Food Expenditure, Food Preparation Time and Household Economies of Scale

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Abstract: This paper is concerned with the effect of household size on the allocation of household money and time to food consumption. A broad literature has examined household economies of scale. Since food is a private good, it might be expected that larger households, which could economize on shared goods such as housing, would spend more per equivalent household member on food. However, recent studies have found the opposite result: for households with similar total expenditures, larger families spend less per capita on food. This paper examines household time inputs and shows that economies of scale in preparing food can explain this result. I introduce economies of scale into a household production model. The size of the household changes both the relative price of a unit of food and the time required to prepare it, affecting household demand for both inputs to food production. Larger households can achieve the same level of consumption at lower expenditure by substituting cheaper production time for more expensive ingredients. Using household expenditure and time-use survey data from Russia, I estimate the effect of changing household size on food expenditures and food-related time. The estimates indicate that doubling the size of household reduces per capita food expenditure by over 30% and per capita preparation time by about 75% in households with two and more people. A married man from a two adult household spends three times less time preparing food than a single man living alone. For a woman, a transition from a single to a two-person households results in more modest time saving of 45% in case such transition is not a result of a marriage. A married woman enjoys no time savings at all, while a

woman with children spends more time in food-related activities than her single counterparts. I also find that the time intensity of meals increases with household size, but that the quality of meals is unaffected by changes in household size.

1 Introduction

Economists have long been interested in comparing welfare between households with different compositions, both for measuring total welfare and for measuring the incidence of poverty. There are many economies of scale to living in a larger household, including shared housing, appliance use, and childcare. Along with sharing expenses, individuals from larger households enjoy a considerable time advantage over their single counterparts. A household with two or more adults can specialize labor within and outside of the home, with household members taking on different responsibilities for market work, housework, and childcare. Because home production is a substitute for goods purchased on the market, households make decisions about expenditures and time use simultaneously. Understanding how changes in family size influence decisions regarding food will improve our understanding of the household's overall well-being and will contribute to explaining individuals' labor market decisions.

However, most studies have focused on economies in sharing expenses and have not addressed time inputs to home production. Lazear and Michael (1977, 1980) estimate that the expenditures of two adults living together are 31-35% lower than a single-adult household using the U.S. Consumer Expenditure Survey (CES), with the largest savings in food and shelter expenditure and smaller savings in personal care. Deaton and Paxson (1998) present evidence of economies of scale in food consumption from a number of developed and developing countries.

The observed economies of scale in food expenditures are particularly interesting and somewhat puzzling. Food itself is a private good which can not be shared, but there likely to be a substantial public component in preparing meals. Models that do not include time costs predict that at a constant per capita expenditure larger households save on public goods like housing and increase per-person expenditures on private goods like food. However, empirical evidence shows the opposite for both modern households and those observed a century ago by Engel. Per capita food expenditures fall as households grow.

This seeming paradox was introduced by Deaton (1980) and extended by Deaton and Paxson (1998). Several subsequent studies have attempted to resolve it in a variety of ways. Gibson (2002) suggests that large estimates of economies in size may be due to a measurement error in recall expenditure data. Gan and Vernon (2003) show that food expenditures increase relative to another more sharable good and decrease relatively to a less sharable good, and therefore that the paradox disappears when subsets of expenditures are examined. Although recent papers shed new light on the nature of household economies, the puzzle remains unresolved: Why do utility maximizing households respond to an increase in size by reducing per-capita food expenditure? It seems rather unlikely that larger households choose to forego part of their meals in exchange for other goods or perhaps even for the pleasure of being a part of a larger household.

This paper explains the puzzle in a novel way, merging current research in food consumption with time use research. I show that lower per capita food expenditure becomes an optimal decision for larger households who allocate money and time simultaneously. If preparation time and purchased ingredients are to some extent substitutes, an increase in household size changes the relative price of food ingredients and time, creating an incentive to reallocate resources within a household. I model this decision within a household production framework. Purchased food is combined with time inputs to produce meals. A meal can be produced using more market inputs (such as more processed or semi-prepared food and eating out) or more time inputs (such as cooking at home, spending time shopping for better deals, buying food in season and conserving it for later use, and growing food in kitchen gardens). As the relative price of time falls and ingredients become more expensive, individuals will substitute where possible away from market expenditures towards home production. As a result, larger households may increase their food consumption while optimally choosing a more time-intensive production technology of meals, so that observable per-capita expenditure on food actually falls.

Deaton and Paxson (1998) question the existence of economies of scale in time and argue that such economies would intensify rather than resolve the food puzzle. They claim that economies of scale in time would make food relatively cheaper for larger households, and that food consumption should therefore increase, not decrease. This would be true if time and ingredients were complements instead of substitutes, in which case a relatively cheaper value of time would increase the demand for both time and ingredients. I maintain and prove that food consumption stays the same or increases, but that food expenditures go down.

Cutler et al. (2003) describe the general trend in food consumption in the U.S. Since

1970, technological innovations in the mass preparation of food have reduced the time Americans spend on cooking and cleaning. At the same time, food consumption, the frequency of consumption, the consumption of food in each group, and the variety of foods consumed by Americans have all increased.

According to the BLS, in 2002 the average U.S. household spent over 14%[1] of its total expenditures, or just over $140 per week, on food and alcohol. In addition to the money spent on food, Gronau and Hamermesh (2003) show that Americans spend a nontrivial amount of our precious time in preparing meals and eating. The average married couple in the U.S. spends 145 hours/month (33.7 hours/week) buying food, cooking and consuming meals. That translates to 4.8 hours a day, or, assuming sleep takes 8 out of 24 hours per day, about 15% of each individual's total waking time. At an average US hourly wage rate of $15, the opportunity cost of preparing meals for a couple is thus over $500. The value of the time inputs to food production in the home dwarf the cost of market inputs. Even if eating itself includes a leisure component (such as enjoyment of time spent together over dinner), a substantial amount of the total time is spent on food preparation. It seems reasonable that larger households would try to take advantage of possible economies of scale in time.

Gronau and Hamermesh (2003) also look at the relative good- and time-intensities of nine commodities that comprise everything households produce/consume at home (sleep, lodging, appearance, eating, childcare, leisure, health, travel, miscellaneous). Data on married couples aged 20-70 from the U.S. and Israel show that eating is relatively goods-intensive. Eating time declines with schooling, while food expenditures and the goods-intensity of food increase. The goods-intensity of eating has an inverse U-shaped relationship with age, reaching its maximum for middle aged couples ages 45-54 and dropping sharply at retirement age household. In this chapter, I use a very different data set but arrive at a similar conclusion: a higher hourly wage increases the goods-intensity of food consumption.

Aguiar and Hurst (2004) report evidence that households adjust food expenditure and time use in response to exogenous factors. They find that the dramatic (17%) decline in expenditures at the time of retirement is matched by an equally dramatic (53%) increase in time spent shopping and preparing food. Despite a decline in food expenditures, neither the quality

[1] Alcohol accounts for 0.8% of average expenditures, or $441 per year, other food is 13.1%, or $6,881 per year. See Bureau of Labor Statistics at ftp://ftp.bls.gov/pub/special.requests/ce/share/2002/cucomp.txt

nor the quantity of food intake deteriorates with retirement status. This indicates that market expenditure may be a poor proxy for consumption.

Using household expenditure and time-use survey data from Russia for the years 1994-98, I use a spline regression to estimate the effect of changing household size on food expenditures. The estimates indicate that doubling the size of household reduces per capita food expenditure by over 30% and per capita preparation time by about 75% in households with two and more people. A single man spends 217% less time preparing food than a man from a two person household. Women enjoy a modest time saving of 45% for a similar transition, all else equal. A married woman enjoys no time savings, while a woman with children spends more time in food-related activities than her single counterpart. Wages and non-labor income also affect expenditure and time allocation in a predictable way. I also find that the time intensity of meals increases with household size, but that the quality of meals is unaffected by changes in household size.

This paper is organized as follows. Section 2 presents a theoretical model and comparative statics results. Section 3 describes the data set. In Section 4 outlines the methodology and tests the model's predictions using data on household expenditures and time allocations. Section 5 concludes and discusses possible extensions of the research.

2 Model and Comparative Statics

2.1 Theoretical Model

Suppose a household is composed of n identical individuals who derive utility from consuming two goods, food and nonfood commodities. Let z_1 and z_2 be total household consumption of each good. Commodity-specific household economies are modeled as a function of family size. In the presence of consumption economies, each individual consumes more than z_i/n share of each commodity. The household maximizes total utility:

$$\text{Max} \quad n * u\left(\frac{z_1}{\phi_1(n)}, \ \frac{z_2}{\phi_2(n)}\right) \tag{1}$$

The scale of consumption economies is equal to

$$\phi_i(n) = n^{1-\sigma_i} \qquad i=1,2 \qquad (2)$$

Here $0 \le \sigma_i \le 1$ is the scale elasticity of the i^{th} commodity within household.

If σ_i = 0, then $\phi_i = n$, implying that the good is a private good that cannot be shared and must be replicated if all family members are to enjoy the good to the same degree as a single individual.

If σ_i = 1, then $\phi_i = 1$ and the good is a pure public good that can enjoyed by any and all members of the family without diminishing the enjoyment of others in the household.

The scale elasticity is derived by taking logs of both sides of (2) and differentiating:

$$\ln \phi_i = (1-\sigma_i)\ln n$$

$$\sigma_i = 1 - \frac{\partial \ln \phi_i(n)}{\partial \ln n} \qquad (3)$$

Along with consumption economies, there are economies in production of each commodity. The commodities are produced by households out of market-purchased inputs and preparation time:

$$z_i = nf_i\left(\frac{x_i}{\psi_{1i}(n)}, \frac{t_i}{\psi_{2i}(n)}\right) \qquad i=1,2 \qquad (4)$$

where x and t are total household inputs of ingredients and time. Time and market inputs are imperfect substitutes. The function $f_i(x_i,t_i)$ describes a constant returns to scale production technology for a one-person household. Production technologies do not vary between households of different sizes, but in the presence of production economies there are increasing returns to household size. Thus, households with two or more persons can produce the same per-capita output of food with less per-capita inputs of market goods and time than would be possible for a single person.

