NUTRITION AND INCOME:
EVIDENCE FROM AN EXPERIMENT IN A DEVELOPING COUNTRY

Habiba Djebbari
The University of Maryland*
hdjebbari@arec.umd.edu

September 2003

Abstract

How does the distribution of power within the household affect the nutrition of its members? In 1998, the largest social program in rural Mexico (PROGRESA) designed a random experiment for the purpose of the evaluation. Households in randomly selected control localities were denied program benefits. Exploiting the experimental nature of the data, I estimate calories demand equations based on the predictions from different models of household behavior. There are three main findings to this study. First, I reject the unitary model and the Pareto-efficiency assumption for the nutrition decisions. Second, I show that changing the wife's income has little effect on the levels of food consumption in the household. Third, I find that neglecting the distribution of power within the household biases the estimate for the income elasticity of calories, a parameter of interest to policy-makers.

JEL: C52, D1, I12, I38, O12

---

* The suggestions from Jeffrey Smith, Anna Alberini, Alice Mesnard and Emmanuel Skoufias have been very helpful. I also thank Pierre Dubois for his guidance and participants to the 6th IZA European Summer School in Labor Economics and seminar participants at the University of Toulouse for their comments.

Introduction

Many of the social programs currently developed in Latin America intentionally direct monetary transfers at the female head of the household (usually the mother). This design reflects the belief that mothers care more about their children's well-being than fathers do. Directing transfers to women also implicitly questions the unitary preference household models. According to the latter, it should not matter who in the household receives the transfer, since optimal choices for the allocation of resources are made subject to a pooled budget constraint. Thus, the income pooling restriction provides a testable implication of the unitary model.

There is substantial evidence against the unitary model (e.g. Thomas 1990 and Schultz 1990 in the context of developing countries; Bourguignon, Browning, Chiappori and Lechène 1993, Fortin and Lacroix 1997 and Phipps and Burton 1998 for developed countries). However, empirical evidence on the effect of the distribution of income on household decisions suffers from issues of endogeneity, measurement error and the lack of support in the data for the joint distribution of incomes. Studies that exploit an exogenous change in the intrahousehold distribution of income to identify the effect of the distribution of income (e.g. Lundberg, Pollak and Wales 1997; Attanasio and Lechène 2002, Duflo 2003) constitute the most convincing pieces of evidence.

The collective model of the household (Chiappori 1988, Browning and Chiappori 1998) acknowledges that household members have different preferences and that household should not be treated as a single unit. The distribution of power within the household influences allocations. The main assumption of this model is that collective decisions are Pareto-efficient. The model imposes testable restrictions on the way in which distribution factors can enter demand equations.

Much of the evidence on whether households attain Pareto-efficient outcomes is drawn from developed countries (e.g. France, Canada), where indeed households are found to make Pareto-efficient consumption decisions. However, using data from sub-Saharan Africa on agricultural production decisions for plots operated by men and women living in the same household, Udry (1996) rejects the Pareto-efficiency assumption underlying the collective models.

The purpose of this study is to test the income pooling restriction and the Pareto-efficiency assumption on the nutrition decisions of poor rural Mexican households.

I rely on data collected for the evaluation of the Mexican program for education, health and nutrition, PROGRESA. The PROGRESA program is a means-tested social program that sends cash transfers to rural households upon compliance with a defined set of requirements. A singular feature of the design of the evaluation of PROGRESA is that a group of eligible households were denied transfers. [1] The sample consists of randomly selected treatment and control villages. The control group, which is denied transfers, is found to be similar to the treated group on all other aspects (Behrman and Todd 1999).

The targeting of benefits to mothers in treatment group localities motivates the identification strategy of the calorie demand equations. Eligible mothers in the treatment group localities receive cash payments from the program that are denied to households in the control group localities. Thus, belonging to the treatment group results in higher household expenditures and higher women's income and is uncorrelated, by design, with the error term in the calorie demand equations. Belonging to the treatment group qualifies as a valid instrument for expenditures and for the distribution of income within the household.

My paper contributes to the existing literature in three ways. First, I apply the models of household behavior to the nutrition decisions. Food expenditures represent 75 percent of the household budget of these poor rural households. I consider a food calorie aggregate that better captures the nutritional status of households than food expenditures in rural regions where consumption out of own production is important.[2]

Second, I exploit a specific module of the survey that collects characteristics of the spouses' families at the time of marriage to get additional identifying restrictions for the expenditures and income endogenous variables. Along with the treatment dummy variable, this set of instruments is likely to lead to a precise estimation of the expenditure

[1] A random assignment of potential beneficiaries in treatment and control groups was conducted in order to evaluate the actual impacts of the program on a range of outcomes. These impacts are assessed using estimators commonly used in program evaluation (e.g. difference-in-difference estimator). Detailed data description and mean impact results are presented in a series of research reports (see http://www.ifpri.org/themes/progresa.htm).

