GIFFEN BEHAVIOR AND SUBSISTENCE CONSUMPTION
ONLINE APPENDIX

ROBERT T. JENSEN AND NOLAN H. MILLER

APPENDIX I. UNDERSTANDING GIFFEN BEHAVIOR

Traditionally, the possibility of Giffen behavior has been motivated by an argument similar to Marshall's. We will argue that the need to maintain subsistence consumption is the critical factor leading to Giffen behavior, drawing connections between Marshall's verbal argument, two mathematical models of the situation, and the graphical analysis found in microeconomics textbooks. Although much of what follows in this section has previously appeared elsewhere, we believe that this analysis provides a useful synthesis of theoretical approaches to the Giffen phenomenon.

Appendix I.A. The Characteristic-preference Model

We consider very poor consumers whose behavior is driven by the need to achieve a subsistence calorie intake. Following Lancaster (1966), rather than having preferences over the foods themselves, we model consumers as having preferences over two fundamental characteristics of foods: calories, c, and taste, t, where taste is meant to capture the non-nutritive aspects of food. For expositional ease, we assume there are only two foods, a basic good, b, such as rice, and a fancy good, f, such as meat. Let (c_b, t_b) and (c_f, t_f) denote the calories and taste provided by a unit of the basic and fancy goods, respectively. Let $p > 0$ denote the price of the basic good and normalize the price of the fancy good to 1. Spending one yuan (or Rmb, the Chinese unit of currency) on the fancy good provides more taste but fewer calories than spending a yuan on the basic good, i.e., $c_f < c_b / p$ and $t_f > t_b / p$.

The consumer's first priority is achieving subsistence calorie intake, which we denote by c^*. Once the consumer achieves subsistence, he attempts to maximize the taste of the foods he eats.[1] Since sufficiently impoverished consumers prioritize calories over taste, we begin by considering a consumer whose objective is to maximize taste subject to budget and subsistence

[1] A more general constraint on minimum nutritional requirements behaves similarly.

constraints; later we allow for more general preferences. Let $w > 0$ be the consumer's wealth, and let b and f denote the units consumed of the basic and fancy goods, respectively. The consumer chooses b and f to maximize $t_b b + t_f f$ subject to the budget constraint, $pb + f \le w$, and the subsistence constraint, $c_b b + c_f f \ge c^*$.

Figure A1 illustrates the consumer's problem. Each point in this "characteristic space" is the calorie-taste outcome arising from a particular combination of the basic and fancy goods. Points F = ($c_f w$, $t_f w$) and B = ($c_b w/p$, $t_b w/p$) represent the calorie-taste bundles resulting from the consumer spending all their wealth on the fancy and basic goods, respectively. The set of affordable calorie-taste bundles is given by the convex hull of these two points and the origin, and the set of points where the consumer spends his entire wealth is the line segment FB. When the consumer's wealth is sufficiently high (i.e., point F lies beyond the subsistence constraint) as in panel A, the consumer can afford to get his calories exclusively from the fancy good. The solution to the consumer's problem is in this case point F.

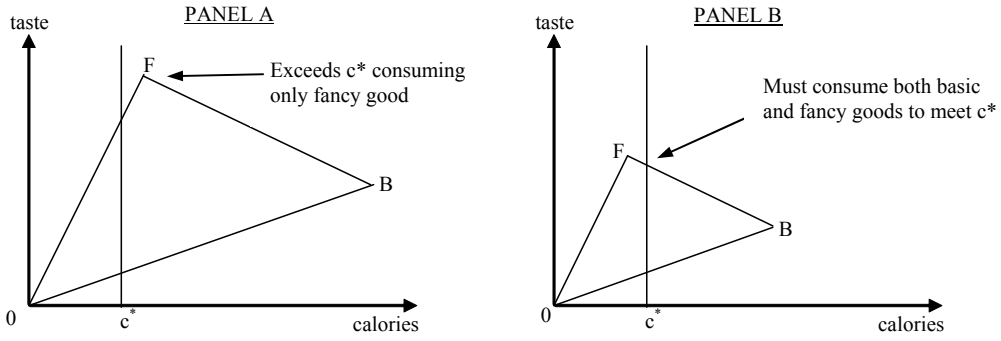

Figure A1: The consumer's problem with non-binding (Panel A) and binding (Panel B) calorie constraint.

