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Subsidized Food Distribution with Endogenous Quality: A Case Study from the Philippines

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Abstract

We argue that parastatal food-distribution organizations are less effective when their agents vary the quality of subsidized food and retail service (henceforth "quality") in response to local market conditions. These actions make assessing need from market signals difficult, hindering the effective allocation of subsidized food. In theory, policies and market conditions can affect outcomes (quality, demand, rationing and pilferage) differently, depending upon how markets for subsidized rice clear. We provide tests to reveal which market clearing mechanism is relevant. Using administrative and household survey data, we find evidence of quality variations, pilferage and market clearing through ad-hoc rationing of subsidized rice in the Philippines. Poorer markets and those facing higher rice prices do not receive more subsidized rice, but do appear to receive lower quality service and smaller rations. This may explain why the nationwide incidence of hunger rose with rice prices in poorer areas during 2003-2007 despite costly subsidies. We recommend explicit rationing rules, increased transparency regarding rice allotments and measured reductions in the amount of subsidized rice distributed.

Key words: Food subsidy, service quality, agency problem

1. Introduction

The food price crisis of 2008 has refocused attention on food security in the developing world. Hunger was rising even prior to 2008 (FAO, 2009) and

[1] This paper expresses the views of the authors, and not those of the Asian Development Bank, its member countries, or its directors.

the risk of further food price spikes remains high (Timmer, 2010). Ensuring the effectiveness of the public food-security apparatus is therefore a priority in many developing countries. Unfortunately, the agencies entrusted with this task are riddled with management problems. Previous literature has highlighted problems with pilferage (e.g. Murgai and Zaidi, 2005; Olken, 2006), inadequate targeting of subsidies to the poor (e.g. Ahluwalia, 1993; Coady et al., 2004), and the poor timing of transfers during times of high need (Clarete, 2008).

A variety of solutions to such management problems have been proposed. Politicians often approach these problems, especially pilferage, from a moral perspective, pinning their hopes on personnel changes. Many economists argue that this misses the point - arbitrage opportunities are invitations to corruption, so that removing subsidies is the key. Given the generally positive reviews of conditional cash transfer programs, they argue for a switch from food-based to cash-based food security arrangements. Other economists (e.g. Rogers and Coates, 2002; Pinstrup-Andersen, 1988) have pointed out that, depending on the environment, food-based systems may have some of the following four advantages over cash-based systems: (i) if food supply is inelastic cash transfers will raise prices, not food consumption; (ii) women – who are often thought to be more attuned to family nutritional needs – are less likely to control cash transfers; (iii) food can be self targeting to the poor if the subsidized food is an inferior good; and (iv) food-based transfers are an easier political sell than cash-based ones, which can be advantageous when political systems are not responsive to the needs of the poor.

Given this debate it is important to properly understand the management problems that agencies charged with distributing subsidized food (henceforth "parastatals") encounter. This paper argues that the task faced by managers of these agencies is much harder than is often acknowledged. This is because the physical quality of the subsidized product and the quality of retailing service may be determined, at least in part, by the parastatal's agents, and vary with local market conditions. This introduces two sets of complications.

First, it makes it difficult to assess demand in different markets because demand is contingent on these quality attributes. In particular, while deeper consumer subsidies and lower incomes directly increase demand for subsidized food, their indirect effect is to reduce quality, which may counteract these direct effects. We will argue that this inability to assess demand may help to explain why parastatals often fail to direct food to local markets in which need is greatest, and the perceived poor timing of imports and stock releases.

Second, it implies that the effects of changes in food policy become more difficult to determine. This is because when quality is variable, or food can be pilfered or rationed, a variety of market clearing mechanisms are possible. The comparative statics of service quality, demand, rationing and pilferage are determined by which of these mechanisms is at play. Moreover, large changes in consumer subsidies, local rice market conditions, incomes, the institutions for holding agents accountable, or the amount of subsidized product allotted to a market could cause the market clearing mechanism itself to switch.

To our knowledge, the agency problems faced by an organization whose agents determine the quality of the food and retail service provided to different local markets have not been understood through a unified theoretical and empirical analysis. This is a potentially important gap given recent attention to endogenous quality determination in segmented food markets without subsidies (e.g. Moschini et al., 2008), and the recognition that the quality of subsidized food determines the effects of food subsidies on the wider food market (Ramaswami and Balakrishnan, 2002). Roumasset (2000) suggests that the relative quality of rice clears the subsidized rice market in the Philippines, but to our knowledge a full derivation and test of market equilibrium under endogenous quality, rationing and pilferage has not been attempted before. Our model yields testable implications of Roumasset's conjecture, which we reject empirically.

We develop a theoretical model in section 4 to formalize our arguments. In keeping with our application of the model to the Philippines rice market in 2006, the model assumes that the subsidy is universal –all households are officially entitled to purchase as much subsidized rice as they want. Thus, we endogenize the rationing regime. This section also and provides testable conditions to determine which market clearing mechanisms are empirically relevant in a given market.

The rest of the paper puts flesh on these bones through a case study of the subsidized rice distribution operations of the Philippines' National Food Authority (NFA), and is structured as follows: Section 2 motivates the paper by providing empirical evidence that hunger in the Philippines rose because prices rose in poorer regions despite massive NFA food subsidies. Section 3 provides relevant institutional details, and reviews literature on the NFA which suggests that management problems at the NFA have blunted its efforts to combat hunger. Section 5 describes our data. Section 6 cites estimates of pilferage from a companion piece, and presents data suggesting that NFA rice is systematically purchased by easier to reach rather than more needy consumers. Section 7 uses regressions of NFA consumption

patterns across households and markets to verify the existence of rationing and variations in NFA rice quality, and asks how quality varies with local market conditions. Our final regression specification is derived from our theoretical model. Section 8 interprets these findings, offers policy insight, and concludes.

2. Motivation: Hunger in the Philippines

Hunger in the Philippines has been rising, even prior to the food price crisis of 2008 (Figure 1). The reasons for this remain poorly understood. Figure 2 summarizes the country's per-capita rice balances. Rice supplies are depicted above the line, and utilization, below it. It shows that hunger did not rise due to declines in per capita rice consumption, which trended upwards. Rising per capita production and imports permitted consumption to rise. Average per capita real-income grew robustly between 2001 and 2008, so there is no growth collapse to explain the rise in hunger (Figure 3). Of course, rising mean incomes could mask declines in income for the poor, but incomes of the poor would have to decline sharply to push the share of households going hungry from 4% to 19% between 2003 and 2007 while mean income grew robustly. Such a large deterioration is implausible: the Gini coefficient fell from 0.4605 in 2003 to 0.4564 in 2006.[2]

Having ruled out income, we ask whether price trends explain rising hunger. One possibility is that food prices received insufficient weight in the GDP deflator and that rising food prices actually drove real incomes down. We can rule this out: the food price index and the price of regular milled rice (rice being the main staple in the Philippines) rose no faster than the GDP deflator prior to 2008 (figure 4). This being said, rising rice prices almost certainly explain much of the increase in hunger in 2008, when they outstripped other components of the GDP deflator.

This leaves only two possible explanations for the trend prior to 2008 – a localized collapses in rice production which increased hunger amongst subsistence farmers, or localized rice price increases. Panel data on rice production by region appear to be unavailable, precluding analysis of the first possibility. However, retail rice prices did rise faster in regions with higher poverty rates (Figure 5). This complements Reyes et al.'s (2009) finding that rice price inflation in the Philippines hurts the poor more because rice

[2] Source: National Statistical Office, Family Income Expenditure Survey 2006 press-release.

is a necessary good: rice prices also hit the poor because they have risen faster in poorer regions.

This large increase in rice prices in poor areas may have a straightforward explanation. In a nation of over 7,000 islands, the observed increase in fuel prices would have increased transport costs, raising the geographic dispersion of retail prices.[3] Moreover, more remote regions of the Philippines – those with higher transport costs – tend to be poorer.

However, even if the correlation between poverty and rice price inflation can be explained, it does underscore the institutional question at the heart of this paper. The NFA's financial losses, which are financed by the Philippines government, amounted to some 0.2% of GDP in 2006 and hit 0.9% of GDP in 2008 (Jha and Mehta, 2010). Its distribution operations, according to official figures, should represent some 13% of the rice consumed in the country. Its mandate includes food price stability in the regions, which implies focusing operations on remote regions when fuel prices increase. If the increase in hunger is indeed related to rising food prices in poorer regions, then it would appear that NFA encountered significant difficulties in fulfilling its mandate. The key question is - what went wrong?

3. The National Food Authority

The NFA runs multiple programs. Here we review only those institutional details and literature relevant to understanding its retail food distribution operations. Jha and Mehta (2010) review its domestic procurement, farm-gate price support and stock management operations.

The NFA is the monopoly importer of rice to the Philippines. It sells rice through accredited retailers at a fixed, below-market price. The retailers receive a fixed margin on NFA sales. Customer purchases of NFA rice in 2006, the period of our study, were not officially rationed. All Filipinos were, and still are, eligible to buy NFA rice.

Prior studies level several criticisms of NFA operations. Roumasset (2000) argues that given its monopoly on rice imports, the NFA imports too little rice, leaving domestic prices significantly above world prices. Hofman (2008) and Timmer (2010) argue that panic-buying by the NFA was in part responsible for driving international rice prices above fundamentals in 2008. This echoes charge by Coxhead (2000) and Clarete (2008) that

[3] Baulch (1997) uses data from the Philippines to validate a model of interregional arbitrage with precisely this prediction

NFA import operations are not well matched to need in terms of timing or quantity. NFA rice is also widely sold to non-poor households. This subsidy leakage, coupled with the NFAs operating costs, combine to yield estimates of the cost to transfer a dollar of subsidy to the poor that range between 2.5 and 4.2 dollars between 1997 and 2008 (Jha and Mehta, 2010; Manasan, 2000). While these estimates do not account for the benefits accruing to the non-poor, they do assume that none of rice the NFA reports having distributed was pilfered. Finally, the World Bank (2001), provides survey evidence that households opt not to consume NFA rice because it is unreliable. Also, consistent with our argument that rising hunger reflects an inability of the NFA to control prices in poor regions, they show that access to NFA outlets is more limited in poorer regions of the country. Our theory, outlined in the next section will provide a plausible explanation for all but the first of these management problems.

These findings have led to frequent efforts to reform the NFA. Unfortunately reforms of food subsidy programs are notoriously difficult politically, and the NFA has proven no exception (Clarete, 2008). A reform program committed to in the late 1990s was aborted after the government changed (Asian Development Bank, 2008). Some policies were changed on a pilot basis since the food price crisis of 2008. This includes trials of a rice-card to permit explicit rationing in Metro Manila. More recently, another change of government has returned attention to the NFA. However, the debate has focused on its fiscal cost more than its operational outcomes. A serious analysis of the NFA's operations from household data is therefore timely.