[2] As an example, as much as half of the households report consuming but not purchasing tortillas, a staple food, in the previous seven days.

elasticity of calories and of the effect of the distribution factors on the demand for calories because of the strong correlation between the instruments and the endogenous variables.[3]

Third, I present evidence on the extent to which inappropriately neglecting the distribution of power within the household affects estimates of the demand for nutrition. In response to the emerging literature on intrahousehold allocation and bargaining power, Rosenzweig (1986) pointed out that the collective models "have not provided clear directions as to how intrahousehold allocation *will* differ when some individual attains more bargaining strength" (p.236). I examine how increasing the ratio of wife's income to husband's income impacts the levels of calories consumed. In addition, I examine the effect of incorrectly omitting the distribution factors on the expenditures elasticity of calories, i.e. the magnitude of the bias from assuming that the unitary model holds. The expenditure elasticity of calories parameter conveys information on the extent to which income growth only can lead to higher household calorie consumption.

There are three main findings to this study. First, I reject the unitary model and the Pareto-efficiency assumption for the nutrition decisions. Second, I show that changing the wife's income has little effect on the levels of food consumption in the household. Third, I find that neglecting the distribution of power within the household biases the estimate for the income elasticity of calories, a parameter of interest to policy-makers.

The paper is organized as follows. In the first section, I describe the PROGRESA program, the experimental evaluation sample and the sampling frame for this study. In the second section, I model the household nutrition decisions using the collective framework. In the third section, I present the empirical strategy, the test of income pooling and the test of Pareto-efficiency for the allocation decisions with respect to nutrition. In the fourth section, I discuss the estimation results.

[3] It is possible that most studies fail to reject the null hypothesis of Pareto-efficiency because the effects of the distribution factors are imprecisely estimated.

1. The Data

A. *Description of the PROGRESA program*

I rely on data collected for the evaluation of the Mexican program for education, health and nutrition, PROGRESA. The PROGRESA program targets poor rural households in Mexico. It has been implemented since 1998. At the end of 1999, it covered 2.6 million families, i.e., about 40% of all rural households and one ninth of all families in Mexico. In 1999, the program's annual budget was approximately $777 million, which corresponds to 0.2 percent of Mexico's GDP (Skoufias, 2001). In January 2002 the Inter-American Development Bank approved its largest loan ever to Mexico for expanding PROGRESA to urban areas of the country. Despite the recent important political changes, PROGRESA has been maintained under the new name Opportunidad.

A baseline census of households provides the information used to determine the eligibility status of the households. Basically, a poverty line is drawn and only households below the poverty line are classified as eligible for program benefits. On average, 78 percent of each locality's population are found to be poor, that is, eligible for the program benefits.

The program benefits are comprised of two components:

1. Educational grants given to families with children in the last three years of primary school and secondary school children. The grant amounts vary by grade and gender, with greater awards to girls and to the most advanced children. The grants are given upon attendance to school. A complex system of verification based on forms completed and signed by teachers and school directors ensures that the attendance requirement is met before sending money to the households.
2. All eligible households can benefit from a monetary transfer designed to help them improve their nutrition. They are encouraged to spend the money on food although not required to do so. In order to receive this cash transfer, they are required to make regular visits to health centers and to participate in health talks. Only one visit per year to a health center is required for adults, two to five visits a year for pregnant and breast-feeding women and two to seven visits a year for infants and children. In addition, nutritional in-kind supplements are provided to under-nourished children and infants and pregnant and breast-feeding women.

An important characteristic of the PROGRESA program with respect to this study is that transfers are made to the mother in the household. Two additional features are that (1) transfers to a household cannot go beyond a given maximum transfer amount regardless of the number of eligible school-age children, (2) transfers are sent to the beneficiaries every two months after checking their compliance with program requirements. For example, the average transfer from October 1998 to November 1999 is about 197 pesos per household and per month, which is equivalent to 20% of the mean value of consumption of a poor household. [4]

B. *Experimental design for the evaluation of PROGRESA*

The evaluation study is designed as an experiment with localities randomly assigned to treatment and control groups. Only eligible households in treatment localities can receive benefits after the start of the program in mid-1998. For the purpose of the evaluation, program benefits are denied to both non-eligible households in the treatment and control localities and eligible households in the control group. The sample includes 506 localities (320 assigned to the treatment group and 186 to the control group).