If the consumer cannot achieve c^* calories by consuming only the fancy good (i.e., $c_f w < c^*$), as in panel B, the solution to the consumer's problem lies at the intersection of the calorie constraint and the budget constraint FB. Thus, the consumer's demanded bundle is (b^*, f^*), where $b^* = (c^* - c_f w)/(c_b - c_f p)$ and $f^* = (w c_b - p c^*)/(c_b - c_f p)$. To see that the basic good is Giffen, note that $\partial b^*/\partial p = c_f (c^* - c_f w)/(c_f p - c_b)^2 > 0$. A price increase leads to increased consumption of the basic good. This can also be seen graphically in figure A2. Here, we overlay vectors representing consumption of the basic and fancy goods; the slopes of these vectors reflect the

calorie-taste combination for each good (they are therefore parallel to line segments 0F and 0B, which reflect choosing only the fancy and only the basic goods, respectively). Panel A shows the initial consumption choices for a consumer who is unable to achieve subsistence calories by consuming only the fancy good. Panel B depicts the impact of an increase in the price of the basic good, which shifts the consumer's budget line from FB to FB'. Note that the vector *b'*, which depicts consumption of the basic good at the higher price, is longer than *b**, which depicts consumption at the original price. Thus an increase in the basic good's price increases its consumption, i.e., the consumer exhibits Giffen behavior.

In our simple model we have assumed that the consumer maximizes taste subject to a calorie constraint. However, the qualitative features remain unchanged for more general preferences, provided that utility increases in taste and the minimum calorie constraint binds, as it will for a sufficiently impoverished consumer.[2]

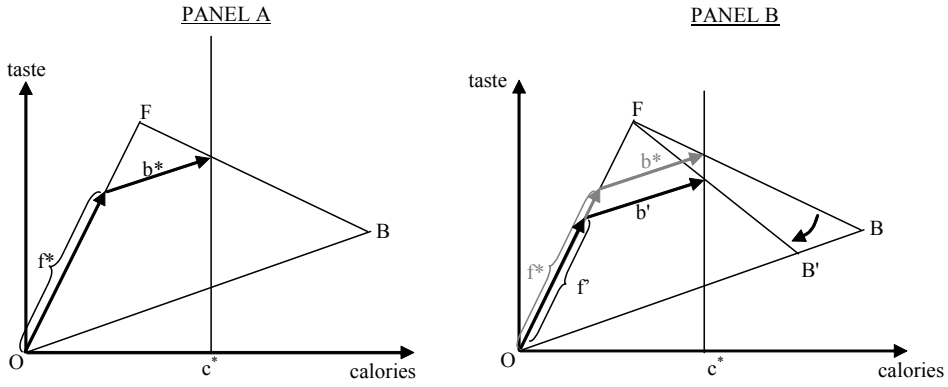

Figure A2: The response to a change in the price of the basic good (given a binding calorie constraint)

Appendix I.B. The Gilley – Karels Model

Gilley and Karels (1991) and Van Marrewijk and van Bergeijk (1990) study Giffen behavior in the context of the neoclassical model with an additional subsistence constraint. The consumer's utility maximization problem is to choose b and f to maximize u(b, f) subject to the same calorie and budget constraints as above, $c_b b + c_f f \geq c^*$ and $pb + f \leq w$, where u(b, f) is the

[2]The argument is essentially the same as the one presented at the end of Appendix Section I.B. Lipsey and Rosenbluth (1971) show in the context of the Lancaster (1966) model that Giffen behavior may be more likely than originally believed, even when the consumer is not subject to a minimum calorie constraint.

consumer's utility function, assumed to be strictly increasing and strictly quasiconcave on all (b, f) that satisfy the subsistence constraint. All other notation is unchanged.

Our first task is to translate figure A2 into the ordinary commodity space. Since $c_b/p > c_f$, the subsistence constraint is steeper than the budget constraint when b is plotted on the horizontal axis, as in figure A3, panel A. The set of feasible consumption bundles is the shaded area above the subsistence constraint (dotted) and below the budget constraint (solid). Panel B depicts two possible budget sets for the consumer. In the first, the consumer has relatively high wealth w_1, and the consumer's subsistence constraint does not bind at the optimal consumption bundle, x_1. In this case, which is the standard case, the consumer's demanded bundle is the point of tangency between his utility isoquants and the budget constraint. However, as wealth decreases it becomes increasingly likely that the subsistence constraint binds at an optimum. In Panel B, wealth level w_0 corresponds to one such case. In this case, the highest utility bundle that satisfies both constraints lies on the intersection of the budget and subsistence constraints, just as it did in the characteristic-preference model. Thus the consumer demands bundle $x_0 = (b^*, f^*)$, where b^* and f^* are as in the previous section. Since the consumer's demand is the same as in the characteristic-preference version of the problem, once again the basic good is Giffen.