The input-specific production economies are modeled similarly to consumption economies. Let $0 \le \gamma_{ji} \le 1$, i, j = 1,2 be the four parameters of the economies in market goods and time, so that

$$\psi_{ji}(n) = n^{1-\gamma_{ji}} \qquad i,j=1,2$$

Economies in purchased food ingredients are measured by the scale parameter γ_{11}. Such economies may arise if larger households buy fewer per-capita ingredients to produce the same number of meals as smaller households. This could occur if larger families waste a lower share of their purchased inputs, buy in bulk and pay less per unit, or substitute home-produced meals for more expensive restaurant meals.

Economies of scale in food preparation time are measured by γ_{21}. If there are no economies of scale in time, then the time inputs required for food preparation for each additional household member are the same as those required for a single person. In terms of the parameters, this implies $\gamma_{21}= 0$ and $\psi_{21}(n) = n$. On the other hand, full economies of scale in food preparation time exist when the time it takes to prepare a meal for n household members is the same as that needed to cook for one person. In that case, $\gamma_{21}=1$ and $\psi_{21}(n) = 1$.

Non-food economies in market input, γ_{12}, are possible due to sharing costs for housing, appliances, etc. Non-food economies in time, γ_{22}, come from within-household specialization in running errands, childcare, etc.

The marginal rate of technical substitution between market ingredients and the time inputs to production of each commodity depends on the relative economies of scale:

$$MRTS_i = -\frac{dx_i}{dt_i} = \frac{\frac{\partial f_i}{\partial t_i}}{\frac{\partial f_i}{\partial x_i}} \frac{\psi_{1i}}{\psi_{2i}} \quad i=1,2 \tag{5}$$

In food production, this MRTS implies that in order to maintain the same level of food-output, a household with more than one adult increases time inputs less when decreasing market inputs by one unit than a single person household would.

Total household time endowment T is allocated between market work l and the production of both commodities:

$$T = l + t_1 + t_2$$

If time t_i and l are measured in hours per week, T is the total number of weekly hours available for market work, food preparation and other activities.

Finally, there is a budget constraint. Assuming market wage rate w and non-labor income V, total household income I is spent on market purchased inputs into food and non-food commodities:

$$p_1 x_1 + p_2 x_2 = wl + V = I$$

where p_1 and p_2 are prices of the market inputs.

The time and money constraints are combined into a full income constraint:

$$p_1 x_1 + p_2 x_2 + wt_1 + wt_2 = wT + V = I \qquad (6)$$

The household problem is to maximize the utility function (1) subject to the production functions (4) and the full income constraint (6). I simplify the problem by making it look like the decision facing a single-person household. These new variables are indicated with asterisks. They may be interpreted as the "effective" quantities and prices for household size n:

$$z_i^* = \frac{z_i}{\phi_i} \qquad x_i^* = \frac{x_i n}{\phi_i \psi_{1i}} \qquad t_i^* = \frac{t_i n}{\phi_i \psi_{2i}}$$

$$p_i^* = \frac{p_i \phi_i \psi_{1i}}{n} \qquad w_i^* = \frac{w \phi_i \psi_{2i}}{n} \qquad i = 1,2$$

The "effective" prices p_i reflect household savings from sharing, as higher economies of scale in a particular input means lower "effective" price per unit of the input. Time has a different "effective" price in each activity, w_i , because economies of scale in time use are different for food and non-food commodities.

The problem becomes:

$$\text{Max} \quad n * u\left(z_1^*, \;\; z_2^*\right) \qquad \text{s.t.}$$

$$z_i^* = f_i\left(x_i^*, t_i^*\right) \qquad i=1,2 \qquad (7)$$

$$p_1^* x_1^* + p_2^* x_2^* + w_1^* t_1^* + w_2^* t_2^* = I$$

Taking derivatives with respect to x_1, x_2 , t_1 t_2 provides the following first-order conditions:

$$\frac{\frac{\partial f_i}{\partial x_i^*}}{\frac{\partial f_i}{\partial t_i^*}} = \frac{p_i^*}{w_i^*} \qquad i=1,2 \qquad (8)$$

$$\frac{\frac{\partial u}{\partial z_1^*}}{\frac{\partial u}{\partial z_2^*}} = \frac{p_1^*}{p_2^*} \frac{\frac{\partial f_2}{\partial x_2^*}}{\frac{\partial f_1}{\partial x_1^*}} = \frac{w_1^*}{w_2^*} \frac{\frac{\partial f_2}{\partial t_2^*}}{\frac{\partial f_1}{\partial t_1^*}} \tag{9}$$

The first condition requires that the marginal rate of technical substitution between goods and time in production of any commodity is equal to the cost of converting time into goods. The second condition guides the allocation of resources between food and nonfood. The ratio of marginal utilities for food and nonfood commodities should equal their relative prices. Each household selects a combination of effective market and time inputs that minimizes the cost of producing commodities.

The solution of the problem is given by four demand functions:

$$x_i{*} = g_{x_i}(p_1^*, p_2^*, w_1^*, w_2^*, I^*) \qquad i=1,2$$

$$t_i{*} = g_{t_i}(p_1^*, p_2^*, w_1^*, w_2^*, I^*) \qquad i=1,2$$

The next step is to examine how household size, wages and non-labor income affect the demand for market and time inputs by deriving the corresponding elasticities of demand. Using zero-degree homogeneity of demand functions and switching back from "effective" to actual quantities, I expand the per-capita demand functions for both inputs:

$$\frac{x_i}{n} = \frac{\phi_i(n)\psi_{1i}(n)}{n^2} g_{x_i}\left(\frac{p_1\phi_1(n)\psi_{11}(n)}{n^2}, \frac{p_2\phi_2(n)\psi_{12}(n)}{n^2}, \frac{w\phi_1(n)\psi_{21}(n)}{n^2}, \frac{w\phi_2(n)\psi_{22}(n)}{n^2}, \frac{I}{n}\right)$$

$$\frac{t_i}{n} = \frac{\varphi_i(n)\psi_{2i}(n)}{n^2} g_{t_i}\left(\frac{p_1\varphi_1(n)\psi_{11}(n)}{n^2}, \frac{p_2\varphi_2(n)\psi_{12}(n)}{n^2}, \frac{w\varphi_1(n)\psi_{21}(n)}{n^2}, \frac{w\varphi_2(n)\psi_{22}(n)}{n^2}, \frac{I}{n}\right)$$

The problem is symmetric with respect to food and non-food goods because the general form of the demand functions is identical. The following results are for the demand for food, but are analogous to those for non-food goods. Taking logs, the demand functions become:

$$\ln\frac{x_1}{n} = ln\phi_1(n) + ln\,\psi_{11}(n) - 2ln\,n + \ln g_{x_1}(\bullet) \tag{10}$$

$$\ln\frac{t_1}{n} = \ln\phi_1(n) + \ln\psi_{21}(n) - 2\ln n + \ln g_{t_1}(\bullet) \quad (11)$$

2.2 Elasticity of Per-capita Food Expenditures with Respect to Household Size

Totally differentiating (10) with respect to ln *n*, I derive the elasticity of demand for market inputs with respect to household size, as follows. The derivation is explained in detail in Appendix.

$$\varepsilon_{x_1 n} = -(\sigma_1 + \gamma_{11})(1 + \varepsilon_{x_1 p_1}) - (\sigma_2 + \gamma_{12})\varepsilon_{x_1 p_2} - (\sigma_1 + \gamma_{21})\varepsilon_{x_1 w_1} - (\sigma_2 + \gamma_{22})\varepsilon_{x_1 w_2} - \varepsilon_{x_1 I} \quad (12)$$

The five components of the above expression reflect five different channels through which household size affects the demand for purchased food inputs. Of interest is how each component of this expression influences the elasticity $\varepsilon_{x_1 n}$.

First, if food is a necessity, then its own price elasticity is $\varepsilon_{x_1 p_1} \in [-1,0]$. The first component is therefore the product of two non-negative numbers. The per-capita demand for market inputs is more likely to decrease with household size when economies in market ingredients are high and the own price elasticity of food is low in absolute value.

The second term indicates that $\varepsilon_{x_1 n}$ is more likely to be negative the more substitutable are food and non-food and the higher are economies of scale in non-food market inputs.

The third term is negative, since a higher price of time spent in food preparation induces substitution towards more good-intensive food production. The higher price of time needed for food production may also induce some substitution away from food, but that effect should be small.

The fourth term is positive. A higher price of time in non-food may result in substitution towards good-intensive production of both goods and may also induce substitution towards food. Since it is subtracted, this represents another negative net effect of household size on the demand for food ingredients. Finally, the fifth term, the income elasticity of demand for market food goods, is also positive, contributing a negative effect to the overall elasticity of food expenditure with respect to household size.

At a constant per-capita full income and price of time, the elasticity of demand for market inputs into food production with respect to household size is described by the first two components of (12):

$$\alpha_1 = -(\sigma_1 + \gamma_{11})(1 + \varepsilon_{x_1 p_1}) - (\sigma_2 + \gamma_{12})\varepsilon_{x_1 p_2}$$

The empirical estimate of α_1 is in the center of Deaton and Paxson's paradox. Using a model which does not consider time inputs, Deaton and Paxson argue that α_1 should be positive because economies in food are close to zero (in the context of this model, $\sigma_1+\gamma_{11}=0$), and the income effect dominates, implying that market purchased food and non-food inputs are complements, or $\varepsilon_{x_1 p_2} < 0$. In their model, a lower effective price of shared goods leads to higher per-capita consumption of food. The production model explains why this may not occur when there is the possibility of economies of scale in preparation time.

Note that α_1 does not directly measure economies of scale in food-inputs. The scale of economies is assumed to be $\sigma_1+\gamma_{11}$. Instead, what the elasticity of demand for inputs with respect to household size represents is a typical household's percentage-point re-allocation of per-capita food expenditures if the household size were to be doubled holding wages and non-labor income constant. Because market inputs are substitutes in a household's budget, and the own price elasticity of food is less than unity in absolute value, α_1 is expected to be negative.