Data are collected to capture the multiple objectives of the program in terms of human capital investment and poverty alleviation. The survey collects both expenditure data at the household level and labor and non-labor data at the individual level (Table 1). It also includes individual-level information on household composition, schooling, migration and health status, and locality-level information on the availability of services and prices. In addition, a module was specially designed to get information on the status of women and on intrahousehold relations.[5]

Table 1: Variables in the PROGRESA sample.

Unit of observation	**Variables**
Individual and household level	Household composition, education, health, paid and non-paid labor, farm activities, income, expenditures, living conditions, assets, decision-making within the household.
Locality level	Availability of services, main economic activities, all prices (including wages)
Module on women's bargaining power	Assets at marriage of the spouses, education of their parents and wealth of their families, current decision-making patterns

[4] The figures are in November 1998 pesos and the value is approximately $20 U.S.
[5] For a description of the module on women's status and intrahousehold relations, see Adato *et al* (2000).

C. *Sampling frame*

The November 1998 survey is collected for 24,073 households (136,250 individuals). I select 20,925 households for which there is an intact couple. I restrict the sample to 17,382 households with a male head of household and his wife who are more than 15 years old and who report some income (labor earnings and non-labor income) and consumption data. There are 899 households in the sample for which the treatment/control and eligible/non-eligible designations are missing. The partition between the treatment and the control group and the eligible and non-eligible groups for the remaining 16,483 households is given in Table 2 below.

Table 2: Partition of households in the restricted sample between eligible / non-eligible and treatment / control groups.

	Treatment localities	Control localities	Total
Eligible households	**Transfers distributed after August 1998** 5,823 households	**No transfer until the end of the evaluation period** 3,400 households	9,223 households
Non-eligible households	**No transfer** 4,314 households	**No transfer** 2,946 households	7,260 households
Total	10,137 households	6,346 households	16,483 households

I restrict the sample further to the 9,223 eligible households. One last restriction consists in selecting households where no other household member but the husband and the wife have some income. The final sample includes 6,562 households.[6] Table A-1 in the appendix presents descriptive statistics for the variables in the selected sample.

D. *Expenditures, Nutrients and Incomes*

Food expenditures include household level data on food outlays made in the seven days preceding the interview for 36 food items. The value of food consumed from own production in that same period of time is added to food outlays to obtain the value of food consumption. Food consumed from own production is valued by imputing either a household-level price or a locality level price when the household does not report any expenditures on the food consumed from own-production. Non-food expenditures are

[6] Note that some variables have missing data for some observations so that the final sample size in the regression is sometimes smaller than 6,562. This is particularly true when I use the spouses' family background variables as exogenous variables.

expenses reported on a weekly, monthly and 6-months basis. Non-food expenses reported on a weekly basis include transportation and tobacco. Monthly outlays include school tuition, health-related expenses, home cleaning, electricity and home fuel expenditures. Expenditures reported on a 6-month basis include home and school supplies, clothes, shoes and toys and payments for special events. The value of consumption is computed as the sum of non-food expenditures and the value of food consumption.

The measure of food calories consumed is constructed from the 7-day recall food consumption data. First, reported units of the 36 food items bought and consumed in the household are converted into kilograms. The second step is to calculate for each food item the "edible" kilograms of food. The edible kilograms are converted into kilocalories.[7] Lastly, instead of dividing this total household calorie consumption by the number of household members, an adjustment is made for the fact that some household members ate outside the home and some non-household members ate in the home during the study period.[8] Thus, the aggregate food calories are represented by the daily per mouth measure of food calorie consumed. I also consider aggregate calories consumed from four different food groups, i.e. calories from vegetables and fruits, calories from grains and cereals, calories from meat and meat products and calories from other food.

The income data include labor and non-labor incomes. Labor income is constructed using wages and the value of employer-provided benefits from all activities. Most of the individuals work as agricultural workers paid on a daily basis. The second most common type of occupation for heads of household is self-employment.[9] Respondents are probed several times in the questionnaire to elicit all labor earnings. In particular, a section of the survey directly concerns more informal types of activities such as sewing and craft-making, cooking and home-cleaning, building, repairs and driving. Non-labor income is comprised of pensions, bank interest, rents and other revenues, government transfers and remittances.

---

[7] The conversions are based on Mexican food tables from *Tablas de Valor Nutritivo de los alimentos de mayor consumo en Mexico* (1996).

[8] This adjustment consists in subtracting from household size the number of people having food outside and adding the number of people eating in the household.

[9] Elsewhere in the questionnaire, detailed information on agricultural activities is collected. However, net profits computed as the difference between sales of agricultural products and expenses on inputs are negative for most of the respondents, which is not plausible. In addition, it is far from straightforward how to assign the agricultural profits to individuals. Therefore reported income from self-employment is the preferred measure of income from agriculture for non-wage-earners farmers.

