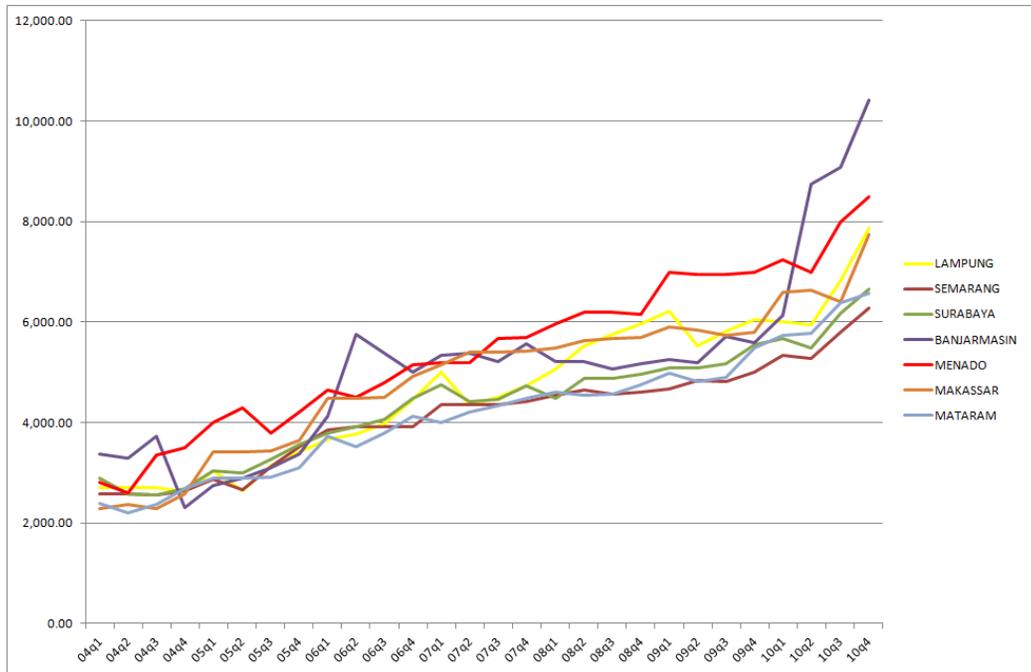
Map: Locations of surveyed villages



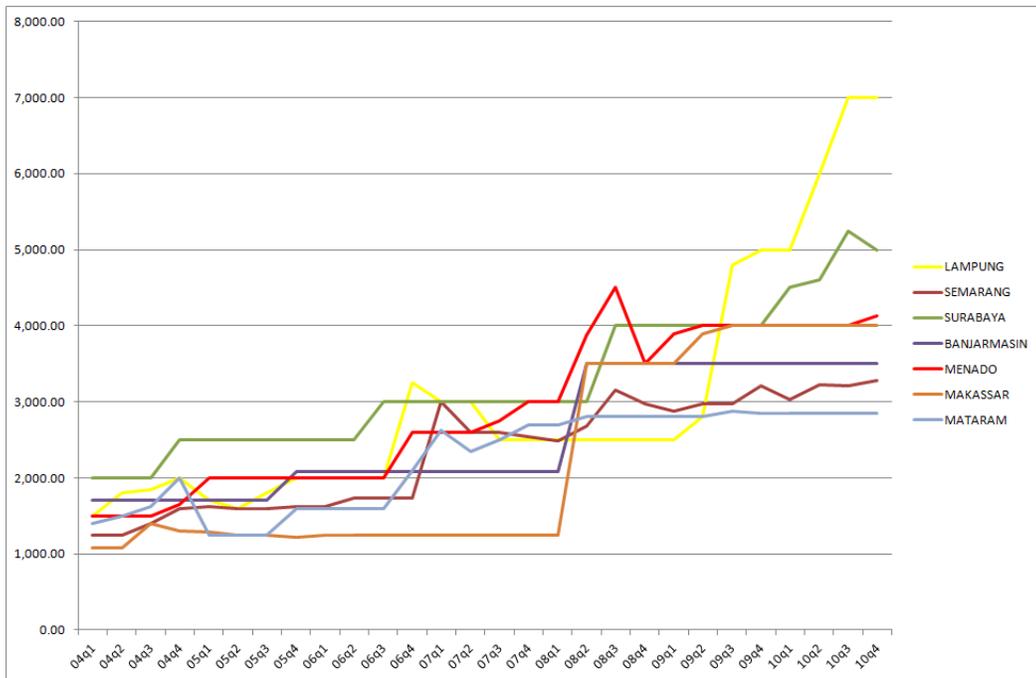
(Source) Bulog, BPS

Figure 1: Prices of rice, maize, cassava, and estate plantation crop in Indonesia