Three features of NFA rice distribution operations make them difficult to study statistically. First, the NFA does not publish disaggregated information on how much rice has been allocated to each province. The NFA did make data available to us on the distribution of rice by region in 2006, but these are not separated by the channel through which they are distributed. This makes it difficult to derive disaggregate measure of pilferage, and so to shed much light on the factors conducive to high levels of pilferage.

Second, there have been, until very recently, no explicit rules for the rationing of NFA rice. It is distributed through a variety of channels, including licensed retailers, church groups, mobile stores, local governments and school feeding programs. Other than the school feeding programs, which account for some 5% of total rice distribution, the NFA does not publish any rules for rationing its subsidized rice. The allotment of rice to dealers is based on several criteria, including "stock inventory, rice allocation, distribution target,

supply/demand situation, commercial stocks and prices, etc."[4] Thus matching supply to demand at the subsidized price is only one objective of many, and anecdotal evidence suggests that it is not met. NFA rice consumers who we interviewed all reported experiencing queuing, maximum purchase limits and stockouts. One NFA agent queried on this indicated that they receive NFA rice every Wednesday, that their allocation usually sells out within a day, that they limited each household to 5 kilograms per store visit in 2006 (tightened to 3 kilograms since 2008), and that consumers were required to purchase one kilogram of commercial rice in order to qualify to purchase two kilograms of NFA rice. None of these practices or outcomes are explicitly prescribed or described by the NFA. Because, anecdotally, rationing is extensive, the quantities of rice purchased are less than the quantities demanded, and the correlations between quantities purchased and exogenous variables will not yield estimates of demand elasticity.

Third, the anecdotal evidence suggests that NFA rice quality varies across local markets. It is allegedly adulterated with inferior broken rice, inadequately protected from the elements, or stored beyond its sell-by date. There is ample evidence that rice demand is responsive to physical quality both in the Philippines (De Dios et al., 2002) and beyond (Yu and Abler, 2009), and to the reliability of supply (World Bank, 2001). The NFA expends significant effort to tackle physical quality variability, as demonstrated by the technical studies it conducts on the subject (e.g. De Dios et al., 2002; Ramirez et al., 2003). Variations in unobserved and endogenous rice quality further complicate efforts to learn about the determinants of demand from correlations between observed purchases and exogenous variables.

With respect to the second and third arguments, we emphasize that while acknowledging these identification problems weakens the empirical claims that may be made from the data, it also opens the door to a realistic discussion of systems control within the NFA. This is the problem we seek to address in this paper.

4. A Theory of Endogenous Quality

We begin by defining terms. *Pilferage* refers to subsidized rice (or some other product) that is not sold at administered prices and is presumably diverted to the regular rice market. Pilferage is distinct from *mistargeted*

[4] NFA Distribution Flowchart. http://www.nfa.gov.ph/image/distribution.jpg. Accessed 3 June 3, 2009.

rice, which is sold at subsidized prices to households above the poverty line. *Quality* is a broad term, encompassing both the physical quality of the subsidized rice (e.g. odor, moisture content, absence of adulterants) and the quality of distribution services (e.g. reliability, predictability, ease of access). *Rationing* resolves the excess of demand over supply at the subsidized price. More frequent or ad-hoc rationing implies a lower quality of service. The distinction between rationing and other determinants of perceived quality (e.g. proximity to the subsidize rice outlet or physical rice quality) is this: while the deterioration in the latter shift the demand curve for subsidized rice to the left, greater rationing not only shifts the demand curve to the left, but also indicates greater unmet demand. We motivate our model by consideration of Philippines rice markets, but the theory is easy to adapt to other subsidized product markets.

4.1. Demand

We assume, for now, that the utility-maximizing representative household in a localized rice market selects per-capita amounts of subsidized rice (N) and regular rice, priced at p_N and p_R respectively, and a numeraire consumption good. The household takes the composite physical quality of subsidized rice and of retailing service, relative to those for regular rice (q) as given. We assume, without loss, that $q = 1$ when subsidized and regular rice are of equal quality. The household per-capita budget (M) is taken as exogenous. The resulting quality-contingent Marshallian demand function for subsidized rice is $N^D(p_N, p_R, M, \mathbf{x}_D; q)$ and may vary with household characteristics ($\mathbf{x}_D$).

We impose the following theoretically permissible and intuitive properties on this demand function. (A1) Demand decreases in price: $\partial N^D/\partial P_N < 0$. (A2) Subsidized and regular rice are substitutes:$\partial N^D/\partial P_R > 0$. (A3) Subsidized rice is an inferior good: $\partial N^D/\partial M < 0$. (A4) Demand increases at a decreasing rate in the quality of subsidized rice: $\partial N^D/\partial q > 0$, $\partial^2 N^D/\partial q^2 < 0$. (A5) Richer people are more responsive to the quality of subsidized rice: $\partial^2 N^D/\partial q \partial M > 0$. We will confirm A2, A3 and A5 empirically in section 7. A1 is not testable because P_N does not vary in the sample, and A4 is tautological. It will be useful to sign $\partial^2 N^D/\partial q \partial P_N$ and $\partial^2 N^D/\partial q \partial P_R$.[5] However, because P_R varies in our sample and P_N does not, we will only be able to sign $\partial^2 N^D/\partial q \partial P_R$ empirically.

[5] Intuitively, one might presume that $\partial(\partial N_D/\partial P_N)/\partial q < 0$ and $\partial(\partial N_D/\partial P_R)/\partial q > 0$, because as the relative quality of the subsidized product rises towards that of regular rice (i.e. as $q \to 1$), they should become more substitutable. Alternatively, one might think

The parastatal's agent (modeled next) determines the quality of rice in response to the demand function P_N, P_R, M and a vector of local market characteristics ($\mathbf{x}_S$). Denote this response function $q^*(P_N, P_R, M, \mathbf{x}_S)$. The equilibrium quantity of subsidized rice demanded is: $N^D(P_N, P_N, M, \mathbf{x}_D; q^*(P_N, P_N, M, \mathbf{x}_S))$.[6] Differentiating it yields:

$$\frac{dN_D}{dP_N} = \frac{\partial N_D}{\partial P_N} + \frac{\partial N_D}{\partial q}\frac{\partial q^*}{\partial P_N} \tag{1a}$$

$$\frac{dN_D}{dP_R} = \frac{\partial N_D}{\partial P_R} + \frac{\partial N_D}{\partial q}\frac{\partial q^*}{\partial P_R} \tag{1b}$$

$$\frac{dN_D}{dM} = \frac{\partial N_D}{\partial M} + \frac{\partial N_D}{\partial q}\frac{\partial q^*}{\partial M} \tag{1c}$$

The first terms in (1a-c) show that under (A1)-(A3), holding quality constant, demand for subsidized rice increases when regular rice prices rise, and decreases when subsidizes rice prices or incomes rise. The second terms indicate that matters are more complicated when quality is variable in response to these parameters and demand is sensitive to quality. Given A4, if quality is lower in richer markets or those receiving deeper subsidies, the total effects of price and income changes on demand are theoretically ambiguous. Similar arguments follow for any variable entering both $\mathbf{x}_S$ and $\mathbf{x}_D$. Thus, the endogeneity of quality makes it difficult for the parastatal to work out when and where demand is likely to be high based upon observable features of markets, making it harder to target subsidized rice to high-demand markets and time periods. This simple theory may help to explain why the NFA has had such a difficult time targeting rice, and why large subsidies have proven ineffective in combatting hunger in the Philippines. We will estimate some of the relationships embedded in equations (1a-c) in Section 7 in order to see whether these theoretical ideas are empirically relevant.

The effort to push subsidized food in localities and periods of high demand is complicated further if quality is unobservable or if it responds to local market conditions in complex ways. In this case, considerable chaos

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that as the price difference is reduced (i.e. $P_N \uparrow$ or $P_R \downarrow$) , quality will matter more : $\partial\left(\partial N_D/\partial q\right)/\partial P_N > 0$ and $\partial\left(\partial N_D/\partial q\right)/\partial P_R < 0$.

[6] Looking ahead to empirical implementation, when we shall have to drop the representative household assumption, we have assumed that quality is the same across all households in a given market and therefore responds to local-market variables, but not household level variables. In other words, $\mathbf{x}_S$ includes local market-level aggregates of some key household characteristics included in $\mathbf{x}_D$.

is expected in subsidized rice markets. To better understand the nature of this chaos, and possible policy responses to it, we examine the supply side next.

4.2. Supply

We assume, as is true in most distribution systems, that the local agent is a monopolist.[7] This agent determines the per capita amount of subsidized rice supplied to consumers (N) and its quality (q) in response to local market conditions, the known consumer demand function (N^D) and some local market characteristics ($\mathbf{x}_s$). It receives an exogenously determined per capita allotment of rice (N_A) at a subsidized procurement price P_W. It sells N units per consumer at the fixed subsidized rice price P_N, and the remaining, pilfered amount ($N_A - N$) at the regular market price $P_R > P_N$, which for tractability, we take as exogenous. The cost of distributing subsidized rice $c(\cdot)$, is assumed (A6) to be an increasing, convex function of its quality, and the quantity distributed per capita, implying that $\partial c/\partial q > 0$, $\partial^2 c/\partial q^2 \geq 0$, $\partial c/\partial N > 0$, $\partial^2 c/\partial N^2 \geq 0$, and $\left(\partial^2 c/\partial N^2\right)\left(\partial^2 c/\partial N^2\right) - \left(\partial^2 c/\partial q \partial N\right)^2 \geq 0$. We assume (A7) that the total cost of supply and the marginal costs of quality and quantity increase in procurement prices: $\partial c/\partial P_W > 0$, $\partial^2 c/\partial P_W \partial q > 0$, and $\partial^2 c/\partial P_W \partial N > 0$. Finally, we assume (A8) the costs of participating in a public program are non-negative: $c(q = 1, P_W) \geq P_W$; and (A9) because one way of reducing the cost and quality of a subsidized product is to adulterate it, procurement price increases have a less than proportionate effect on the marginal cost of quantity: $\partial^2 c/\partial N \partial P_W \leq 1$. While we cannot test assumptions A6-A9 because we have no measures of cost, they are intuitive and reasonable.

Now, if the above commercial considerations were all that agents took into account, they would usually have incentives to sell no rice at subsidized prices, or (equivalently) to reduce the quality of the subsidized product until demand evaporates.[8] Social and political pressures are likely to pre-

[7] There are no publicly available data on the density of NFA outlets. However, consumers and retailers both indicate that when multiple retailers serve a local market, they all sell the same rice stock, which is shipped to either a cooperative or Bigasang Bayan (a "town rice market") that houses the authorized retailers and is presided over by one of them. Moreover, one town will be supplied by one warehouse. Assuming a monopolist supplier is therefore reasonable.