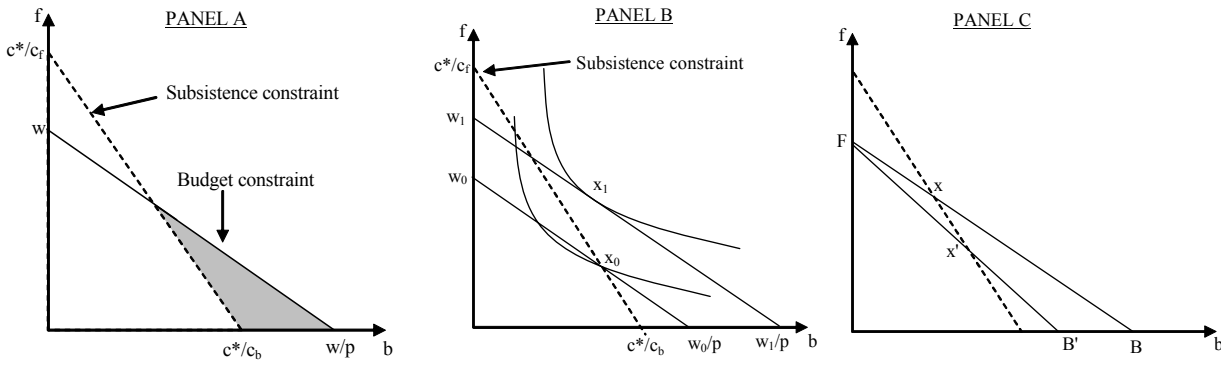

Figure A3: Giffen Behavior in the Gilley-Karels Model.

To see the consumer's reaction to a price increase graphically, consider panel C, which presents the price increase from p to p' shown in panel B of figure A2. At price p, the budget constraint is line FB, where F = (0, w) and B = (w/p, 0), and the consumer demands bundle x. The price increase to p' pivots the budget constraint clockwise to line FB' (B' = (w/p', 0)) and moves the intersection of the budget and subsistence constraints to point x'. Whichever bundle

the consumer demands, it must lay on the new budget line between points *x*' and B'. However, any such point involves consuming more of the basic good, i.e., Giffen behavior.

Appendix I.C. The Graphical (Textbook) Approach

Approaches such as those presented above have been criticized on the grounds that consumer theory posits consumers who maximize preferences subject to a budget constraint. Any need for subsistence should therefore be built into the consumer's preferences (Wichers 1994). In this section we present the textbook explanation of the Giffen phenomenon and argue that implicit in the shape of the indifference curves needed to account for Giffen behavior is a subsistence motive.

The standard pedagogical tool of intermediate microeconomics for explaining the Giffen phenomenon involves a graphical explanation. However, the indifference map needed to induce Giffen behavior is not standard. For example, typical, Cobb-Douglas indifference curves cannot generate Giffen behavior. In the typical presentation, the indifference curves used to illustrate Giffen behavior appear to "fan out," becoming closer together as you move to the northwest, as depicted in figure A4, panel A, where demand for the basic good increases as the price of the basic good increases.[3]

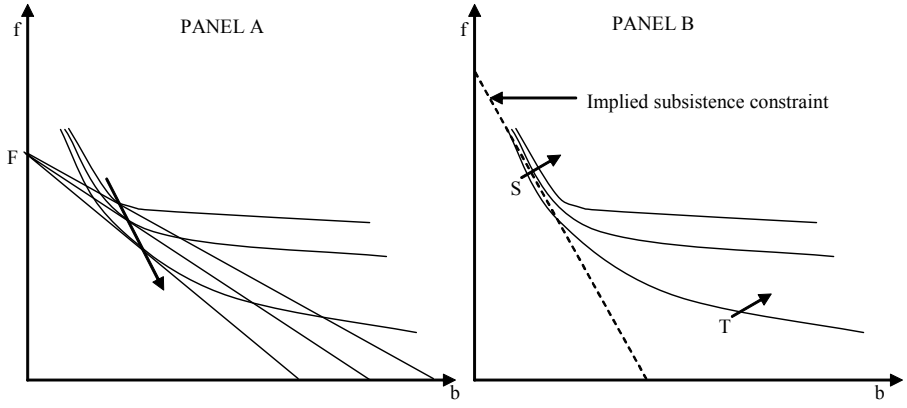

Figure A4: The Textbook Approach to Giffen Behavior

The link between the graphical presentation and the subsistence-constraint models is found in the shape of the indifference curves used to induce Giffen behavior. Consider figure A4, panel B, which isolates the indifference curves from panel A. Notice that because of the shape of the indifference curves, the consumer's utility increases more steeply when moving

[3] Spiegel (1994) constructs a utility function that leads to Giffen behavior whose isoquants exhibit this shape.

perpendicular to the dotted line than when moving parallel to it, and that utility also increases more steeply near the dotted line (point S) than above it (point T). Because utility increases rapidly perpendicular to the dotted line, the consumer will behave as if he faces a constraint to choose, whenever possible, a consumption bundle laying to the northeast of this line. It is, in effect, an implied subsistence constraint; thus the subsistence motive underlies even the standard pedagogical treatment of the Giffen phenomenon.

