

DO CONSUMER PRICE SUBSIDIES REALLY IMPROVE NUTRITION?

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Abstract—Many developing countries use food-price subsidies or controls to improve nutrition. However, subsidizing goods on which households spend a high proportion of their budget can create large wealth effects. Consumers may then substitute toward foods with higher nonnutritional attributes (such as taste) but lower nutritional content per unit of currency, weakening or perhaps even reversing the subsidy's intended impact. We analyze data from a randomized program of large price subsidies for poor households in two provinces of China and find no evidence that the subsidies improved nutrition. In fact, they may have had a negative impact for some households.

I. Introduction

A number of low-income countries use consumer price subsidies or price controls to protect or improve the nutrition of the poor. For example, both India and Egypt spend about 1% of GDP subsidizing basic foods such as rice and wheat, making them among the largest forms of social assistance in both countries.¹ Critics often attack such policies on the grounds that they distort market signals, lead to shortages, promote smuggling and black market activity, or in practice are poorly targeted and disproportionately benefit the least poor. However, the more fundamental question remains: Do food subsidies actually improve nutrition?

While the proposition that subsidizing the prices of staple foods will improve nutrition seems straightforward, the prediction from theory is ambiguous. Consider a simplified depiction of an impoverished consumer near a subsistence level of nutrition, whose diet consists of only two foods: a basic or staple good like rice, wheat, or maize and a “fancy” good like meat. The basic good offers a high level of calories at low cost, while the fancy good is preferred because of its taste but provides few calories per unit of currency. The poorest consumers will eat a lot of the staple in order to get enough calories and other nutrients to meet their basic needs, and they will use whatever money they have left over to purchase meat. As a result, consumers

spend a high fraction of their budget on, and receive most of their nutrition from, the staple. By lowering the cost of the staple, subsidies free up substantial funds to be spent in other ways, that is, they induce large wealth effects. As households respond by substituting toward the types of goods that wealthier households consume, they may switch away from these nutritious staples, which are typically strongly inferior goods, and toward foods such as meat that offer more taste or add variety to the diet but are more costly sources of nutrients,² or toward nonfood items. More generally, if consumers value the nonnutritional attributes of foods in addition to the nutritional attributes, the net nutritional consequences of a subsidy will depend on how consumers substitute among foods (as well as between food and nonfood items). If this substitution toward less nutritive foods is substantial enough, consumers may weaken or potentially even reverse the intended nutritional impact of the subsidies.

While price subsidy programs may be an effective welfare tool independent of their nutritional consequences, assessing their nutritional impact is important since nutritional objectives are often a primary justification for introducing such programs or for choosing them over other welfare policies. In addition, food-based welfare programs such as subsidies often enjoy greater public and political support than, for example, unconditional cash transfers, specifically because of the perception and general presumption that they improve nutrition, whereas there is no “control” over how cash would be spent by recipients. Finally, given the widespread incidence of undernutrition in the developing world,³ the commitment to addressing hunger stated in the first U.N. Millennium Development Goal, and the well-established links between nutrition and health and welfare, it is important to understand which programs most effectively address the problem.

Consumer price subsidies have been studied widely, with a particular focus on the incidence and targeting of such programs in practice (see Behrman & Deolalikar, 1988, for a summary). However, surprisingly few studies have considered their nutritional impact.⁴ Two notable exceptions are Kochar (2005), who finds that India's subsidy program has only a limited effect on caloric intake, and Tarozzi (2005), who finds similarly limited effects on children's weight in one state of India. However, as Kochar (2005)

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¹ Further, the use of such programs is expanding worldwide in response to recent increases in world food prices (World Bank, 2008).

² A large literature is concerned with estimating the income elasticity of demand for calories, including, for example, Behrman and Deolalikar (1987), Bouis and Haddad (1992), and Subramanian & Deaton (1996). See Strauss and Thomas (1995) and Deaton (1997) for summaries.

³ The FAO estimates that 850 million people worldwide are undernourished (Food and Agricultural Organization, 2006).

⁴ There have been assessments of the nutritional impacts of related programs. For example, Stifel and Alderman (2006) find that a program in Peru providing milk and milk substitutes had no effect on child nutrition.

notes, the limited impact of India's program is primarily due to low take-up rates and low purchases of subsidized goods conditional on take-up. The reasons for low take-up and use are unclear, although they may result from unique incentives under the program for shopkeepers to undersupply subsidized goods (Kochar, 2005).⁵ It therefore remains important to determine whether a subsidy that more effectively reaches the poor does improve nutrition.

There is also a large, related literature on the nutritional impact of price changes in developing countries, much of which is summarized by Behrman and Deolalikar (1988). These studies, which include Williamson-Gray (1982), Pitt (1983), Strauss (1984), Pitt and Rosenzweig (1985, 1986), Behrman and Deolalikar (1987), Behrman, Deolalikar, and Wolfe (1988), and Guo et al. (1999), have generally found mixed results. While some have found the more intuitive result that calorie intake decreases when food prices increase, several others have found the opposite. While the latter results may be attributable in some studies to the impact of food prices on incomes of farm households rather than pure consumer price effects, in several studies this effect holds even when accounting for any such income effects. One lingering concern with much of this literature, however, is whether price variation can be treated as exogenous.⁶

In this paper, we present results from a field experiment exploring the response of poor households in China to food price subsidies. For five months, randomly selected house-

⁵ Although these studies improve dramatically on earlier evaluations, some empirical problems may bias both estimates of the program effect toward zero. For example, Kochar's study relies in part on variation across households in the value of the subsidy and the quantity of the subsidized good for which a household is eligible, which is largely determined by whether they are below the poverty line (BPL). However, BPL status is not measured in the data and must be estimated from observable characteristics. Any mistakes in classification, "assigning" the program to the nonpoor and "nonassigning" it to the poor, will bias toward finding no effect of the subsidy. Complicating factors further is that in practice, BPL "cards" are poorly targeted, with only 57% of eligible poor receiving benefits and 21% of all benefits accruing to noneligible households (Planning Commission, 2005). And while variation over time and space in the value of the benefits is also used, such variation may not be exogenous with respect to consumption. In addition, BPL status is an eligibility requirement for a variety of other government welfare programs that also affect consumption (including food for work, which would reduce food purchases). Thus, it is difficult to attribute differences in consumption to the subsidy program alone (especially since these other benefits may vary over space and time along with the subsidy program). Finally, prices are not directly measured in the data, but are derived as unit values (expenditure divided by quantity). Such variation could reflect differences in the variety or quality of the grain households choose or measurement error, which would again bias toward finding no effect. Tarozzi (2005) exploits an increase in the value of the subsidy coupled with variation in survey interview dates across households to estimate the impact of the program by duration of exposure. However, actual receipt of benefits is not observed, and again low take-up would lead toward finding no effect. Additionally, due to data limitations the study focuses only on children under the age of 4, whose nutritional status it may be easier to buffer due to their lower needs. Finally, variation in survey interview date provides differences in program exposure of only 1 to 3 months, which may be insufficient time for the nutritional impacts to be felt.

⁶ For example, higher demand for food (and thus greater caloric intake) could increase prices rather than the reverse. Alternatively, spatial or time-series price variation may be correlated with factors affecting nutrient demand.

holds in two provinces, Hunan and Gansu, were given vouchers that subsidized purchases of their province-specific dietary staple: rice in Hunan and wheat flour in Gansu. The study households were chosen from among those officially designated as the urban poor, a population that includes approximately 90 million individuals throughout China (Ravallion, 2007). This sample provides a useful test case, since consumer price subsidies are typically intended to improve the nutrition of the poorest. In a previous study (Jensen & Miller 2008a), we used this experiment as a source of exogenous price variation to test for the existence of Giffen behavior (an increase in the quantity demanded of a good in response to an increase in the price of that good) and, more generally, to document the behavior of households living near the boundary of subsistence. In this paper, our interest is in the broader household consumption response to a price subsidy and, in particular, the impact the subsidy has on nutritional outcomes.

Our study offers several important advantages over previous studies of subsidies. First, take-up of the subsidy was universal among eligible households, unlike the case for India's program. Second, we have clean, exogenous price variation with which to identify the effects of the subsidy. Finally, we measure consumption from dietary intake diaries rather than expenditure data, which may not as accurately measure consumption or nutrition due to food given (or fed) to others or wasted, or meals eaten elsewhere, such as food provided at work or purchased at food stalls or restaurants.

Using consumption surveys gathered before, during, and after the subsidy was introduced, we find no evidence that the subsidy improved nutrition for the pooled sample. Considering the provinces separately, we find that poor households in Hunan actually reduce their intake of calories and several important vitamins and minerals in response to the price subsidy. In Gansu, intake does not increase for any nutrient group; the point estimates are generally positive for calories and protein but negative for vitamins and minerals, though in all cases, the effects are small and not statistically significantly different from 0. Thus, we find no evidence that subsidies improve nutrition for the poor and may in fact even harm it in some cases. Finally, in both provinces, there is evidence that in response to the subsidy, households alter their consumption patterns in ways intended to improve the nonnutritional attributes (specifically, taste) of their diets.

The paper continues in section II, where we discuss the field experiment, data, and estimation strategy. Section III presents the results, and section IV discusses and concludes.

II. Data and Empirical Strategy

A. The Experiment

Our field experiment provided randomly selected poor households in two Chinese provinces with subsidies for their locally relevant staple good: rice in Hunan and wheat

flour (used primarily to make buns, a simple bread called *mo*, or noodles) in Gansu.⁷ Households were randomly assigned to either a control group or one of three treatment groups. Households in the treatment groups were given printed vouchers entitling them to a price reduction of 0.10, 0.20, or 0.30 yuan (Rmb; 1 Rmb = \$0.13) off the price of each *jin* (1 *jin* = 500 g) of the staple good. The subsidy level stayed fixed for each household over the course of the study. These subsidies represented substantial price changes, since the average preintervention price of rice in Hunan was 1.2 yuan per *jin*, and the average for wheat flour in Gansu was 1.04 yuan per *jin*.⁸ The vouchers were printed in quantities of 1, 5, and 10 *jin*, and the month's supply of vouchers was distributed at the start of each month, with each household receiving vouchers for 750 g per person per day (about twice the average per capita consumption as measured by our preintervention survey). All vouchers remained valid until the end of the intervention, giving households time to spend down any accumulated vouchers at the end of the study. Households were told in advance they would receive vouchers for five months and that any unredeemed vouchers would not be honored after the end of the intervention.

The vouchers were redeemable at local grain shops, the owners of which were later reimbursed for the cost of the vouchers and given a fixed payment for complying with our guidelines in implementing the subsidy. Households could use the vouchers only to purchase the province-specific staple good and were not permitted to resell the vouchers or the goods purchased with the vouchers (they were told there would be auditing and accounting to make sure they were in compliance with the rules, and that any violations would result in their removed from the study without any additional compensation). Jensen and Miller (2008a) discuss additional safeguards put in place to prevent cheating, or "cashing out," and provide evidence from voucher use that suggests that if any such cheating took place at all, it was extremely limited. We also provide evidence to suggest it is unlikely that the vouchers affected consumption through a behavioral or "salience" effect as opposed to a pure price effect, or to the extent that those effects occurred, they would actually work counter to our predictions and results, and thus do not weaken our conclusions.⁹

⁷ Poor urban households in Gansu primarily prepare these foods at home using wheat flour. However, they also sometimes purchase packaged noodles or other prepared wheat-based foods like bread. Our subsidy applied only to raw wheat flour, and thus did not affect the prices of these prepared foods (which account for approximately 5% to 10% of total household wheat consumption in our sample).

⁸ Using our expenditure data (discussed below), we can rule out that shopkeepers took advantage of the subsidy by increasing prices for subsidy households by comparing prices net of the subsidy for treatment and control groups. Shopkeepers were told they would be monitored and audited to ensure they followed the program rules. Further, grain prices move slowly and somewhat predictably (often by season), so any changes would have been easily detected, and contested, by subsidy households.