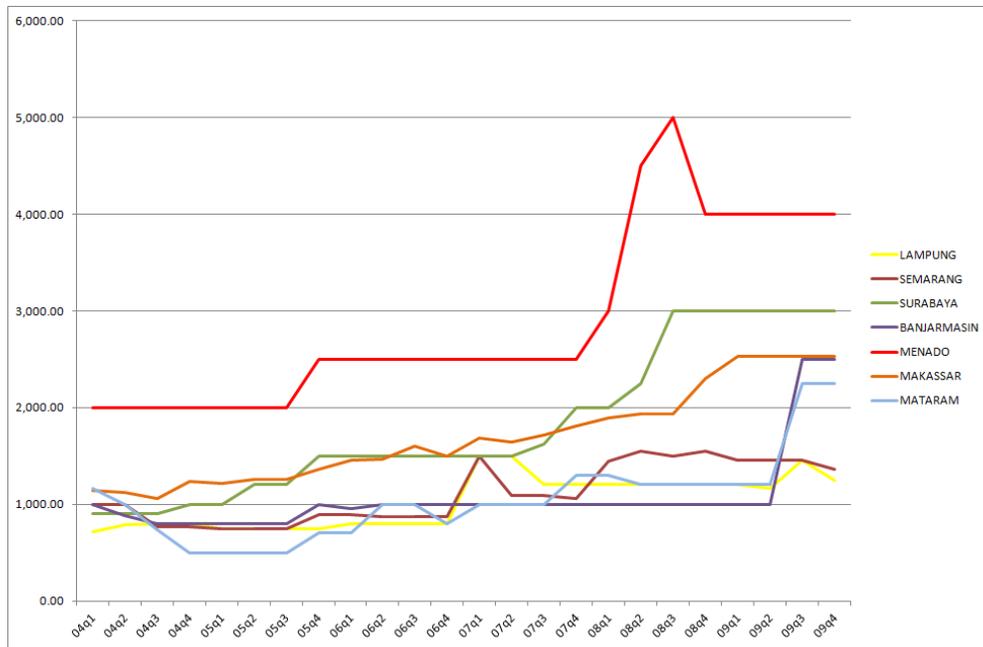
(Note) We do not have local price data of estate plantation crop from Bulog. The index (2007=100) is from BPS.



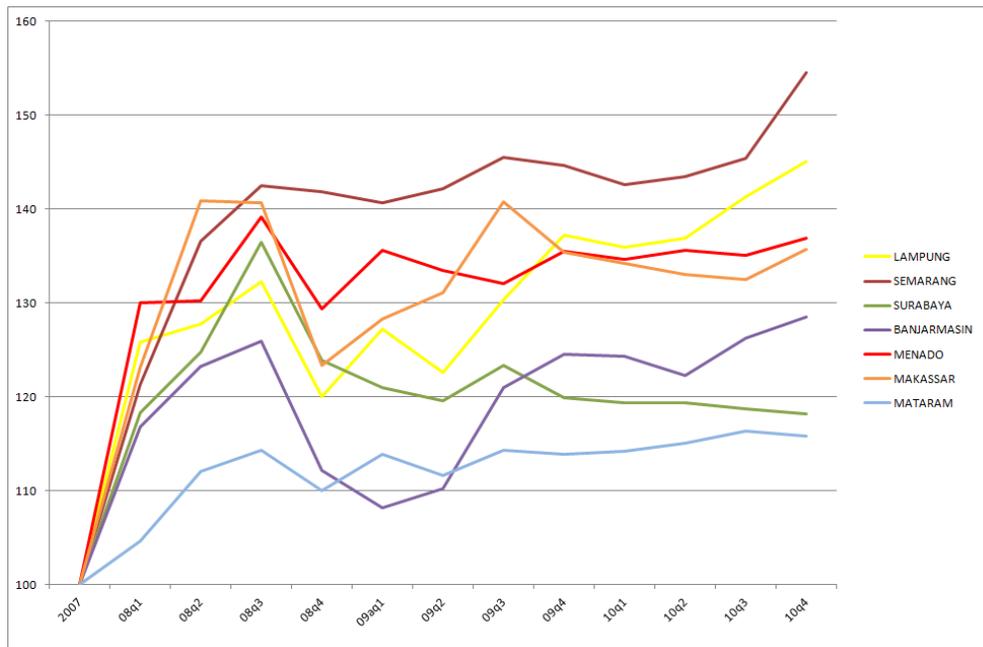
Dynamics of rice price (from 2004q1 – 2010 q4)