[8] We say "usually", because, if it is considerably cheaper to distribute subsidized rice than regular rice, agents could have incentives to sell as much rice as is demanded, and to set quality to generate the amount of demand that maximizes profits. This corresponds to "Regime 3", which we will show is not currently empirically interesting.

clude this. In particular, the NFA has repealed the accreditation of agents in response to excessive consumer complaints, NFA agents report that it is unpleasant to deal with consumers who are annoyed, and local political leaders have incentives to lean on agents who excessively inconvenience consumers. We therefore postulate the existence of a general money-metric social penalty function $S(q, N)$. We assume that: (A10) penalties decrease in performance ($\partial S/\partial q, \partial S/\partial N < 0$), and that (A11) the penalty function is strictly convex in q and N. We also assume, intuitively, that (A12) quantity reductions increase penalties more if quality is low: $\partial^2 S/\partial N \partial q \geq 0$.

Thus, the supplier selects N and q to solve the constrained maximization problem with Lagrangian:

$$\begin{aligned} L &= P_N N - c(q, N, P_W) + (P_R - P_W)(N_A - N) - S(q, N) \\ &\quad + \lambda_D \left[N^D(P_N, P_R, M, q) - N \right] + \lambda_A \left[N_A - N \right] + \mu_N N \end{aligned} \tag{2}$$

Under the assumptions made, the objective function and constraints are convex in N and q. Therefore, the Kuhn Tucker Conditions identify a global solution to the problem.

4.3. Equilibria

We restrict attention to only those cases in which some rice is sold at subsidized prices. The Kuhn Tucker conditions are then the constraints and complementary slackness conditions associated with multipliers $\lambda_D \geq 0$ and $\lambda_A \geq 0$, plus:

$$\left[(P_R - P_W) - \left(P_N - \frac{\partial c(N^*, q^*)}{\partial N} \right) \right] + \lambda_D + \lambda_A = -\frac{\partial S(N^*, q^*)}{\partial N} \tag{3a}$$

$$\frac{\partial c(N^*, q^*)}{\partial q} = -\frac{\partial S(N^*, q^*)}{\partial q} + \lambda_D \frac{\partial N^D(q^*)}{\partial q} \tag{3b}$$

To save space, we define the marginal arbitrage opportunity $MAO^* \equiv (P_R - P_W) - (P_N - \partial c(N^*, q^*)/\partial N)$, replace $S(N^*, q^*)$ and $c(N^*, q^*)$ with S^* and c^*, and write partial derivatives using subscripts (e.g. $S_N^* \equiv \partial S(N^*, q^*)/\partial N$).

In principle, four regimes are possible, depending upon whether or not subsidized rice is rationed and pilfered. Denote the agent's optimal quality and quantity by q^* and N^*. The extent of rationing is $N^D(q^*) - N^*$. Pilferage is $N_A - N^*$. We rule out the knife-edge regime with no rationing and no pilferage because it is unlikely a policy maker could pick $N_A = N^D(q^*)$. The remaining three regimes are depicted in Figure 1.

1. The unconstrained regime ($\lambda_A = \lambda_D = 0$): Quality is set to equate the marginal cost of quality with the marginal reduction in penalties due to quality improvements: $c_q^* = -S_q^*$. The amount of rice sold at subsidized prices equates the marginal cost of such sales (the foregone arbitrage opportunity) with their marginal benefit (reductions in penalties): $MAO^* = -S_N^*$. Label this unconstrained optimum quantity $N^U(q^*)$. In this case $N^D(q^*) - N^U(q^*) \geq 0$ is per capita rationing, and $N_A - N^U(q^*) \geq 0$ is pilfered.
2. The allotment constrained regime ($\lambda_A > 0$, $\lambda_D = 0$): This occurs when $N^U(q^*) > N_A$ and $N^D(q^*) > N_A$. In this case the quantity sold at subsidized prices is constrained by the allotment ($N^* = N_A$), excess demand is $N^D(q^*) - N_A > 0$, and there is no pilferage. As in Regime 1, q^* is set to equate the marginal cost with the marginal reduction in penalties from quality improvements: $c_q^* = -S_q^*$.
3. The demand constrained regime ($\lambda_A = 0$, $\lambda_D > 0$): This occurs when $N^U(q^*) > N^D(q^*)$ and $N_A > N^D(q^*)$. In this case $N = N^D(q^*)$, there is no rationing, and $N_A - N_D > 0$ units are pilfered. This regime corresponds to Roumasset's (2000) conjecture that rationing is not required because quality clears the market for the subsidized product.

4.4. Comparative Statics

We introduce two generic exogenous variables: remoteness, R, is an argument of the cost function, and stands in for any variable that increases the marginal costs of quality or quantity (i.e. $c_{q,R} > 0$ and $c_{N,R} > 0$); and the force of accountability, F, is an argument of the penalty function, standing in for anything that increases the marginal penalties associated with low quality or quantity (i.e. $S_{q,F} < 0$ and $S_{N,F} < 0$). Localities with sound road networks or high concentrations of consumers density will have a lower R, while increasing transparency, political accountability, or incomes may empower consumers, increasing F.

Table 1 summarizes the comparative statics of the individual parameters under the three regimes. The results are derived and their intuition sketched in the appendix. The comparative statics depend upon the regime. In Regime 1 quality is traded off against quantity to minimize costs and penalties $(c + S)$. Therefore, unless the exogenous parameter is an argument of either function, quality and quantity move in opposite directions. In Regime 2, unless the allotment changes, only quality is variable. In Regime 3, quality varies to generate the optimal level of demand. Therefore, unless the exogenous parameter effects demand directly (i.e. for all parameters other than P_N, P_R and M), quantity and quality move in the same direction.

The effects of subsidy reductions (increases in P_N) illustrate the point nicely. In Regime 1, they simply reduce the arbitrage opportunity, thereby inducing agents to sell more rice at the subsidized price. This increases the marginal cost of quality while reducing the penalties that quality eliminates on the margin, inducing the agent to reduce quality. In Regime 2, subsidy reductions have no effect on the quantity sold, which is determined only by allotments. This implies no change in the marginal costs or benefits of quality, so quality remains unchanged also. In Regime 3, lower subsidies can induce higher quality, because they reduce the arbitrage opportunity inducing agents to seek larger markets for the subsidized product. However, any quality driven changes in the demand for the subsidized product will be counteracted by demand decreases due to its higher price.

These comparative statics are, however, simplified, because a number of variables have been excluded from the penalty function. For example, higher income consumers may be able to inflict larger penalties on agents, entailing incentives to provide more or higher quality service. Thus, income effects equilibrium outcomes through two vectors - its direct effects on demand are captured by the comparative statics of M; its effects on political penalties are captured by the comparative statics of F. An unambiguous result is obtained when they move in the same direction. Similarly, the full effects of subsidy changes can be appreciated by noting that *cetris paribus*, P_R and P_N are probably positively correlated with F: consumers in tighter rice markets will be more demanding of agents.[9]

We will demonstrate, in Sections 6 and 7, that Regime 1 is the empirically relevant case in Philippine rice markets. The full comparative statics under this regime indicate that: (i) higher income markets will obtain higher quality rice, because income only effects equilibrium through the penalty function; (ii) the effects of increases in P_R and P_N are an empirical issue, because, in addition to the simple comparative statics, both are likely to increase accountability, and this has ambiguous effects on quality and quantity individually; (iii) modest changes in the allotments of rice to each local market (N_A) have no impact whatsoever on equilibrium, because each allotment, being hidden from public view, is a slack variable[10]; and (iv) remoteness reduces quantity, quality or both.

The foregoing arguments illustrates that the effects of policy changes

[9] An alternative approach is to introduce the quantity demanded as an argument of the penalty function. The results are not qualitatively different.

[10] Mehta and Jha (2010) discuss this point in detail.

are impossible to predict, unless one has credible empirical evidence on two scores: (1) which market clearing regime binds, and (2) the effects of those variables whose effects cannot be signed by theory alone. The remainder of this paper seeks this evidence for the Philippines rice subsidy program.

5. Data

We utilize four data sources. The first, the 2006 Family Income and Expenditure Survey (FIES) is a multi-stage stratified random sample covering 38,483 households collected by the Philippines National Statistical Office (NSO). Each household was visited twice, once in July 2006 and once in January 2007, responding each time to the same survey instrument. The publicly released FIES data-sets contain only annual aggregates of household variables based on these two samples. Each household was asked to self-report the average weekly consumption of each major food type, as well as unit prices. Unfortunately, the unit price data are not distributed to the public, precluding estimation of the quantity of rice consumed. However, because NFA rice was sold at a fixed price of 18 pesos/kg, the quantities of subsidized rice consumed by each household could be recovered.[11]

The FIES sampling frame contains 1,567 geographic strata, delineated by province, urbanity, the proportion of dwellings that are permanent structures, the importance of agricultural employment, and average income. This ensures maximal representation of the population geographically, in terms of livelihoods, local government and in terms of community income. Each stratum was divided into primary sampling units (PSUs), each of which is comprised of either one Barangay of 500 households or more, or multiple smaller Barangay's put together to reach that figure. The Barangay is the smallest unit of governance in the Philippines. Between 2 and 7 PSUs were sampled at random within each stratum, implying randomization with respect to communal governance. All of the above matters because our main variables of interest are conditions in local markets, which are estimated by average values of variables at the PSU level. The stratification scheme implies that the distribution of these conditions in the data will be nationally representative. Unless otherwise indicated, all estimates account for probability weights, stratification and clustering at the PSU level.

[11] Some higher quality NFA rice is sold for a higher price. However we do not have information on this breakdown. We therefore overestimate of the quantity of NFA rice consumed. This is yet one more reason that regressions of imputed NFA rice consumption will not yield estimates of demand elasticity.

The FIES sampling scheme excludes remote areas accounting for 0.4% of the population, and some figures for the National Capital Region (NCR) were imputed after a fire destroyed some surveys collected in the. We drop all observations from the NCR in this paper. The estimates used in this paper are representative of the rest of the country.

We also use data on regional/provincial food prices and production from the Philippines Bureau of Agricultural Statistics (BAS), as well as measures of regional GDP per capita, fiscal resources, provincial road density and type and the availability of banks of different types from National Statistical Consulting Board (2007). Finally, the NFA also granted us access to the official figures for the total distribution of subsidized rice to different regions of the country in 2006. These data are not in the public domain, but are occasionally released to researchers for specific purposes. The Philippines has 85 provinces which are currently arranged into 17 regions. However, the NFA uses an older mapping of provinces to regions, which we accommodate through aggregation and concordance in the usual fashion.