⁹ For example, if vouchers increased the salience of the staple, we would expect consumption of it to increase. Since these are the cheapest

B. Data

The survey and intervention were conducted by employees of the provincial-level agencies of the Chinese National Bureau of Statistics. The sample consisted of 100 to 150 households in each of eleven county seats in the two provinces (Anren, Baoqing, Longshan, Pingjiang, Shimen, and Taojiang in Hunan, and Anding, Ganzhou, Kongdong, Qingzhou, and Yuzhong in Gansu), for a total of 1,300 households (650 in each province), with 3,661 individuals. Within each county, households were chosen at random from lists of the urban poor maintained by the local offices of the Ministry of Civil Affairs. Households on this list fall below a locally defined poverty threshold (the *Di Bao* line), typically between 100 and 200 yuan per person per month or \$0.41 to \$0.82 per person per day, which is below even the World Bank's "extreme" poverty line of \$1 dollar per person per day. These are the type of households that price subsidies are typically designed to provide with nutritional protection: they are China's poorest, and they are also extremely poor by international standards. This sample therefore provides a useful case for studying the impacts of a price subsidy.

The questionnaire consisted of a standard income and expenditure survey, gathering information on the demographic characteristics of household members as well as data on employment, income, asset ownership, and expenditures. A key component of the survey was a 24-hour food recall diary completed by each household member.¹⁰

sources of calories, we would then expect calories to increase as well, the opposite of what we conclude here. Alternatively, and perhaps less likely, households may view the vouchers as providing adverse signals about the staple; for example, they may view the attempt to sell more rice as an indication that there is something wrong with the current stock, in which case they might want to consume less of it (though consumers were told the subsidies were being provided by outside researchers rather than merchants, farmers, or the government). However, Jensen and Miller (2008a) shows that subsidy-induced consumption changes vary with measures of wealth, suggesting that any salience effect would also have to vary with wealth, which seems less likely. Finally, if the consumption of the treatment groups responded both to having received any subsidy at all (the signal or salience effect) and to size of the subsidy received, we could eliminate the former and identify the nutrient elasticity off the size of the subsidy alone by running regressions excluding the control group. Doing so yields very similar results to those below, indicating that the effects are not driven by some common signaling or salience effect among the treatment groups. It is, of course, possible that larger subsidies create stronger signaling effects, so these results do not imply there were no such effects at all.

¹⁰ Alternative methods for assessing food intake include the household inventory and food frequency approaches (see Strauss & Thomas 1995, 1998). With the household inventory approach, enumerators use scales to weigh ingredients before cooking and waste following consumption. This method is likely to more accurately measure foods eaten within the home (but not outside) than the 24-hour individual food recall used here, since, for example, it will not be subject to variation in preparation. However, a validation study by Zhai et al (1996) using data from a survey that applied both the diary and household inventory approaches finds that the two yield similar results, especially for calories (provided attention is given to cooking oil in the diary). Given this validation, plus the high costs and intrusiveness of the inventory approach (enumerators need to be present all day to weigh all food preparation and waste), we chose to implement the intake diary.

Respondents were asked to report everything they ate and drank the previous day, whether inside or outside the home,¹¹ by specifically listing the components of all foods eaten.¹² These foods were recorded in detail in order to match with the 636 food items listed in the 1991 Food Composition Tables constructed by the Institute of Nutrition and Food Hygiene at the Chinese Academy of Preventative Medicine. Because the households in our sample are very poor, most diets are simple and consist of a small number of basic (nonprocessed, nonprepared, or nonpackaged) foods like rice, bean curd, or stir-fried cabbage. Consequently, concerns about coding the specific quantities of the various ingredients in a complex dish or meal are not significant.

Data were gathered in three rounds, conducted in April, September, and December 2006. After completing the first survey, treatment households were told they would receive the price subsidies for five months, from June through October. Thus, the initial interviews occurred before treatment households knew of or received the subsidies, the second occurred after the subsidy had been in place for slightly more than three months, and the final interviews were conducted one to two months after the subsidy had ended, by which time treatment households would likely have exhausted any stocks of rice or wheat flour they may have purchased with the subsidy and will therefore again be purchasing at the full market price. Sample attrition was extremely low, since the three rounds occurred in a relatively short span. Only 11 of 1,300 households (less than 1%) in the first round did not appear in the second round. All households in the second round were interviewed in the third round.

C. Food Nutrient Content Data

The 1991 China Food Composition Tables contain data on calorie and protein content for each food item, which we can use to convert the food diary entries into calorie and protein intake. However, while measuring total calorie intake is straightforward, protein intake is more difficult since a complete protein consists of twelve essential amino acids. Animal protein such as meat or eggs contains all of these amino acids and therefore provides a complete protein. By contrast, the protein found in grains and pulses lacks one or more of these essential amino acids. However,

¹¹ Though because the sample households were so poor, very little food (less than 2% of calories) was eaten outside the home. While this may seem small, this is similar to what was found by Popkin, Lu, and Zhai (2002) using intake diary data for China (the authors also note that this is not due to a weakness of that data collection strategy, since the same approach yields evidence of substantial food consumption away from home in the Philippines).

¹² While it may seem difficult to recall or estimate how many grams of, say, rice was eaten with a meal, for the extreme poor who are on a very limited budget, food is often apportioned and accounted for much more carefully. Further, diets for these extremely poor households often vary little or not at all from day to day, except on special occasions, so recalling the quantity of specific food items is not as difficult.

if a person's diet contains both grains and pulses, in combination they do supply complete protein (they supply adequate levels of all amino acids). For example, while both rice and wheat are relatively deficient in the essential amino acid lysine, consuming these foods along with even a fairly small amount of bean curd provides sufficient lysine to make up for this deficiency. Thus, while nutrition tables such as those used here report protein values, the true amount of available protein will depend on the combination of foods people eat and the amino acid contents of that food. Unfortunately, data on amino acid content is not available in the Food Composition Tables, and there is no agreed-on empirical model for converting detailed food consumption into protein intake. We therefore simply use the reported protein contents, without adjusting for protein completeness. This will likely lead us to overestimate protein consumption overall. And under our hypothesis that households may substitute away from basic foods like grains and toward luxuries like meat, we would likely underestimate protein gains from the subsidy. However, the results are robust to a range of alternative estimates of protein content.¹³

For other nutrients, we match our food consumption data with the 2007 release of the U.S. Department of Agriculture (USDA) National Nutrient Database for Standard Reference. This database provides complete content information for ten minerals (calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper, manganese, and selenium) and nine vitamins (vitamins A, C, B₁ (thiamin), B₂ (riboflavin), B₃ (niacin), B₅ (pantothenic acid), B₆, B₉ (folic acid) and B₁₂) for approximately 7,500 foods.¹⁴ However, there are some important limitations to matching this information with our data. First, the food item descriptions in the USDA tables differ from those in the Chinese tables used for coding our data. We therefore had to hand-match foods based on their descriptions, which may have led to coding errors. Further, there were cases where one of the two databases contained more detailed varieties or compo-

¹³ We use two alternative measures of protein. First, we use protein digestibility corrected amino acid scores (PDCAAS), the method designated as preferred by an expert body of the FAO and WHO (FAO/WHO, 1991). PDCAASs range from 0 to 1 and assess protein based on the quantity of the limiting amino acid in a food as a percentage of the content of that same amino acid in a reference pattern of amino acids (further adjusted for digestibility). However, these scores are available for only a small subset of foods. As an alternative but related approach, we match our data to the USDA National Nutrient Database (discussed below), which contains amino acid content for about 80% of foods recorded in our survey. For each individual, we add up the intake of all amino acids and measure protein availability as the amount of the amino acid the individual consumes the least of. In other words, if the individual consumes 2 grams of lysine and 3 or more of all other amino acids, we assign a protein measure of 2 (this creates differences in units between protein and amino acid intake but will not affect our results since we will examine percentage changes in intake). Both approaches yield similar conclusions to using unadjusted protein content.

¹⁴ While nutritionists recognize at least thirty essential vitamins and minerals, data are not available for these other nutrients for 20% or more of foods matched between our intake data and the nutrient database, so we exclude them from our analysis.

nents of foods than the other,¹⁵ so the matches are imprecise.¹⁶ Finally, for some of the foods recorded in our data, there were no corresponding matches in the USDA database, and thus we do not have augmented nutrition data for these foods. Overall, we are unable to match 5.5% of the foods entries reported in our consumption diaries. However, many of these items are plants or roots used for tea or in traditional Chinese medicine, and therefore they have very little nutritional content, especially in the quantities typically consumed. For example, based on the China Food Composition Tables, these unmatched foods account for only 0.8% of average caloric intake and less than 0.001% of protein intake. Thus, although we omit these foods from our measures of vitamin and mineral intake, it is unlikely they substantially affect the results. Further, we find that the subsidy had no effect on the total consumption of these foods, so, again, their exclusion is unlikely to bias our estimates of the effect of the subsidy on mineral and vitamin intake.

We use the merged USDA data to create summary measures of per capita vitamin and mineral intake. In particular, for each household h , we first compute a normalized intake for each vitamin v (or mineral m) by adding up total household intake of that vitamin (mineral) for all individuals i in the household and then dividing by the total recommended amount that household should be consuming based on gender- and age-specific USDA Dietary Reference Intakes (DRIs).¹⁷ We then aggregate across all vitamins (minerals) and divide by the number of vitamins V (or minerals M) and the number of people in the household:

$$V_h = \frac{\sum_v (\sum_i \text{Vitamin}_{v,i} / \sum_i \text{DRI}_{v,i})}{V \cdot \#people_h},$$

$$M_h = \frac{\sum_m (\sum_i \text{Mineral}_{m,i} / \sum_i \text{DRI}_{m,i})}{M \cdot \#people_h}.$$

Thus, V_h and M_h can be interpreted as an average vitamin or mineral sufficiency or adequacy index; they represent the average per person intake per vitamin (mineral), with measures greater than 1 indicating that on average, members of the household are consuming above the DRIs for the average vitamin (mineral) and values less than 1 indicating they are below the DRIs. Normalizing vitamins and minerals by their associated DRIs is important because the quantities in

which the individual vitamins and minerals are typically consumed (and thus the DRIs) vary by orders of magnitude, from grams to micrograms (10^{-6} g). We discuss some limitations of these aggregated measures below.

D. Covariate Balance

Table 1 provides means, standard deviations, and pairwise tests of equality for treatment and control groups for key variables in the baseline survey. Overall, for the pooled sample in the first four columns, the randomization appears to have achieved balance across the control and three treatment groups. The differences across all groups for all key variables are small, and none are statistically significant.

However, splitting the sample by province reveals some notable differences. For example, while only a few of the pairwise differences are statistically significant, in both provinces some baseline nutrition measures appear to vary monotonically with the treatment. In particular, baseline caloric intake strictly increases with the subsidy size in Hunan and strictly decreases in Gansu. Focusing on the end point cases, in Hunan the 0.3 subsidy group consumes 84 more calories (about 5%) than the control group (though this is not statistically significant). In Gansu, the 0.3 subsidy group consumes 82 fewer calories (about 5%) than the control group (though it is not statistically significant). While the strictly monotonic pattern does not hold for protein, vitamins, and minerals in the two provinces, it remains the case that in Hunan, intake of these three nutrients is highest in the 0.3 subsidy group and lowest in the control group (with the differences statistically significant at the 1% level for vitamins and the 10% level for minerals), and vice versa for Gansu (with the difference statistically significant for protein at the 10% level). For expenditure per capita, there is no evident pattern in either province, and none of the twelve pairwise differences is statistically significant.