Dynamics of maize price (from 2004q1 – 2010 q4)



Dynamics of cassava price (from 2004q1 – 2010 q4)



Dynamics of price for estate plantation crop (from 2007 – 2010q4)

(Source) Bulog, BPS

Figure 2

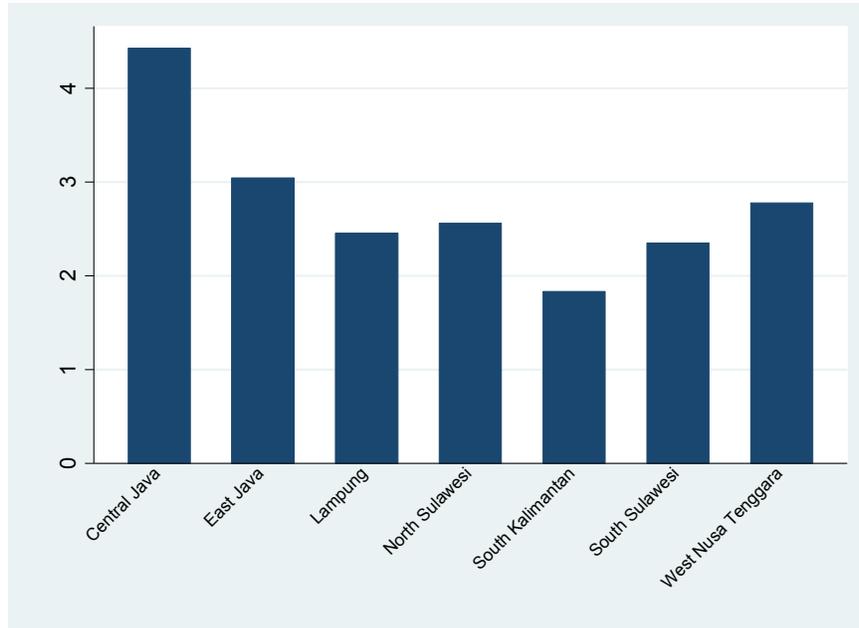


Figure 3: Distribution of average number of crops cultivated by farmers (by provinces)