6. Pilferage and Consumption

Our estimates of the amount of NFA rice pilfered, and a series of robustness tests of those estimates are provided in a separate paper (Mehta and Jha, 2010). The headline figure is that some 48% of rice that the NFA claims to have distributed (excluding the NCR and rice distributed through school feeding programs) does not appear in the FIES data. We report there that three types of recall bias, three types of sampling error, and two types of reporting error cannot reconcile the official distribution figures with estimated consumption from the FIES. In terms of our theoretical model: . This implies that if all local rice markets operate under the same market clearing conditions, Regime 2 is ruled out for the Philippines in 2006. A direct implication of this finding, (Table 1, Regimes 1 or 3), is that N_A, the amount of rice the NFA sends (or claims to send) to local markets is a slack variable: it exerts no influence on (N^*, q^*). If it were reduced marginally, this would reduce pilferage, kilogram for kilogram ($\partial \left(N_A - N^*\right) / \partial N_A = 1$), without reducing consumer welfare.

In order to shed light on why NFA marketing operations did not prevent price rises in poorer regions, we now examine how the amounts of NFA rice reaching households per the FIES, and the amount disappearing en route, vary with local market conditions.

Table 2 shows the correlation across provinces (excluding the NCR) between our FIES estimates of per capita NFA rice consumption (our estimate

of N at the provincial level) and provincial characteristics. Estimated correlations will be downwards biased, given sampling error in our estimates of provincial NFA rice consumption. This said, estimated NFA rice consumption is not significantly correlated with provincial mean incomes or poverty headcounts. Correlations with local prices are also low and insignificant, implying that tight rice markets do not receive much more subsidized rice either. In fact, there are only two measurable trends. First, more rice is received per person in provinces with denser road networks. Thus it seems to reach places that are easy to service (i.e. low R markets), rather than those that need it because prices or poverty are high. This result echoes findings from studies of a range of subsidized products, including food aid in Ethiopia (Jayne et al., 2002), and kerosene in India (Rehman et al., 2005). This was predicted by our theory under Regime 3, and is consistent with our theory under Regime 1.

Second, more NFA rice is received in low population density areas. This is harder to interpret in terms of our model because population density has ambiguous effects on R (population density increases the cost of service if it brings scale economies, or reduces it if it creates congestion), and F (large groups of consumers may find it harder to take collective action against errant agents, but may be more forceful when they do).

Where does more NFA rice go missing? Figure 7 plots the estimated per-capita consumption of NFA rice against the official distribution figures, by region, weighted by population. Estimates for all but one region are to the southeast of the 45° line, but are widely dispersed, suggesting that pilferage occurs everywhere, but to differing degrees. Figure 8 suggests little relationship between the amount of rice the NFA pushes into the system (our regional estimate of NA) and the fraction of it that goes missing. Figure 9 shows significantly lower rates of pilferage in poorer regions. Together, these charts imply that redirecting NFA rice towards poorer regions may reduce pilferage.

7. Market Clearing: Rationing and Quality Variations

7.1. Some crude evidence

Figure 10 shows that most households purchase very little NFA rice. As NFA rice was cheaper than market rice (BAS data confirm that this was so) this must imply that NFA rice was either less desirable ($q < 1$), rationed $\left(N^* < N^D\left(q^*\right)\right)$, or both.

A simply tally reveals that 48% of PSUs outside the NCR contain no interviewed households who consume NFA rice. To gain some sense of

whether local non-participation is likely to be driven by suppply or demand, Table 3 provides the correlations, across primary sampling units, between the a variable indicating that a PSU contains NFA rice consumers, and some PSU and province-level variables. The PSUs most likely to contain NFA consumers are rural, poor, less-educated, and have higher rice prices and larger families, all of which suggests that the absence of participants is demand driven. However, those with lower employment rates and fewer roads are also less likely to have participants, consistent with the possibility that some markets are completely rationed out of the program.

7.2. Regression based evidence on market clearing

Note that demand operates on two margins - the extensive margin (households choose whether or not to buy NFA rice); and the intensive margin (they decide how much to buy). The main difficulty is that demand on the intensive margin is unobserved if it is rationed. However, we argue that we can capture the correlates of demand on the extensive margin by observing which households in participating markets do and do not consume NFA rice. There is a long tradition in the literature on limited dependent variables and disequilibrium markets, of interpreting latent variables in terms of supply and demand (e.g. Lee and Trost, 1978; Maddala and Nelson, 1974). This requires a separation assumption. Ours is that everybody in a market that has NFA consumers who wishes to consume NFA rice does so, and nobody consumes it without wishing to. We believe this is plausible because NFA rice is delivered to most local markets weekly, and the anecdotal evidence suggests that while most markets do not receive enough rice weekly to meet weekly demand, they usually receive some rice every week. Therefore, a household with positive (extensive) demand for NFA rice is extremely likely to be able to buy some rice in the year. Formally, if p is the (serially uncorrelated) probability of receiving no ration in a given week, the probability that a household that desires NFA rice participates is $1 - p^{52} \approx 1$. Households who want no NFA rice will not participate. Obviously, we exclude all households in PSUs reporting no \NFA rice consumption, to account for the possibility that the entire market is rationed out. This does not qualitatively alter the results, but is nevertheless conservative.

We therefore conduct Probit and Logit regressions of NFA participation decisions to uncover the determinants of demand on the extensive margin. So long as the fixed costs of NFA participation are small, demand on both margins will be closely correlated, and the model presented in Section 4 may be applied to interpret the results from the participation equation. The

independent variables are summarized in Table 4, and include a fairly comprehensive list of household characteristics, provincial retail prices of regular rice, and an array of other local characteristics. The local characteristics include sixteen regional dummies (to control for culture and preferences), and the sample-average value of each of the included household variables within the PSU.

If, controlling for rice prices, household characteristics, and region, participation varies significantly with other characteristics of the local market, this suggests quality variations that are correlated with local market characteristics.[12] The coefficients on provincial characteristics are unlikely to be contaminated by endogeneity, and have a causal interpretation. Classical attrition bias due to sampling error in the measurement of local, PSU-level variables will lead us to underestimate their significance. This biases us against finding evidence of quality variation.

Table 5, columns 1-2 provide participation regression results. All household variables enter with intuitive signs: households with a higher percentage of teenagers have greater demand for NFA rice, as do poorer and less educated households and those who do not farm. TV-ownership, which we include as a proxy for class, reduces participation. Households whose heads are employed are more likely to buy NFA rice, which may reflect the fact that employment is associated with mobility and one may have to travel modest distances to purchase NFA rice (World Bank, 2001). Resolving the ambiguity of equation (1a), demand for NFA rice rises with retail prices of regular-milled rice. Thus any indirect, quality-driven effects of tighter rice markets are dominated by their direct effects on demand.

The results also suggest that quality varies with local market conditions: despite the inclusion of many control variables, some local market characteristics do influence participation. Markets in provinces with higher road density and lower population density have higher NFA participation. This recalls the findings in the previous section from cross-province correlations that high road density and low population density promote NFA consumption. Whereas that finding indicated that N^* is higher in less remote and less densely populated provinces, this finding suggests that $N^D(q^*)$, and

[12] The only alternative interpretation of evidence that demand varies systematically across local markets that has been suggested to us involves neighborhood effects –class concerns or information spillovers may render households more likely to purchase NFA rice if their neighbors buy it. However, such an explanation on its own would not account for the fact that markets with particular characteristics are more likely to buy it than others.

therefore q^* itself, are higher in these areas. The Logit specification also suggests weakly that richer communities obtain better service, consistent with the model under both regimes if high-income communities are better able to hold agents accountable.

The OLS regression in column (3) of Table 5 captures the correlates of the quantity of NFA rice consumed, conditional on participation. The coefficients have no structural interpretation if rice is rationed. However these coefficients are usefully compared with those from the participation equations. If there were no rationing, and no unmeasured fixed costs of participation, the quantity consumed and the quantity demanded would coincide, and a Tobit model would adequately capture both participation and quantity. Appendix B reports on tests that reject the suitability of the Tobit model.

More can be learned simply by comparing the signs of coefficients on market-level variables in the participation and quantity regressions. Participation is higher in low income locations (significantly so, in the probit regression) and those with high regular rice prices (significant in both regressions). Yet, we saw, in section 6 that provincial NFA rice consumption per capita (unconditional on the share of the population participating) does not vary with income and price. Thus, local markets with lower incomes and higher rice prices would be expected to experience tighter rations. Indeed, the quantity regression confirms this expectation. Conversely, higher road densities and lower population densities increase both participation rates and quantities purchased conditional on participation, but this is reconcilable with the fact that provincial per capita NFA rice consumption unconditional on participation is increased by these factors as well (Section 6). The data are therefore fully consistent with the existence of rationing, even though the NFA had no rationing rules at the time.

Providing further comfort, every household variable that is significant in the both the participation and quantity regressions appears with the same sign in each of them. This is as expected, given that the amount of rationing is determined by local market conditions, not household variables. It also suggests that, controlling for quality, the household level determinants of demand on both margins are similar.

The coexistence of pilferage and rationing implies that the market clears as per Regime 1.

7.3. Determinants of, and responses to quality

The model underscores that latent demand depends on the interaction of unobserved quality and other observed variables. Wooldridge (2002, p. 67)

introduces an NLS model capable of capturing this situation when quantity demanded is observed so long as good proxies for quality are included. We adapt this specification to estimate the determinants of household participation decisions using a Logit model with latent demand that is nonlinear in household and local market variables:

$$N^D = \alpha + \boldsymbol{\beta}_z'\mathbf{z} + \beta_P P_R + \beta_M M_{HH} + \boldsymbol{\gamma}'\mathbf{q}\left(1 + \boldsymbol{\delta}'\mathbf{v}\right) + u; \tag{4}$$

where $\mathbf{q}$ is a vector of PSU- and province-level variables that proxy for NFA service quality, $\mathbf{v}$ contains variables determining the sensitivity of demand to quality, $\mathbf{z}$ contains household controls, and M_{HH} is household income. The greek symbols capture parameters. The error, u, has a logistic distribution, and a household participates if and only if $N^D \geq 0$. This specification nests the derivatives of demand in equations (1a) and (1c), and several parameter values are helpful for testing our modeling assumptions and comparative statics results.

