ECONOMIES OF SCALE, HOUSEHOLD SIZE, AND THE DEMAND FOR FOOD: THE MISSING LINK

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ABSTRACT: For the same level of per capita resources, larger households are deemed better off due to possible scale economies from consuming household public goods. Contradictory evidence that per capita demand for food declines with household size has puzzled economists. This paper suggests that larger households have costs associated with sharing food, especially high-value foods, and so they substitute towards cheaper and basic foods, whose per capita demand increases with household size. However, since high-value foods form a larger proportion of the budget on all foods, per capita demand for all foods declines with household size when Engel food-share equation is estimated using aggregate food expenditure data.

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1. Introduction

Estimates of food-share equations based on the assertion that, for the same level of per capita resources, larger households are better off because they achieve scale economies and, therefore, should have larger food expenditure per capita have yielded two puzzles. Deaton and Paxson (1998) find that the relationship between food expenditure per capita and household size is negative. Furthermore, the effect is larger in poorer countries where nutritional and calorie requirements are more likely to be undersatisfied.

The evidence is puzzling because of their following reasoning. Suppose two separate households are brought together while maintaining their original incomes so that per capita income in the joint household is the same as it was for the separate households. Then given shared public goods such as heat and light, the joint household is now better off. In particular, the prices of the shared public goods are reduced for the previously separate households and so there will be substitution towards the shared public goods. However, for private a good such as food that is not shared, substitution and income effects will operate in opposite directions. Since food is not easily substitutable and it has low own- and cross-price elasticities, the income effect will dominate and food consumption per capita will rise. The assertion assumes that prices, in addition to income per capita, remain unchanged. Yet, the evidence presented using data from both rich and poor countries contradict these predictions. For example, they find that a unit increase in the logarithm of household size reduces food expenditure per capita by about 11% and 3% in South Africa and the United States, respectively.

This paper attempts to solve the puzzle as to why larger households have lower food expenditure per capita. First, the way in which household members interact to purchase, share, and consume food are important in determining the composition of their diets. Secondly, household diets vary with size (Price, 1988). Suppose that food is purchased together and then shared among members according to some sharing rule, say, proportional to daily metabolic requirements. Suppose further that there are monitoring and allocation costs associated with food sharing to ensure that each member receives and consumes their share of food, and that the costs are increasing in household size. Then the effective price of food facing the household is the market price of food plus the monitoring and allocation costs. If now we bring the two separate households together, the increase in household size will have an additional effect that is similar to an own-price effect, due to an increase in the monitoring and allocation costs. Assuming that food is a normal good, this "own-price" effect would be negative and it may dampen and outweigh the income effect that is caused by a reduction in the price of the public good. Thus, we have two opposing scale effects: economies from shared public goods and diseconomies from food monitoring and consumption. Which one of these two would dominate, is an empirical issue.

Households monitor the consumption of food in various ways. While I am yet to come across explicit documentation on this phenomenon, my observations in Ghana suggest that monitoring is prevalent and it varies with the type of food and size of the household. Furthermore, evidence of bias in intrahousehold food allocation, especially for high-value foods, also suggests that food is monitored. See Haaga and Mason, 1987, for a literature review on the bias in intrahousehold food allocation. In general, high-value foods such as meat, fish, eggs, and dairy products are more closely monitored than basic and relatively inexpensive foods such as grain (maize and sorghum), tubers (cassava and cocoyam), and beans. It is not uncommon for high-value foods to be "hidden" in the bedrooms of those in charge and storage rooms with locks on their doors. Even refrigerators and deep freezers have been known to be locked. Customary feeding order is another form of monitoring. As monitoring costs soar, due to frequently broken locks, disappearing supplies, and violation of sharing rules and norms, household managers may be forced to reduce and sometimes abandon the purchase of those foods in favor of other less desirable ones. Small households rarely experience such distortions, as it is easier for members to cooperate and obey sharing rules. The idea of storing food in bedrooms and mounting locks on refrigerators may sound very bizarre in rich countries where food is considered a basic commodity, bounding on inferior. Still, larger households may experience uncooperative behavior, but rather than reduce their consumption of say beef, they may switch from expensive brands to cheaper generic varieties. For example, bulk purchasing, which has been cited as a reason for lower food expenditure per capita in larger households, is consistent with this type of substitution, as bulk items are more common for generic and store brands.

Therefore, to the extent that monitoring applies to certain types of food and brands, their per capita demand would decline, as household size increases. As the evidence, using data from the 1991/92 Ghana Living Standards Survey, shows, aggregating all foods for analysis trivializes the substitutions among individual food items and brands.