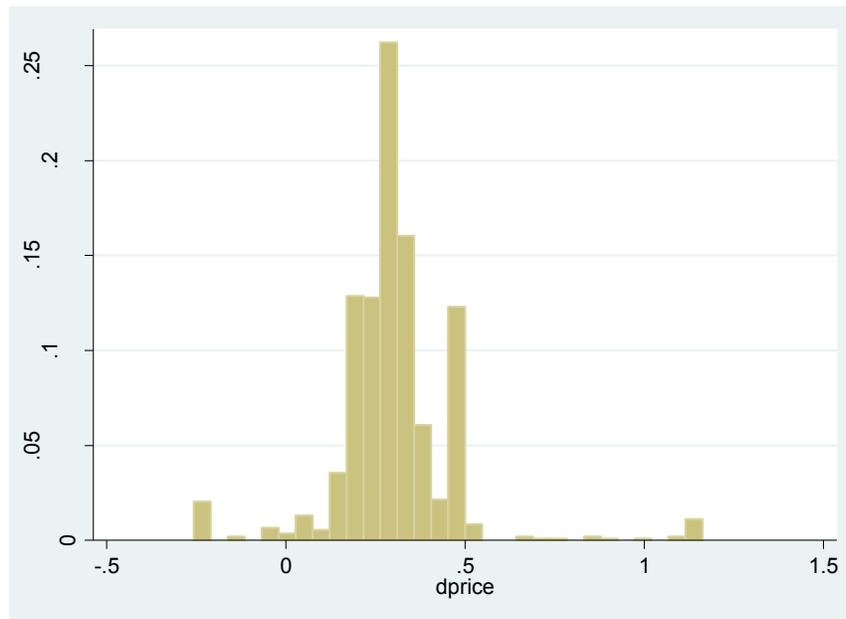


Figure 4: Distribution of food price variable (N=1,083)

Appendix: Farm profits and investment

Figure 5 shows the distribution of the change in farm profits from 2007 to 2010 (in real term, a unit is rescaled to be 1,000 Rp). As shown in the figure, the farm profits have grown rapidly from 2007 to 2010. In this appendix, we provide a preliminary evidence that the investments on farm equipments enhanced agricultural productivity during 2007 and 2010.

We regress the first-differenced farm profits (Δy) on the investments on farm equipment ($\Delta \ln k$), controlling for other variables X such as the land size in 2007, and the change in fertilizer use. The fertilizer use variable (D_{fert}) is ordered in three categories, which takes 1 (newly started using it), 0 (remain using or not using it), or -1 (stop using it). Since our variable of interest is $\Delta \ln k$ (not ΔP), we use 1,578 agricultural households for the following regression model.

$$\Delta y_{ij} = \gamma_1 \Delta \ln k_{ij} + \gamma_2 X_{ij} + D_j + \Delta \varepsilon_{ij}$$

As shown in the following table, 1% increase in gross capital investment creates substantial gains by 444,100 Rp. This result means that food price surge has already created substantial productivity gains for producers amid food price crisis.

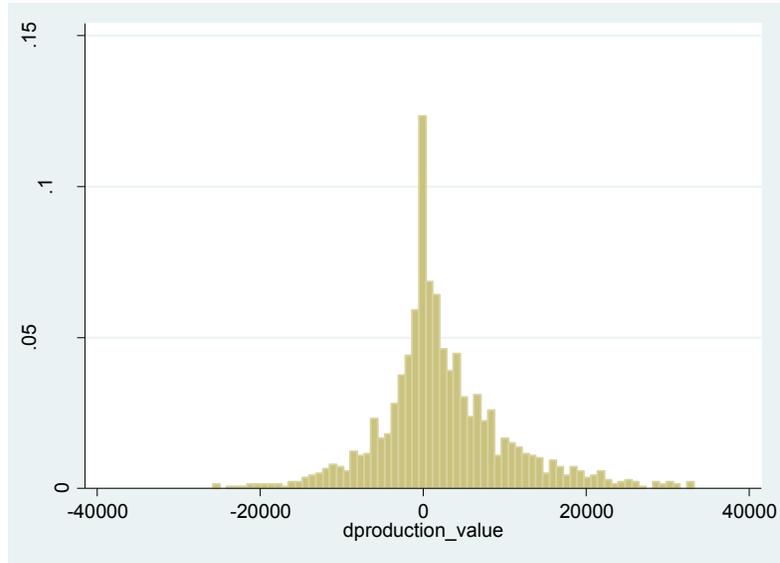


Figure 5: Distribution of the change in farm profits (N=1,578)

Farm profit and investment

VARIABLES	(1) dproduction_value
inv	444.1** (207.5)
Land size in 07	778.1*** (222.4)
D_fert	2,638.8*** (721.2)
Constant	1,086.2 (3,162.2)
Provincial dummies included but not reported	YES
Observations	649
R-squared	0.112

*** p<0.01, ** p<0.05, * p<0.1; Standard errors are clustered at the village level and reported in parentheses.