For estimation purposes we drop the representative household assumption, distinguishing between household income and average local income. Higher household income is expected to directly reduce NFA demand (i.e. under A3, $\beta_M < 0$), but also to increase the responsiveness of NFA demand to NFA quality (i.e. under A5, household income should enter $\boldsymbol{\delta}'\mathbf{v}$ positively). Quality, on the other hand, depends on local income, not household income, so that per the full comparative statics of Regime 1, local income should enter $\boldsymbol{\gamma}'\mathbf{q}$, positively if and only if agents are more accountable to the rich. Similarly, under Regime 1, higher local prices of regular rice should directly lift demand for NFA rice (under A2, $\beta_P > 0$), but their effects on quality is an empirical question. We also allow regular rice prices to alter sensitivity to quality in one variant of the specification, expecting less quality responsiveness when rice is scarce. Finally, we expect remoteness, proxied for by road density, to reduce quality.

Table 6 presents estimates of two variants of this specification. All significant control variables take on expected signs and are at least marginally significant. Higher regular rice prices directly increase demand for subsidized rice and reduce sensitivity to quality. We also find that high prices reduce quality, suggesting that more desperate consumers hold less sway over NFA agents (i.e. F is negatively correlated with P_R). Controlling for quality, richer households consume significantly less NFA rice, confirming that it is an inferior good. They are also more responsive to quality. Quality, in turn, rises with local incomes confirming that NFA agents are more accountable to the rich. Finally, quality rises with road density, confirming

the remoteness reduces quality. Thus, the broad predictions of our model of demand with endogenous quality variations are confirmed, and none of its assumptions are invalidated. The takeaway from this analysis is that quality is lower and rations are tighter in remote, poor localities in which rice is scarce lends.

Finally, we calculate the Spearman rank correlation coefficient between PSU-level quality in 2006, imputed post-estimation, and the rate of rice price inflation for the province between 2003 and 2007. It is -0.389, and the p-value on the null of independence is zero. This, and the regression results, lend credence to our explanation that hunger rose in the Philippines despite large food subsidies because the NFA is not substantially in control of the quality of service in its marketing channel, and so could not prevent prices from rising fast in poorer and more remote locations.

8. Policy Implications

We subscribe to the institutional perspective that changes to food security policy must be considered on a case by case basis, taking local economic conditions, culture and politics into account . We therefore limit our policy remarks to the Philippines case. However, the exercise shows how a combination of theoretical modeling and empirical tests can illuminate the design of policy in other environments.

Our policy implications for the Philippines revolve around three findings: First, quality appears to be lower in poorer areas with tighter rice markets – probably the very markets that have seen the most rapid rise in hunger. Second, widespread rationing of subsidized rice implies that quality variations do not suffice to clear the market - there is significant rationing, Because no official rationing rules existed in 2006, such rationing was probably ad-hoc – a finding confirmed anecdotally. Third, pilferage is rife. This implies that the allotment of NFA rice to local markets is a slack variable. Overall the picture that emerges is one of chaos - not a random chaos, but one that systematically deprives the poor and remote of the benefits of food subsidies.

This analysis recommends the following policy changes: An official, widely publicized, rationing scheme should be introduced. Rations entail not only upper limits on consumption, but also entitlements, which would empower consumers to demand better service. They would also reduce inconvenience from ad-hoc rationing rules, and permit NFA managers to calculate (at least at an upper bound) how much rice is needed to eliminate additional, unofficial, ad-hoc rationing in each local market. Our work sheds

no light on the appropriate size of these rations, but previous studies from markets with rationing schemes have shown that the effects of subsidies on nutrition and local market prices (Ramaswami and Balakrishnan, 2002) are largest when poor households' rations cover their entire demand. This, together with budgetary constraints, implies that rations must be targeted. If our analysis of the causes of rising hunger is correct, then geographic and temporal targeting will help: poorer regions should be allocated higher rations, and rations should be raised when local rice prices spike. Our finding that pilferage is lower in poorer areas reinforces the view that more geographic targeting would be benign at worst.

The second key policy improvement would be greater transparency with respect to how much rice has been sent where. This would make it much easier to detect pilferage at the local level, and so to prevent it.

Third, we have shown quality is influenced by political considerations (otherwise quality wouldn't fluctuate with income when demand is nonbinding), so improving feedback mechanisms should empower consumers to demand better service. Future research should examine what institutional changes would be effective in this regard.

Fourth, because the allotment is a slack variable, holding quality constant, reducing the quantity of rice provided to local markets marginally would reduce pilferage kilo for kilo, saving taxpayer money with no effect on consumer welfare. At the time of writing, policy proposals are being discussed by a newly elected government which include massive cuts to allotments and increases in the price of subsidized rice. Our suggestion that cuts to subsidized rice allotments would be welfare-neutral does not extend to large cuts that could reduce the amount of rice actually sold to consumers at subsidized prices.

What of changes to consumer subsidies? The direct effect of subsidy reductions is to reduce welfare by increasing the cost of food. However, we have shown that its indirect effect on consumer welfare would be positive, because it raises the quality of rice. Reduced form participation regression results show greater participation in markets with the deepest subsidy, suggesting that the direct effects dominate and subsidy reductions would be welfare reducing. We therefore conclude that institutional reforms to empower consumers to demand higher quality service, explicit rationing rules favoring the poor and those in tough rice markets, and small reductions in the size the program provide a more sound policy mix than the removal of price distortions if food security concerns trump efficiency concerns.

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A. Appendix A: Comparative statics

For notational convenience, define:$B = c_{q,N} + S_{q,N}$, $C = c_{q,q} + S_{q,q}$ and $D = c_{N,N} + S_{N,N}$. Note that $B, C, D > 0$.

A.1. Regime 1

With non-binding demand, the objective function reduces to: $L = P_N N - c(q, N, p_w, R) + (P_R - P_W)(N_A - N) - S(q, N, F)$, with negative definite hessian matrix H, and $|H| = CD - B^2 > 0$. The comparative statics results are then calculated in the usual way as:

1. P_N: $\frac{\partial N^*}{\partial p_N} = \frac{C}{|H|} > 0, \frac{\partial q^*}{\partial p_N} = \frac{-B}{|H|} < 0$. Intuitively, obtaining a higher price for the subsidized product leads to increases in the amount of subsidized product sold. Quantity then substitutes for quality.

2. P_W: Subsidized product may be adulterated. Therefore, higher procurement prices increase the cost of subsidized rice by less than the price increase. Thus, $E = (1 - c_{N,P_W}) \geq 0$, and it follows that: $\frac{\partial N^*}{\partial p_W} = \frac{1}{|H|}\left[CE + Bc_{q,Pw}\right] > 0$, $\frac{\partial q^*}{\partial p_W} = \frac{1}{|H|}\left[-CB + -Dc_{q,P_W}\right] < 0$. Higher procurement prices reduce the margins on pilferage, increasing the quantity sold at subsidized prices. Quantity then substitutes for quality
3. F: $\frac{\partial N^*}{\partial F} = \frac{1}{|H|}\left[\underbrace{-CS_{N,F}}_{(+)} + \underbrace{BS_{q,F}}_{(-)}\right] \gtrless 0$, $\frac{\partial q^*}{\partial F} = \underbrace{\frac{-DS_{q,F}}{|H|}}_{(+)} + \underbrace{\frac{BS_{N,F}}{|H|}}_{(-)} \gtrless 0$. Increased accountability does not necessarily increase the quality or quantity of subsidized rice sales. This is because increased accountability has both direct effects ($-CS_{N,F} > 0$ and $-DS_{q,F} > 0$), and substitution effects (i.e. quality increases induce quantity decreases). However, accountability increases will not reduce both quantity and quality. To see this, suppose that $\frac{\partial N^*}{\partial F} < 0$. This implies that $-S_{q,F} > -S_{N,F}\frac{C}{B}$. But then $\frac{\partial q^*}{\partial F} = \frac{1}{|H|}\left[-S_{q,F}D + S_{N,F}B\right] > \frac{1}{|H|}\left[-S_{N,F}\frac{C}{B}D + S_{N,F}B\right] = \frac{1}{|H|}\left(\frac{-S_{N,F}}{B}\right)\left[CD - B^2\right] = \left(\frac{-S_{N,F}}{B}\right) > 0$. The converse is proven in the same way.
4. N_A: Allotments are irrelevant.
5. R : $\frac{\partial N^*}{\partial R} = \frac{1}{|H|}\left[\underbrace{-Cc_{N,R}}_{(-)} + \underbrace{Bc_{q,R}}_{(+)}\right] \gtrless 0$, $\frac{\partial q^*}{\partial R} = \frac{1}{|H|}\left[\underbrace{-Dc_{q,R}}_{(-)} + \underbrace{Bc_{N,R}}_{(+)}\right] \gtrless 0$. However, remoteness cannot increase both quality and quantity. The proof parallels that for the effects of F.
6. P_R: $\frac{\partial N^*}{\partial p_R} = \frac{-C}{|H|} < 0$, $\frac{\partial q^*}{\partial p_R} = \frac{B}{|H|} > 0$. If prices are high, agents have incentives steal more, and then substitute quality for quantity.
7. M: Income is irrelevant because demand is non-binding.

A.2. Regime 2

With N fixed at N_A, the objective function reduces to: $L = P_N N_A - c\left(q, N_A, p_w, R\right) - S\left(q, N_A, F\right)$, with second derivative $L_{qq} < 0$.

1. P_N: $\frac{\partial q^*}{\partial P_N} = 0$. Because the quantity sold at subsidized prices is fixed, retail prices are irrelevant.
2. P_W: $\frac{\partial q^*}{\partial P_w} = \frac{c_{qP_w}}{Lqq} < 0$. Raising procurement prices increases the cost of quality

3. F: $\frac{\partial q^*}{\partial F} = \frac{S_{qF}}{Lqq} > 0$. More accountability increases the benefts of quality.
4. N_A: $\frac{\partial q^*}{\partial N_A} = \frac{S_{qN}+c_{qN}}{L_{qq}} < 0$. More rice to distribute reduces the cost but increases the benefits of quality.
5. R: $\frac{\partial q^*}{\partial R} = \frac{c_{qR}}{Lqq} < 0$. It is more expensive to provide quality service in remote areas.
6. P_R: $\frac{\partial q^*}{\partial P_R} = 0$. Because the quantity sold at subsidized prices is fixed, retail prices are irrelevant.
7. M: Income is irrelevant because demand is non-binding.

A.3. Regime 3

With N constrained to meet demand, the Lagrangian function is: $L = P_N N - c(q, N, p_w, R) + (P_R - P_W)(N_A - N) - S(q, N, F) + \lambda\left[N^D(P_N, P_R, M, q) - N\right]$, with bordered hessian matrix H_B, and $|H_B| = C + 2N_q^D B + \left(N_q^D\right)^2 D - \lambda N_{qq}^D > 0$. The comparative statics results are then calculated in the usual way as follows. Note that intuitively, because quantity is constrained to operate on the demand curve, any variable that does not directly shift the demand curve only changes quantity because it shifts quality. For notational convenience, let $G = -\lambda N_{q,q}^D + C + 2BN_q^D + D\left(N_q^D\right)^2 > 0$.