While the patterns in calories and, to a lesser extent, the other nutrients, are puzzling, we believe they are the result of chance rather than any systematic factor. Since any fixed initial differences arising at random can be easily addressed empirically, the most important empirical concern is whether the initial differences reflect differential underlying trends. For example, we may be concerned that our implementing agency gave higher subsidies to households that were on a downward trend in calories in Gansu before our intervention (perhaps due to illness or declining wages or employment prospects in their industry) and to those on an upward trend in Hunan (such households might be expecting income increases, which might enable them to bribe the implementing agency). In these cases, calories would have changed differentially even in the absence of the subsidy, and our estimates would be biased. However, we believe that subsidy assignment based on such differential trends could not have occurred. Randomization and assignment to control and treatment groups were made by the authors, not the implementing agency. Further, the subsidy assignment

¹⁵ For example, the Chinese tables contain separate entries for the leaves, stems, and roots of raw mustard greens, whereas the USDA data contain only one entry for the whole plant in its raw form.

¹⁶ In the few cases where there were multiple, nondistinguishable entries for a particular food in either database, we matched using the entries with the smallest sum of absolute differences for the three nutrients in common to both data sets (calories, protein, and fat).

¹⁷ The DRIs are from the National Academy of Sciences, Institute of Medicine, Food and Nutrition Board's summary table, "Dietary Reference Intakes: Recommended Intakes for Individuals." The table is available online from the USDA National Agricultural Library, Food and Nutrition Information Center, <http://fnic.nal.usda.gov/>.

TABLE 1.—MEANS, STANDARD DEVIATIONS, AND TESTS OF BASELINE COVARIATE BALANCE

	Means				<i>t</i> -Tests of Equality					
	Control	0.1 subsidies	0.2 subsidies	0.3 subsidies	0–0.1	0–0.2	0–0.3	0.1–0.2	0.1–0.3	0.2–0.3
A. Total										
Family size	2.9 [1.2]	2.8 [1.2]	2.9 [1.2]	2.7 [1.1]	0.090 (0.095)	0.021 (0.095)	0.15 (0.092)	–0.068 (0.094)	0.064 (0.090)	0.13 (0.089)
Expenditures per capita	259 [255]	279 [274]	249 [267]	290 [376]	–19.6 (20.8)	10.1 (20.5)	–28.8 (25.3)	29.7 (21.3)	–11.2 (24.2)	–40.9 (25.3)
Calories per capita	1752 [565]	1758 [570]	1767 [526]	1752 [569]	–6.0 (44.6)	–14.7 (42.9)	–0.28 (44.6)	–8.7 (43.1)	5.7 (44.9)	14.4 (43.2)
Protein per capita	48.5 [19.4]	47.8 [17.0]	47.8 [17.8]	48.2 [17.8]	0.76 (1.43)	0.76 (1.46)	0.35 (1.47)	0.003 (1.37)	–0.40 (1.37)	–0.41 (1.40)
Minerals	1.00 [0.34]	1.02 [0.36]	1.02 [0.36]	1.01 [0.35]	–0.019 (0.028)	–0.016 (0.028)	–0.001 (0.027)	0.004 (0.028)	0.009 (0.028)	0.006 (0.028)
Vitamins	1.17 [0.38]	1.20 [0.47]	1.19 [0.43]	1.21 [0.43]	–0.034 (0.034)	–0.024 (0.032)	–0.042 (0.032)	0.010 (0.035)	–0.008 (0.036)	–0.018 (0.034)
Observations	324	324	324	321	648	648	645	648	645	645
B. Hunan										
Family size	2.8 [1.3]	2.9 [1.3]	3.0 [1.4]	2.7 [1.1]	–0.056 (0.15)	–0.15 (0.15)	0.12 (0.14)	–0.093 (0.15)	0.18 (0.14)	0.27* (0.14)
Expenditures per capita	316 [252]	330 [316]	299 [290]	364 [482]	–13.3 (31.8)	16.7 (30.2)	–47.6 (28.0)	30.0 (33.7)	–31.7 (45.7)	–62.7 (44.6)
Calories per capita	1767 [628]	1783 [588]	1817 [549]	1851 [601]	–16.3 (67.7)	–49.6 (65.7)	–84.3 (68.8)	–33.6 (63.2)	–68.0 (66.4)	–34.4 (64.3)
Protein per capita	45.6 [19.0]	46.4 [16.6]	46.0 [18.4]	48.8 [19.1]	–0.76 (1.99)	–0.41 (2.08)	–3.2 (2.13)	0.35 (1.95)	–2.43 (2.00)	–2.78 (2.09)
Minerals	1.05 [0.37]	1.10 [0.38]	1.07 [0.39]	1.12 [0.37]	–0.050 (0.042)	–0.026 (0.042)	–0.074* (0.041)	0.025 (0.043)	–0.024 (0.042)	–0.049 (0.042)
Vitamins	1.13 [0.39]	1.21 [0.49]	1.19 [0.46]	1.26 [0.47]	–0.074 (0.049)	–0.054 (0.048)	–0.13*** (0.048)	0.020 (0.053)	–0.055 (0.053)	–0.075 (0.052)
Observations	161	162	162	159	323	323	320	324	321	321
C. Gansu										
Family size	2.9 [1.1]	2.7 [1.1]	2.7 [0.95]	2.7 [1.1]	0.24* (0.12)	0.19* (0.11)	0.19 (0.12)	–0.043 (0.11)	–0.049 (0.12)	–0.006 (0.11)
Expenditures per capita	202 [247]	228 [214]	198 [231]	216 [201]	–25.3 (25.6)	4.1 (26.5)	13.4 (24.9)	29.4 (24.7)	11.9 (23.0)	–17.5 (24.1)
Calories per capita	1737 [496]	1732 [553]	1716 [500]	1655 [520]	4.43 (58.3)	20.6 (55.3)	82.1 (56.4)	16.2 (58.5)	77.6 (59.6)	61.4 (56.6)
Protein per capita	51.4 [19.4]	49.2 [17.3]	49.5 [17.0]	47.6 [16.4]	2.24 (2.04)	1.89 (2.02)	3.84* (2.00)	–0.35 (1.90)	1.61 (1.87)	1.96 (1.86)
Minerals	0.95 [0.31]	0.94 [0.32]	0.96 [0.32]	0.90 [0.29]	0.013 (0.035)	–0.005 (0.035)	0.053 (0.033)	–0.018 (0.035)	0.041 (0.034)	0.058* (0.034)
Vitamins	1.20 [0.37]	1.20 [0.45]	1.19 [0.39]	1.16 [0.39]	0.005 (0.046)	0.006 (0.042)	0.046 (0.042)	0.000 (0.047)	0.039 (0.047)	0.039 (0.043)
Observations	163	162	162	162	325	325	325	324	324	324

Standard deviations in brackets, standard errors in parentheses. Expenditure per capita is in 2006 yuan (Rmb), protein is measured in grams, and vitamins and minerals are a sufficiency index measuring the average per person intake relative to the DRI. The 0.1, 0.2, and 0.3 subsidies groups received 0.1, 0.2, and 0.3 yuan per *jin* subsidy (1 *jin* = 500 g). All variables as measured in the round 1 survey.

was made after some preliminary household demographic data were collected for the sample and household identification codes were assigned, and thus we can verify that the implementing agency could not have switched household identification codes after subsidy assignment was made. It is these assignment categories and household identifiers that we use for the analysis, so the implementing agency could not have altered the treatment assignment featured in table 1.¹⁸ Therefore, we believe that the differences in initial nutrient intake are due to random sampling and the (relatively) small size of our sample rather than any systematic factors. However, it will be important for our empirical strategy to take these patterns into consideration

as fixed differences across subsidy groups, and thus it will be more appropriate to either consider changes in nutrient intake across survey rounds or use a household fixed-effects strategy rather than simply regressing treatment period (round 2) nutrient intake on the subsidy level, as would otherwise be appropriate in a randomized trial setting.

E. Assessing Baseline Nutrient Intake

The nutrient intakes in table 1 represent averages across all age and sex groups. As a more useful benchmark for assessing baseline intake, the mean preintervention caloric intake among working-aged adults (18–60 years) for the pooled sample is 2023 kcal for men and 1726 kcal for women. While we cannot rule out some undercounting of calories, these values are far below even the low range of international standards (2335–3164 kcal for adult men and 1846–2154 kcal for adult women, depending on level of

¹⁸ While they may not have later implemented the program as we chose (giving the vouchers out differently than we had assigned them), monitoring and auditing were put in place and show no evidence to support this possibility.

physical activity (FAO/WHO/UNU, 1985)).¹⁹ This again suggests that our sample represents a group that subsidies are typically intended to help: the undernourished.²⁰ For protein, the recommended intake is 1 g per kg of weight per day and is generally not conditioned on age or sex, so we can use the means in table 1 to assess intake. While we unfortunately did not gather data on weight in our survey, evidence from an alternative data set, the China Health and Nutrition Survey (CHNS), shows that average weight for a comparable sample of urban poor persons is about 54 kg.²¹ Thus, as a rough approximation, individuals in our sample are about 11% below the recommended daily protein intake (with average intake greater in Gansu than Hunan).

Overall deprivation, however, appears to be somewhat lower for other nutrients, with individuals close to or slightly above the recommended vitamin and mineral intakes.²² However, these averages mask significant variation across vitamins and minerals, including cases of shortfalls for some nutrients offset by intakes above the DRI for others. Table 2 shows the baseline intake levels for each vitamin and mineral relative to the associated DRI. For the pooled sample, intake on average is close to or above requirements for four of the ten minerals (iron, copper, manganese, selenium) and five of the nine vitamins (vitamin C, thiamin, riboflavin, niacin, and folate). By contrast, intake is one-third or less of the DRI for calcium, potassium, sodium, and vitamin B₁₂ and about one-half for magnesium, phosphorus, zinc, and vitamin A. There is some variation by province. In both, dietary intake is close to or above requirements for iron, copper, manganese, selenium, vitamin C, thiamin, niacin, and folate, while households in Gansu are also above the DRI for riboflavin and similarly for pantotheonic acid and vitamin B₆ in Hunan. Both provinces have average intakes of one-third or less of the DRI for vitamin B₁₂, potassium, and sodium, while households in Gansu are also similarly deficient in calcium. Finally, both provinces have intake of about half the requirements for magnesium, phosphorus, and vitamin A, with Hunan adding calcium and Gansu adding zinc and pantotheonic acid.

Finally, since we motivated our analysis by considering households whose diets primarily consist of a large quantity of a staple good and a little bit of a luxury good (a more expensive source of nutrition like meat), table 3 provides

data on the basic consumption patterns in the two provinces in the preintervention survey round. The dominance of staple goods in household diets is best seen for the disaggregated sample since the staple food differs by province. In Hunan, households receive on average 64% of their calories from rice, while in Gansu, wheat-based foods comprise 69% of calories.²³ The reliance on basic, staple foods for nutrition is underscored even more by the fact that the average total calorie share from all cereals or grains is 72% in Hunan and 77% in Gansu. Further, in both provinces, on average 13% of calories come from edible oils (mostly vegetable oil), which is primarily used in cooking and is generally not a substitute for other forms of consumption or nutrition. Thus, the consumption of all other foods combined on average contributes only 10% of calories in Gansu and 15% in Hunan. In Hunan, the greatest remaining share comes from meat, comprising 7% of average caloric intake. In Gansu, meat consumption is much lower, with pulses (primarily bean curd or tofu) providing a larger share of calories than meat. This difference is likely due to the lower income levels in Gansu; pulses are often referred to as “poor man’s meat” because they are a cheaper source of protein (when combined with other foods typically eaten as staples, as noted above).

F. Estimation Strategy

Given the random assignment of the subsidy and the panel nature of our survey, plus the slight differences in preintervention caloric intake noted above, our basic empirical strategy is to compare changes in nutrient intakes for treatment and control groups. Our primary specification focuses on the household as the unit of observation rather than the individual, for both consistency with the literature on food and nutrition in developing countries and because with food diary surveys, there is a concern that in some cases, a primary respondent may simply report what food was prepared for the household and then divide it roughly among members, rather than each individual reporting his or her actual consumption. To the extent that such reporting takes place, it is more appropriate to focus on the household as the unit of observation. Below, we show that using individual-level data yields nearly identical results.²⁴

¹⁹ While individuals in our sample are somewhat shorter and weigh less than the populations for which these standards are constructed, we have cited the requirement levels for the lowest body weight categories (54 kg or 119 pounds for men and 47 kg or 103 pounds for women), which are likely to be low even for our sample.