2.3 Elasticity of Per-capita Food Preparation Time with Respect to Household Size

The elasticity of per-capita food preparation time with respect to household size is derived in Appendix 2 in a similar fashion:

$$\varepsilon_{t_1 n} = -(\sigma_1 + \gamma_{21})(1 + \varepsilon_{t_1 p_1}) - (\sigma_2 + \gamma_{12})\varepsilon_{t_1 p_2} - (\sigma_1 + \gamma_{21})\varepsilon_{t_1 w_1} - (\sigma_2 + \gamma_{22})\varepsilon_{t_1 w_2} - \varepsilon_{t_1 I} \quad (13)$$

The expression has five components. In the first term, the elasticity of time-demand with respect to the price of the market inputs should be positive, even though a higher price of food may also induce some small substitution away from food. With the negative sign, this component should have a negative effect on $\varepsilon_{t_1 n}$.

In the second term, the sign of the elasticity of demand for food preparation time with respect to the price of nonfood is ambiguous. On the one hand, a relatively more expensive price for nonfood goods results in substitution towards food and towards more time-intensive meals. On the other hand, higher market prices of nonfood goods lead to more time-intensive production of nonfood and perhaps away from food preparation time. In the third term, the time-price elasticity must be negative. The third effect, therefore, works in the opposite direction, as it affects $\varepsilon_{t_1 n}$ positively. In the fourth term, a higher price of time in nonfood implies substitution to more good-intensive production of nonfood, but the effect on time in food is ambiguous since substitution towards more food preparation time is also possible. In the fifth term,, higher income should increase the demand for market ingredients relative to time, contributing a positive effect on $\varepsilon_{t_1 n}$.

At constant income and wages, the time demand elasticity with respect to household size becomes:

$$\beta_1 = -(\sigma_1 + \gamma_{21})(1 + \varepsilon_{t_1 p_1}) - (\sigma_2 + \gamma_{12})\varepsilon_{t_1 p_2}$$

As in the case of the demand elasticity for market inputs, the time elasticity with respect to household size, $\beta_{1,}$ does not provide a direct measure of the economies in time $\gamma_{21.}$ Rather, it gives the overall effect of an increase in household size that shifts relative prices within a household, a percentage-point change of per-capita food preparation time if the household size were to be doubled holding wages and non-labor income constant. The parameter β_1 is expected to be negative, and it is larger in absolute value when economies of scale in food preparation time γ_{21} are large, when the time demand elasticity with respect to the price of market food $\varepsilon_{t_1 p_1}$ is large and when the substitution away from food preparation time in response to an increase in the price of nonfood $\varepsilon_{t_1 p_2}$ is small.

2.4 Elasticity of Per-capita Food Expenditures with Respect to Wage

The effect of an increase in wage on per-capita food expenditure at constant household size is:

$$\alpha_2 = \frac{d \ln \frac{x_1}{n}}{d \ln w} = \varepsilon_{x_1 w_1} + \varepsilon_{x_1 w_2} + \varsigma_w \varepsilon_{x_1 I} \tag{14}$$

Here $\varsigma_w = \frac{\partial \ln((wT + V)/n)}{\partial \ln w}$ is the elasticity of full income with respect to wage, which is a positive number close to one. The demand for market ingredients in food should increase with wages, since all components of this elasticity are expected to be positive.

Holding income constant, the wage elasticity is a sum of elasticities with respect to the price of time in both activities should be a positive number:

$$\alpha_2 = \frac{d \ln \frac{x_1}{n}}{d \ln w} = \varepsilon_{x_1 w_1} + \varepsilon_{x_1 w_2}$$

2.5 Elasticity of Per-capita Food Preparation Time with Respect to Wage

The demand for food preparation time responds to an increase in hourly wage in the following way:

$$\beta_2 = \frac{d \ln \frac{t_1}{n}}{d \ln w} = \varepsilon_{t_1 w_1} + \varepsilon_{t_1 w_2} + \varsigma_w \varepsilon_{t_1 I} \tag{15}$$

The first term is the substitution effect – a higher price of time reduces the demand for food preparation time. The second term is the effect of a higher price of time in the alternative activity. This effect may be positive if it results in substitution towards food and away from nonfood goods. However, it is likely that a higher price of time would cause a shift towards good-intensive techniques in food as well. Finally, there is also an income effect - individuals can afford more of both time and market goods as total income increases, which may increase or decrease the demand for time. However, the net effect is most likely negative since the substitution effect should dominate.

At constant income, the parameter of interest is given by the sum of elasticities of the price of time:

$$\beta_2 = \frac{d \ln \frac{t_1}{n}}{d \ln w} = \varepsilon_{t_1 w_1} + \varepsilon_{t_1 w_2}$$

2.6 Elasticity of the Goods-Intensity of Meals with Respect to Household Size

The goods-intensity of food varies with household size as follows:

$$\chi = \frac{d \ln \frac{x_1}{t_1}}{d \ln n} \tag{16}$$

The goods-intensity of meals decreases with household size ($\chi<0$) if larger households find time relatively cheaper and substitute time for market ingredients.

2.7 Elasticity of Food Share with Respect to Household Size

The share of food in total household expenditures is:

$$s_f = \frac{p_1 x_1}{p_1 x_1 + p_2 x_2}$$

Differentiating with respect to *n*,

$$\delta = \frac{ds_f}{dn} = \frac{p_1 p_2}{\left(p_1 x_1 + p_2 x_2\right)^2} \left(x_2 \frac{\partial x_1}{\partial n} - x_1 \frac{\partial x_2}{\partial n} \right) \tag{17}$$

The food share decreases with household size if $x_2 \frac{\partial x_1}{\partial n} < x_1 \frac{\partial x_2}{\partial n}$, which is equivalent to

$$\frac{\partial \ln(x_1 / n)}{\partial \ln n} < \frac{\partial \ln(x_2 / n)}{\partial \ln n}, \quad \text{or} \quad \varepsilon_{x_1 n} < \varepsilon_{x_2 n}.$$

The last condition implies that the budget share of the good declines with household size if the demand for that good is more responsive to changes in household size than the demand for the other good. A negative value of δ implies that the demand for market purchased food inputs is more elastic with respect to household size than the demand for everything else. In the simple Barten model, a lower share of food expenditures at a given budget is assumed to mean lower consumption of food, because food expenditures are treated as synonymous with food consumption. In contrast, there is no direct link between food share of expenditures and food consumption in the household production model. A decline in the food share of expenditures as household size increases may take place while per capita food consumption, z_1^* remains unchanged or even increases,, if larger households adopt less goods-intensive food production technologies.

3 Data

3.1 Russian Longitudinal Monitoring Survey 1994-98

The data are four waves of the Russian Longitudinal Monitoring Survey (RLMS) for the years 1994-98. The RLMS, a project of the Carolina Population Center at the University of North Carolina at Chapel Hill, is a household-based survey with information on 41,069 individuals representing over 15,000 households. Many of those households participated in more than one rounds of the survey, providing a panel component which I do not taking advantage of in this chapter. The RLMS includes information on household expenditures for a number of food and nonfood items, along with information on demographic characteristics and labor market participation. The RLMS is a representative sample of the Russian population, and households of different sizes are well represented.

Most importantly for this research, the survey provides weekly-recall data for all household members on the amount of time spent in several major food production activities, including shopping for food, cooking food, and growing food for home consumption. Survey respondents are asked “How much time in the last 7 days did you spend looking for and purchasing food items? ” “How much time in the last 7 days did you spend preparing food and washing dishes?” and “How much time in the last 7 days did you spend working on your individual land plot, dacha, or garden plot, excluding farm plots, or on a personal subsidiary farm?” Unfortunately, the amount of time spent consuming food is not recorded, and neither is time spent cleaning after meals other than washing dishes. The survey asks respondents about the total time spent cleaning last week, but it is impossible to distinguish between cleaning related to food production and other household cleaning. The total time of “food preparation” is thus taken as the sum of time spent on shopping for food, cooking, and growing food in kitchen gardens[2].

This measure of food-related time almost certainly underestimates actual time households spend on food. It does not include time for eating and cleaning the kitchen. It also excludes time households spend collecting wild mushrooms and berries. And because the survey is taken in the late fall and the winter while the peak gardening time is late spring, summer and early fall, our measure of time spent on the kitchen plot underestimates actual time households spend growing food.

The primary advantage of this survey is that both expenditure and time data are available for the same household over the same week. The main drawback is the recall nature of the time-use component. Time-use data collected through recall are generally of inferior quality compared to those collected through detailed time diaries. Another drawback is that expenditure data are only available at the household level, and cannot be assigned to individuals within a household.

An ideal survey for my analysis would record food-related expenses for each individual in the household as well as diary time use for each individual over the same period of time. Individuals of such a survey would need to be drawn randomly from households of different size. Most surveys contain either expenditure or time use data, but not both[3]. Several surveys from developing countries contain expenditure and time use data on households[4]. Those datasets may be good candidates for the future empirical research if quality of those data can be ascertained. In the absence of the ideal data, the RLMS provides a good basis for an empirical analysis of the model.

Most of the analysis below uses a sample of adults aged 18 and older. The household level data is also used for examining the relative good-and time-intensity of food production. To construct a sample of individuals, I pool four years of observations, remove children and

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[2] Many Russian households have dachas or other small plots of land where they grow fruits and vegetables. Russians also spend time collecting wild mushrooms and berries. The imputed value of home produced food reflects the valued of food grown in the kitchen garden and collected in the wild. The time spent in the garden is recorded in the survey but the time spent collecting mushrooms and berries is not available.

[3] The United Nations Statistical Division provides an overview of available time-use surveys: http://unstats.un.org/unsd/demographic/sconcerns/tuse/

[4] For example, Nicaragua Living Standards Measurement Study Survey 1993, 1999, 2001 and Kazakhstan Living Standards Measurement Survey 1996 available from the World Bank at http://www.worldbank.org/lsms/guide/select.html.

individuals with missing household size, missing food expenditures or missing food related time use. This leaves a final sample of 30,734 observations on individual adults and 14,395 households. Households with complete time, age, expenditure and demographic records are included in the final sample of households with 14,395 observations.

Expenditures on market food inputs include all expenditures on food eaten at home, food eaten away from home, and alcohol. The survey also provides imputed values for home-produced food, which make up over 20% of total food consumption. However, these are not included in total food expenditures. If anything, they should be highly correlated with household production time in late spring and summer. Per-capita food expenditures are calculated as household expenditure divided by the family size where family size includes all household members, adults and children.