2. Applying the models of household behavior to household nutrition

A. *The unitary model of the household*

Suppose households derive utility U not from nutrition N directly, but from the effect of nutrition on health H. The production of health is also assumed to be affected by household characteristics θ_h (e.g. innate health status, access to a sewage system and to electricity) and locality characteristics θ_l (e.g. access to health facilities). Nutrition itself depends on the consumption of food X_k. In addition, the choice of the diet determines the absorption of nutrients. Thus, nutrition N also depends on household-specific characteristics μ_h that include the education of each spouse. Suppose that the household consumes K different food items with price p_k along with a composite good Z (p_z = 1) and that total household income is Y. Thus, the household solves the following maximization problem:

$$\max_{Z,X_1,\dots,X_K} U(H,Z) \text{ subject to:}$$
$$\sum_{k=1}^{K} p_k X_k + Z = Y$$
$$H = H(N,\theta_h,\theta_l)$$
$$N = N(X_1,\dots,X_K,\mu_h)$$

The optimal demands for food are functions of prices, total household income and household and locality characteristics as given in equation (1):

$$(1) \qquad \forall k = 1,\dots,K : X_k = X_k(p,Y,\theta_h,\theta_l,\mu_h)$$

The unitary model embodies an important assumption with regards to household preferences. A household is assumed to behave "as one". This occurs if all household members have the same preferences or if one household member imposes his preferences, acting as a dictator. This implies that the distribution of power within the household does not affect household decisions. In particular, the distribution of income, which is likely to affect the distribution of power within the household, should not affect household choices because the household pools all individual incomes. The income pooling restriction provides a testable implication of the unitary model.

Consider the previous model assuming that only the husband and the wife have some income in the household. Let *WF* represent the ratio of wife's income to husband's income. Denoting by y_f and y_m the female's income and male's income, *WF* is defined as follows: $WF = \frac{y_f}{y_m}$ and $y_f + y_m = Y$

Testing the income pooling restriction consists in testing that *WF* has no effect on the demand for food X_i, after controlling for total income and all other factors affecting X_i. Thus, testing income pooling is based on the null hypothesis defined below:

$$\boldsymbol{H_o} : \forall k = 1,...,K : \quad \frac{\partial X_k}{\partial WF}(p, Y, \theta_h, \theta_l, \mu_h) = 0$$

Similar tests have been proposed in the literature for different *X* outcomes. The most common outcomes include a system of budget shares for different categories of goods[10] and health status of children.[11]

Individual total incomes, non-labor incomes and labor earnings, current assets and assets at the time of marriage for each spouse are all factors that are assumed to affect the distribution of power within the household. According to the unitary model, none of these factors should affect the demand for goods. The choice of factors in each study strongly depends on the assumptions made on the issues prevailing in the estimation. Although individual incomes are likely to be related to the distribution of power within the household, it is difficult to argue that the distribution of income is exogenous to household demand for goods. Thus, some papers rely on context-specific features of the

[10] Thomas (1993) finds an effect of individual incomes on budget shares for urban Brazil. Bourguignon, Browning, Chiappori and Lechène (1993) find similar evidence from French data using individual incomes and total household income. Hoddinott and Haddad (1995) using data from Cote-d'Ivoire show that the wife's share of income significantly affects budget shares. Doss (1996) finds that household budget shares in Ghana depend on the share of current assets held by women. Browning and Chiappori (1998) reject the unitary model of the household with Canadian data on budget shares and individual incomes. Attanasio and Lechène (2002) find that the wife's share of income significantly affects the budget shares with the same sample of Mexican households I use in this study.

[11] Thomas (1990) finds an effect of individual incomes on anthropometric measures for children and children's survival probabilities in urban Brazil. Haddad and Hoddinott (1994) find an effect of the wife's share of income on anthropometrics of Ivorian children. Thomas (1994) presents evidence for urban Brazil, urban Ghana and the US of an effect of parents' education on child health. Thomas, Contreras and Frankenberg (2002) provide evidence of an effect of assets brought at time of marriage by the father and the mother on child health. Duflo (2003) finds that the presence of an elderly woman eligible to an old-age pension plan is associated with a large impact on the health of girls residing in the same household. This effect is negligible for elderly men on both girls and boys residing in the same household. Concerning household nutrition, Thomas (1990) investigates the effect of individual incomes on the per capita intakes of calories and proteins with data from urban Brazil.

population under study to select the distribution factors that are likely to affect the distribution of power within the household, such as assets brought at time of marriage.[12]

B. *The collective model of the household*

In contrast to the unitary model, the collective model only imposes Pareto-efficiency on the allocation decisions of the individual household members. The outcome is Pareto-efficient if no one in the family can be made better off without making someone else worse off.