²⁰ The FAO estimates that about 150 million people in China are undernourished (FAO, 2006).

²¹ The CHNS is collected by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. The data are available at <http://www.cpc.unc.edu/projects/china>.

²² In this table the values are already normalized by the age- and sex-specific DRIs, so we do not need to present them for subgroups in order to address sufficiency of intake.

²³ These goods are also the cheapest source of calories in each province: rice in Hunan yields 1399 calories per yuan, while wheat in Gansu yields 1655 calories per yuan. By contrast, the calories per yuan for other common foods are wheat (1221), millet (537), pork (331), bean curd (239), and cabbage (141) in Hunan; and millet (1105), rice (980), pork (340), bean curd (224), and cabbage (173) for Gansu.

²⁴ One question that can be addressed only using individual-level data is whether households respond to the subsidy by providing more food and nutrition to specific members. For example, Pitt, Rosenzweig, and Hassan (1990) find that households concentrate calories on household members involved in activities where productivity is the most responsive to health (and nutrition). Alternatively, households may choose to focus nutrients on those whose health or development is most vulnerable to nutritional shocks, such as children or the elderly. Additional results (available from the authors) show that the effects do not vary significantly across age × gender groups.

TABLE 2.—BASELINE NUTRIENT INTAKES AND SUBSIDY COEFFICIENTS

	Pooled Sample		Hunan		Gansu	
	Intake	Coefficient	Intake	Coefficient	Intake	Coefficient
Minerals						
Calcium	0.33 [0.27]	-0.314** (0.156)	0.39 [0.28]	-0.376* (0.249)	0.25 [0.22]	-0.111 (0.201)
Iron	2.1 [0.94]	-0.039 (0.092)	2.1 [0.92]	-0.143 (0.141)	2.1 [1.2]	0.054 (0.121)
Potassium	0.33 [0.16]	-0.061 (0.110)	0.32 [0.15]	-0.211 (0.169)	0.33 [0.18]	0.046 (0.144)
Sodium	0.29 [0.44]	-0.002 (0.243)	0.31 [0.39]	-0.262 (0.343)	0.24 [0.46]	-0.086 (0.334)
Magnesium	0.55 [0.27]	-0.156 (0.110)	0.57 [0.25]	-0.250* (0.149)	0.55 [0.37]	-0.106 (0.154)
Phosphorus	0.54 [0.27]	0.106 (0.115)	0.58 [0.28]	0.098 (0.178)	0.51 [0.30]	0.072 (0.153)
Zinc	0.61 [0.27]	-0.069 (0.092)	0.73 [0.26]	-0.100 (0.127)	0.48 [0.23]	-0.091 (0.126)
Copper	1.4 [0.69]	-0.012 (0.095)	1.6 [0.65]	-0.104 (0.134)	1.1 [0.75]	-0.004 (0.129)
Manganese	2.2 [0.90]	-0.139 (0.087)	2.6 [0.85]	-0.222* (0.116)	1.8 [0.77]	-0.085 (0.122)
Selenium	1.8 [0.89]	0.104 (0.150)	1.4 [0.55]	-0.068 (0.153)	2.4 [1.1]	0.309 (0.229)
Vitamins						
Vitamin C	0.93 [0.91]	-0.044 (0.188)	1.0 [0.97]	-0.398 (0.316)	0.79 [0.56]	0.204 (0.234)
Thiamin	2.6 [0.91]	0.029 (0.086)	2.4 [0.78]	-0.039 (0.120)	2.8 [0.93]	0.095 (0.112)
Riboflavin	1.2 [0.72]	0.093 (0.112)	0.63 [0.32]	-0.073 (0.188)	1.7 [0.62]	0.148 (0.149)
Niacin	1.5 [0.52]	0.002 (0.086)	1.3 [0.41]	-0.068 (0.117)	1.7 [0.54]	0.080 (0.119)
Pantotheonic acid	0.79 [0.36]	-0.059 (0.091)	0.99 [0.31]	-0.133 (0.115)	0.58 [0.23]	-0.054 (0.130)
Folate	2.4 [0.93]	-0.037 (0.098)	2.7 [0.93]	-0.213* (0.130)	2.1 [0.74]	0.119 (0.137)
Vitamin B ₆	0.82 [0.44]	-0.055 (0.109)	0.98 [0.45]	-0.163 (0.144)	0.66 [0.32]	0.007 (0.155)
Vitamin B ₁₂	0.13 [0.37]	0.314 (0.266)	0.16 [0.34]	0.571 (0.454)	0.08 [0.16]	0.144 (0.333)
Vitamin A	0.44 [0.66]	-0.572** (0.279)	0.46 [0.67]	-0.785* (0.441)	0.40 [0.50]	-0.189 (0.364)

Data in the "Intake" columns represent baseline intake as a ratio of the DRI; standard deviations are in brackets. The "Coefficient" columns provide the elasticity of intake with respect to the subsidy; they are coefficients from regressions for each vitamin and mineral, where the dependent variable is the arc percentage change in household per capita intake and the independent variable is the arc percentage change in price due to the subsidy; standard errors, clustered at the household level, are in parentheses. Significant at *10%, **5%, ***1%.

In our preferred specification, we regress the percentage change in per capita nutrient intake for household h in period t on the change in the subsidy, measured as a percentage of the average market price of the subsidized good.²⁵ The percentage change formulation normalizes for factors such as household age and sex composition and activity level, and it allows us to directly interpret the coefficients as elasticities (consistent with the literature on nutrient intake). For each household, we observe two changes: the change between periods 2 and 1 ($t = 2$), capturing the effect of imposing the subsidy, and the change between periods 3

and 2 ($t = 3$), capturing the effect of removing the subsidy. Thus we estimate

$$\% \Delta \text{Nutrient}_{h,t} = \alpha + \beta \% \Delta \text{Subsidy}_{h,t} + \Delta \varepsilon_{h,t}, \quad (1)$$

where $\% \Delta \text{Nutrient}_{h,t}$ is the percentage change from period $t - 1$ to period t of household h 's per capita consumption of the given nutrient, and $\% \Delta \text{Subsidy}_{h,t}$ is the percentage change in the price of the staple due to the subsidy over the same period (positive for $t = 2$ and negative for $t = 3$). All regressions also include a round indicator variable. We compute all changes as arc percentage changes ($100 \cdot (x_t - x_{t-1}) / (.5 \cdot (x_t + x_{t-1}))$).²⁶ The percentage value of the subsidy is computed as 100 times the change in the subsidy divided

²⁵ One concern with this strategy is that price (independent of the subsidy) is likely to be endogenous. For example, a food demand shock will increase both nutrient intake and the price of foods. However, below we show that the results are robust to using just the level of the subsidy without normalizing by the market price or to including county \times time fixed effects so that identification is due only to variation in price within a county due to the subsidy.

²⁶ The arc percentage change specification is preferred over the simple percentage change because the subsidies represent large changes, and because the arc formulation has the desirable property of being symmetric over time.

TABLE 3.—BASELINE CONSUMPTION PATTERNS

	Pooled Sample	Hunan	Gansu
% of calories from:			
Rice	0.353 [0.324]	0.640 [0.171]	0.068 [0.131]
Wheat	0.384 [0.337]	0.080 [0.117]	0.685 [0.173]
Other cereals	0.006 [0.039]	0.002 [0.022]	0.009 [0.050]
Vegetables and fruit	0.056 [0.045]	0.046 [0.044]	0.065 [0.045]
Meat	0.044 [0.090]	0.074 [0.115]	0.014 [0.037]
Pulses	0.022 [0.050]	0.022 [0.043]	0.022 [0.056]
Dairy	0.0046 [0.028]	0.000 [0.003]	0.009 [0.039]
Fats	0.129 [0.092]	0.131 [0.095]	0.126 [0.090]
Observations	1,293	644	649

Standard deviations in brackets.

by the average (net of subsidy) market price of the staple good in the two corresponding rounds. Below, we show that the results are robust to a wide range of alternative specifications, including log-log, simple (i.e., nonarc) elasticities, specifying the dependent or independent variables in levels, using household total nutrient intake rather than per capita measures, including additional controls or county \times time fixed effects for additional precision, and, as noted, using individual-level data.

III. Results

A. Nutritional Outcomes

Table 4A presents the primary results for intake of calories, protein, vitamins, and minerals for the full sample. Standard errors are clustered at the household level.²⁷ Before turning to our preferred specification, equation (1), the first column for each nutrient category provides results from regressions following the basic experimental setup, where round 2 intake is regressed on the subsidy level. Given the baseline treatment control differences in some nutrients revealed in table 1, we would not interpret these results as estimates of the causal effect of the treatment; they are presented simply for consistency with the literature. The subsidy coefficients have been converted to elasticities (evaluated at sample means) for consistency with the results in the other specifications (and the standard errors

²⁷ This clustering accounts for serial correlation in the errors within households. However, one concern is that there may be shocks that are correlated over time and across households within a county, which might suggest clustering at the county level. However, estimates of standard errors under clustering are not consistent when the number of clusters is small relative to the number of observations within each cluster (see Wooldridge, 2003). Since our sampling used only six counties in Hunan and five in Gansu, we do not believe it is appropriate to cluster the standard errors at this level. However, table 5 shows that the results are robust to doing so.

adjusted accordingly). For each of the nutrient measures, we cannot reject that the subsidy had no effect on intake. The point estimates of the elasticities are in fact all negative, though they are extremely small and none is statistically significant.

The second column for each nutrient contains the results from the specification in equation (1), with no other covariates added. The advantage of this specification is that it controls for fixed differences in baseline nutrient intake and other characteristics across groups. Provided there were no preexisting differential trends in nutrient intake across these groups, we can interpret these results as the causal effect of the subsidy. Again, for each nutrient, we cannot reject that the subsidy had no effect. The point estimates of the elasticities are small, ranging from about -0.02 to -0.07 . The estimates make it possible to reject anything other than fairly modest positive effects of the subsidy. For example, at the 95% level, we can reject elasticities greater than 0.15 for each of the nutrients.

Finally, in order to absorb any residual variation and potentially obtain more precise estimates, in the last column for each nutrient, we add a vector of percentage changes in other control variables, including earned income, unearned income (government payments, pensions, remittances, rent, and interest from assets), and household size. While there is a concern that these variables may themselves be affected by the subsidy, below we show that this is not the case.²⁸ Overall, the results are not changed substantially by adding these controls. All of the point estimates remain negative and extremely small, and none is statistically significantly different from 0.

While the pooled sample represents our estimate of the overall effect of the subsidy, it is worthwhile to consider the two provinces separately. Besides the difference in the staple food subsidized, table 1 revealed important differences between the provinces. For example, preintervention mean expenditure per capita in the Gansu sample is approximately 30% lower than in the Hunan sample (on average, the locally defined poverty thresholds are set lower in Gansu). Households in Gansu also consume fewer calories on average than those in Hunan, which might limit their willingness to substitute toward foods with higher nonnutritional attributes (consistent with the results in table 3 that households in Gansu do not consume as much meat, a primary luxury food, as households in Hunan). Finally, the cost of meat in Gansu is higher than in Hunan;²⁹ thus, even with the savings from the subsidy, the price of the usual luxury good households would typically substitute toward may be too high for households in Gansu to afford. Thus, we might expect different responses to the subsidy in the two provinces.

²⁸ Though these behaviors may still be endogenous with respect to the nutritional measures (for example, greater caloric intake leading to increased productivity and thus higher earnings).

²⁹ The mean price of the cheapest meat in both provinces (fish) is 5.7 yuan/kg in Gansu and 4.0 yuan/kg in Hunan.