Hourly wages are computed from the total weekly earnings and time spent in all jobs for pay. Over 20% of households claim to have no wage earners, and over 40% of adults are either unemployed or do not provide information on weekly earnings and time spent in the labor market. For such individuals I impute hourly wages using a standard two-step estimation technique with a participation equation and a wage function.

3.2. Analysis of Summary Statistics

Table 1 summarizes the key characteristics of the sample of individuals. Each round of the survey contributed about an equal number of observations to the final sample. An average individual is 45 years old and comes from a household of 3-4 people. In this sample, 43% are men and 59% of the sample is employed. Every fourth person is retired and every fourth lives in a rural area. Over half of adults come from households with children, 28% own a house, and 19% own a car.

An average adult spends 14.6 hours a week in food preparation, including 8.5 hours cooking, 2.9 hours shopping for food and 3.2 hours gardening. Gardening is an important source of food for many families: some 68% grow some of their own food. Expenditures on groceries make up the largest share of food expenditures – 87%. Meals eaten out make up 12.5% of the total food budget. Alcohol makes up only 0.5% of total expenditures on food[5].

Relatively low per-capita income numbers suggest that income is most likely grossly under-reported. Average reported income is less than half of average food expenditures. While underreporting of income is a common problem in most surveys, especially those that are not focused on collecting income data alone, the problem may be greater in Russia than in other industrialized countries, given high income tax rates, possibly unfamiliarity with and suspicion of household surveys, and a higher reliance on informal labor relations and transfers from family. The hope is that the reported income is highly correlated with actual income, but estimates on income should be interpreted with caution.

Table 2 reports the averages for most of these variables by year of the survey. From those we see some trends over time. A decrease in employment, hours worked, labor earnings and hourly wages is accompanied by a decrease in food expenditures. The average household spent two times less on food in 1998 than it did in 1994. It is unclear whether households actually cut their real expenditures on food by 50%, since some of the drop may be attributed to price changes even though I used numbers that were corrected for price changes. Price changes were complicated by the devaluation of the Russian currency which made buying imported food much more expensive but led to increased local production, and it is unclear how much of this is captured in price changes.

Food preparation time decreased over the years by about 20%. Part of this change is probably due to improvements in household production technologies such as the availability of new household appliances during economic liberalization or the expansion of retail outlets and the greater availability of more processed foods. If, on the other hand, lower food expenditures reflect a trend of lower quantity of food consumed in the later years of the survey, then lower time inputs may be due to the production of fewer meals. Even if the quantity of food consumed remained unchanged over the four years of the survey, the quality of foods slightly decreased, as indicated by the declining percent of protein in individuals' daily diet but the standard deviation of this variable is low and the difference may not be significant.

[5] Food expenditures account for about 68% of total household expenditures. The high share of food is in part due to subsidized housing. In 1994-98 rounds of RLMS, the average share of housing, including utilities, was just over 6% of the household budget.

Table 3 presents the summary statistics by gender and employment status. The average age of employed men and women is 39 while the average age of the non-employed is over 51. Women's earnings and wages are lower than men's. Employed men and women spend about 10% more on groceries than non-wage earners, twice as much on food eaten out, and 40% more on alcohol.

Of particular interest are the differences in time use between men and women. A non-employed woman spends twice as much time on food preparation as a non-employed man, contributing 21 hours compared to only 10.7 hours contributed by a man. A working woman spends three times more time on food preparation than a working man, 18.7 hours compared to 6.2 hours. Gardening time accounts for almost half of men's time spent in food preparation. Men spend 40% more time gardening than women. Employed women spend the most time shopping for food, 3.9 hours compared to 3.8 hours for non-employed women, 2.1 hours for non-employed men and 1.4 hours for employed men. Women who do not work for wage spend more time cooking than any other group of individuals: 13.7 hours compared to 13 hours for the employed women, 3 hours for non-working men and under 2 hours for employed men.

To compare per-capita time use and food expenditures by households of different sizes, I tabulate these variables by household "type" in Table 4, selecting those types for which I have more than one hundred observations. The type is defined as a two-digit number; the first digit is the number of adults and second is the number of children.

Table 5 presents some of those mean values for households without children. Each mean value is followed by an index number in parentheses. The index is calculated as a ratio of the expenditure or time devoted to food by an average individual from a larger household to the corresponding mean expenditure or time spent on food by a single adult. These indices may serve as a rough measure of the household economies of scale. In absence of any economies, each additional adult would add at least as much as a single individual to the total household expenditure on food, so the index for a two adult household would be no less than two. With no economies in time, individuals from larger households would on average spend as much time as single adults in food-related activities, after accounting for men and women's intra-household specialization.

As one can see from the table, the index numbers under total household food expenditures are lower than the corresponding number of family members. A two-adult household spends only 50% more on food than a single person and a family of five spends less on food than three separate individuals. Thus per-capita expenditure on food decreases with household size. The index under per capita expenditure shows that a member of a two-adult household spends 25% less money on food than a single adult, with the corresponding food expenditure 75% of those of a single individual. A member of a three-adult household spends 39% less while a member of a five-adult household spends 49% less than their single counterpart. The economies diminish as household size grows with the largest savings occurring for two single people creating a joint household. The transition from a single to the joint household is accompanied by a relatively larger drop in expenditure on alcohol and restaurant meals than that on groceries.

Again, there is a substantial gender difference in changes in time allocation associated with different household structures. For women, a move from a one- to a two-person household is accompanied by a 22% increase in food preparation time, from 17.2 to 21 hours per week, including a 29% increase in cooking time (from 10.5 to 13.5 hours), a 17% increase in shopping time (from 3.4 to 4 hours), and a 7% increase in gardening time (from 3.3 to 3.5 hours). A further increase in family size results in steadily decreasing food-related time for women. But even being part of a four-adult household, an average woman spends more time cooking than her single counterpart. A woman from a five-adult household spends only 8% less time in food-related activities than a single woman.

All the benefits of the household economies of scale in time use accrue to men. The economies are particularly large for men moving from a single to a two-person household. As part of a two-adult household, an average man spends 29% less time on food preparation than a single man, 9.7 hours compared to 13.7 for a single man. That includes a large drop in the man's cooking time to less than a third of a single guy's time spent in the kitchen, from 7.8 to 2.5 hours per week, and a 32% drop in the shopping time. Men's involvement in cooking decreases steadily with household size: a man from a five-adult household spends seven times less in the kitchen than his single counterpart, just over on hour. As women spend more hours cooking, men from households size two and larger accept more gardening responsibilities. The transition to a joint household by a single man is accompanied by an 84% increase in time spent cultivating land.

Overall, per-capita food preparation time decreases with household size for men and women. An exception is single women moving to a two-person household. Even taking into account extra hours spent on food preparation by a married woman and extra gardening hours for a married man, the net per-capita food preparation time supplied by men and women together decreases steadily with household size.

Table 3.4 includes age, gender and labor market participation data for individuals by household type. Demographics explain some of the differences in food-related expenditures and time between different types of households. For example, individuals in smaller households are older and more likely to be retired, with low incomes and a low opportunity cost of time. Therefore age may be associated with a higher level of time inputs and lower level of market inputs.

For households of a similar type, on average men generally spend more per-capita on food than women. Per-capita expenditures on food decrease with the number of children when the number of adults is held constant. This is expected, since young children need less food than adults. Individuals from households with children are on average younger and more likely be employed than those without children. As the number of children increases, women specialize more in cooking: the average time a woman spends cooking increases with each extra child and men's average time in the same activity goes down. An extra child is associated with some additional gardening time for men and women and a reduction in time spent shopping for food.

4 Regression analysis

4.1 Methodology

The size economies from Table 3.5 almost certainly do not represent the true scale of household economies because simple averages do not account for household composition and other factors that may affect demand for meals and inputs into production of meals. For example, if older people living in households of different size tend to spend less money and more time on food, than the simple averages would confound the effect of household size with the effect of age. A three-person family with two parents and a child may have lower per-capita expenditures on food than a three adult household because children need less food. Married people may spend more time in food-related activities if they enjoy shopping and cooking together. Individuals from rural areas most likely grow more food and spend less on market ingredients.

The pattern in simple averages with regard to household size suggests that per capita expenditure and time inputs do decrease with household size, but perhaps discontinuously, with a distinct change at the two-person household. A move from a one- to a two-person household is associated with an increase in women's time spent on food while every subsequent increase in family size is associated with a lower per-capita time input. For men, on the other hand, average food preparation time decreases substantially with a move from a one- to a two-person household. Much of the discontinuity between these two types of households is likely to be explained by factors other than economies of scale.

Let x_i and t_i be the individual's expenditure on food and food preparation time, respectively. In order to account for additional factors that affect households decisions and for the possible discontinuity, I model the demand for food-inputs as spline functions of household size n and the following variables: individual wage w, per-capita non-labor income v, the number of children of different ages, age, employment and married status, geographical location and the year of the survey.

Let d be an indicator for a family size one or two: $d = 1 \; if \;\; n \leq 2$. Then the demand functions are:

$$\ln x_i = \alpha_0 + \gamma_1 d + (\alpha_1 + \gamma_2 d) \ln n + \alpha_2 \ln w + \alpha_3 \ln(v) + \alpha_4 X + \xi_1 \qquad (18)$$

$$\ln t_i = \beta_0 + \gamma_3 d + (\beta_1 + \gamma_4 d) \ln n + \beta_2 \ln w + \beta_3 \ln(v) + \beta_4 X + \xi_2 \qquad (19)$$

The spline method in this case is equivalent to splitting each of the samples into two sub-samples representing (households size two and larger, and households size one and two) and estimating separately the demand functions in each sample. Thus equation (3.18) can be split into a demand function for households size two and larger, with intercepts α_0 and slope α_1, and a function for households size one and two with intercept $\alpha_0 + \gamma_1$ and slope $\alpha_1 + \gamma_2$. To join the two parts of the function at the knot, the value of the dependent variable must be the same at $n=2$, or

$$\alpha_0 + \alpha_1 \ln 2 = \alpha_0 + \gamma_1 + (\alpha_1 + \gamma_2) \ln 2$$

This imposes the following restriction on the coefficients:

$$\gamma_1 = -\gamma_2 \ln 2 \quad \text{and similarly: } \gamma_3 = -\gamma_4 \ln 2$$

Inserting this restriction into (18) and (19) yields two equations:

$$\ln x_i = \alpha_0 + \alpha_1 \ln n + \gamma_2 d(\ln n - \ln 2) + \alpha_2 \ln w + \alpha_3 \ln(v) + \alpha_4 X + \xi_1 \qquad (18')$$

$$\ln t_i = \beta_0 + \beta_1 \ln n + \gamma_4 d(\ln n - \ln 2) + \beta_2 \ln w + \beta_3 \ln(v) + \beta_4 X + \xi_2 \qquad (19')$$

To assign household expenditures to individuals within the household, I assume that consumption is shared equally among men, women and children within the household. This allows the use of per-capita food expenditure on the left hand size of equation (18'). Assigning per-capita expenditure to adults implies that adults with more children will have a lower ratio of total expenditures to family size than households with fewer or no children. The demand regressions correct for the number and ages of children and fix this problem. A more serious problem with this approach is that the assumption of equal distribution of goods within the household may not be realistic. If men consume more food and spend more money on food, then for households with more than one person men's true expenditures on food will be understated and women's true expenditures overstated.