1. P_N: $\frac{\partial q^*}{\partial P_N} = \underbrace{\frac{1}{|H_B|}}_{(+)}\left[\underbrace{-N_{P_N}^D(B+D)}_{(+)} + \underbrace{N_q^D}_{(+)} + \underbrace{\lambda N_{P_N,q}^D}_{(?)}\right] \gtrless 0$. Price increases have three effects: (1) They reduce the quantity over which quality must be assured; (2) Prices are higher at the margin, so it is more helpful to raise quality to permit more sales at this price; and (3) Increasing demand through quality changes carries a benefit of λ on the margin, but, since we are not sure whether demand is more or less senstive to quality as the subsidy is reduced, we don't know in which direction. The first two effects encourage higher quality. The third encourages quality if demand becomes more responsive to quality at higher prices. If this is the case, deeper subsidies will imply lower quality service.
   Raising prices has two effects: (1) It directly reduces demand; (2) It induces (ambiguous) changes in quality which in turn shift demand. $\frac{\partial N^*}{\partial P_N} = \underbrace{\frac{1}{|H_B|}G\frac{\partial N_D}{\partial P_N}}_{(-)} + \underbrace{\frac{\partial N_D}{\partial q}\frac{\partial q^*}{\partial P_N}}_{(?)} \lessgtr 0$.If $N_{P_N,q}^D > 0$, then the effects will work in opposing directions.

2. P_W: As discussed under Regime 1, higher procurement prices increase the cost of subsidized rice by less than the price increase. Thus, $E = (1 - c_{N,P_W}) \geq 0$. Then $\frac{\partial q^*}{\partial P_W} = \underbrace{\frac{1}{|H_B|}}_{(+)} \left[\underbrace{EN_q^D}_{(+)} + \underbrace{(-c_{P_W,q})}_{(-)} \right] \gtrless 0$. Intuitively, procurement price increases have ambiguous effects, because they induce increases in quality in order to expand the market, but also increase the marginal cost of quality. Because procurement prices only Procurement prices only alter quantity by shifting, $\frac{\partial N^*}{\partial p_W} = N_q^D \frac{\partial q^*}{\partial P_W} \lesseqgtr 0$.
3. F: Increased accountability increases quality: $\frac{\partial q^*}{\partial F} = \frac{-S_{q,F}}{|H_B|} + \frac{N_q^D(-S_{N,F})}{|H_B|} > 0$; and therefore, quantity: $\frac{\partial N^*}{\partial F} = N_q^D \frac{\partial q^*}{\partial F} > 0$.
4. N_A: Allotments, being, non-binding, are irrelevant.
5. R: Remoteness increases the cost of quality: $\frac{\partial q^*}{\partial R} = \frac{-N_q^D c_{N,R} - c_{q,R}}{|H_B|} < 0$; and the loss of quality reduces demand: $\frac{\partial N^*}{\partial R} = N_q^D \frac{\partial q^*}{\partial R} < 0$.
6. P_R: Regular retail prices, which enter the constraint, have ambiguous effects on quality: $\frac{\partial q^*}{\partial P_R} = \frac{1}{|H_B|} \left(\underbrace{-N_{P_R}^D \left(B + DN_q^D \right) - N_q^D}_{(-)} \right) + \underbrace{\frac{\lambda}{|H_B|} N_{P_R,q}^D}_{(?)} \gtrless 0$, unless $N_{P_R,q}^D < 0$; and therefore on quantity: $\frac{\partial N^*}{\partial P_R} = \underbrace{\frac{1}{|H|} G \frac{\partial N_D}{\partial P_R}}_{(+)} + \underbrace{N_q^D}_{(+)} \underbrace{\frac{\partial q^*}{\partial P_R}}_{(?)} \lesseqgtr 0$. The intuition is the same as for P_N.
7. M: Richer localities have lower demand, which increases the net benefits of quality, and demand in richer localities is more sensitive to quality. Therefore quality increases in income. $\frac{\partial q^*}{\partial M} = \frac{-N_M^D \left(B + DN_q^D \right)}{|H_B|} + \frac{\lambda N_{M,q}^D}{|H_B|} > 0$. The direct (Engel) and indirect (quality) effects of higher income therefore oppose each other. $\frac{\partial N^*}{\partial M} = \underbrace{\frac{1}{|H|} G N_M^D}_{(-)} + \underbrace{\frac{\partial N_D}{\partial q}}_{(+)} \underbrace{\frac{\partial q^*}{\partial M}}_{(+)} \lesseqgtr 0$.

B. Appendix B: Tobit specification test

Consider a Heckman selection model, given by:

$$\begin{aligned} z_i^* &= \boldsymbol{\beta}_z' \mathbf{x}_i + \boldsymbol{\gamma}' \mathbf{y}_i + u_i;\ z_i = \begin{cases} 1 \text{ if } z_i^* \geq 0 \\ 0 \text{ otherwise} \end{cases}; \\ N_i^* &= \boldsymbol{\beta}_N' \mathbf{x}_i + e_i; \\ V(u_i, e_i) &= \begin{pmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{pmatrix} \end{aligned}$$

The independent variables $\mathbf{x}$ are those utilized in our regressions and are common to both equations. The variables in $\mathbf{y}$ are introduced to improve the identification of ρ. We use television and radio ownership for this purpose. As indicators of class, these variables could effect willingness to participate in a government program for the poor, but should not effect how much of that rice households wish to buy, once we control for income and education.

This collapses to the Tobit specification when $\boldsymbol{\beta}_z = \boldsymbol{\beta}_N$, $\boldsymbol{\gamma} = \mathbf{0}$ and $\rho = 1$. With clustering, likelihood ratio tests are unavailable, so Wald tests are used. The three restrictions are rejected individually, in pairs, and all together, all with p-values of 0.00. The estimated value of ρ is -0.12, and is statistically different from zero at better than 2.5% significance, suggesting that quantity decreases when demand is high - consistent with rationing.

Table 1: Effects of Incresaes in Exogenous Variables on (N,q)

Variable	**Regime 1** No constraints	**Regime 2** N fixed at N_A	**Regime 3** N constrained to equal $N^D(q^*)$
Subsidized Price (P_N)	$N \uparrow, q \downarrow$	No effect	N ambiguous, $q \uparrow$ if $\frac{\partial^2 N^D}{\partial P_N \partial q} > 0$
Procurement Price (P_W)	$N \uparrow, q \downarrow$	$q \downarrow$	Ambiguous
Accountability (F)	At least one rises	$q \uparrow$	$N \uparrow, q \uparrow$
Rice Allotment (N_A)	No effect	$N \uparrow, q \downarrow$	No effect
Remoteness (R)	At least one falls	$q \downarrow$	$N \downarrow, q \downarrow$
Regular retail Prices (P_R)	$N \downarrow, q \uparrow$	No effect	N ambiguous, $q \downarrow$ if $\frac{\partial^2 N^D}{\partial P_R \partial q} < 0$
Income (M)	No effect	No effect	N ambiguous, $q \uparrow$

Table 2

Correlations with estimated per capita NFA rice consumption across provinces

	Correlate	Correlation Coefficient	p-value	# of Provinces
Income				
	Average Per Capita Income	0.077	0.497	81
	Poverty Headcout Index	0.020	0.861	81
Prices				
	Annual Retail Price - Regular Milled Rice	0.166	0.140	81
	Peak (July) Retail Price - Regular Milled Rice	0.075	0.507	80
	Annual Wholesale Price - Regular Milled Rice	0.185	0.124	71
	Peak (July) Wholesale Price - Regular Milled Rice	0.142	0.237	71
Other				
	Road Density (km of road /km^2 of area)	0.413	0.000	76
	Population Density (Persons/km^2)	-0.216	0.053	81

Note: Correlations are estimated from FIES and BAS data. National Capital Region is excluded.

Table 3

Correlations with PSU-Level NFA Participation Rates

Correlate	Correlation Coefficient	P-value	# of PSUs
Average Per Capita Income	-0.149	0.000	2,604
Average Years of Schooling of HH Heads	-0.134	0.000	2,604
Average Household Size	0.056	0.004	2,604
Urban (0=No, 1=Yes)	-0.096	0.000	2,604
Annual Retail Price - Regular Milled Rice	0.038	0.054	2,604
Road Density (km of road /km^2 of area)	-0.078	0.000	2,477
Employment Rate	0.103	0.000	2,604

Note: Correlations are estimated from FIES and BAS data. National Capital Region is excluded.

Table 4

Descriptive Statistics for regression samples and variables

Variables	# of Obs.	Mean	Std. Dev.	Min	Max
Household Variables					
HH consumes NFA rice (1=yes, 0=no)	32,322	0.14	0.35	0.00	1.00
Per Capita Expenditure on NFA Rice (pesos/month)					
- All Households	17,332	260.25	620.04	0.00	6,145.46
- Only NFA rice consuming households	4,719	955.84	864.41	2.00	6,145.46
HH Income per capita (Pesos/year)	17,332				
Years of schooling completed by HH Head	17,332	7.28	3.80	0.00	14.00
# of Persons in HH	17,332	4.92	2.23	1.00	30.50
Is the HH Head Employed? (0=No, 1=Yes)	17,332	0.86	0.34	0.00	1.00
Sex of HH Head (0=Male, 1=Female)	17,332	0.17	0.38	0.00	1.00
Age of HH Head	17,332	49.01	14.12	13.00	99.00
Is the HH Head a farmer? (0=No, 1=Yes)	17,332	0.17	0.38	0.00	1.00
# of non-relatives living in HH	17,332	0.01	0.05	0.00	0.80
Fraction of Family members aged 1-6	17,332	0.12	0.16	0.00	0.80
Fraction of Family members aged 7-14	17,332	0.18	0.19	0.00	1.00
Fraction of Family members aged 15-24	17,332	0.16	0.20	0.00	1.00
Fraction of Family members aged 25-59	17,332	0.40	0.23	0.00	1.00
Fraction of Family members aged > 60	17,332	0.13	0.26	0.00	1.00
Radio Ownership (0=No, 1=Yes)	17,332	0.56	0.50	0.00	1.00
TV Ownership (0=No, 1=Yes)	17,332	0.61	0.49	0.00	1.00
Sample Weight	17,332	423.53	127.00	158.00	1,303.00
Local Variables					
Average Income Per Capita in PSU	1,271	32.38	21.31	5.85	292.62
Average Year of Schooling of HH Heads in PSU	1,271	7.28	2.03	1.25	13.14
Average # of persons per HH in PSU	1,271	4.92	0.71	2.50	8.50
Fraction of HH Heads in PSU that are empoyed	1,271	0.86	0.12	0.33	1.00
Urbanity of the PSU (0=rural, 1=urban)	1,271	0.36	0.48	0.00	1.00
Provincial Variables					
Provincial Road Density (km/ 100 km^2)	75	0.12	0.06	0.01	0.36
Population Density (Persons/km^2)	75	357.52	332.14	27.72	2,018.19
Banks per Capita (Banks/1,000 Persons)	75	0.06	0.03	0.01	0.18
Annual retail price of regular-milled rice (pesos/kg)	75	21.24	1.09	18.54	25.00

Note: These descriptive statistics have not been weighted by household weights. Descriptive statistics for local, provincial and regional variables are weighted by the number of households sampled in each distinct observed unit. The sample is the same as that used for all participation regressions, and excludes all PSUs that report no NFA rice consumption.