TABLE 4.—NUTRITIONAL RESPONSE TO THE PRICE SUBSIDY

	A. Full Sample											
	Calories			Protein			Minerals			Vitamins		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Experimental Setup	% Change	% Change with Controls	Experimental Setup	% Change	% Change with Controls	Experimental Setup	% Change	% Change with Controls	Experimental Setup	% Change	% Change with Controls
% Δ Subsidy	-0.013 (0.042)	-0.027 (0.076)	-0.032 (0.076) 0.024*** (0.007)	-0.030 (0.049)	-0.024 (0.089)	-0.027 (0.088) 0.027*** (0.009)	-0.010 (0.048)	-0.057 (0.081)	-0.061 (0.081) 0.020** (0.008)	0.036 (0.064)	-0.044 (0.085)	-0.051 (0.085) 0.029*** (0.008)
Earned Income												
Unearned Income												
Household Size												
Constant	1,722*** (67.7)	-2.4 (7.1)	-0.0 (7.1) 0.05) (0.05)	45.7*** (2.17)	-10.6 (8.3)	-9.1 (8.2) 2,527 (0.06)	0.96*** (0.016)	-22.7*** (7.4)	-21.0*** (7.4) 2,527 (0.55)	-0.059** (0.023)	-28.0*** (7.9)	-24.9*** (7.9) 2,527 (0.059)
Observations	1,271	2,527	2,527	1,271	2,527	2,527	1,271	2,523	2,527	1,271	2,523	2,527
R ²	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.02	0.02	0.00	0.02	0.03

	B. By Province: Hunan											
	Calories			Protein			Minerals			Vitamins		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Experimental Setup	% Change	% Change with Controls	Experimental Setup	% Change	% Change with Controls	Experimental Setup	% Change	% Change with Controls	Experimental Setup	% Change	% Change with Controls
% Δ Subsidy	0.0061 (0.0081)	-0.214* (0.112)	-0.218* (0.111) 0.024*** (0.010)	0.020 (0.039)	-0.001 (0.001)	-0.105 (0.137) 0.037*** (0.012)	0.004 (0.010)	-0.149 (0.120)	-0.153 (0.119) 0.036*** (0.011)	0.029*** (0.013)	-0.195 (0.129)	-0.201 (0.127) 0.034*** (0.011)
Earned Income												
Unearned Income												
Household Size												
Constant	1,861*** (97.3)	24.9** (10.0)	27.6*** (10.0) 0.034) (10.6)	47.0*** (1.39)	8.7 (12.2)	11.6 (12.1) 1,258 (11.1)	1.02*** (0.024)	-21.6** (7.4)	-18.6* (7.4) 0.027 (0.073)	0.022	-11.5	-7.4
Observations	631	1,258	1,258	631	1,258	1,258	631	1,258	1,258	631	1,258	1,258
R ²	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.03	0.04	0.00	0.02	0.04

TABLE 4.—(CONTINUED)

	C. By Province: Gansu											
	Calories			Protein			Minerals			Vitamins		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
% Δ Subsidy	Experimental Setup -0.010 (0.010)	% Change 0.146 (0.101)	% Change with Controls 0.148 (0.101)	Experimental Setup -0.075 (0.081)	% Change 0.072 (0.115)	% Change with Controls 0.081 (0.114)	Experimental Setup -0.0072 (0.0097)	% Change -0.014 (0.107)	% Change with Controls -0.011 (0.107)	Experimental Setup -0.017 (0.012)	% Change 0.068 (0.113)	% Change with Controls 0.069 (0.113)
Earned Income			0.022** (0.011)			0.015 (0.012)			0.006 (0.012)			0.020* (0.012)
Unearned Income			0.031 (0.019)			0.051** (0.021)			0.031 (0.020)			0.037* (0.021)
Household Size			-0.07 (0.09)			-0.08 (0.10)			0.018 (0.089)			0.007 (0.10)
Constant	1,583.6*** (32.8)	-31.1*** (10.0)	-32.1*** (10.2)	44.4*** (1.01)	-32.5*** (11.1)	-35.7*** (11.2)	0.91*** (0.022)	-21.2** (10.4)	-22.3** (10.7)	-0.14*** (0.032)	-43.4*** (11.3)	-43.7*** (11.5)
Observations	640	1,269	1,269	640	1,269	1,265	640	1,269	1,265	640	1,265	1,265
R ²	0.00	0.01	0.02	0.00	0.01	0.02	0.00	0.01	0.02	0.00	0.03	0.03

Standard errors, clustered at the household level, in parentheses. The first column for each nutrient is a regression of the round 2 intake level on the subsidy level—the experimental setup; the coefficient has been converted to an elasticity (and the standard error adjusted accordingly). The second two columns regress the arc percentage change in household per capita nutrient intake on the subsidy, measured as a percentage of the average price in the two associated periods (% Δ Subsidy). These regressions also include a round indicator. % Δ Earned is the arc percentage change in the household earnings from work; %Unearned is the arc percentage change in the household income from unearned sources; % Δ People is the arc percentage change in the number of people in the household. Calories and protein are daily intakes (in kcal and grams, respectively), vitamins and minerals are sufficiency indexes measuring the average per person intake relative to the DRI. Significant at *10%, **5%, ***1%.

Table 4B focuses on Hunan. As with the pooled sample, for each of the nutrients, the estimated impact of the subsidy is negative when using the changes specification. The coefficient for calories is significantly different from 0 (p -values of 0.057 and 0.051 without and with controls, respectively). While the calorie elasticities are relatively small, they indicate that the price subsidy actually caused a decline in intake. For protein, minerals, and vitamins, the point estimates are negative, but we cannot reject that the subsidy had no effect on intake. We note, however, that using the undifferenced regression of round 2 intake levels on the subsidy, the elasticities are positive for each nutrient and statistically significant for vitamins, though each of the elasticities is small. The positive effect here can again be attributed to the higher baseline levels of intake for the higher-subsidy groups observed in table 1. When these baseline levels are differenced out, the effect of the subsidy is broadly negative.

The results for Gansu, presented in table 4C, differ from those for Hunan. Here, the estimated elasticities are positive for calories, protein, and vitamins, though none is significantly different from 0. Thus, we cannot reject that the subsidy had no effect on nutrient intake in Gansu. The largest nutrient elasticity, 0.148 for calories, is still fairly modest, while the others are extremely small (less than 0.08). Of course, while we cannot reject the subsidy having no effect, we also cannot rule out more substantial effects. For example, for calories, protein, minerals, and vitamins, we cannot reject elasticities of 0.34, 0.30, 0.19, and 0.28, respectively, at the 95% significance level. Finally, and again the reverse of Hunan, here the simple undifferenced regressions yield the opposite signs, with negative (though small and not statistically significant) effects of the subsidy on intake.

One limitation to the summary measures of vitamin and mineral intake is that they treat changes in (normalized) intakes of each vitamin and mineral equally. However, increased intake of a nutrient for which the individual is currently far below adequate levels is likely to be of greater health consequence than one for which they currently have already achieved required levels. Further, being over the DRI on some nutrients is not likely to offset the health effects of being under on others. A final limitation is that some vitamins and minerals, such as iron and vitamin A, are often considered to be greater public health concerns, not just because deficiencies are more widespread but because those deficiencies have more serious consequences for health and well-being.

The columns labeled “Coefficient” in table 2 provide regression results for all nineteen individual vitamins and minerals individually using specifications like equation (1) above. We do not adjust the p -values for the multiplicity of the tests (with nearly twenty regressions per province, we would expect that even by chance, at least one would yield a statistically significant coefficient even if the true effect were 0 for all of them), for example, by using Bonferroni-style adjustments to the p -values. Thus, these hypothesis

tests should be interpreted with caution, as such adjustments would decrease the likelihood of rejecting the hypothesis of no effect.

For the pooled sample, the elasticity point estimates have mixed signs, though most (fourteen of nineteen) are negative. The effects are statistically significant (at the 5% or 10% level) for calcium, manganese, and vitamin A. From a nutrition perspective, it is worth noting that households are on average deficient in all three micronutrients at baseline (receiving about one-third to one-half of the DRI).³⁰ Most of the positive point estimates are very small (less than 0.10), excluding vitamin B₁₂ (0.31). However, for many vitamins and minerals, the standard errors are large. While we can rule out elasticities greater than 0.15 for thirteen of the vitamins and minerals, we cannot rule out moderate to large elasticities for the others (ranging from about 0.30 for phosphorous, selenium, and riboflavin to 0.40 to 0.80 for sodium, vitamin C, and vitamin B₁₂).

For Hunan, seventeen of the nineteen estimated elasticities are negative. However, only five are statistically significant (at the 5% to 10% level): calcium, magnesium, manganese, folate, and vitamin A. The declines are large for two particularly important nutrients: calcium, where the point estimates suggest a 1% price subsidy leads to a nearly 0.51% reduction in intake, and vitamin A, where a 1% subsidy leads to a 0.83% reduction. Among other things, these two nutrients are important for the growth and maintenance of bones, and deficiencies can lead to a variety of significant long-term health problems. This is especially important in light of the fact that on average, households were receiving less than half the DRIs for these minerals at baseline.

In Gansu, the signs of the point estimates for the various vitamins and minerals are more mixed, though none is statistically significant. The point estimates are extremely small in most cases, with all elasticities less than 0.11 except for selenium (0.31) and vitamin C (0.20), which are still fairly small. However, the standard errors are again in many cases large, so we cannot rule out moderate to large positive effects for a number of nutrients. For example, we cannot rule out elasticities of 0.50 or greater for selenium, vitamin C, sodium, vitamin B₁₂, and vitamin A (with households deficient at baseline for the latter three).

B. Robustness

In table 5, we present results from a range of alternative specifications, including using individuals as the unit of

³⁰ Of course, this does not indicate that those who cut back were those who were initially deficient at baseline. Given difficulties in assessing deficiency, since need varies with many (observed and unobserved) characteristics, we do not explore heterogeneity along this dimension. Alternatives such as measuring the deficit of nutrient intake (i.e., adding up only shortfalls) would be similarly limited. Further, such a measure would require making assumptions on the shape of the relationship between intake relative to DRIs and other outcomes (for example, moving from a deficit of 0.12 to 0.20 might have a greater impact on health than moving from 0.82 to 0.90) or assuming there is no beneficial effect of increased nutrient intake above the DRI.

TABLE 5.—NUTRITIONAL RESPONSE TO THE PRICE SUBSIDY: ROBUSTNESS

	Calories	Protein	Minerals	Vitamins
Pooled				
1. Non-arc	-0.072 (0.093)	-0.066 (0.121)	-0.079 (0.101)	-0.088 (0.120)
2. County-clustered SE	-0.032 (0.072)	-0.027 (0.047)	-0.061 (0.044)	-0.051 (0.066)
3. County × Time FE	0.012 (0.074)	0.018 (0.086)	-0.054 (0.078)	-0.023 (0.083)
4. Not per capita	-0.033 (0.076)	-0.029 (0.089)	-0.061 (0.081)	-0.051 (0.085)
5. Individual data	0.023 (0.074)	0.020 (0.043)	-0.048 (0.064)	0.008 (0.097)
6. Levels	0.005 (0.117)	0.051 (0.124)	-0.021 (0.041)	-0.023 (0.051)
7. Log-log	-0.123 (0.077)	-0.041 (0.075)	-0.044 (0.067)	-0.023 (0.066)
Hunan				
1. Non-arc	-0.228* (0.118)	-0.035 (0.157)	-0.151 (0.150)	-0.2153 (0.181)
2. County-clustered SE	-0.218** (0.064)	-0.105 (0.103)	-0.153** (0.045)	-0.201 (0.113)
3. County × Time FE	-0.204* (0.109)	-0.094 (0.134)	-0.149 (0.115)	-0.190 (0.122)
4. Not per capita	-0.219** (0.120)	-0.104 (0.136)	-0.153 (0.119)	-0.201 (0.127)
5. Individual data	-0.148** (0.041)	-0.002 (0.074)	-0.088 (0.074)	-0.082 (0.112)
6. Levels	-0.207 (0.131)	-0.084 (0.190)	-0.056 (0.060)	-0.096 (0.073)
7. Log-log	-0.220** (0.100)	-0.022 (0.100)	-0.001 (0.089)	-0.114 (0.087)
Gansu				
1. Non-arc	0.087 (0.126)	-0.028 (0.162)	-0.048 (0.130)	-0.016 (0.148)
2. County-clustered SE	0.148 (0.086)	0.081 (0.052)	-0.011 (0.037)	0.069 (0.088)
3. County × Time FE	0.159 (0.100)	0.099 (0.113)	0.013 (0.105)	0.092 (0.112)
4. Not per capita	0.148 (0.101)	0.079 (0.114)	-0.011 (0.107)	0.069 (0.113)
5. Individual data	0.136 (0.108)	0.035 (0.058)	-0.021 (0.100)	0.067 (0.148)
6. Levels	0.207* (0.116)	0.170 (0.138)	0.016 (0.057)	0.054 (0.069)
7. Log-log	0.045 (0.117)	-0.008 (0.113)	-0.095 (0.100)	0.121 (0.102)