Time is reported for each individual, allowing the use of adults' own time inputs for the dependent variable in (19'). One problem is that older children, especially teenagers, participate in food preparation. In this sample, 82% of girls and 68% of boys aged 14-17 report positive food preparation time. An average girl in this age group spends 6.1 hours a week on food preparation (1.3 hours buying food, 3.8 hours cooking, and 1 hour gardening). An average boy spends 4 hours a week (0.8 buying food, 1.1 cooking and 2.1 gardening). Children are not included in estimating the demand equations. Rather, the time they spend in food preparation is including in the total time spent by the household for the household-level regression of goods-intensity of food. In addition, a small share of younger children report their time contribution in preparing food. However I take a skeptical view as to the ability of young children to help solve the household problem of time scarcity and I view their cooking time as leisure and omit it entirely.

4.2 Imputed Wages

Before the demand equations can be estimated, wages for the unemployed individuals are imputed using a two-step wage regression consisting of a labor market participation equation and a corrected wage equation for the employed.

The probability of labor market participation is modeled as the function of education, age, gender, marital status, the interaction of marital status and gender, household size, presence of pre-school children, an interaction of a the latter with gender, per capita income of other household members, rural location and unemployment rate by the site of the survey. I also include dummies for asset ownership (ownership of land and a house) as indicators of wealth and better employment opportunities. Dummies for students, retired and disabled mark groups that are less likely to earn wages. Finally, the dummy variables for the year of the survey are included in order to correct for the general declining trend in employment and wages.

Hourly wages are assumed to be determined by some of the same variables as labor market participation (education, age, gender, married status, rural location, income of other household members, land and house ownership, year of the survey). I exclude presence of young children, its interaction with gender, household size, local unemployment rate and the student or retired status. Those variable supposedly matter for individual's decision to work for wage, but they do not affect the wage level. The wage function includes several new variables: an indicator for wage arrears, dummies for seven geographical regions and ownership of a car. Less than 10% of Russian households own cars and having own transportation should afford better earnings opportunities for the employed individuals.

The full probit procedure results for the first step are reported in Table 6 and the wage equation OLS results in Table 7.

The estimated coefficients of the participation and wage regressions largely conform to the expectations. The probability of being employed and wage increase with the level of education and the profile is concave in age. Married men are more likely to work and receive higher pay. Students and retired and disabled individuals are less likely to work for wages, as are married women with young children. Individuals from rural areas and those whose salaries are in arrears receive substantially lower wages. The estimate for lambda- a factor that corrects for a possible participation bias- is significant and positive, suggesting that not correcting for this bias would result in underestimation of wages. I use the estimated wage function coefficients to impute wages for individuals with missing wage data.

4.3 Demand Equations

4.3.1 Per Capita Food Expenditures

I estimate the demand equations (18') and (19') with OLS separately for men and women. The full sets of coefficients are in Table 8[6]. Gamma denotes the slope of the extra term in the spline functions.

Negative coefficients on household size for men and women suggest that the demand for both inputs into food decreases with household size. In households of two or more persons, doubling the size of the household decreases per capita food expenditure by 31-32%. The drop in per capita expenditures may be larger for single individuals moving in together, but the evidence is not strong since the negative coefficient is not significant at the 5% level.

The demand for market inputs increases with wage and income and is higher for the employed and wealthier car-owners. As expected, per-capita expenditures are lower for families with children, especially young children who consume less food. Married women spend more money on food than single women do, while marital status does not affect men's food expenditures. Rural households, households living in a house, and those that own a plot of land spend less per capita on food. Food expenditures are also lower in several relatively poor regions of the country, and they declined on average over the years the survey was taken.

The age profile of food expenditures, on the other hand, is convex, indicating that expenditures decrease with age. The age profile of this cross-section is steeper than a typical individual's life cycle profile. This is because the sample was drawn at the time of economic reforms in Russia that impoverished older persons relative to younger adults. This shows up as a steep decline in food expenditure at older ages in this sample.

4.3.2 Food-Related Time

[6] I am interested in analyzing the marginal effects. My demand equations have the following general form: $\ln y = \alpha + \beta \ln x + \delta z + \varepsilon$, therefore the marginal effects are $\frac{\partial y}{\partial x} = \beta \frac{y}{x}$ and $\frac{\partial y}{\partial z} = \delta y$

The coefficients on household size in the time demand equations suggest that doubling the size of the household decreases individuals' food preparation time by 74-77% for households with two or more persons. This suggests that potentially economies in food preparation time are larger than economies in food expenditures. However, because of intra-family specialization and because of differences in household composition, the gains so afforded are not distributed evenly between men and women.

The gamma-coefficient on the spline term is highly significant for men and women suggesting a structural break at $n=2$ in the demand for time for both men and women. Adding large negative gamma to the coefficient on household size in the regression for men, I calculate that the typical man's time input into food is 217% higher when he lives alone compared to a man from a two-person family. On top of that, a married man however spends only 18% more time in food-related activities than a single man. When this "marriage time premium" is considered, a single man still spends almost 200% more time preparing food than a married man from in a two-person household. In other words, by getting married a typical man may expect a three times reduction in food preparation time, which corresponds to time savings of 4-6 weekly hours in this sample.

An employed man spends 34% less time on food than a non-employed man. Each pre-school age child adds 20% to men's food preparation time while each older child adds up to 15%. Men from rural areas, those who own a house and come from households that grow food spend a combined 84% more time on in food related activities than men from urban areas who live in apartments and do not engage in subsistence agriculture.

For women, the gamma-coefficient has the opposite sign, it is positive. Adding the spline term coefficient to the coefficient on household size I conclude that women living in a two-person household economize 45% on food preparation time compared to their single counterparts.

If women's food-related time decreases even when we move from one person to a two-person household, why do the mean values in Table 3.4 show increased time inputs from women? There are several explanations. First, there is an age affect. Age is one the main determinants of the women's time allocation, as seen from highly significant and positive coefficient on age in the women's time regression. Second, the coefficient on the dummy for marital status suggests that married women spend almost 47% more time in food-related activities. Thus, a 45% drop in food-related time due to economies in household size, combined with a 47% increase in food related time for married women, results in a net increase in time spent looking for food and cooking. In households with children, an average woman spends 18% more time on food. In addition, every preschool age child increases the time a woman spends in food preparation by 20%, while every older child increases it by fewer than 12%. Thus women with children from small households spend more time in food-related activities than single women.

There is a small positive coefficient on wages in the men's time regression. This should be interpreted cautiously, since the wages of the employed are calculated as a ratio of earnings to time spent in the labor market, and the latter may be negatively correlated with food preparation time.

The effect of the total per-capita income of other household members on the demand for market inputs and time is positive and relatively larger for men's time: the higher the income of other household members, the more time individuals spend on food. The fact that both market and time inputs respond positively to an increase in income suggests that wealthier households consume higher quantities of food and perhaps higher quality. For women, the percentage increase in market inputs due to a unit increase in the income of other household members is proportionally larger than the increase in preparation time for women, suggesting substitution into more goods-intensive meals in response to higher income.

In this sample, the age profile of time inputs into meals is increasing with age and concave, indicating that older men and women spend relatively more time cooking than younger people. The coefficients on the survey year dummies indicate that over time food expenditures per capita decreased as did the time women spend on food, while men's time in food-related activities (mostly gardening) increased slightly due to food shortages during the transition period. Both men and women in rural areas spend more time and less money on food.

The time regression for men has a poor fit, suggesting that most of the variation in men's time use comes from unobservable individual or household characteristics and preferences which are not explained by wages, income, family size, composition and demographics.

Interestingly, when I merge residuals from the men's and women's regressions by household, I find a significant positive correlation (equal to 0.09) between the unexplained component in women's and men's time use. Husbands who spend more time in the kitchen tend to have wives who spend more time in the kitchen as well, and vice versa. The correlation of residuals from women's food expenditures and time use regressions is also significant and positive, but small, only 0.026. This may suggest that the purchase of more ingredients, for example for a holiday meals, requires more time to shop and cook, but the value of this coefficient is too small to derive any conclusions. For men, residuals from time and expenditure regressions are not correlated suggesting men do not change their cooking-shopping-gardening effort in response to unusually large or small purchases of food.

4.4 The Goods-Intensity of Food

As seen from the estimates for men and women, expenditures on market inputs decrease with household size proportionately less than time spent in meal preparation. If economies of scale for market food inputs are smaller than economies in food preparation, than larger households choose more time-intensive food production techniques. I test this prediction in a sample of households using total household food expenditures and total food preparation time. This enables me to include the time supplied by 14-17 year olds. I estimate the following function:

$$\ln(x/t) = \alpha_0 + \gamma_1 d + (\alpha_1 + \gamma_2 d)\ln n + \alpha_2 \ln w + \alpha_3 \ln(v) + \alpha_4 X + \xi_3 \qquad (20)$$

The goods-intensity of food is defined as total household food expenditures divided by food preparation time. I model the goods-intensity of meals as a function of household size, wage, unearned income, household composition defined by the ratio of children different ages to household size and ratio of men to household size, the share of employed adults to the number of adults, asset ownership, year of the survey and geographical location. The wage, age and gender of the household head are also included, with the household head being the person in the household with the highest wage. Estimates are reported in Table 9.