The rest of the paper is organized as follows. Section 2 presents a household utility optimization model, which features monitoring costs to examine the conditions under which food demand per capita may increase and decrease with household size. Section 3 presents the data. Estimation, results, and discussion are presented in Section 4, and Section 5 concludes.

2. Household Size and Demand for Food

Suppose that the household, which is made up of *n* adults, has a utility function given by

(1) $$u = n \cdot v\left(\frac{q_f}{n}, q_h\right),$$

where q_f and q_h are levels of household consumption of food (private good) and public good, respectively, and $v(\cdot)$ is at least twice differentiable. The household budget constraint in per capita terms is given by

(2) $$p_f(n)\left(\frac{q_f}{n}\right)+\left(\frac{p_h}{n}\right)q_h=\frac{x}{n}.$$

Where $p_f(n)$ and p_h are the prices of food and the public good, respectively, and x is total outlay. In particular, $p_f(n)=\overline{p}_f+c(n)$. Where $\overline{p}_f$ is the market price of food and $c(n)$ is the cost of monitoring and allocating food to ensure that each person gets and consumes their share of food. We assume that $c(n)$ is increasing in household size, but at a declining rate. Let food demand per capita, a solution to maximization of (1) subject to (2) and $p_f(n)=\overline{p}_f+c(n)$, be given by

(3) $$\left(\frac{q_f}{n}\right)^*=g\left(\overline{p}_f,\frac{p_h}{n},\frac{x}{n},n\right).$$

Then it can be shown that (see the appendix for derivations)

(4) $$\frac{\partial(q_f/n)^*}{\partial n}=c_n\frac{\partial(q_f/n)^*}{\partial\overline{p}_f}-\left(\frac{p_h}{n}\right)\frac{\partial(q_f/n)^*}{\partial p_h}.$$

Equation (4) shows that the total effect of a change in household size on food demand per capita is made up of two scale effects: diseconomies from rising costs of food monitoring and economies from declining prices of shared public goods. The overall effect is ambiguous. However, given that there are monitoring costs associated with food consumption, which depends on household size, it is clear that ignoring the costs would lead to biased estimates.

An important revelation from this model is that Deaton and Paxson (1998) estimate the total effect of a change in household size on the per capita demand for food. However, they interpret their results as though they were estimating the right hand side of (4) only. Suppose that food is a normal good, that is $\partial(q_f/n)^*/\partial(x/n)>0$. Then the second term on the right hand side of (4) is positive (see the appendix for proof). However, since the first term is negative by the Slutsky relations, it dampens and could outweigh the second term so that per capita food demand would decline with household size. Suppose further that c_n is zero. Then $\partial(q_f/n)^*/\partial n$ would be equal to the second term, which is positive in this model.

This model, as well as Deaton and Paxson's, is based on Barten's (1964) model that family composition exerts price-like effects on the consumption of goods. However, Deaton and Paxson consider the scale effect of consuming household public goods only.

In order to test the predictions of the model presented here, we estimate food share equations for all foods and then for low-monitored foods only using household food expenditure data from the 1991/92 Ghana Living Standards Survey. Note that there is no information in the data set on monitoring and allocation costs associated with the consumption of individual food items. However, personal knowledge and experience are employed to aggregate individual food items into relatively low-monitored (basic) and high-monitored (high-value) foods. Table 1 shows the description of food and the monitoring class to which each food item is classified.

3. The Data

The 1991/92 Ghana Living Standards Survey (GLSS3) forms part of the Living Standards Measurement Study (LSMS) household surveys started in 1980 by the World Bank. The aim of the LSMS household survey is to collect individual, household, and community-level data and measure levels and changes in living standards of the population.

A total of 4,552 households (and 20,403 individuals) in Ghana were surveyed in eight two-day interval and eleven three-day interval interviews for rural and urban households, respectively. Information on many aspects of household and individual well being, including