Standard errors, clustered at the household level, in parentheses. This table contains robustness checks for tables 4A, 4B, and 4C. The base specification for the first four rows for all panels regresses $\% \Delta \text{per capita intake on } \% \Delta \text{subsidy}$ using household-level data and clustering standard errors at the household level, as in the previous tables. The regressions here modify one part of this basic specification. The first row for each panel uses non-arc percentage changes instead of arc changes, the second row uses county-clustered standard errors instead of household level, and the third row adds county × time fixed effects. The fourth row uses household-level $\% \Delta \text{ intake}$ rather than per capita percentage changes. The fifth row also uses $\% \Delta \text{ intake}$, but using individual-level data rather than household level. The sixth row uses levels instead of percentages, regressing Δintake on $\Delta \text{subsidy}$, and the final row regresses $\Delta \log(\text{intake})$ on $\Delta \log(\text{subsidy})$. Calories and protein are daily intakes (in kcal and grams, respectively), vitamins and minerals are sufficiency indexes measuring the average per person intake relative to the DRI. Significant at *10%, **5%.

observation rather than the household; simple (non-arc) elasticities; a log-log specification; using calorie intake and price subsidy levels rather than percentage changes; using household total nutrient intakes rather than per capita measures; clustering standard errors at the county level; and including county × time fixed effects for added precision (allowing us in effect to compare the changes for households with different subsidy levels within the same community, thus controlling for any county-level factors that change over time, such as the prices of foods, labor market

conditions, or the value of government transfer programs). The coefficients are fairly stable across the various specifications. In a few cases, particular coefficients occasionally move from just above to just below marginal statistical significance or vice versa, though these typically represent only slight changes in p -values and we would not want to make much of the marginal significance or not in these cases. For Hunan, the effect on calories is consistently negative and statistically significant, with point estimates of the elasticity varying from 0.15 to 0.25. The effects on protein, mineral, and vitamin intake in Hunan are generally negative, but only a few are (marginally) statistically significant, so there is no robust evidence of declines. In Gansu, the results are again fairly robust to alternative specifications. The point estimate of the calorie elasticity in particular varies only from about 0.10 to 0.20, though it is only (marginally) statistically significant in one of the specifications, where household totals instead of per capita measures are used.³¹ The elasticities are generally positive for the other nutrients, but are in general fairly small, and are statistically significant. Overall, we again conclude that there is no evidence the subsidy improved nutrition and may have perhaps slightly worsened calorie intake in Hunan.

C. Relationship Between Nutrient Elasticities and Wealth

Our primary conclusions represent the average effect of the subsidy in our sample. An important possibility to explore is whether the analysis overlooks important heterogeneity in the response. In particular, we might expect that the poorest households—those that are presumably consuming the lowest levels of nutrients relative to need—might be less inclined than wealthier households are to trade off taste for nutrients. And for a policymaker, the effect on the most nutrient deprived might be more important than the average effect. Therefore, although our sample already focuses exclusively on urban households officially classified as the poorest, it is worth exploring whether the subsidies might have at least improved nutrition among the poorest of the poor. While one must of course be mindful of the potential problems in interpreting results based on ex post stratifications of the data, we believe this exercise is valuable because the prediction of a heterogeneous response would follow from basic consumer theory for consumers near subsistence (see Jensen & Miller, 2008a) and because this is likely to be of greater policy interest than the average effect.

Ideally, stratifying the sample would be done according to some measure of nutritional intake adequacy or by whether households are above or below a subsistence threshold. Unfortunately, there is no consensus on what the true subsistence threshold is, or indeed whether it even exists (see, for

example, the discussion in Dasgupta, 1993). We therefore take a simple, flexible approach to exploring heterogeneity using a series of locally weighted regressions. At each level of (preintervention) log expenditure per capita,³² we estimate equation (1) using a window of observations on either side of that point; within that window, we estimate a weighted regression, where observations closest to the central point receive the most weight (we use a biweight kernel, though the results are robust to alternatives). Figure 1 plots the resulting coefficients (the subsidy price elasticities) at each level of wealth, along with the associated 95% confidence intervals.³³

For calories in panel A, the figures yield similar patterns for the two provinces. In both cases, the wealthiest households respond to the subsidy by decreasing calories (though this is statistically significant over only a small range in Hunan and not at all in Gansu). The figure also shows that the decline in calories associated with the subsidy in Hunan was largely driven by wealthier (but still quite poor) households. By contrast, the point estimates of the elasticities are positive for the poorest households in both provinces, though they become statistically significant only in Gansu for the very bottom of the expenditure distribution (corresponding to around \$0.10 to \$0.15 per person per day). In fact, there is a rough consistency between the results in the two provinces. The crossing point from negative to positive point estimates occurs at log monthly expenditures per capita of 5.5 in Hunan and 5.0 in Gansu. Thus, there is perhaps some suggestive evidence that the very poorest of the poor may have increased caloric intake. Again we are cautious not to overinterpret these results given that this ex post stratification deviates from our original experimental design and since the effect is only statistically significant over a very small range, and only in Gansu.

The same pattern of the response to the subsidy along the wealth distribution generally does not appear for other nutrients in panels B to D, however. While there is evidence of a negative relationship between expenditure and the elasticities of protein, vitamin, and mineral intake in Hunan, the elasticity is almost uniformly negative throughout the expenditure distribution, and the positive point estimates are not statistically significant over any range (though this

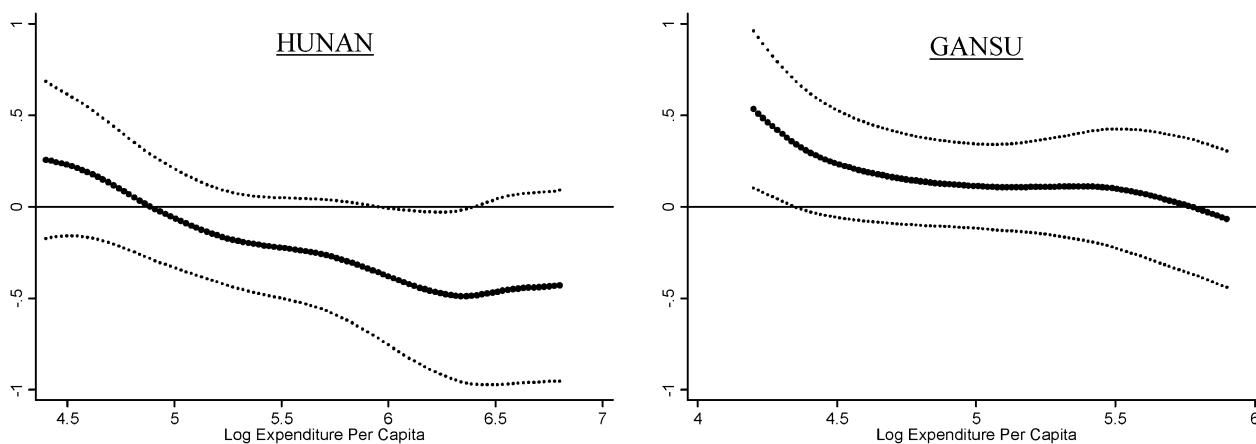
³² Although it might seem more meaningful to estimate the effects based on initial caloric intake rather than expenditure, categorizing individuals in this way is problematic. Calorie needs vary widely by age, sex, height, weight, body fat and muscle composition, level of physical activity, health status, and a range of other factors. Thus, you could have two individuals with the same caloric intake, but one has a physically demanding job and is consuming fewer calories than needed, while the other is retired and consuming more calories than needed for subsistence. However, performing the analysis using baseline caloric intake yields broadly similar conclusions to those below (though the evidence that calories increase for the most deprived households in Gansu is weaker).

³³ In Jensen and Miller (2008a), we argue that the share of calories a household consumes in the form of a staple good is a reliable indicator of whether a household is consuming at, above, or below subsistence. Using this alternative variable yields broadly similar conclusions to those observed with expenditures, so for simplicity, we present only the expenditure-based results.

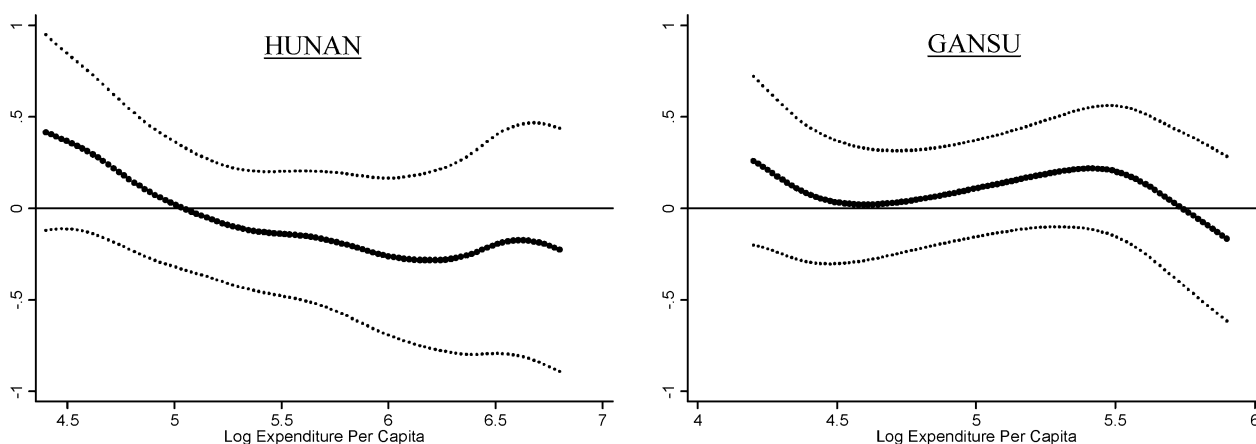
³¹ However, this variation itself is not robust to the other variations, such as using levels rather than percentage changes, a log-log specification, or clustering standard errors at the county level.

FIGURE 1.—NUTRIENT-PRICE SUBSIDY ELASTICITIES BY EXPENDITURE PER CAPITA

A. Calories



B. Protein



approach does reduce sample sizes, decreasing precision). Thus, as above, overall for Hunan, we generally conclude that the subsidy did not improve intake of any nutrient, and perhaps decreased it for calories.

For Gansu, there is no evidence for a downward-sloping relationship in wealth for the protein, mineral, and vitamin elasticities. The point estimates are generally positive for much of the expenditure distribution, but there is no range over which they are statistically significant. Thus, while there may be some suggestive evidence of a calorie improvement for the very poorest households in Gansu, there is no evidence of gains in any other nutrients. Below, we will show that these results are consistent with changes in food consumption patterns.