The coefficient on household size is negative, suggesting that larger households choose more time-intensive methods of food production compared to smaller households. Doubling household size decreases the goods-intensity of food by 26%. There is evidence to support the hypothesis of a structural break in the function at $n=2$: the gamma-coefficient is significant and negative, implying that goods-intensity decreases with a steeper slope between one- and two-person households.

As expected, the goods-intensity of food increases with the hourly wages. Older households choose more time- intensive food technologies, as do households from poorer geographical regions, and rural areas and owners of land for small scale agriculture. The goods-intensity of food increases with the number of school-age children with the exception of teenagers 14-17 years of age, who themselves contribute their time to food preparation. Ownership of a car, which is a proxy for wealthier households and those able to work more jobs, is associated with a higher goods-intensity of food. At the same time, ownership of a house and ownership of a plot of land is associated for lower goods-intensity of food. The goods-intensity of food use decreased over time during the transition. Per-capita non-labor income (transfer payments, property income, etc) does not affect the goods-intensity of food production.

4.5 Household Size and Nutrition

So far I have found evidence that larger households economize of food expenditures and time, and that relatively high economies in time induce substitution toward more time-intensive meals. However, this does not answer an important question of whether larger households have higher per-capita food consumption. Assuming limited substitution between food and everything else in the household utility function, food consumption per capita should not decrease with household size. Deaton and Paxson assume expenditures approximate consumption; hence evidence of economies in food expenditures is viewed as puzzling because lower food expenditures imply individuals in larger families consume less food. My model explains that expenditures are only one of the two inputs into food, and per capita expenditures may decrease with household size while food consumption per capita remains the same or even rises.

It would be interesting to find empirical evidence showing whether larger households do not consume lower quantity and/or quality of food. A non-negative relationship between individuals' caloric intake and household size would indicate non-decreasing quantity of food consumed. The source of calories – fat, carbohydrates or protein – may convey information about the quality of foods consumed.

Unfortunately, RLMS does not provide information on publish individuals' caloric intake. However, it does include the share of fat, carbohydrates and protein in every surveyed individual's daily diet calculated by the Carolina Population Center at the University of North Carolina at Chapel Hill[7]. Assuming the quality of nutrition may be measured by the share of protein in the individual's daily diet, I model the quality of nutrition, p_i, as a function of household size, age, gender, number of children in each age group, wage, employment status, per-capita income of other family members, asset ownership, marital status, geographical location and year of the survey. The average adult obtains 12.7% of total calories from protein. I estimate the following equation using the full sample of adults:

$$p_i = \alpha_0 + \gamma_1 d + (\alpha_1 + \gamma_2 d)\ln n + \alpha_2 \ln w + \alpha_3 \ln(v) + \alpha_4 X + \xi_4 \qquad (21)$$

The coefficient estimates are reported in Table 10. The coefficient on household size is not significantly different from zero, suggesting that the quality of meals does not decrease with family size. In fact, gamma, the extra term of the spline function, is positive, implying that the move from a one-person to a two-person household results in a 37% increase in the protein content of meals.

Higher quality meals are also associated with higher wages and higher unearned income. Men, married and employed individuals, those who live in rural areas and those who own a car consume better quality meals, while households that grow their own food and live in relatively poorer locations have a lower quality nutrition. Family composition and age do not affect the quality of meals. Overall, the share of protein in the diet decreased slightly over time.

However, the nutrition regression has a very poor fit. The model is only able to explain about 3% of the variation in the protein content of the diet. There is little variation in the dependent variable, and its standard deviation (as reported in Table 4) is very low.

5 Conclusions

[7] Nutrition data is missing for 100 people in my sample.

This paper examined the sources of household economies of scale in food in a household production framework. Previous research has been unable to explain why larger households spend less per capita on food. By explicitly incorporating time requirements for food production in the model, I showed that household decisions depend on the relative prices of market-purchased inputs and the time needed to prepare meals, and that these relative prices are affected by household size. In the presence of large economies of scale in food preparation time, optimizing households choose more time-intensive food production technologies in response to an increase in household size.

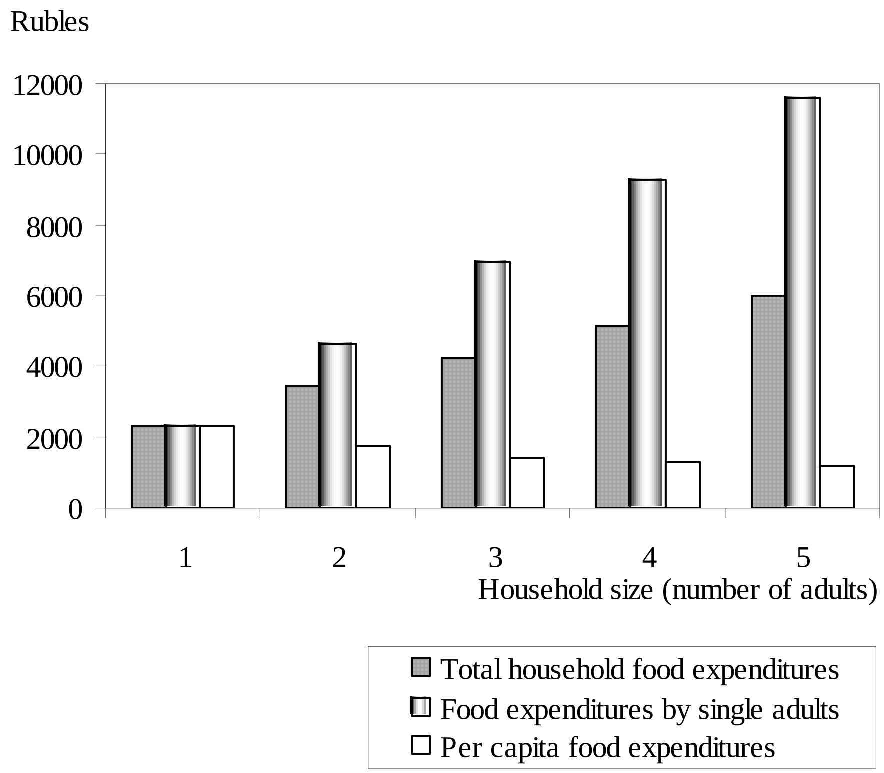
The evidence from Russia supports the existence of economies in food expenditures and food preparation time. I estimate that for households with two or more people doubling household size while holding wages, non-labor income and family composition constant decreases household food expenditures by over 30% and decreases individuals' food preparation time by over 75%. The economies of scale from moving from a one-person household to a two-person household differ by gender. After moving into a two-person household, a man may expect to spend three times less time preparing food, while a woman will on average spend 45% less time preparing food if she is not married and no less time as before if she gets married. I find evidence that a larger household size induces substitution towards relatively more time-intensive meals. The quality of meals most likely does not decrease with household size, but more research is needed to confirm this finding.

This research can be extended in several ways. First, estimates from other countries are needed in order to generalize the evidence on the size of household economies of scale in food. The estimates may be affected by the level of income and development. Russia presents a specific example of an industrialized country with low incomes and high food expenditures. Anderson and Vahid (1997) provide evidence that the income elasticity of family food consumption may be affected by the level of household income.

Second, more reliable nutrition data would provide additional insights into how the quantity and quality of food is affected by household size. Such information would be invaluable if the key interest is in household welfare.

Third, this paper focused on food without considering the demand for other goods. However, there are likely to be substantial opportunities for larger households to economize in other important areas, such as housing. Extending the analysis of household economies to other goods is a good way to learn more about the nature of household economies of scale.

Figure 1. Expenditures on Food for Households with no Children and Differing number of Adults



Note. – The first bar shows average total household food expenditures on food. The second bar illustrates how large the household's food expenditures would be if each adults lived separately (calculated as the number of adults times single person's average food expenditures). The third bar is per capita actual food expenditures.

Figure 2. Per Capita Food-Related Time for Men and Women from Household without Children

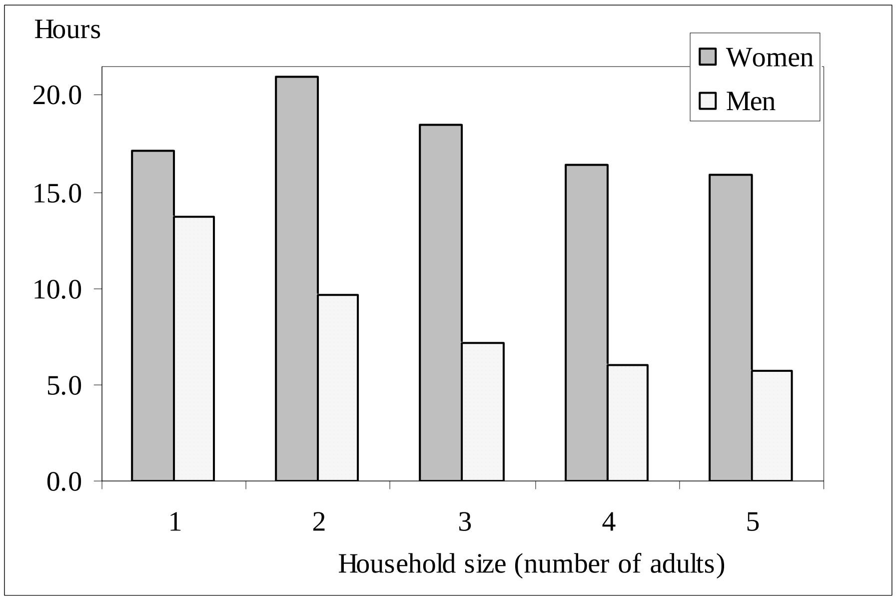


Table 1. Sample Means, Standard Deviations, Minimum and Maximum Values

Variable	Mean	Std	Minimum	Maximum
Household size	3.5	1.5	1	12
Male	0.432	0.5	0	1
Age	45.5	17.5	18	101
Married	0.721	0.4	0	1
Employed	0.588	0.5	0	1
Student	0.032	0.2	0	1
Retired	0.259	0.4	0	1
Hourly wage rate for the employed	28.4	82.5	0.13	4634
Hours worked per week	20.9	22.8	0	160
Earnings per week, Rb	356	823	0	28702
Per capita total income	540	1113	0	80652
No children	0.469	0.5	0	1
Children under 7	0.284	0.6	0	5
Children 7-13	0.358	0.6	0	6
Children 14-17	0.186	0.4	0	3
Per capita food expenditures, weekly,Rb	1435	1675	0	85750
Including: Groceries	1254	1351	0	33156
Food eaten out	110	645	0	64571
Alcohol	70	214	0	6805
Imputed value of home produced food	323	2114	0	250882
All food-related time, weekly hours	14.6	14.9	0	122
Including: Shopping for food	2.9	4.4	0	42
Cooking	8.5	9.9	0	98
Gardening	3.2	8.8	0	98
Percent protein in daily diet	12.7	3.6	0	57
Own house	0.279	0.4	0	1
Own car	0.192	0.4	0	1
Grow food	0.676	0.5	0	1
Rural area	0.258	0.4	0	1
Year=1995	0.246	0.4	0	1
Year=1996	0.245	0.4	0	1
Year=1998	0.251	0.4	0	1

Note. – Here and in the tables below, unless otherwise specified, the sample includes adults age 18 and older, the sample size is 30,734.