Let $\lambda(p, A^1, A^2)$ be the factor weighting the spouses' preferences in the household welfare function, where A^1 and A^2 are distribution factors affecting the distribution of power within the household. Each utility functions U_f and U_m are assumed to satisfy the standard differentiability conditions. Both utility functions depend on the household health status. As previously, health H production is affected by the nutritional status of the household N and by household and locality characteristics θ_h and θ_l. Nutrition itself depends on the consumption of K food items X_k and household characteristics μ_h. The family with total income Y optimally chooses to consume quantities X_k of K food items at price p_k and a composite good Z, as shown below:

$$\max_{Z, X_1, \ldots, X_k} \lambda\, U_f(H, Z) + (1-\lambda)\, U_m(H, Z) \text{ subject to:}$$

$$\sum_{k=1}^{K} p_k X_k + Z = Y = y_f + y_m$$

$$H = H(N, \theta_h, \theta_l)$$

$$N = N(X_1, \ldots, X_K, \mu_h)$$

The unitary model is a special case of the collective model wherein individual household members have the same preferences (i.e., $U_f(.) = U_m(.)$). A rejection of the income pooling restriction is not consistent with the unitary preference model but is compatible with the collective model of the household.

In the collective model, the optimal demands for food X_k are given by:

$$(2) \qquad \forall k = 1, \ldots, K: \quad X_k = X_k(p, Y, \lambda(p, A^1, A^2), \theta_h, \theta_l, \mu_h)$$

Pareto-efficiency can be empirically verified by testing the hypothesis that the ratio of the effects of the two distribution factors across pairs of goods is constant. This ratio would be equal to one if the unitary model holds. The idea is that the distribution

[12] For example, in Indonesia, women are found to retain property on assets brought at time of marriage,

factors, such as individual incomes, only affect consumption of a good through their effect on the factor weighting the utility function of each partner in the household objective function.

For any two goods *i* and *j*, a testable implication of Pareto-efficiency[13] is based on the null hypothesis given below:

$$\boldsymbol{H_0} : \forall i, j = 1,...,K : \quad \frac{\partial X_i / \partial A^1}{\partial X_i / \partial A^2} = \frac{\frac{\partial X_i}{\partial \lambda} * \frac{\partial \lambda}{\partial A^1}}{\frac{\partial X_i}{\partial \lambda} * \frac{\partial \lambda}{\partial A^2}} = \frac{\partial \lambda / \partial A^1}{\partial \lambda / \partial A^2} = \frac{\partial X_j / \partial A^1}{\partial X_j / \partial A^2}$$

Testing this null hypothesis requires selecting variables that capture the distribution factors A^1 and A^2. Bourguignon, Browning, Chiappori and Lechène (1993) find that the ratio of the effects on commodity demands of each of household member's individual income are constant across goods using data on French households in which both spouses work full time and have at most one child. Thomas and Chen (1994) provide similar evidence for households in Taiwan. Browning and Chiappori (1998) use the log of the ratio of wife's earnings to husband's earnings and the wife's log earnings as the two distribution factors to test for Pareto-efficiency in a budget shares system for Canadian households. They cannot reject Pareto-efficiency. Thomas, Contretas and Frankenberg (2002) provide evidence that Indonesian households make Pareto-efficient decisions with respect to children's health. They consider the value of assets brought to marriage by each spouse as the two distribution factors affecting the distribution of power within the household.

In contrast, using Canadian data, Phipps and Burton (1998) find that income pooling can be rejected for certain goods but not for others. This suggests that the ratio of male and female income effects across pairs of goods is not constant. Non-Pareto-efficient decisions would be consistent with a model in which each spouse is responsible for making decisions on different goods (e.g., the separate sphere bargaining model, Lundberg and Pollak 1993).

---

which justifies the use of these assets as distribution factors (Thomas, Contreras and Frankenberg 2002).

[13] In order to test for Pareto-efficiency, one needs to identify two factors that affect the distribution of power within the household. Recall that testing income pooling only requires the use of one distribution factor.

3. Empirical model

A. *The collective models*

The income pooling restriction implies that how much each household member contributes to the household does not matter. In other words, no distribution factor should enter the demand for calories once we control for total household expenditures. Testing the Pareto-efficiency assumption requires the use of two distribution factors and several goods. Following Browning and Chiappori (1998), I estimate two models. The restricted collective model (2.1) includes only one distribution factor, the log of the ratio of wife's income to husband's income. Thus, model (2.1) allows testing the income pooling restriction. The unrestricted collective model (2.2) is applied to the demand for calories from four food groups, i.e. calories from vegetables and fruits, calories from cereals and grains, calories from meat and meat products and calories from other food. Model (2.2) includes two distribution factors, the log of the ratio of wife's income to husband's income and the log of the wife's total income. The unrestricted collective model allows testing of the Pareto-efficiency assumption for the nutrition decisions.