D. Food Substitution Patterns

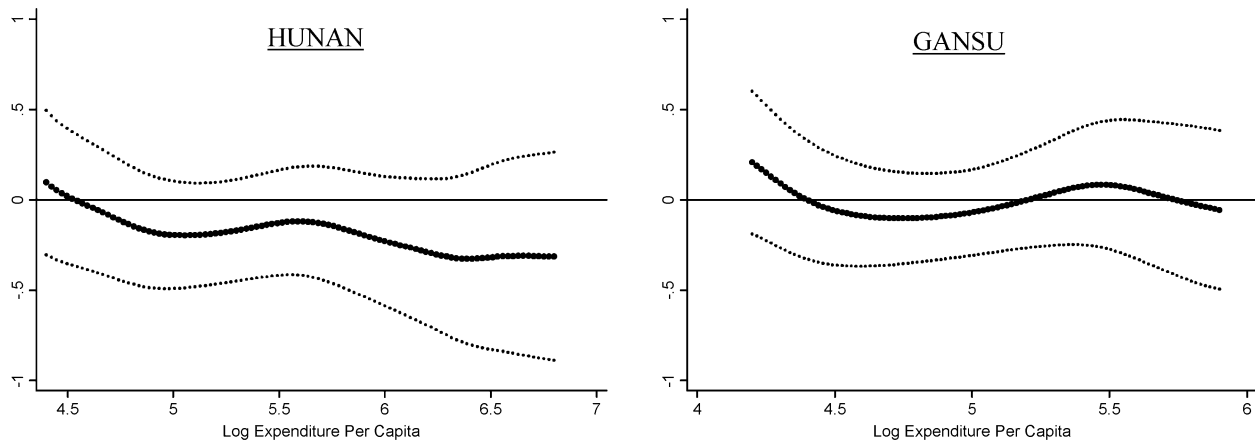
The motivating hypothesis for this study is that when faced with a decline in the price of a staple food, households will change the composition of the basket of goods

they consume, possibly substituting toward foods with higher nonnutritional attributes (or that add variety to their diet). In table 6, we consider the impact of the subsidy on dietary patterns using the percentage change in consumption of various aggregated food categories, with data from the food intake diaries as the dependent variables in regressions like equation (1). Given the widely differing results by province, for the remaining analyses, we omit the results for the pooled sample. We also present p -values adjusted for multiple testing, using Bonferroni-style adjustments due to Holm (1979) and Benjamini and Hochberg (1995).³⁴ However, we note that our original model for this paper and

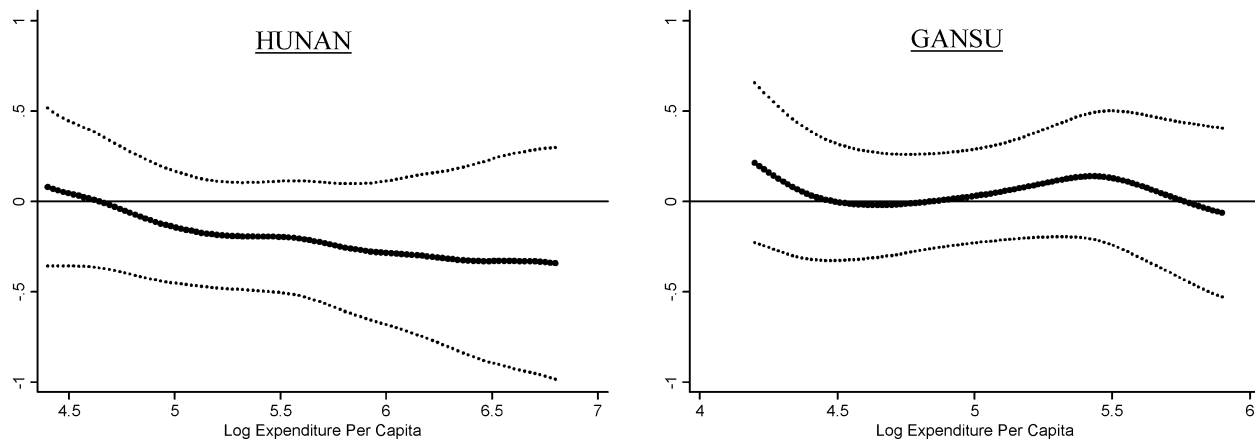
³⁴ Holm (1979) ranks p -values across the k tests from largest to smallest and multiplies each p -value by its rank from 1 to k . Benjamini and Hochberg (1995) also rank p -values across k tests from largest to smallest, but multiply each p -value by k/rank . Benjamini-Hochberg is a less conservative test and thus more likely to allow false positives. We view these as two book-end adjustment options. Though Holm is not as conservative as the unadjusted Bonferroni method where each p -value is simply multiplied by the number of tests, it yields a similar rate of false positives as this conservative approach, and less rejection of true positives.

FIGURE 1.—(CONTINUED)

C. Minerals



D. Vitamins



Jensen and Miller (2008a) yielded a specific prediction that a price subsidy on a staple good would (negatively) affect consumption of the staple good and (positively) a “fancy” good like meat or pulses, with the other food categories presented here simply for completeness; thus, in principle, the unadjusted p -values for rice or wheat, meat, and pulses are the correct ones. In the final column of the table, we also provide the p -values of standard F -tests of the null hypothesis that the effect of the subsidy is 0 for all of the consumption groups.

The results provide insight into the effect of the subsidy on nutrient intake. In Hunan, the rice price subsidy causes consumers to cut back on their consumption of rice—the Giffen behavior documented in Jensen and Miller (2008a). In addition, they cut back on their consumption of vegetables (a category dominated primarily by cabbage and spinach), pulses (primarily bean curd or tofu), and fats (primarily cooking oils). Offsetting these cutbacks is an increase in seafood consumption (primarily fish, the cheapest meat in both provinces). While we know only the foods

eaten, not how they were combined as eaten, our fieldwork revealed that the primary diet for most households in our Hunan sample was rice, eaten with bean curd and cabbage or spinach, stir-fried in oil. The results in table 6 therefore suggest that in response to the subsidy, households in Hunan substituted away from this primary meal (with statistically significant reduction for each of these food items) in favor of adding fish to their diet. While a great deal of calories were lost from the reduced consumption of rice and pulses (cabbage and spinach have very few calories), only part of this loss was recovered through the increased consumption of fish, leading to a net decline in calories. Additionally, the large decline in vitamin A in Hunan is likely explained by the reduced consumption of spinach, which is among the richest sources of that vitamin. However, we note that no coefficients are statistically significant when p -values are adjusted using the more conservative Holm correction, and only fruits and vegetables and fats are (marginally) significant using the Benjamini-Hochberg adjustment.

TABLE 6.—CONSUMPTION RESPONSE TO THE PRICE SUBSIDY

	Rice	Other Cereal	Fruit/Vegetables	Meat	Seafood	Pulses	Fats	Food Out	Nonfood	F-Test Joint Significance [p-Value]
Hunan										
% Δ Subsidy(rice)	-0.255* (0.143)	0.398 (0.357)	-0.644*** (0.236)	0.155 (0.294)	0.478** (0.229)	-0.812* (0.480)	-0.622** (0.317)	0.176 (0.348)	0.153 (0.210)	2.75 [0.0037]
Multiple test adjusted p-values										
Holm-Bonferroni	0.374	>1.0	0.210	>1.0	0.224	0.117	0.180	0.669	>1.0	
Benjamini-Hochberg	0.135	0.392	0.090	0.718	0.126	0.117	0.068	0.669	0.621	
Observations	1,258	1,258	1,258	1,258	1,258	1,258	1,258	1,258	1,258	
R ²	0.15	0.03	0.06	0.03	0.01	0.01	0.03	0.01	0.12	
Gansu										
% Δ Subsidy(wheat)	0.337 (0.261)	-0.258 (0.335)	0.051 (0.193)	0.320 (0.352)	-0.016 (0.016)	0.253 (0.328)	0.544** (0.252)	0.150 (0.279)	0.022 (0.184)	0.93 [0.497]
Multiple test-adjusted p-values										
Holm-Bonferroni	>1.0	>1.0	>1.0	>1.0	>1.0	>1.0	0.252	>1.0	0.928	
Benjamini-Hochberg	0.882	0.729	>1.0	0.849	0.728	0.740	0.252	0.967	0.928	
Observations	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269	
R ²	0.03	0.01	0.06	0.02	0.01	0.02	0.03	0.00	0.11	

Standard errors, clustered at the household level, in parentheses. The dependent variables are the arc percentage change in household consumption of the good listed at the top of the column. % Δ Subsidy is the rice or wheat price subsidy, measured as a percentage of the average price. The last column is an F-test and associated p-value for the hypothesis that the coefficients on the subsidy variable are jointly 0 across all consumption categories within each province. Holm-Bonferroni p-values adjust for multiple testing using Holm (1979). p-values across k tests are ranked from largest to smallest, and each p-value is multiplied by its rank, from 1 to k. Benjamini-Hochberg adjusted p-values apply Benjamini-Hochberg (1995). p-values across k tests are ranked from largest to smallest and each p-value is multiplied by k/rank. Significant levels, unadjusted for multiple hypothesis testing: Significant at *10%, **5%, ***1%.

In addition to documenting patterns of food substitution, these results also show that while the subsidy had only modest effects on nutrition, it is not the case that households did not respond at all to the subsidy (or that our data or empirical strategy were inadequate for detecting such changes). Rather, there were substantial changes in household food consumption patterns in response to the price subsidy, which in the aggregate had a negative, though small, impact on nutrition.³⁵

In Gansu, there is less evidence of systematic substitution across foods. For the most part, the elasticities for the most commonly eaten foods are positive but not significantly different from 0. The only coefficient that is statistically significant is for fats, a category that primarily consists of edible oil (though the significance is not robust to adjustment for multiple testing). In Gansu, oil is sometimes eaten with or brushed on top of the simple home-made bread *mo* (the dominant form in which wheat is consumed in our sample) in order to add flavor; alternatively, both the flavor and texture of *mo* can be enhanced by adding more oil to the dough before cooking. Therefore, one interpretation of this result is that as in Hunan, subsidized households again sought to add taste to their diet, but since they could still not afford meat or seafood, they opted for the lower-cost option of increasing edible oils. Since consumption of other foods such as the staple did not decline, overall average caloric intake did not decline. In fact, per unit currency, oil adds more calories than wheat, but little or nothing in the way of other nutrients, which could explain why the subsidy had a positive effect on calories in Gansu (though not statistically significant except perhaps for the poorest of the poor) but no effect on any other nutrient categories. Thus, even any marginal gains in calories for Gansu come with the caveat that the gain may be driven purely by additional consumption of edible oil, largely devoid of any other nutrients.

E. Behavioral Responses

A final consideration is whether the subsidies lead to any behavioral responses. For example, the subsidy represents a wealth shock that might increase the demand for leisure and reduce labor supply. We would still want to consider such changes an effect of the subsidy. And such a result would be of interest in light of the large literature estimating the behavioral responses to public programs. However, the interpretation of the nutrition results might then differ, as

³⁵ We also note that we cannot reject that total expenditures on nonfood items did not change as a result of the subsidy in either province. In the appendix table, we consider the effects of the subsidy on disaggregated expenditure categories. The only statistically significant results are an increase in communications expenditures in Hunan (most likely cell phones; though the large elasticity represents only a small change in expenditure because the baseline level is extremely small) and an increase in food expenditures in Gansu (perhaps consistent with the increased consumption of oil noted below, which is expensive in relative terms). These coefficients are not significant when adjustments are made for multiple testing, however.

TABLE 7.—BEHAVIORAL RESPONSE TO THE SUBSIDY

	(1) Hours Worked	(2) Wages and Salary	(3) Unearned Income	(4) Number of People
Hunan				
<i>%ΔSubsidy (rice)</i>	0.12 (0.30)	0.085 (0.32)	-0.071 (0.24)	0.015 (0.053)
Constant	-53.7 (4.4)	-62.4 (26.7)	43.2 (21.0)	-0.98 (5.03)
Observations	1,258	1,258	1,258	1,258
R^2	0.01	0.01	0.01	0.01
Gansu				
<i>%ΔSubsidy (wheat)</i>	0.09 (0.31)	0.29 (0.28)	-0.19 (0.16)	0.042 (0.041)
Constant	-120.0 (33.0)	-103.1 (29.7)	67.5 (15.3)	-16.9 (4.78)
Observations	1,269	1,269	1,269	1,269
R^2	0.03	0.01	0.02	0.03

Standard errors, clustered at the household level, in parentheses. The dependent variables are the arc percentage change in the variables listed at the top of each column. *%ΔSubsidy* is the rice or wheat price subsidy, measured as a percentage of the average price.

we would want to assess changes in, say, calories, relative to reduced need as a result of lower physical activity.