Table 2 Sample Means by Year of the Survey

	1994	1995	1996	1998
N	7929	7560	7536	7709
Per capita food expenditures, Rb	1808	1665	1387	874
Including: Groceries	1568	1464	1214	765
Food eaten out	135	135	106	67
Alcohol	105	66	67	42
Imputed value of home produced food	468	329	231	256
Food-related time, hours per week	15.6	15.4	14.7	12.5
Including: Cooking	3.7	2.9	2.4	2.4
Shopping for food	9.6	8.4	8.1	7.9
Gardening	2.3	4.1	4.1	2.3
Age	45.2	45.6	45.6	45.5
Per capita total income	680	561	530	388
Household size	3.6	3.3	3.3	3.6
Male	0.44	0.43	0.43	0.43
Employed	0.61	0.60	0.58	0.56
Hourly wage rate	35.1	26.8	29.9	20.9
Hours worked per week	21.4	21.6	21.0	19.4
Earnings per week, Rb	459	367	358	234
Percent protein in daily diet	12.8	12.8	12.7	12.5

Table 3 Sample Means by Gender and Employment Status

	WOMEN		MEN	
	Non-employed	Employed	Non-employed	Employed
	8495	8928	4191	9120
Per capita food expenditures, Rb	1251	1525	1357	1556
Including: Groceries	1139	1318	1221	1316
Food eaten out	63	135	71	150
Alcohol	50	71	65	90
Imputed value of home produced food	352	268	434	297
Food-related time, hours per week	21.0	18.7	10.7	6.3
Including: Shopping for food	3.8	3.9	2.1	1.4
Cooking	13.7	13.0	3.0	1.9
Gardening	3.6	1.9	5.6	3.0
Age	55.2	39.6	51.8	39.3
Per capita total income	440	597	456	618
Earnings per week, Rb	0	479	0	729
Hours worked per week	0	32.7	0	38.3

Table 4 Sample Means by Household Type

Household type (adults, children)	**10**	**11**	**12**	**20**	**21**	**22**	**23**	**30**	**31**	**32**	**33**	**40**	**41**	**42**	**50**	**the rest**
ALL INDIVIDUALS																
Number of observations	1882	440	198	6850	4207	3423	495	3503	2336	832	159	1498	1461	843	559	2048
Per capita food expenditure	2325	1746	1068	1738	1503	1170	1029	1424	1285	1094	809	1292	1126	954	1196	947
Including: Groceries	1994	1518	934	1534	1282	1016	899	1254	1142	968	704	1123	993	846	1049	836
Food eaten out	181	165	106	115	141	101	74	104	98	89	82	101	84	74	96	68
Alcohol	150	63	27	89	79	52	56	66	44	37	22	69	49	34	51	43
Home produced food	370	208	174	437	220	280	263	343	233	260	311	253	206	254	271	503
Age	58.1	38.9	37.1	56.7	36.5	35.7	36.3	47.9	40.6	41.4	37.9	46.5	42.5	43.8	46.5	41.4
Per capita total income	748	551	387	603	625	483	332	551	485	419	364	503	457	338	551	404
Male	0.34	0.07	0.06	0.42	0.47	0.49	0.50	0.47	0.43	0.41	0.46	0.43	0.42	0.43	0.44	0.45
Employed	0.39	0.79	0.83	0.40	0.77	0.82	0.73	0.54	0.66	0.63	0.64	0.56	0.61	0.55	0.53	0.54
Hourly wage rate	234	480	392	227	526	566	401	297	397	359	310	332	361	307	296	257
Hours worked per week	13.1	26.3	29.5	14.2	27.7	29.5	26.5	19.2	23.1	23.0	25.9	19.8	20.2	20.1	18.7	19.7
WOMEN																
Per capita food expenditure	2067	1736	1083	1628	1483	1159	1034	1403	1231	1062	805	1233	1112	940.4	1116	945
Food-related time	17.2	16.3	18.8	21.0	20.4	23.6	25.8	18.5	18.9	20.1	23.7	16.4	17.8	21.6	15.9	18.9
Including: Cooking	3.4	3.5	3.7	4.0	4.3	4.1	3.9	3.6	3.8	3.5	3.1	3.3	3.9	3.7	2.9	3.2
Shopping	10.5	11.7	14.3	13.5	14.6	16.8	17.6	12.4	12.8	13.3	15.9	11.0	12.2	14.8	9.9	12.5
Gardening	3.3	1.0	0.8	3.5	1.6	2.6	4.3	2.5	2.3	3.4	4.6	2.1	1.7	3.1	3.1	3.2
MEN																
Per capita food expenditure	2832	1877	810.5	1892	1525	1181	1023	1446	1354	1140	813.3	1371	1146	971.1	1297	950.1
Food-related time	13.7	8.0	10.4	9.7	6.1	6.9	7.9	7.2	6.2	6.7	7.8	6.1	6.5	7.5	5.7	6.9
Including: Cooking	3.2	1.9	1.2	2.2	1.5	1.4	1.3	1.5	1.2	0.9	1.0	1.3	1.2	1.1	1.4	1.1
Shopping	7.8	4.1	3.1	2.5	2.1	1.9	1.9	2.0	1.8	1.4	1.4	1.5	1.8	1.2	1.1	1.2
Gardening	2.8	2.0	6.0	5.0	2.5	3.6	4.7	3.6	3.2	4.3	5.4	3.2	3.5	5.1	3.2	4.6

Table 5. Per Capita Expenditures on Food and Adult Food Preparation Time in Households without Children and Differing Number of Adults

Household size (number of adults)	1	2	3	4	5
ALL ADULTS					
Household food expenditures, Rb	2325	3476	4271	5170	5978
	(1)	(1.5)	(1.84)	(2.22)	(2.57)
Per capita food expenditures, Rb	2325	1738	1424	1292	1196
	(1)	(0.75)	(0.61)	(0.56)	(0.51)
Including: Groceries	1994	1534	1254	1123	1049
	(1)	(0.77)	(0.63)	(0.56)	(0.53)
Food eaten out	181	115	104	101	96
	(1)	(0.64)	(0.57)	(0.56)	(0.53)
Alcohol	150	89	66	69	51
	(1)	(0.59)	(0.44)	(0.46)	(0.34)
WOMEN					
Food preparation time, hours	17.2	21.0	18.5	16.4	15.9
	(1)	(1.22)	(1.08)	(0.96)	(0.92)
Including: Shopping for food	3.4	4.0	3.6	3.3	2.9
	(1)	(1.17)	(1.05)	(0.96)	(0.83)
Cooking	10.5	13.5	12.4	11.0	9.9
	(1)	(1.29)	(1.18)	(1.05)	(0.94)
Gardening	3.3	3.5	2.5	2.1	3.1
	(1)	(1.07)	(0.77)	(0.65)	(0.95)
MEN					
Food preparation time, hours	13.7	9.7	7.2	6.1	5.7
	(1)	(0.71)	(0.52)	(0.44)	(0.42)
Including: Shopping for food	3.2	2.2	1.5	1.3	1.4
	(1)	(0.68)	(0.48)	(0.42)	(0.46)
Cooking	7.8	2.5	2.0	1.5	1.1
	(1)	(0.32)	(0.26)	(0.2)	(0.14)
Gardening	2.8	5.0	3.6	3.2	3.2
	(1)	(1.84)	(1.32)	(1.16)	(1.15)

Note.- Numbers in parentheses are shares relative to a single adult household

Table 6 Labor Market Participation Equation

Variable	Coef	Chi-sq	Prob
Intercept	0.627	31.72	<.0001
No high school	-0.168	27.63	<.0001
Vocational school	0.076	6.37	0.0116
Technical school	0.221	55.00	<.0001
College degree	0.307	84.89	<.0001
Male	-0.250	40.95	<.0001
Age	0.073	294.97	<.0001
Age squared	-0.001	202.39	<.0001
Married	0.419	130.84	<.0001
Married * woman	-0.579	161.78	<.0001
Kids under 7 * woman	-0.517	129.84	<.0001
Log household size	-0.139	27.93	<.0001
Kids under 7 dummy	0.170	20.65	<.0001
Log per cap income of others in hhold	-0.059	55.10	<.0001
Student	-1.362	596.73	<.0001
Retired	-2.739	3807.52	<.0001
Disabled	-0.556	130.23	<.0001
No alcohol consumption reported	-0.123	33.09	<.0001
Own land	0.145	39.03	<.0001
Own house	-0.114	17.62	<.0001
Unemployment rate by site of survey	-2.646	670.63	<.0001
Rural area	0.082	8.68	0.0032
Year=1995	0.059	4.13	0.042
Year=1996	-0.068	5.62	0.0177
Year=1998	-0.089	9.24	0.0024

Note. - Probit regression coefficients.
Dependent variable: Employed (N=12,670), Unemployed (N=18,048).
Log-Likelihood = -10405.