Apart from the distribution factors, the equation describing the household demand for calorie consumption includes the log of the per capita value of consumption.[14] Value of consumption is the preferred proxy for household wealth because it fluctuates less than current income.[15]

The restricted collective model is as follows:

(2.1) $$\ln Cal = \alpha + \beta \ln PCE + \gamma \ln WF + Z\theta + \varepsilon$$

$\ln Cal$ is the log of per mouth household calorie consumption
$\ln PCE$ is the log of per capita value of consumption
WF is the log of the fraction of wife's income to husband's income
Z is a vector of household and locality characteristics
ε is the error term
$\alpha, \beta, \gamma, \theta$ are parameters to be estimated

The models underlying equations (1) and (2) require that the prices of goods be included in a demand function. Prices of the ten most commonly consumed food items,

[14] The value of consumption is denoted ln*PCE* and β is referred to as the expenditures elasticity of calories for the sake of brevity.
[15] Seasonality needs to be taken into account when measuring income, especially agricultural income. Households are also more likely to smooth consumption over time (see Deaton 1997, pp.26-32).

i.e. tomatoes, onions, maize tortillas, noodle, rice, beans, eggs, coffee, sugar and vegetable oil, are included in the Z vector.[16] Household size and household composition are included to capture the effect of economies of scale. The number of individuals in different age and gender groups and the logarithm of household size capture household composition. Households derive utility not from nutrition directly, but from the effect of nutrition on health. Thus, I add household and village characteristics that affect the production of health and nutrition (e.g. presence at the locality level of health facilities, access to a sewage system and to electricity, husband's years of education and wife's years of education).

The unrestricted collective model for calories consumed from four different food groups is as follows:

$$(2.2)\forall i = 1,...,4: \qquad \ln Cal^i = \alpha^i + \beta^i \ln PCE + \gamma_1^i \ln WF + \gamma_2^i \ln WTY + Z\theta^i + \varepsilon^i$$

$\ln Cal$ is the log of per month household calorie consumption from food group i
$\ln PCE$ is the log of per capita value of consumption
$\ln WF$ is the log of the fraction of wife's income to husband's income
$\ln WTY$ is the log of the wife's total income
Z is a vector of household and locality characteristics
ε is the error term
$\alpha, \beta, \gamma, \theta$ are parameters to be estimated

In addition, a quadratic specification in $\ln PCE$ is attempted order to allow the elasticity of calories to diminish with household wealth.[17]

B. *Testing models of household behavior*

Testing the income poling restriction.

The restricted collective model (2.1) allows testing of the income pooling restriction for total calories consumed by testing whether the distribution factor, as captured by the ratio of the wife's income to the husband's income, affects the quantity of calories consumed by the household. The test is based on the null hypothesis:

$\boldsymbol{H_0}: \; \gamma = 0$

If applied to the demand for calories from the four different food groups, the restricted collective model (2.1) can also be used to test the income pooling restriction for

[16] At least 50% of the sample reported some consumption of each of these food items.

the demands for calories from each food group. Alternatively, the unrestricted collective model (2.2) provides a basis for testing the income pooling restriction for the calories consumed from each food group using the following joint hypothesis:

$$\boldsymbol{H_0} : \forall i = 1,...,4 : \quad \gamma_1^i = \gamma_2^i = 0$$

Testing the Pareto-efficiency assumption.

Testing the Pareto-efficiency assumption requires the estimation of the unrestricted collective model (2.2) for the various food groups. A Wald test for non-linear restrictions is computed on each pair of goods for the following null hypothesis:

$$\boldsymbol{H_0} : \forall i, j = 1,...,4 : \quad \frac{\gamma_1^i}{\gamma_2^i} = \frac{\gamma_1^j}{\gamma_2^j}$$

Testing ratios of coefficients can be problematic when denominators are close to zero. An alternative version of this test for each pair of goods is specified as:

$$\boldsymbol{H_0} : \forall i, j = 1,...,4 : \quad \gamma_1^i \times \gamma_2^j - \gamma_2^i \times \gamma_1^j = 0$$

In order to test for Pareto-efficiency in a joint manner for the calories consumed from the different food groups, a Wald test is computed for the following non-linear restrictions:

$$\boldsymbol{H_0} : \quad \frac{\gamma_1^1}{\gamma_2^1} = \frac{\gamma_1^2}{\gamma_2^2} = \frac{\gamma_1^3}{\gamma_2^3} = \frac{\gamma_1^4}{\gamma_2^4}$$

Under the null hypothesis, the Wald test is asymptotically distributed as a chi-square with four degrees of freedom.