Table 7 shows the impact of the subsidy on labor supply, earnings (wages and salary), unearned income, and household composition,³⁶ using regressions like equation (1), with percentage changes in these other variables as the dependent variable (though the results are robust to alternative specifications like those explored in table 5). Overall, there is no evidence that the subsidy had any effect on these behaviors. This is perhaps not surprising, given the extreme poverty of the households in our sample (and, regarding household composition, the scarcity of large extended families due to decades of the one-child policy).

IV. Discussion and Conclusion

Overall, we find no evidence that the consumer price subsidy improved nutrition, and it may have actually reduced caloric intake in one of our provinces. This is despite the fact that the households in our sample are extremely poor, by both Chinese and international standards, and appear to be very undernourished by international standards. That is, they are exactly the households at which subsidy programs are typically targeted. While the subsidies did not appear to strongly affect nutrition, they did affect household con-

³⁶ The possibility that the subsidy may attract other noneligible family members to the household is one case where the subsidy as we implemented it may yield different impacts from general subsidy. Our subsidy was assigned to only a subset of households, creating a potential pool of ineligible persons related to an eligible person. In the case of a universal subsidy for which all individuals are eligible, or a subsidy targeted to the poor where there is high correlation in poverty among relatives, we would not expect the same household composition response. While this is a potential threat to the external validity of our study, the fact that we find that no such changes took place makes this concern less important.

³⁷ Further, nutrition is, of course, an important outcome to assess in its own right. Protecting or improving nutrition is often one of the explicit goals of subsidy programs. Further, nutrition is the outcome of interest for many domestic and international organization such as the FAO, and the first Millennium Development Goal is to halve hunger (estimated to afflict 750 million people worldwide), defined in terms of caloric intake.

sumption patterns. Especially in Hunan, they induced substitution away from the subsidized staple food toward other foods with higher nonnutritional attributes.

While our analysis focused on nutrition rather than health or welfare, there are clear links from the former to the latter.³⁷ In fact, changes in nutritional status are perhaps more easily measured than changes in these other outcomes, which may arise only in the long run. For example, it is well established in the medical and public health literature that reduced calcium and vitamin D intake over long periods increases the likelihood of osteoporosis. While changes in the intake of these nutrients can easily measured with survey data, the loss of bone mineral density or an increased incidence of bone fractures would be detectable only after many years. Thus, nutrient intake provides important insight into health and long-term health risks; in the case in this paper, the absence of any gains in nutrition suggests it is unlikely the subsidy will have any positive health impacts.³⁸ Similarly, while there are well-established links between nutrition and important nonhealth outcomes such as work productivity, school performance, and cognitive development for children, we would again conclude it is unlikely the subsidy had any effect on these outcomes, since there was little to no effect on nutrition.

Ultimately, policies aimed at helping the poor should be evaluated in terms of their welfare impact. While the sign of the effect of the subsidy on nutrition is ambiguous (both theoretically and empirically), the welfare effect is not. By virtue of expanding households' budget sets, in a revealed preference framework (people are rational and make well-informed decisions) the subsidies must improve welfare regardless of whether they improve nutrition.³⁹ According to this view, consumers' choices maximize their utility, and if they make choices that reduce their nutrition, then it must be that they gain more from the increased taste or variety than they lose in calories or long-term health status.⁴⁰ But again, the primary conclusion remains that subsidies improve welfare.

³⁸ It is possible that the subsidy affects health through mechanisms other than nutrition. For example, households could use the savings from the subsidies to improve sanitation or water quality. While we cannot rule out impacts such as these, our failure to find an effect on household non-food expenditure categories is evidence against this hypothesis. It is also possible that the subsidy affects nutrient absorption while largely leaving the nutrient content of foods consumed unchanged due to changes in food quality, storage, or preparation (Schiff & Valdes 1990a, 1990b; for example, buying more expensive meat that is less likely to be contaminated and thus less likely to result in diarrhea or dysentery that would block nutrient absorption or cause illness). However, we find no evidence that the subsidy leads to increases in prices paid for foods in our sample, which is evidence against this hypothesis.

³⁹ If consumers are either not rational or not well informed about the consequences of their decisions, then this may not hold. In particular, if consumers are not well informed about the health consequences of their consumption decisions, then it is possible that a subsidy program accompanied by consumer education would result in households' improving nutrition in response to the combined program.

⁴⁰ This may be especially likely if consumers heavily discount the future, so they are willing to sacrifice long-term health in favor of short-term utility gains.

However, a number of other policy instruments such as cash or in-kind transfers also improve welfare for the poor, and price subsidies or controls are generally held to have a number of disadvantages relative to these other instruments (such as distorting price signals, leading to shortages, and promoting smuggling and black market activity). Although subsidies may have other advantages such as superior targeting, ease of administration, or political palatability, the primary justification for choosing subsidies over other policy instruments has been that they improve not just welfare but nutrition as well. This argument, at least in our data, does not appear to be valid.

If consumers simply prefer less nutritious foods, then policymakers, confronted with the reality of utility-maximizing consumers, can either abandon their concerns over nutrition or take a more paternalistic approach toward nutrition, perhaps as motivated by a public good aspect of good nutrition. If the former approach is adopted, then, seen in this light, our results should not be interpreted as saying that consumer price subsidies have no value or that food price increases should be ignored. High or rising food prices have adverse welfare consequences for the poor,⁴¹ and public policy must find ways to address these concerns. However, policymakers may have to be satisfied with knowing that giving wealth to the poor improves their welfare, and thus with assessing the gains of any efforts in terms of wealth transferred, not in terms of nutrition.

If, on the other hand, policymakers remain focused on improving nutrition, it is not clear that alternative policies will necessarily be more effective in achieving this goal.⁴² Our finding of no nutritional gain from the subsidy is driven by the wealth effect of the price change. When the subsidy increases households' real wealth, they substitute toward the less nutritious foods that wealthier households consume. Consequently, we would expect similar effects to occur with any other type of program aimed at improving nutrition that increases real wealth, including cash transfers or in-kind transfers of food.⁴³

While there should always be caution in generalizing results, we believe that the conditions displayed by our sample that lead to our predictions—poor households consuming

a large fraction of their calories from a staple good, along with lesser quantities of a small number of substitute goods, some of which are taste preferred but more expensive sources of calories—are likely to arise elsewhere. In many developing countries, staples such as maize, sorghum, millet, or cassava play a role in the traditional diet of the poor analogous to the role of rice and wheat in our Chinese sample. Indeed, our results help to substantiate the findings of no nutritional effect for food price subsidy programs found elsewhere in the literature (Kochar, 2005; Tarozzi, 2005; and a number of the papers surveyed in Behrman & Deolalikar, 1988).

There are reasons that the effects may differ in other environments. For example, if the prices of meat and other expensive sources of calories are not as high relative to the staple, then the calories gained by increasing consumption of these luxury foods may be sufficient to offset the calories lost by reducing consumption of the staple. Similarly, differences in the availability (or attractiveness) of substitutes for the staple or the more expensive source of calories may also alter the pattern of substitution among commodities and, consequently, the effect of the subsidy. Further, our study focused on subsidizing the price of only one good per province. It is possible that subsidizing a wider range of goods would cause different patterns of substitution and, accordingly, different nutritional outcomes. Finally, differences in the income levels of the target population could also affect the results. While the households in our study represent the poorest in urban China, who live on far less than the World Bank's extreme poverty line of \$1 dollar per person per day, it may simply be that our sample is largely beyond subsistence consumption. It may be that even poorer households would behave differently (and we note that there was some suggestive evidence of slight improvements for the very bottom of our sample). These remain empirical questions that can be answered only in other specific settings. However, our results do point out the importance of understanding the consequences of food substitution and the recognition that it will dampen the intended effects of subsidy or other programs and under certain conditions may neutralize or even reverse them.

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- ⁴¹ Again in terms of nutrition, Jensen and Miller (2008b) find that households in China were able to buffer caloric intake against at least the early phase of recent increases in world food prices.
- ⁴² This is, of course, not to say that programs such as fortifying foods (for example, adding iodine to salt) are not likely to be effective in increasing the intake of specific micronutrients.
- ⁴³ For interpretation of our results, it is important to keep in mind that we find that the subsidy does not improve nutrition relative to a baseline in which there is no subsidy. This is not the same as saying that price subsidies are less effective than cash aid in improving nutrition. In fact, if indeed it is the wealth effect of the subsidy that leads consumers to reduce nutrition, then the problem could be even more severe in the case of pure cash aid (of equivalent value). Put another way, while both cash and subsidies entail a wealth effect that reduces nutrition, the subsidy program also carries a substitution effect, which, by reducing the relative price of the nutritious staple, works in the opposite direction—toward improving nutrition. Thus, when compared to a cash aid program, an equivalently valued subsidy program may lead to better nutritional outcomes.
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APPENDIX TABLE

Impact of the Subsidy on Other Expenditures

	(1) Food	(2) Housing	(3) Fuel	(4) Utilities	(5) Communication	(6) Health	(7) Education	(8) Transport	(9) Clothing	(10) Entertainment	F-Test Joint significance [p-Value]
Hunan											
Subsidy(rice)	−0.103 (0.133)	0.107 (0.210)	0.275 (0.182)	0.159 (0.229)	0.705** (0.304)	−0.052 (0.364)	0.239 (0.298)	−0.019 (0.338)	−0.531 (0.355)	0.041 (0.319)	1.57 [0.112]
Multiple test adjusted <i>p</i> -values											
Holm-Bonferroni	0.496	>1.0	0.917	>1.0	0.189	>1.0	>1.0	0.954	0.822	>0.899	
Benjamini-Hochberg	0.279	0.786	0.393	0.734	0.189	>1.0	0.765	0.954	0.308	0.899	
Observations	1,258	1,258	1,258	1,258	1,258	1,258	1,258	1,258	1,258	1,258	
<i>R</i> ²	0.05	0.02	0.13	0.05	0.02	0.06	0.14	0.10	0.18	0.17	
Gansu											
Subsidy(wheat)	0.379*** (0.115)	0.258 (0.220)	−0.090 (0.175)	0.037 (0.176)	0.148 (0.290)	0.371 (0.291)	−0.093 (0.284)	−0.244 (0.301)	0.567 (0.322)	−0.215 (0.258)	1.65 [0.089]
Multiple-test adjusted <i>p</i> -values											
Holm-Bonferroni	0.009	>1.0	>1.0	0.833	>1.0	>1.0	>1.0	>1.0	0.711	>1.0	
Benjamini-Hochberg	0.009	0.605	0.869	0.833	0.765	0.680	0.827	0.697	0.395	0.814	
Observations	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269	
<i>R</i> ²	0.08	0.01	0.57	0.05	0.06	0.04	0.22	0.10	0.09	0.11	

The dependent variables are the arc percentage change in expenditures listed at the top of the column. Standard errors clustered at the household level. Coefficients are on the variable arc percentage change in the rice or wheat subsidy. The last column is an *F*-test and associated *p*-value for the hypothesis that the coefficients on the subsidy variable are jointly 0 across all expenditure categories within each province. Holm-Bonferroni *p*-values adjust for multiple testing using Holm (1979); *p*-values across *k* tests are ranked from largest to smallest, and each *p*-value is multiplied by its rank. Benjamini-Hochberg adjusted *p*-values apply Benjamini-Hochberg (1995); *p*-values across *k* tests are ranked from largest to smallest, and each *p*-value is multiplied by *k*/rank. Significance levels, unadjusted for multiple hypothesis testing: Significant at *10%, **5%, ***1%.