Thus, despite ostensibly different approaches, the intuition underlying all four motivations for Giffen behavior is the same. Poor consumers with few substitution possibilities facing a real or implied subsistence constraint will be forced, following an increase in the price of a basic good, to consume more of the cheapest source of calories available and less of other goods. As Gilley and Karels (1991, p.181) note, this suggests that "the most likely place [to find Giffen behavior] would be among the very poor, consuming a few staples, with limited substitution possibilities."

While these factors make detecting Giffen behavior more likely, there is one additional factor that must be considered. The mechanics of substitution accompanying Giffen behavior involve the consumer decreasing consumption of more desirable foods such as meat in order to increase consumption of the staple. However, extremely impoverished consumers may be so poor that they cannot afford to consume any of the fancy good. In this case, even if the price of the basic good goes up, Giffen behavior is not possible since there is no good whose consumption can be reduced to fund increased purchases of the basic good. Thus, while consumers must be poor, they cannot be too poor.

In light of this, the consumer's preferences can be thought of as falling into three distinct zones, as illustrated in figure A5. In panel A, the outer set of indifference curves correspond to the standard case, where the consumer's calorie intake is well above subsistence. Over this range the consumer trades off between calories and taste (and thus between the basic and fancy goods) in an ordinary way, and thus in panel B they respond to an increase in the price of the basic good by decreasing consumption of that good. The middle group of indifference curves corresponds to the range of consumption bundles over which the consumer crosses from malnutrition into nutritional stability. Over this range, the consumer is willing to sacrifice a great deal of taste (and thus the fancy good) in order to maintain calories; thus in panel B, they respond to an increase in the price of the basic good by consuming more of it, i.e., they exhibit Giffen behavior. Finally, in

the inner-most, calorie-deprived zone, the consumer is struggling to achieve subsistence calorie intake, and therefore values increases in calories almost exclusively. Further, they may be using their entire budget on only the basic good, and thus as seen in panel B, they have no choice but to respond to a staple price increase by consuming less of it.

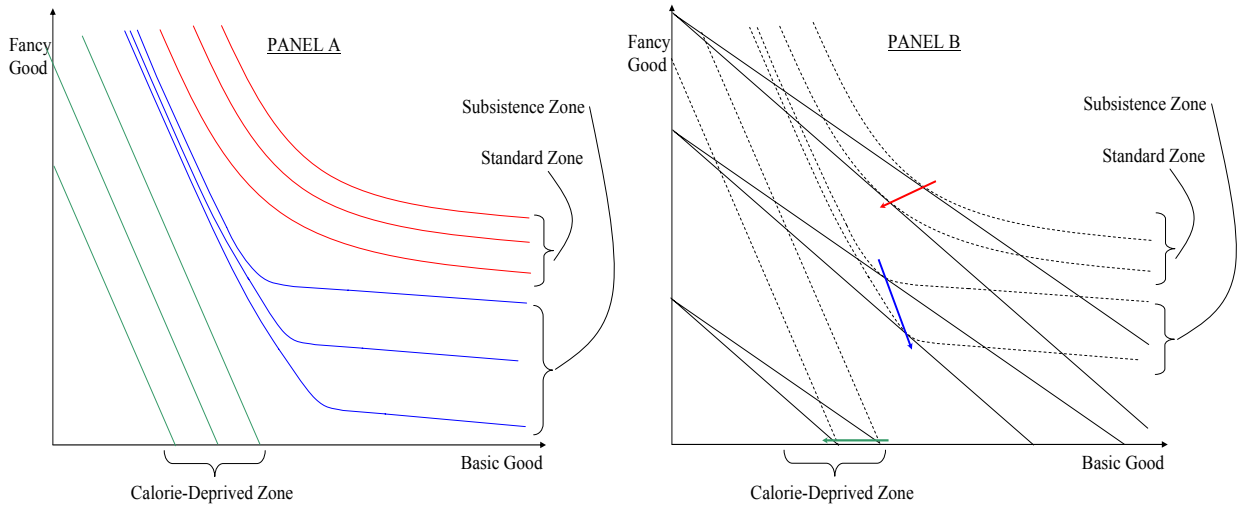

Figure A5. The Different Zones of Consumer Preferences

APPENDIX REFERENCES

Gilley, Otis and Gordon V. Karels (1991). "In Search of Giffen Behavior," *Economic Inquiry*, 29(1), p. 182-9.

Lancaster, Kelvin J (1966). "A New Approach to Consumer Theory," *Journal of Political Economy*, 74(2), p. 132-157.

Lipsey, Richard G. and Gideon Rosenbluth (1971). "A Contribution to the New Theory of Demand: A Rehabilitation of the Giffen Good," *Canadian Journal of Economics*, 4(2), p. 131-163.