C. *Estimation issues*

Total Expenditures

Estimating the expenditures elasticity of calories is problematic because of the likely endogeneity between expenditures and calories consumed (Bouis and Haddad 1992; Bouis 1994). There are three possible sources of endogeneity.

First, when total value of consumption is used to capture household wealth, then any measurement error in the food quantity data can be found in food calories (the

[17] Strauss and Thomas (1990) estimate the shape of the calorie expenditure curve non-parametrically using data from urban Brazil. Bhalotra and Attfield (1998) carry out a semi-parametric estimation of the income-nutrition relationship for rural Pakistan.

dependent variable) as well as in the value of consumption (the explanatory variable). A problem of common measurement error arises.

Second, data usually over-estimate consumption for rich households, because they include consumption by non-household members (e.g. employees) and usually under-estimate consumption for poor households, whose members eat out more often. The error term is then correlated with household wealth. When estimating a food calorie equation, household income is therefore endogenous.

Third, another potential endogeneity issue can rise from the existence of a feedback effect from nutrition to income, as described in the efficiency wage literature (Stiglitz 1976).

Two main approaches are taken to address the estimation issues. First, when panel-data are available, fixed-effects or random effects estimates that correct for unobserved, time-invariant family heterogeneity are computed (Behrman and Deolalikar 1987). Second, the value of consumption is instrumented using individual incomes or assets and household characteristics. Subramanian and Deaton (1996) review the empirical evidence on the food income elasticity. They question the validity of any of the instruments used to correct the endogeneity issues in the value of consumption. They show that the OLS estimate for the elasticity of calories, after adjusting the calorie aggregate to account for household members eating outside the home and non-household members eating with the household, is in the range 0.3-0.4.

<u>Individual Incomes</u>

Three main empirical issues arise in estimating the effect of the intrahousehold distribution of income.

First, it is difficult to argue that the individual incomes are exogenous with respect to the outcome of interest. In the context of developed countries, researchers usually avoid this issue by restricting their sample to couples where both partners are full-time workers, controlling for the occupations of husbands and wives in order to hold labor supply constant across households. In the case of developing countries, this restriction would lead to very selective samples.

The endogeneity issue concerns labor income and to a lesser extent non-labor income. Earnings are the product of a wage rate and the number of hours worked. It is plausible that the decisions on labor supply and consumption are taken jointly. Differential effects of husband's earnings and wife's earnings would thus be consistent with the unitary model. Phipps and Burton (1998) find that expenditures on restaurant meals respond more strongly to the wife's income than to the husband's income. In their review of the literature on bargaining and distribution in marriage, Lundberg and Pollak (1996) interpret this finding as a price effect. [18] In addition, non-labor income is often comprised of pensions which represent the outcome of past labor supply choices.

Second, the differential effect of male and female incomes can be driven by different measurement errors in male and female incomes. This issue raises concerns about the interpretation of the results (Haddad 1999).

Third, the data are usually concentrated in certain regions of the joint distribution of husband's income and wife's income. In particular, in most developing countries datasets, as in the PROGRESA control localities, women have little income. This means that the variation that parametrically identifies and singles out the effects of husband's income and wife's income is of a limited type, making identification of the effects difficult. Because PROGRESA gives income to women in the treatment group, this dataset is useful for examining the role of the mother's income in household decisions.

In short, evidence on the effect of the distribution of income on household decisions suffers from issues of endogeneity, measurement error and the lack of support in the data for the joint distribution of incomes.

Lundberg, Pollak and Wales **(**1997) [19] and Duflo (2003) [20] exploit natural experiment settings characterized by an exogenous change in the intrahousehold

[18] The opportunity cost of the wife's time accounts for a large part of the cost of home prepared meals, which are a substitute for restaurant meals.

[19] Lundberg, Pollak and Wales (1997) exploit a natural experiment in the UK where child allowance benefits were redistributed to women to test for income pooling. However, along with a change in the distribution of income within marriage, a change in policy instruments, i.e. from tax relief to the father to direct child allowance to the mother, also occurred.

[20] Duflo (2003) exploits a natural experiment setting in South Africa. She finds that pensions received by women had a large impact on the anthropometric status of girls living in the same household and none on that of boys. In contrast, pensions received by men have no effect on either boys or girls. The differential

distribution of income. These studies show that the distribution of income within the household impacts decisions and constitute the most convincing pieces of evidence. However, studies based on natural experiments cannot provide substantive evidence on the extent to which neglecting the intrahousehold distribution of power affects the values of other parameters of interest such as the expenditures elasticity.