Table 7. Wage Equation

Variable	Coef	t-stat
Intercept	2.442	21.17
Inverse Mills ratio	0.120	3.08
No high school	-0.197	-6.27
Vocational school	-0.091	-3.45
Technical school	0.071	2.76
College degree	0.264	9.88
Male	0.151	3.97
Age	0.044	8.94
Age-squared	-0.001	-10.15
Married*woman	-0.209	-4.84
Log per cap income of others in household	0.027	4.28
Married	0.168	4.85
No alcohol consumption reported	-0.157	-8.87
Disabled	-0.104	-1.84
Own land	-0.085	-4.4
Own car	0.216	10.37
Own house	-0.120	-4.47
Wage arrears reported	-0.435	-23.86
Rural	-0.419	-16.24
Northwest	-0.070	-1.69
Central	-0.408	-12.67
Ural	-0.306	-9.1
Volga	-0.612	-18.23
Caucasus	-0.336	-8.75
East Siberia	-0.061	-1.6
West Siberia	-0.019	-0.49
Year=1995	-0.203	-8.51
Year=1996	-0.112	-4.61
Year=1998	-0.466	-18.88

Note. - OLS regression coefficients.
Dependent variable: Log hourly wage, N=12,812, R-squared = 0.25.

Table 8. Demand for Market Inputs and Food Preparation Time for Men and Women

	MEN, N=13,310				WOMEN, N=17,422			
	Market inputs		Time		Market inputs		Time	
	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat
Intercept	6.864	56.5	-1.182	-5.6	6.095	57.3	0.196	1.6
Log household size	-0.321	-7.7	-0.740	-10.2	-0.306	-8.9	-0.771	-19.8
Log wage	0.196	13.7	0.061	2.5	0.229	14.5	0.028	1.5
Gamma*	-0.137	-1.4	-1.431	-8.3	-0.074	-1.0	0.321	3.9
No children in household	-0.022	-0.6	-0.044	-0.7	-0.030	-0.9	-0.182	-4.9
Number children under 7	-0.078	-3.0	0.195	4.4	-0.079	-3.3	0.205	7.7
Number of children 7-13	-0.051	-2.3	0.142	3.6	-0.059	-2.8	0.112	4.8
Number of children 14-17	-0.017	-0.6	0.150	3.0	-0.006	-0.2	0.118	3.9
Log per cap income others	0.106	13.3	0.133	9.6	0.149	19.7	0.047	5.4
Age	-0.022	-5.3	0.065	9.1	-0.007	-2.4	0.132	37.7
Age-squared	0.000	6.6	-0.001	-8.3	0.000	3.4	-0.001	-39.3
Employed	0.233	8.7	-0.337	-7.2	0.230	10.5	-0.282	-11.3
Own house	-0.354	-11.6	0.099	1.9	-0.302	-11.2	0.061	2.0
Own car	0.272	10.3	-0.172	-3.7	0.244	9.6	-0.051	-1.8
Grows food	-0.140	-5.4	0.342	7.6	-0.083	-3.7	0.121	4.8
Married	-0.025	-0.8	0.183	3.2	0.068	3.0	0.465	17.7
Rural area	-0.710	-23.4	0.397	7.5	-0.693	-25.9	0.096	3.2
Year=1995	-0.022	-0.7	0.097	1.9	0.050	1.8	-0.020	-0.7
Year=1996	-0.188	-6.2	0.192	3.7	-0.110	-4.1	-0.057	-1.9
Year=1998	-0.521	-16.6	-0.005	-0.1	-0.499	-17.6	-0.078	-2.4
Northwest	0.079	1.4	-0.045	-0.5	0.129	2.7	0.005	0.1
Central	-0.078	-1.7	-0.293	-3.8	-0.002	0.0	-0.027	-0.6
Urals	-0.176	-3.8	-0.383	-4.7	-0.147	-3.7	-0.195	-4.3
Volga	-0.424	-9.2	-0.418	-5.2	-0.311	-7.7	0.048	1.1
Caucasus	0.242	4.8	-0.178	-2.1	0.280	6.4	-0.007	-0.2
East Siberia	-0.031	-0.6	-0.193	-2.2	-0.039	-0.9	-0.025	-0.5
West Siberia	-0.233	-4.6	-0.081	-0.9	-0.282	-6.4	-0.030	-0.6
R-squared		0.26		0.09		0.25		0.18

Note. - OLS regression coefficients.
Dependent variables: log per capita expenditures on food, *ln(x/n)* and log food preparation time, $ln(t_i)$
*Gamma is the slope of the extra term in the spline functions.

Table 9. Goods-Intensity of Food

	Estimate	t-stat
Intercept	4.713	32.03
Log household size	-0.256	-5.6
Gamma	-0.212	-2.79
Log wage	0.276	14.74
Only adults, no children	0.048	0.77
Age	-0.030	-6.84
Age-squared	0.000	8.44
Male	0.027	1.06
Log per cap non-labor income	0.002	0.23
Share of children under 7	0.484	2.98
Share of children 7-13	0.556	4.0
Share of children 14-17	0.085	0.52
Share of men in adults	0.010	0.2
Employed	0.492	13.43
Own house	-0.221	-6.57
Own car	0.300	9.32
Grows food	-0.304	-10.88
Rural area	-0.650	-19.54
Year=1995	-0.003	-0.09
Year=1996	-0.189	-5.79
Year=1998	-0.280	-8.38
Northwest	-0.006	-0.11
Central	-0.005	-0.1
Urals	0.042	0.85
Volga	-0.319	-6.34
Caucasus	0.093	1.7
East Siberia	-0.043	-0.8
West Siberia	-0.24	-4.48

Note. - OLS regression coefficients. Dependent variable: *ln (x/t)*.
Sample: households, N=14,394, R-squared =0.26

Table 10. Percent Protein in Daily Diet

	Estimate	t-stat
Intercept	11.121	47.5
Log household size	-0.038	-0.48
Log wage	0.268	8.53
Gamma	0.370	2.15
No children in household	0.107	1.47
Number of children under 7	0.002	0.03
Number of children 7-13	-0.060	-1.32
Number of children 14-17	-0.080	-1.36
Log per cap income of others	0.107	6.63
Male	0.470	10.94
Age	0.005	0.66
Age-squared	0.000	-0.1
Employed	0.250	5.0
Own house	0.021	0.34
Own car	0.515	9.52
Grows food	-0.270	-5.4
Married	0.194	3.54
Rural area	0.346	5.83
Year=1995	0.100	1.69
Year=1996	0.039	0.66
Year=1998	-0.035	-0.56
Northwest	-0.556	-5.19
Central	-0.647	-7.49
Urals	-0.441	-4.9
Volga	-0.096	-1.07
Caucasus	-0.112	-1.15
East Siberia	-0.519	-5.33
West Siberia	-0.58	-5.98

Note. – OLS regression coefficients. Sample: adults, N=30,635.
Dependent variable: Percent of protein in daily diet. R-squared = 0.03.

Appendix

This is how elasticities of demand for inputs with respect to household size in equation (12) and (13) are derived:

$$\varepsilon_{x_1 n} = \frac{d \ln \frac{x}{n}}{d \ln n} = \frac{\partial \ln \phi_1(n)}{\partial \ln n} + \frac{\partial \ln \psi_{11}(n)}{\partial \ln n} - 2 +$$

$$+ \frac{1}{g_{x_1}} \left(\frac{\partial g_{x_1}}{\partial p_1^*} \frac{\partial \left(\frac{p_1 \phi_1(n) \psi_{11}(n)}{n^2} \right)}{\partial \ln n} + \frac{\partial g_{x_1}}{\partial p_2^*} \frac{\partial \left(\frac{p_2 \phi_2(n) \psi_{12}(n)}{n^2} \right)}{\partial \ln n} + \frac{\partial g_{x_1}}{\partial w_1^*} \frac{\partial \left(\frac{w \ \phi_1(n) \psi_{21}(n)}{n^2} \right)}{\partial \ln n} + \right.$$

$$\left. + \frac{\partial g_{x_1}}{\partial w_2^*} \frac{\partial \left(\frac{w \ \phi_2(n) \psi_{22}(n)}{n^2} \right)}{\partial \ln n} + \frac{\partial g_{x_1}}{\partial (I/n)} \frac{\partial (I/n)}{\partial \ln n} \right) =$$

$$= -(\sigma_1 + \gamma_{11})(1 + \varepsilon_{x_1 p_1}) - (\sigma_2 + \gamma_{12})\varepsilon_{x_1 p_2} - (\sigma_1 + \gamma_{21})\varepsilon_{x_1 w_1} - (\sigma_2 + \gamma_{22})\varepsilon_{x_1 w_2} - \varepsilon_{x_1 I}$$

$$\varepsilon_{t_1 n} = \frac{d \ln \frac{t}{n}}{d \ln n} = \frac{\partial \ln \phi_1(n)}{\partial \ln n} + \frac{\partial \ln \psi_{21}(n)}{\partial \ln n} - 2 +$$

$$+ \frac{1}{g_{t_1}} \left(\frac{\partial g_{t_1}}{\partial p_1^*} \frac{\partial \left(\frac{p_1 \phi_1(n) \psi_{11}(n)}{n^2} \right)}{\partial \ln n} + \frac{\partial g_{t_1}}{\partial p_2^*} \frac{\partial \left(\frac{p_2 \phi_2(n) \psi_{12}(n)}{n^2} \right)}{\partial \ln n} + \frac{\partial g_{t_1}}{\partial w_1^*} \frac{\partial \left(\frac{w \ \phi_1(n) \psi_{21}(n)}{n^2} \right)}{\partial \ln n} + \right.$$

$$\left. + \frac{\partial g_{t_1}}{\partial w_2^*} \frac{\partial \left(\frac{w \ \phi_2(n) \psi_{22}(n)}{n^2} \right)}{\partial \ln n} + \frac{\partial g_{t_1}}{\partial (I/n)} \frac{\partial (I/n)}{\partial \ln n} \right) =$$

$$= -(\sigma_1 + \gamma_{21})(1 + \varepsilon_{t_1 p_1}) - (\sigma_2 + \gamma_{12})\varepsilon_{t_1 p_2} - (\sigma_1 + \gamma_{21})\varepsilon_{t_1 w_1} - (\sigma_2 + \gamma_{22})\varepsilon_{t_1 w_2} - \varepsilon_{t_1 I}$$

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