Spiegel, Uriel (1994) "The Case of a 'Giffen Good'," *Journal of Economic Education*, c, p. 137–47.

van Marrewijk, Charles and Peter A.G. van Bergeijk (1990). "Giffen Goods and the Subsistence Level," *History of Political Economy*, 22(1), p. 145-8.

Wichers, Robert (1994) "In Search of Giffen Behavior: Comment," *Economic Inquiry*, 32, p. 166-167.

APPENDIX II: THE MINIMUM COST DIET AND THE STAPLE CALORIE SHARE

Individual requirements for calories and essential amino acids vary a great deal and depend on a range of characteristics. To investigate the extent to which it might be possible to judge whether a particular person was meeting their essential nutritional needs, we solved a simplified version of the "diet problem," i.e., minimizing the cost of achieving certain nutritional requirements. To capture the importance of complete protein sources, using information from the National Research Council we imposed intake requirements for calories and 11 amino acids.[A1] We considered diets consisting of rice and bean curd in Hunan, and wheat flour and bean curd in Gansu. In both provinces, the staple is the cheapest source of calories, but it is relatively deficient in the essential amino acid lysine. Complementing cereal grains with legumes such as in bean curd is typically the cheapest way to ensure that a person receives all essential amino acids. Typically, only small amounts of bean curd are needed to complete the protein.

Nutritional content information was taken from the USDA National Nutrient Database for Standard Reference (the Chinese food tables used in the paper do not contain information on amino acid content of foods).[A2] Calorie requirements are computed using the Estimated Energy Requirement equations from the Institute of Medicine.[A3] In order to capture the realities of cooking technology, we assume that households receive 13% of their calories from fats, in this case in the form of cooking oil. In most cases this implies consumption of less than one tablespoon of oil per day.

We considered a number of different representative "people" of both sexes with a range of different height, weight, and activity level specifications ("V" denotes very active, "A" denotes active, "L" denotes less active, and "S" denotes sedentary). Scenarios G – J are chosen with typical heights for Chinese men and women who are slightly underweight or normal weight (by body mass index). For each person, we solved for the minimum-cost diet that satisfies the nutritional requirements for calories and each of the essential amino acids. In all cases, the calorie and lysine constraints bind and determine the solution. Hence to conserve space we do not report the other amino acid requirements.

The results of this exercise show wide variability in both caloric requirements and the cost of the least-cost diet (see table below). Daily calories required and the least-cost diet range from 1351 calories and 1.15 yuan/day in Gansu (1.21 in Hunan) for a sedentary elderly woman (scenario E) to 4264 calories and 2.69 yuan/day in Gansu (2.91 in Hunan) for an active young man (scenario A). Thus the calorie

---

[A1] National Research Council, *Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, And Amino Acids (Dietary Reference Intakes),* National Academies Press, Washington DC, 2005.

[A2] USDA National Nutrient Database for Standard Reference, http://www.nal.usda.gov/fnic/foodcomp/search/.

[A3] Gerrior, S. et al., "An Easy Approach to Calculating Estimated Energy Requirements," *Preventing Chronic Diesase,* 2006, October; *3(4)*: A129.

requirements and income requirements necessary to be in good nutrition are both highly variable and highly sensitive to the underlying characteristics of the person under discussion.

We also report the proportion of calories from the staple for each scenario. The staple calorie share in the least-cost diet, while variable, is significantly less variable than either total calories or cost, ranging from 0.79 to 0.86 in Hunan and 0.78 to 0.85 in Gansu. While this is the staple calorie share associated with the least-cost diet, we are interested in those who have more than enough money, and thus will not purchase the least-cost diet. Since wealthier people will tend to get a greater proportion of their calories from non-staple sources, this suggests a reasonable cut-off of somewhere around 0.8. We expect that people who get less than 80 percent of their calories from the staple will have some slack in their food budget, and thus it will be theoretically possible for them to exhibit Giffen behavior, while those with staple calorie share chronically greater than 0.9 will likely be deprived of essential nutrients.[A4]

Finally, we must keep in mind that households in Gansu get part of their staple calories from noodles and other forms of wheat (approx. 7% percent), which we do not count as part of "staple calories." Thus, an appropriate cut-off for Gansu may be more in the range of 0.7 than 0.8.