Table 1. Description of Food Items Subject to Monitoring

Type of monitoring	Food Group	Food Item
Low-monitored	Cereals and cereal products	Sorghum, maize, millet, maize flour
(basic foods)	Starchy roots and starchy products	Cassava, cocoyam, kokonte, cassava dough
	Pulses	Beans
	Oil seeds and nuts	Dawadawa, kolanut
	Vegetable oil and fats	Palm kernel oil, shea butter
	Fruits (fresh and canned)	Mango, oranges
	Vegetables (fresh and canned)	Kontomire, garden eggs, okro, green pepper
	Sugar, condiments, and spices	Salt
	Prepared meals	Banku and stew, kenkey, kooko
High-monitored	Cereals and cereal products	Rice, bread, buns, biscuits
(high-value foods)	Starchy roots and products	Plantain, yam, gari
	Pulses	Groundnuts
	Oil seeds and nuts	Palmnut
	Vegetable oil and fats	Coconut, groundnut, and red palm oils, margarine
	Fruits (fresh and canned)	Avocado pear, banana, pineapple, canned fruits
	Vegetables (fresh and canned)	Tomato, canned tomato puree
	Meat	Canned/fresh beef, goat, mutton, pork, bushmeat
	Poultry and eggs	Chicken, duck, guinea fowl, poultry eggs
	Fish	Smoked, canned, dried, and fresh fish, lobster
	Milk and milk products	Fresh, canned, and baby milk, cheese, butter
	Sugar, condiments, and spices	Sugar, dried pepper
	Coffee/tea/cocoa, etc	Coffee, tea, milo and chocolate drinks
	Prepared meals	Rice and stew, fufu and soup, tuo and soup
	Miscellaneous food items	Jams, honey, ice cream
	Minerals and soft drinks	Soft drinks and minerals
	Alcoholic beverages	Beer, liquor, palm wine, pito
	Tobacco and tobacco products	Cigarette and other tobacco

Notes: The food items listed here exclude "other food" categories within food groups. Most of these categories did not have any expenditure information.

consumption, expenditures, income, and housing, were collected. Concerning food, expenditure information was collected for 107 individual food items (classified into 23 good groups) that were purchased and consumed. Values for home produced and consumed food items were imputed. Then, an annual food expenditure in Cedis was calculated for each individual food item. At the time of the survey, 1 US$ was approximately 500 Cedis.

4. Estimation and Results

The econometric model estimated is

(5) $$\frac{\bar{p}_f * q_f}{x} = w_f = a + b \ln\left(\frac{x}{n}\right) + g \ln(n) + \sum_{j=1}^{J-1} h_j r_j + d z + m .$$

Equation (5) is the food share equation estimated by Deaton and Paxson. Where w_f is the food share (food expenditure in total expenditure), x is total expenditure, n is household size, and r_j is the proportion of males and females aged 0-6, 7-14, 15-50, and over 50 years in the household. Vector z represents other household variables. These are proportion of adults employed and dummies for location (rural coastal, rural forest, rural savanna, other urban excluding the capital, and the capital, Accra), month in which the household was surveyed, and home produced and consumed food.

Table 2 shows summary statistics for some of the variables used in the estimation. All foods make up sixty-one percent of the household budget while "basic" foods make up sixteen percent of the household budget (about 27% of the budget on all foods). The average number of household members is 4.5. About 38% of them are less than 14 years old and almost 50% are between the ages of 15 and 50 years. Fifty-one percent are employed and a little over 60% live in rural areas.

Table 2. Summary Statistics (N=4516)

Variable	Mean	Standard Deviation
food share (aggregate)	0.614	0.162
food share (basic)	0.158	0.110
total expenditure per capita	221.14	198.03
household size	4.480	2.831
rm06	0.096	0.144
rf06	0.095	0.143
rm714	0.095	0.142
rf714	0.090	0.136
rm1550	0.244	0.290
rf1550	0.232	0.205
rm51+	0.067	0.183
rf51+	0.081	0.206
adult employment rate	0.571	0.298
home produced (all)	0.660	
home produced (basic)	0.105	

Notes: Expenditure is measured in 1000 cedis. At the time of the survey, 1 US$≈500 Cedis. Variables beginning with "r" are the sex and age ratios of household members. For example, rm06 refers to the proportion of household members who are males and up to six years of age. To save space, summary statistics of dummy variables for location and month of household interview are not reported.

The model shown in equation (5) is estimated by Ordinary Least Squares (OLS) separately for all foods aggregated as in Deaton and Paxson and for "basic" foods.[1] The results are shown in Table 3 and the discussion focuses on the effect of household size. As expected, household size has a negative effect on total food share but a positive effect on "basic" food share. The two respective coefficients are also statistically significant.