Table 5

Determinants of NFA rice consumption on the intensive and extensive margins, Reduced Form

Independent Variables	Participation Probit (1)	Participation Logit (2)	Quantity OLS (3)
Constant	-3.539 ***	-6.015 ***	1,324.403 ***
Household Variables			
HH Income per capita ('000s of Pesos/year)	-0.010 ***	-0.024 ***	0.773 ***
Years of schooling completed by HH Head	-0.039 ***	-0.059 ***	-4.973
# of Persons in HH	0.019 ***	0.024 **	-24.170 ***
Is the HH Head Employed? (0=No, 1=Yes)	0.108 ***	0.183 ***	75.546 *
Sex of HH Head (0=Male, 1=Female)	0.039	0.075	0.009
Age of HH Head	-0.002 **	-0.003 *	-0.459
Is the HH Head a farmer? (0=No, 1=Yes)	-0.227 ***	-0.395 ***	-91.402 ***
# of non-relatives living in HH	0.255	0.068	445.877
Fraction of HH members aged 1-6	0.430 **	0.700 **	402.340 **
Fraction of HH members aged 7-14	0.619 ***	1.030 ***	642.271 ***
Fraction of HH members aged 15-24	0.499 **	0.891 ***	934.003 ***
Fraction of HH members aged 25-59	0.413 **	0.780 **	744.515 ***
Fraction of HH members aged > 60	0.408 **	0.729 **	793.950 ***
Radio Ownership (0=No, 1=Yes)	-0.030	-0.051	-25.857
TV Ownership (0=No, 1=Yes)	-0.283 ***	-0.420 ***	-89.991 ***
Local Variables			
Average Income Per Capita in PSU	0.002	0.003 **	-1.673 **
Average Years of Schooling of HH Heads in PSU	0.023 **	0.037 *	7.176
Average # of persons per HH in PSU	0.031	0.062	8.281
Fraction of HH Heads in PSU that are empoyed	-0.025	-0.033	-82.385
Urbanity of the PSU (0=rural, 1=urban)	-0.025	-0.028	75.593 ***
Provincial Variables			
Provincial Road Density (km/km^2)	2.583 ***	4.617 ***	2,927.303 ***
Population Density ('000s of People/km^2)	-0.348 ***	-0.624 ***	-578.796 ***
Banks per thousand persons	0.278	0.664	1,286.892 **
Annual retail price of regular-milled rice (pesos/kg)	0.130 ***	0.219 ***	-56.500 ***
# of Households Observed	17,332	17,332	4,719

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. National Capital Region is excluded. All regressions include regional dummy variables.

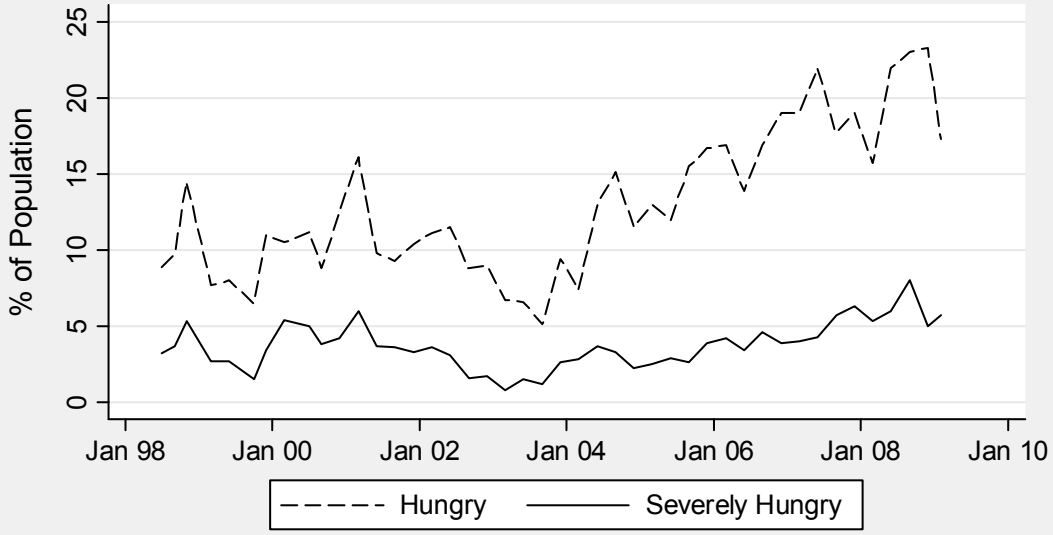
Table 6

Determinants of NFA rice consumption on the extensive margin, Structurally derived form.

Independent Variables	Specifications (1)	(2)
Constant	0.342	0.422
Direct Effects		
HH Income per capita ('000s of Pesos/year)	-0.026 ***	-0.027 ***
Years of schooling completed by HH Head	-0.053 ***	-0.055 ***
# of Persons in HH	0.019 *	0.017 *
Is the HH Head Employed? (0=No, 1=Yes)	0.185 ***	0.186 ***
Sex of HH Head (0=Male, 1=Female)	0.068	0.065
Age of HH Head	-0.002	-0.002
Is the HH Head a farmer? (0=No, 1=Yes)	-0.431 ***	-0.418 ***
# of non-relatives living in HH	0.317	0.214
Fraction of HH members aged 1-6	0.532	0.548
Fraction of HH members aged 7-14	0.813 **	0.825 **
Fraction of HH members aged 15-24	0.695 **	0.703 **
Fraction of HH members aged 25-59	0.586 *	0.573 *
Fraction of HH members aged > 60	0.584 *	0.579 *
Annual retail price of regular-milled rice (pesos/kg)	0.385 ***	0.319 ***
Banks per 1,000 persons (provincial)	-7.381 ***	-6.901 ***
Visayas	-0.983 ***	-1.035 ***
Mindanao	-0.589 ***	-0.634 ***
Does the household own a radio? (0=No, 1=Yes)	-0.028	-0.029
Does the household own a TV? (0=No, 1=Yes)	-0.402 ***	-0.409 ***
Effects on Quality		
Average Income Per Capita in PSU	0.004 ***	0.004 ***
Average Years of Schooling of HH Heads in PSU	0.011	0.015
Average # of persons per HH in PSU	0.104 ***	0.089 ***
Fraction of HH Heads in PSU that are empoyed	-0.017	0.050
Urbanity of the PSU (0=rural, 1=urban)	-0.066	-0.053
Provincial Road Density (km/km^2)	4.690 ***	3.964 ***
Population Density ('000s of People/km^2)	-0.535 ***	-0.515 ***
Annual retail price of regular-milled rice (pesos/kg)	-0.183 ***	-0.103
Effects on Sensitivity to Quality		
HH Income per capita ('000s of Pesos/year)	0.012 **	0.018 ***
Annual retail price of regular-milled rice (pesos/kg)	-0.360 ***	
# of Households Observed	17,332	17,332

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. National Capital Region is excluded.

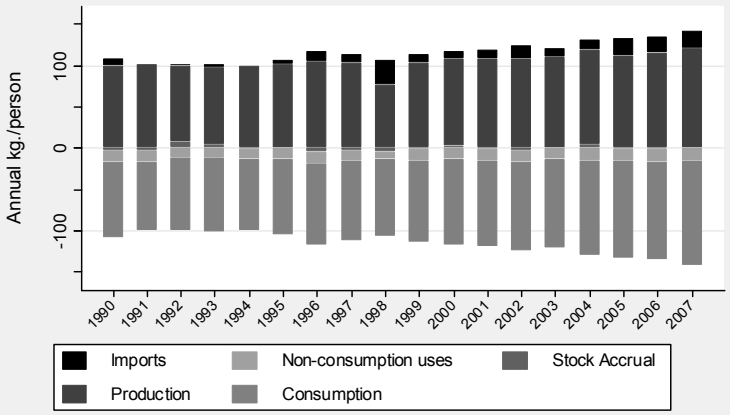
Figure 1. Self-Reported Hunger in the Philippines



Note: Severely hungry households report involuntarily going without food in the last 3 months. Hungry households report involuntarily going without food at least once in the last 3 months.

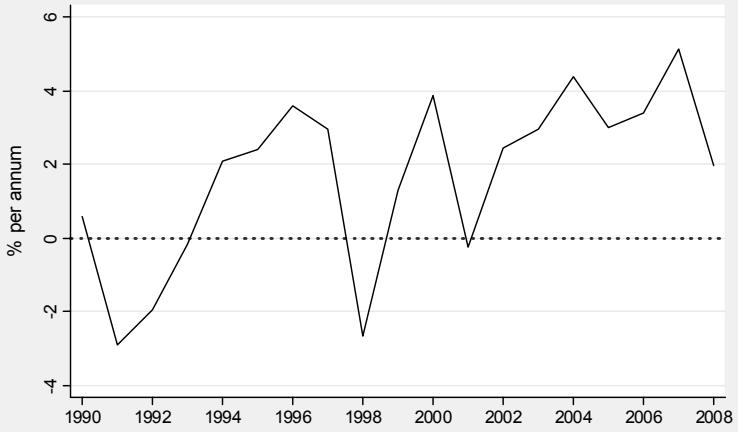
Source: Philippines Social Weather Stations (http://www.sws.org.ph/)

Figure 2. Per-Capita Rice Balances



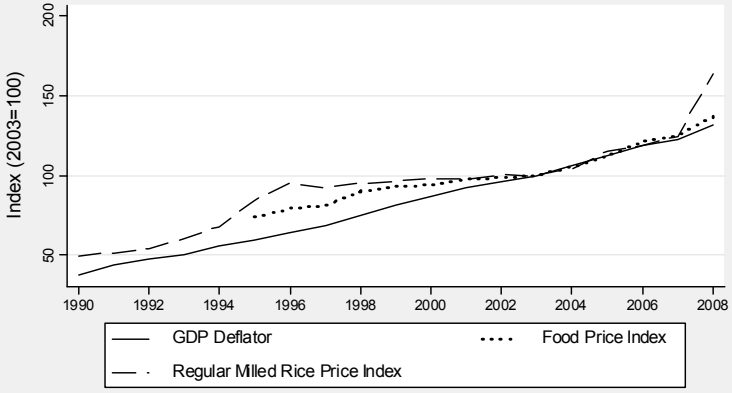
Source: Authors' calculations using data from the Philippines Bureau of Agricultural Statistics' CountrySTAT database.