Table A1. Staple Calorie Share of Minimum Cost Diet

Scenario	A	B	C	D	E	F	G	H	I	J
Sex	M	M	M	F	F	F	M	F	M	F
Age	25	35	75	35	85	22	40	40	40	40
Height (feet)	6'2"	5'9"	5'4"	5'8"	5'2"	5'4	5'7"	5'2"	5'7"	5'2"
Height (m)	1.88	1.75	1.63	1.73	1.57	1.63	1.70	1.57	1.70	1.57
Activity	V	L	S	L	S	V	A	A	A	A
Weight (lbs.)	220	180	120	140	110	130	121	104	141	121
Weight (kg)	100	82	55	64	50	59	55	47	64	55
Nutrient Requirements										
Calories	4264	2812	1727	2223	1351	2717	2554	2070	2718	2174
Lysine (mg)	3100	2536	1691	1973	1550	1832	1705	1465	1987	1698
Least-Cost Diet (Hunan)										
Rice (g)	996	636	385	504	291	641	603	485	634	503
Bean Curd (g)	123	208	162	156	185	41	35	50	81	93
Cooking Oil (g)	19.1	12.6	7.7	10	6.1	12.2	11.4	9.3	12.2	9.7
Cost (yuan)	2.91	2.17	1.40	1.70	1.21	1.78	1.67	1.39	1.86	1.54
Staple Calorie Share	0.85	0.82	0.81	0.83	0.79	0.86	0.86	0.86	0.85	0.84
Least-Cost Diet (Gansu)										
Wheat (g)	986	629	381	499	288	635	597	480	628	498
Bean Curd (g)	198	256	191	194	207	89	80	86	129	131
Cooking Oil (g)	19.1	12.6	7.7	10	6.1	12.2	11.4	9.3	12.2	9.7
Cost (yuan)	2.69	2.03	1.31	1.59	1.15	1.64	1.53	1.29	1.72	1.43
Staple Calorie Share	0.84	0.81	0.80	0.82	0.78	0.85	0.85	0.84	0.84	0.83

1 cup uncooked rice = 185 grams. 1 cup uncooked flour = 125 grams. 1 tablespoon cooking oil = 13.6 grams.

[A4] Nutritional sufficiency does not require consuming all essential amino acids at every meal. Thus even a consumer with a very high staple calorie share on the day of our survey may be nutritionally stable provided that they consumed more non-staples on other days.

APPENDIX III: STAPLE BUDGET SHARE

This section shows results using the initial staple *budget* share (ISBS) to categorize households into consumption zones to test for Giffen behavior. As mentioned in the text, we believe the staple calorie share is the ideal method for identifying consumption zones, both for theoretical reasons and due to limitations in the expenditure data gathered in our survey. However, intuitively the ISBS captures the household's ability to substitute away from luxuries in response to a staple food price change, and is worth exploring as an alternative. In table A2 below, we show results from estimation of equation (1) where households are now stratified by whether they spend more than 20 percent of their total budget on the staple good. For Hunan, the results again suggest that the poorest households are Giffen consumers. Consistent with expectations, the elasticity is smaller for wealthier households, though the point estimate is positive and we can't reject that they also are Giffen consumers (or that the elasticity is the same as for the poorer households). For Gansu, the same broad pattern also fits, with a much greater coefficient for the poorest households, though in this case both point estimates are negative.

We can explore the demand elasticity-budget share relationship in more detail by examining the coefficient plots, as in figure 2 in the main text. In figure A6 below, the inverted-U pattern of the elasticities is again strongly evident for Hunan. The elasticity is large and positive for households in the middle range of ISBS, i.e., households that are poor-but-not-too-poor. The elasticity then declines towards zero for both poorer and wealthier households. However, the coefficients never become statistically significantly negative. For Gansu, there is no evidence of an inverted-U shaped pattern of elasticities, with the curve largely negative and declining over much of the range of ISBS. However, as stated in the main text, our predictions for household consumption patterns may fail because on average, households in Gansu do not satisfy the conditions of the basic set up we described. Therefore, in the bottom panel of the figure, we condition on households consuming at least 50 grams of meat. Under these conditions, a clear inverted-U shaped pattern emerges, with statistically significant Giffen behavior over a middle range of ISBS, with declining elasticities for both wealthier and poorer households. However, as with Hunan, the elasticities do not become statistically significantly negative for the poorest or wealthiest households. But overall, for both Hunan and Gansu, with this alternative measure we again find statistically significant evidence of Giffen behavior for a range of consumers, and an inverted-U shaped pattern of elasticities. However, as anticipated, the ISBS does not as accurately segregate households into different consumptions zones as ISCS.