Table 3. OLS Estimates of Food-Share Equations

	All Foods		Basic Foods	
Variable	coefficient	|t|	coefficient	|t|
ln total expenditure per capita	-0.0556	15.126	-0.0213	7.872
ln household size	**-0.0499**	**11.565**	**0.0129**	**4.132**
rm06	-0.0408	2.378	-0.0455	3.612
rf06	-0.0402	2.321	-0.0327	2.567
rm714	-0.0632	3.490	-0.0462	3.466
rf714	-0.0837	4.512	-0.0440	3.226
rm1550	-0.1264	11.751	-0.0824	10.413
rf1550	-0.0867	7.003	-0.0520	5.716
rm51+	-0.0471	3.356	-0.0424	4.110
adult employment rate	0.0278	3.104	0.0508	8.032
home produced	0.1032	19.164	0.0201	4.304
constant	1.3120	27.098	0.4430	12.689
R^2	0.3825		0.2720	

Notes: Expenditure is measured in 1000 cedis. At the time of the survey, 1 US$≈500 Cedis. Variables beginning with "r" are the sex and age ratios of household members. For example, rm06 refers to the proportion of household members who are males and up to six years of age. To save space, estimates are not reported for location and month of household survey dummy variables. With the exception of the coefficients of 2/92 and 8/92 in the "All Foods" and 3/92, 4/92, and 8/92 in the "Basic Foods" equations, all the other coefficients were statistically significant. Also, except for the coefficients for the months of April, May and June of 1992, which had the same positive sign in both equations, the coefficients for the other months were of opposite signs. They were negative in the "Basic Foods" equation.

A unit increase in the logarithm of household size decreases total food share by 5%. This value is similar to those obtained by Deaton and Paxson for poor countries of South Africa (5.98%: African households), urban Thailand (5.37%), rural Thailand (5.48%), and Pakistan

[1] Deaton and Paxson, in addition to OLS, use three other estimates. The Fourier flexible functional form, which includes the sin and cos of the logarithm of total expenditure per capita, Estes-Honore model, which allows total expenditure per capita to enter non-parametrically while other variables enter linearly, and Instrumental Variables for possible measurement error in the logarithm of total expenditure per capita. Since their qualitative results were not affected by the choice of functional form, using only OLS here does not affect the comparative analysis.

(5.65%). However, a unit increase in the logarithm of household size increases "basic" food share by a little over 1%. In food expenditure per capita terms, which is obtained by the ratio of the coefficient of the logarithm of household size to the food share (i.e., g/w_f), the above changes represent a decline in all foods by 8% and an increase in "basic" foods by the same margin. Note that Engel's assertion is upheld in both food-share equations. That is, the food shares are declining in total expenditure per capita.

The impact of household size shown here is consistent with those obtained by Hassan and Babu (1991). They find that, in rural Sudan, family size increases the share of basic food (sorghum bread) while it decreases the share of higher-value foods (animal products). They also find that the share of aggregate food increases with family size. Note that this latter finding, as well as Deaton and Paxson's, is consistent with the theory presented here of an ambiguous effect of household size on total food expenditure per capita. Hassan and Babu's Engel share equations do not include family composition as defined here. However, the dependency ratio that they include to capture similar effects, was not statistically significant. They also use total expenditure, which did not hold up to Engel's assertion in the total food-share equation, instead of total expenditure per capita. The results obtained here, however, contradict those obtained by Price (1988). Price finds that, in the United States, per adult equivalent consumption of various food groups are declining in household size, due to lower edible discard of food and lower unit prices paid by larger households. However, as it was suggested earlier, larger households in rich countries such as the United States, may respond to increasing monitoring cost by substituting brands/varieties within a particular food item rather than among individual food items. Therefore, Price's results do not refute the theory presented here, which still needs to be tested with data from rich countries and other poor countries.

5. Conclusions and Implications

This paper has tried to solve an empirical puzzle as to why food expenditure per capita declines with household size even though larger households, for the same level of per capita resources, are deemed better off due to scale economies form the consumption of household public goods. Larger households are more likely to experience difficulties in sharing food, especially high-value foods, and so they may substitute towards low-value and basic foods. Using data from the 1991/92 Ghana Living Standards Survey, a unit increase in the logarithm of household size reduces total food expenditure per capita by 8%. However, a unit increase in the logarithm of household size increases basic food expenditure per capita by a similar margin of 8%. Since high-value foods form a larger proportion of the total budget on food (about 73%), the negative effect of household size on the consumption of high-value foods outweighs the improvement in the consumption of basic foods, when food-share equation is estimated using aggregate data.