Figure 3. Per-Capita GDP Growth



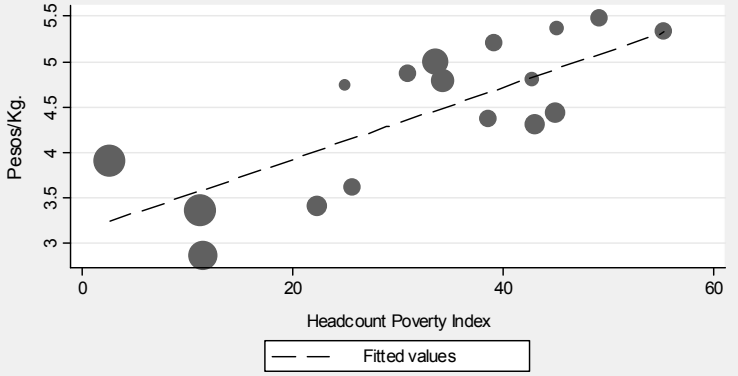
Source: World Development Indicators

Figure 4. Comparison of Price Indices
(National Aggregates)



Source: GDP deflator from World Development Indicators. Food and Rice Price Deflators from the Philippines Bureau of Agricultural Statistics' CountrySTAT database.

Figure 5. Retail Rice Price Change (2003-2007) vs. Poverty Rate (2006)
(by NFA Region, Population Weighted)



Source: Authors' calculations using data from the Bureau of Agricultural Statistics' CountrySTAT database.

Figure 6: Optimal Subsidized Rice Sales and Quality

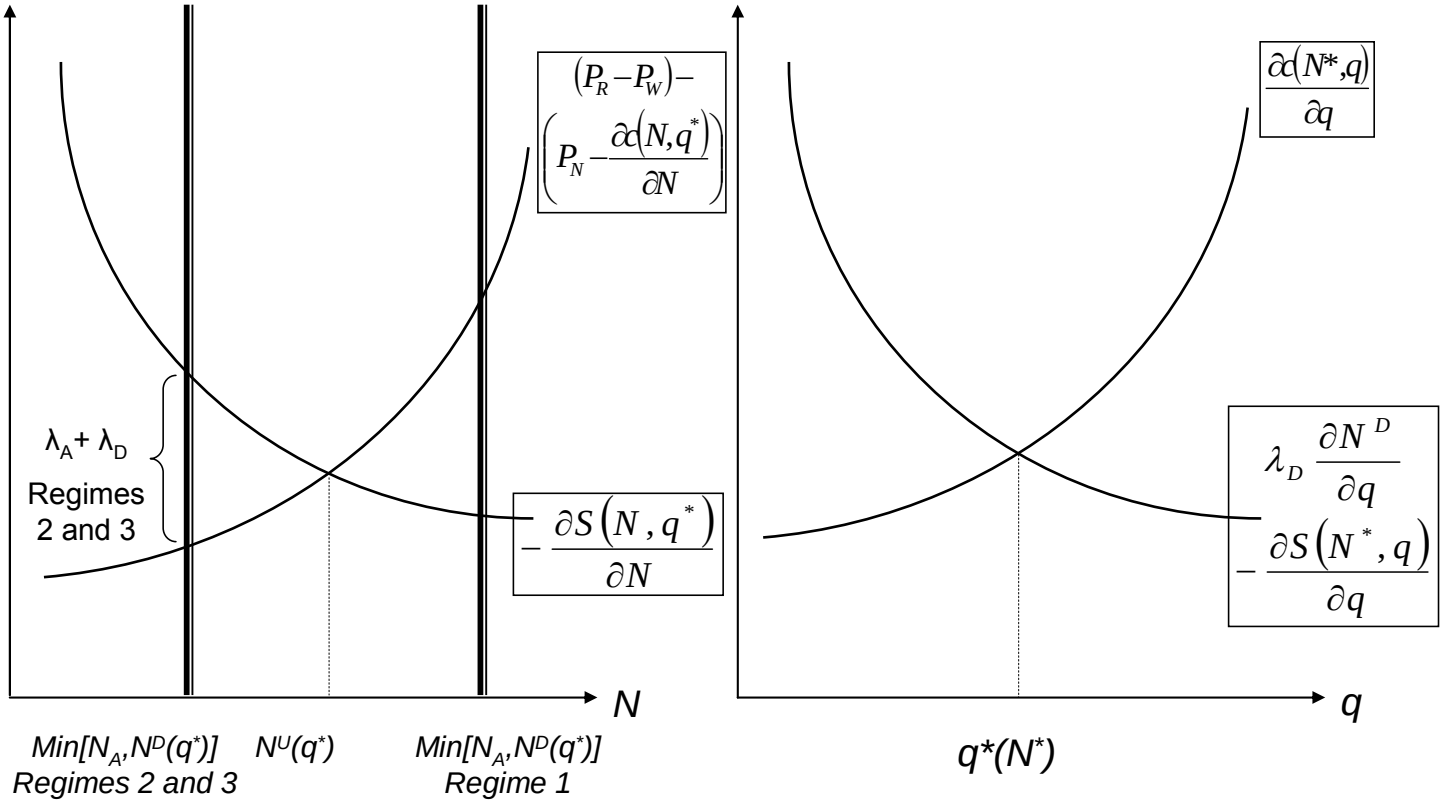
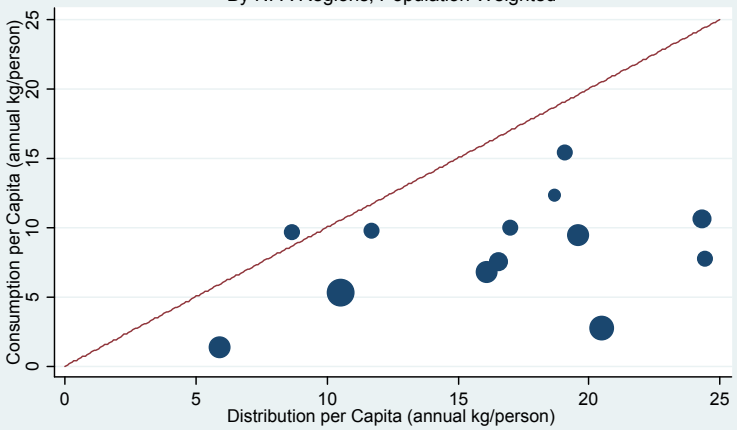


Figure 7: NFA Rice Distributed and Consumed

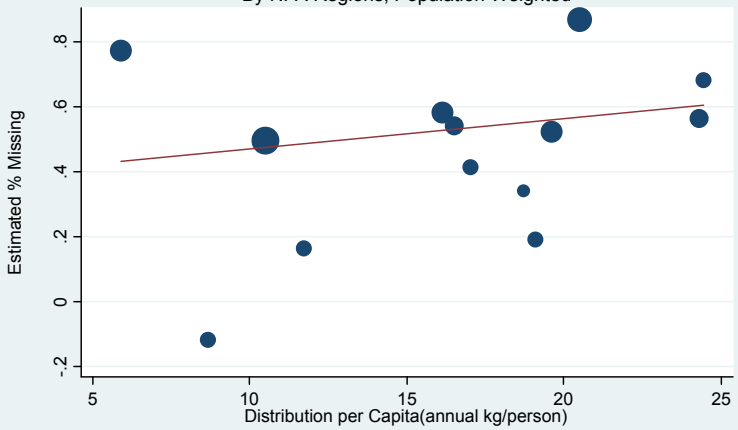
By NFA Regions, Population Weighted



Note: National Capital Region Excluded. Diagonal line is: y=x.
Source: Consumption estimated by authors from FIES; Official NFA figures used for distribution.

Figure 8: NFA Rice Distributed and the Fraction Missing

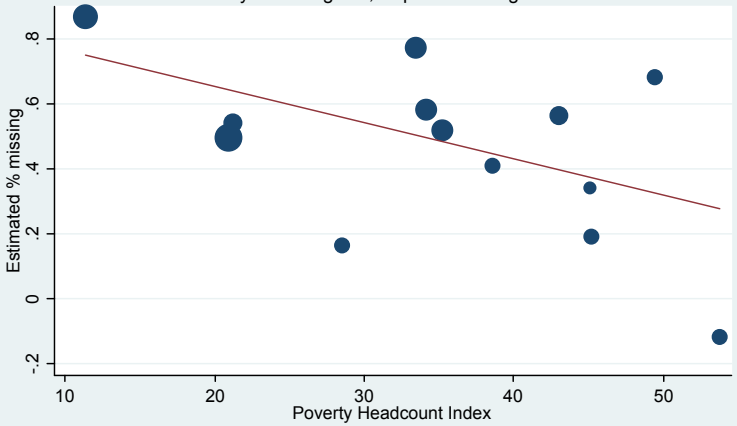
By NFA Regions, Population Weighted



Note: National Capital Region Excluded.
Source: Authors Calculation from FIES and official NFA distribution data

Figure 9: Poverty and the Fraction of Rice Missing

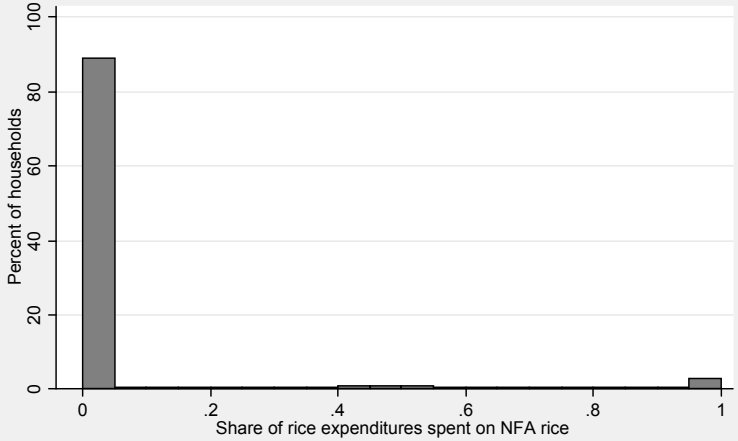
By NFA Regions, Population Weighted



Note: National Capital Region Excluded.
Source: Authors calculations from FIES 2006 and official NFA distribution data

Figure 10: Distribution of NFA Dependency Ratio

Across Households



Source: Calculations from FIES 2006, 33,087 non-NCR rice-consuming households.