Table A2. Consumption Response to the Price Subsidy: Initial Staple Budget Share

	HUNAN		GANSU	
	(1)	(2)	(3)	(4)
	ISBS ≤.20	ISBS >.20	ISBS ≤.20	ISBS >.20
%ΔPrice(rice/wheat)	0.275*	0.144	-0.184	-1.067**
	(0.154)	(0.301)	(0.288)	(0.511)
%Δ Earned	0.049***	0.014	0.122***	-0.099
	(0.016)	(0.022)	(0.041)	(0.072)
%ΔUnearned	-0.052*	0.013	-0.024	0.066
	(0.029)	(0.049)	(0.105)	(0.170)
%ΔPeople	0.86***	1.32***	0.52**	0.88**
	(0.09)	(0.18)	(0.25)	(0.44)
Constant	5.1***	-1.5***	-24.7***	-30.7***
	(1.1)	(2.1)	(2.6)	(4.9)
Observations	1059	199	1062	207
R^2	0.19	0.30	0.07	0.18

Notes: Regressions are county*time fixed-effect regressions. The dependent variable is the arc percent change in household rice (Hunan) or wheat (Gansu) consumption. Standard errors clustered at the household level. %ΔPrice(rice/wheat) is the change in the subsidy, measured as a percentage of the average price of rice/wheat. %ΔEarned is the arc percent change in the household earnings from work; %ΔHH Unearned is the arc percent change in the household income from unearned sources (government payments, pensions, remittances, rent and interest from assets); %ΔPeople is the arc percent change in the number of people living in the household. ISBS (Initial Staple Budget Share) refers to the share of the total household budget devoted to the staple good in the pre-intervention period. *Significant at 10 percent level. **Significant at 5 percent level. ***Significant at 1 percent level.

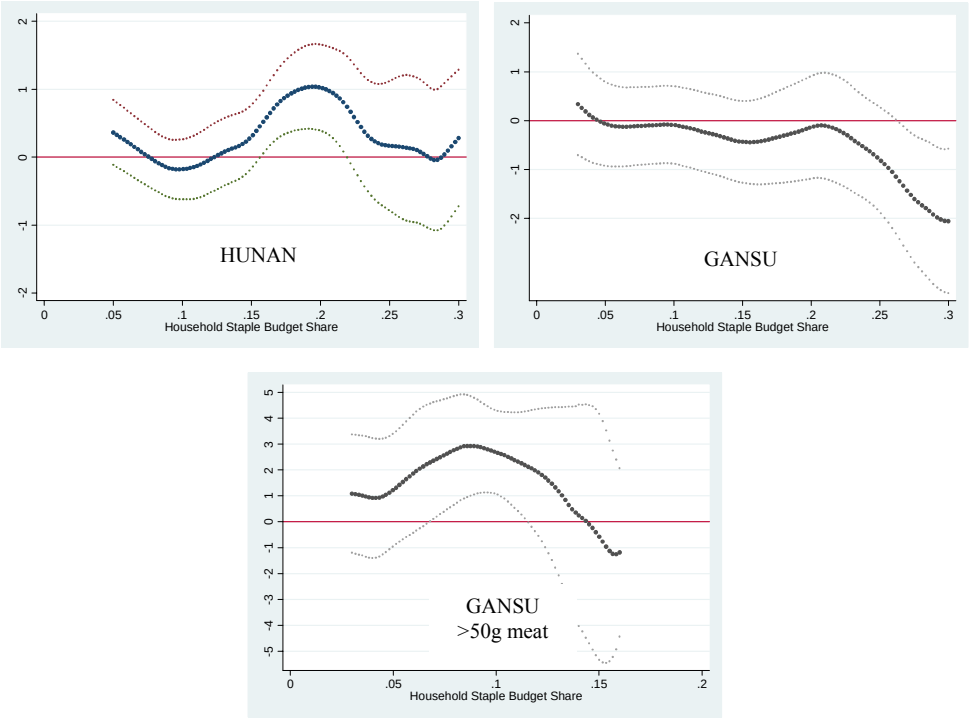

Figure A6: Coefficient Plots

APPENDIX IV. CALCULATING VOUCHER USE TO EXAMINE POTENTIAL CASHING OUT

An ideal measure of whether households had cashed out vouchers would compare, for each household, the total number of vouchers redeemed over the course of the intervention with the total amount of the staple consumed by the household and any increase in storage of the staple. However, this measure is simply not feasible since it would require continuously observing both variables for the whole period.[4] Since our consumption data is based on only single-day observations on the survey dates, our estimate of total consumption over the subsidy period is imprecise.[5] In addition, while we attempted to collect data on storage, response rates for the storage questions were very low because of respondents' difficulties in interpreting the questions. As a result, while these data can provide broad guidance in understanding the implementation of the intervention, the inherent imprecision associated with these measures is quite high. Nevertheless, for the sake of completeness we present approximate calculations.