To the extent that households behave strategically in food consumption depending on the food item and their size, there is doubt on using food expenditure per capita as an appropriate welfare measure (see Anand and Harris (1994) for concerns about different welfare measures). Furthermore, given the conventional view that larger households tend to be poorer (Hassan and Babu, 1991), subsidizing high-value foods can actually hurt the relatively poor whilst subsidizing low-value foods can improve their diets (see Waterfield, 1985). This means that consumption of aggregate food forms only part of the picture for food policy. Patterns of substitution among individual food items and among varieties within a particular food item are important for policy on overall nutritional and calorie intake.

While caution is necessary in interpreting and generalizing the results, the evidence is interesting enough to stimulate further research. A more rigorous theory of an intrahousehold bargaining type, as pioneered by Manser and Brown (1980) and McElroy and Horney (1981), that describes the roles and strategies of households and members to achieve some nutritional and caloric objective is needed. Such a model would help identify specific food items that are subject to monitoring and other food consumption costs in general. Consequently, it would facilitate testing with data sets from rich and poor countries alike, without resorting to personal experience as utilized here. Obtaining data on household food monitoring activities and the strategies employed to reduce monitoring costs are also essential.

APPENDIX

(A1) $$\max_{\frac{q_f}{n},q_h} \; v\left(\frac{q_f}{n}, q_h\right), \quad \text{subject to}$$

(A2) $$(\bar{p}_f + c(n))\left(\frac{q_f}{n}\right) + \left(\frac{p_h}{n}\right) q_h = \frac{x}{n}.$$

Write the lagrangian as

(A3) $$v\left(\frac{q_f}{n}, q_h\right) + l\left\{\frac{x}{n} - (\bar{p}_f + c(n))\left(\frac{q_f}{n}\right) - \left(\frac{p_h}{n}\right) q_h\right\}.$$

Differentiate (A3) with respect q_f/n, q_h, and l to obtain the following first-order necessary conditions.

(A4) $$\left(\frac{q_f}{n}\right): \quad v_{\frac{q_f}{n}} - l \cdot (\bar{p}_f + c(n)) = 0$$

(A5) $$q_h: \quad v_{q_h} - l \cdot \frac{p_h}{n} = 0$$

(A6) $$l: \quad \frac{x}{n} - (\bar{p}_f + c(n))\left(\frac{q_f}{n}\right) - \left(\frac{p_h}{n}\right) q_h = 0$$

Assuming that the second-order sufficient conditions for maximization are satisfied, let the following be the solutions to the optimization problem.

(A7) $$\left(\frac{q_f}{n}\right)^* = g_f\left(\overline{p}_f, \frac{p_h}{n}, \frac{x}{n}, n\right)$$

(A8) $$q_h^* = g_h\left(\overline{p}_f, \frac{p_h}{n}, \frac{x}{n}, n\right)$$

(A9) $$l^* = g_l\left(\overline{p}_f, \frac{p_h}{n}, \frac{x}{n}, n\right)$$

Substitute the solutions, (A7), (A8), and (A9), into the first-order necessary conditions to obtain identities. Differentiate the resulting identities with respect to $\overline{p}_f$ and then solve for $\partial(q_f/n)^*/\partial\overline{p}_f$, using $l^*=n\times v_{q_h}/p_h$ where necessary. Perform the same exercises for p_h, x/n, and n. The following comparative static equations are obtained.

(A10) $$\frac{\partial(q_f/n)^*}{\partial\overline{p}_f} = \frac{q_f\cdot\left(p_f(n)\cdot v_{q_hq_h} - \frac{p_h}{n}\left(v_{\frac{q_f}{n}q_h}\cdot q_f + v_{q_h}\right)\right)}{|H|}$$

(A11) $$\frac{\partial(q_f/n)^*}{\partial p_h} = \frac{\frac{q_h}{n}\cdot\left(p_f(n)\cdot v_{q_hq_h} - \frac{p_h}{n}v_{\frac{q_f}{n}q_h}\right) + \frac{p_f(n)}{n}v_{q_h}}{|H|}$$

(A12) $$\frac{\partial(q_f/n)^*}{\partial(x/n)} = \frac{\left(p_f(n)\cdot v_{q_hq_h} - \frac{p_h}{n}v_{\frac{q_f}{n}q_h}\right)}{|H|}$$

Where $|H|$ is the determinant of the bordered Hessian. Suppose food is a normal good, then (A12)>0 $\Rightarrow$ (A11)>0. With the comparative static for n, use results of (A10) and (A11) to obtain

(A13) $$\frac{\partial(q_f/n)^*}{\partial n} = c_n\,\frac{\partial(q_f/n)^*}{\partial\overline{p}_f} - \frac{p_h}{n}\cdot\frac{\partial(q_f/n)^*}{\partial p_h}$$

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