Each household was issued vouchers sufficient to purchase 750g of the staple per person per day. This corresponds to vouchers sufficient to purchase (on average) 2106 grams per day of rice for a typical household in Hunan. Overall, only 51% of vouchers that had been distributed as of the second survey had actually been redeemed by that time, meaning that the average household had redeemed the equivalent of 1078 grams per day.[6] Estimated daily rice consumption for subsidized households during the subsidy period was 964 grams, implying a residual difference of 114 grams of rice per household per day, or 11% of the total number of vouchers redeemed before the second round of the intervention. However, as stated, it is likely that households used the subsidy to stock up on rice for later consumption. While our storage data are limited, we find that on average, household rice stores increased from 0.6 *jin* to 14.5 *jin*,[7] which corresponds to redeeming an additional 93g of vouchers per household per day, accounting for much of the discrepancy between rice consumed and vouchers redeemed. And observations by our survey teams corroborate that households were, in fact, increasing storage

[4] Further, due to administrative difficulties in assigning and recovering individual identifiers from the vouchers, we unfortunately have only data on aggregate voucher usage to work with.

[5] There is evidence of seasonality in consumption, especially for wheat in Gansu, with the control groups in each county displaying a decline in consumption between rounds 1 and 2. In the analysis we present, we do not adjust for this trend. However, adjusting for the trend does not significantly change the findings of this section.

[6] Overall, 76% of all vouchers issued were redeemed; as expected, there was a substantial increase in voucher redemption as the subsidy period drew to a close.

[7] Due to low response rates (19% in round 2) we base this calculation only on households that responded to the storage question in both the first and second rounds of the survey.

during this time. Thus, as a rough approximation, only 2%[8] more vouchers were redeemed than were consumed or stored,[9] suggesting that if there were any cashing out or re-selling, it was extremely limited.[10]

In Gansu, a typical household received 1996 grams of vouchers per day, and only 47% of vouchers available before the second-round survey were redeemed before that survey. Average household wheat intake in the first two rounds of the survey was 743g, while approximately 942g worth of vouchers per day were redeemed, for a difference of 199g per household per day. There is also evidence of increased storage in Gansu, which accounts for approximately 111g of additional voucher usage per day, leaving approximately 88g (about 3/4 cup) of voucher redemptions unaccounted for, and a net-of-storage excess voucher redemption rate of 9%.[11]

There are in particular two counties in Gansu that account for much of the discrepancy; Kongdong (39% unaccounted for vouchers) and Anding (41%). We discovered that the high rate of voucher redemptions in Anding was due to the implementation team departing from our protocol and explicitly advising households to purchase as much wheat as possible and store it in order to take advantage of the subsidy program.[12] And the implementation team reports that households were, in fact, purchasing and storing a great deal of extra wheat in Anding (given the imperfections in our storage data, it would not be surprising if we did not measure this increase). We have been unable to uncover the reason for the high voucher redemption rate in Kongdong, although our ground personnel report high storage levels and little evidence of cashing out of vouchers.[13] While we have no direct evidence of cheating in these counties and the high redemption rates were apparently due to increasing wheat storage, as an additional robustness check we estimated regression (1) for Gansu under two scenarios. The first excludes just

[8] While estimates at the county level are less precise, the only real outlier, with 176g grams or 13% more vouchers redeemed than can be accounted for by consumption and storage is Pingjiang county. To the extent that we view this as an outlier, the results of table 4 are robust to removing this county.

[9] Further, there may be additional 'leakage' our survey doesn't capture, such as consumption by visitors to the household, or rice lost or wasted during the cooking process, which may further explain the remaining discrepancy.

[10] While it is possible that households cashed out vouchers and then inflated their reported rice consumption to hide what they had done, this type of sophisticated cheating would work against our finding Giffen behavior.

[11] It is likely that in Gansu leakage is somewhat higher than in Hunan since flour is frequently used incidentally in the cooking process (e.g., covering surfaces for kneading bread) in ways that may not appear in the intake data.

[12] To the extent that this advice encourages households to reduce consumption expenditure today in order to purchase and store wheat, this might work against our finding of Giffen behavior since when households spend less on current consumption they tend to consume relatively more wheat.

[13] In fact, both counties show large increases in reported wheat purchases between the first and second round of the survey (despite there being a 40% across-the-board decline in wheat consumption and all other counties reporting reduced purchases). Reported purchases match up well with voucher usage in Anding and Kongdong.

Kongdong, for which we have no clear reason for the discrepancy. Doing so, the resulting elasticity estimate for the 0.4 - 0.6 staple-calorie share group actually increases in both magnitude and statistical significance (1.37 (.67)) relative to the results using all counties (1.06 (0.56)). Excluding both Anding and Kongdong, which reduces the sample size by 42%, results in an elasticity estimate of 0.79 with a p-value of 0.27. Thus, while the elasticity estimate remains positive, it is no longer statistically significant.[14]

[14] Running the main regression in equation (1) with interactions for whether the household was a treated household in Anding or Kongdong, we are unable to reject the null hypothesis that these counties are the same as the other Gansu counties. For this reason, we have not eliminated them from the regressions reported in tables 7 and 8.