Using a model with family-specific fixed-effect, Thomas, Contreras and Frankenberg (2002) find evidence of a differential effect of male and female value of assets brought at time of marriage on girls' health outcomes and boys' health outcomes in Indonesian data. This study only exploits the within-household variation but obtains estimates that are robust to measurement error. Finding a differential effect of higher wife's assets for girls and boys provides evidence on gender discrimination. However, it fails to assess the magnitude of the effect of wife's assets on the levels of the children's health measures.

D. *Estimation strategy*

In this paper, I treat the value of consumption and the distribution factors in model (2.1) and model (2.2) as endogenous. The targeting of benefits to mothers in treatment group localities motivates the identification strategy. Eligible mothers in the treatment group localities receive cash payments from the program that are denied to households in the control group localities. Thus, belonging to the treatment group results in higher household expenditures and higher women's income and is uncorrelated, by design, to the error term in the nutrition demand equations (2.1) and (2.2). Thus, belonging to the treatment group qualifies as a valid instrument for expenditures, for the log of wife's income and for the log of wife's income to husband's income.

Using the same Mexican dataset I use in this study, Attanasio and Lechène (2002) test the income pooling restriction in a budget shares system that includes food, alcohol and tobacco,[21] transportation, services, woman's clothing, men's clothing, girl's clothing and boy's clothing. They exploit the exogenous change in women's income created by

effect on children's health of the old age pension in South Africa according to the gender of the recipient is strong evidence against the unitary model of the household.

[21] On average, 97% and 95% of all households, respectively, report zero expenditure for alcohol and tobacco.

the targeting of program's benefit to mothers within randomly selected treatment localities to instrument both the total expenditures and the wife's share of income in total income as outlined above.[22] They reject the income pooling restriction in the budget shares system but do not test the Pareto-efficiency assumption.

My paper contributes to the existing literature in three ways. First, the focus of this study is on nutrition decisions rather than budget shares. Second, I exploit a specific module of the survey that collects characteristics of the spouses' families at time of marriage to get additional identifying restrictions for the expenditures and income endogenous variables. Along with the treatment dummy variable, this set of instruments is likely to lead to precise estimates of the expenditures elasticity of calories and of the effect of the distribution factors on the demand for calories because of the strong correlation between the instruments and the endogenous variables. Using the estimates of the distribution factors from model (2.2) for the various food groups, I test the Pareto-efficiency assumption for the nutrition decisions. It is possible that most studies fail to reject the null hypothesis of Pareto-efficiency because the effects of the two distribution factors are very imprecisely estimated. Third, I present evidence on the extent to which inappropriately neglecting the distribution of power within the household affects the estimated demand for nutrition. I examine how increasing the ratio of wife's income to husband's income impacts the levels of calories consumed. In addition, I examine the effect of incorrectly omitting the distribution factors on the estimated expenditures elasticity of calories, i.e. the magnitude of the bias from assuming that the unitary model holds.

E. *Potential caveats*

The results would be misleading if the program impacts nutrition decisions through the health talks that the households are required to attend in order to receive benefits. After checking the strength of the correlation between the instruments and the endogenous variables, I test for over-identifying restrictions to assess whether there is any additional effect of the program on the demand for nutrition above the income effect.

[22] Along with the random allocation of benefits between treatment group women and control group women, the authors use village-level agricultural wages as an additional instrument.

Non-participation by eligible households in the program could lead to a selection bias. However, very few households, representing less than 1.5 percent of the total sample, choose not to participate.

Another potential instrument for expenditures and the distribution of income is the amount households are entitled to receive. The advantage of this instrument is that it has more variability than the dummy variable identifying households in the treatment group. However, a problem with using this variable is that the grant awards that constitute the larger part of the transfer vary with the gender and degree of advancement of children. Thus, the amount households are entitled to receive varies with household composition. However, family composition presumably affects nutrition in a direct way through economies of scale. Omitting the family composition variables would lead to a correlation between the benefit amount levels and the error terms in model (2.1) and model (2.2). This would lead to biased estimates.

4. Results and discussion

This section is organized as follows. First, I discuss the estimation results for the calories equations derived from the collective model. I test the validity of the instruments used in the two-stage least squares. Second, I test the income pooling restriction and the Pareto-efficiency assumption. Third, I examine the effect of changing the wife's income on the levels of calories consumed. Fourth, I examine the effect of neglecting the distribution of power within the household on the expenditures elasticity.

A. *Estimation results*

Table A-2 presents the 2SLS results from the estimation of the restricted collective model. Table A-3 contains results for the unrestricted collective model.

In the restricted collective model, the expenditures elasticity of total calories is 0.44, a value in the range of estimates found in the literature.[23] The expenditures elasticity is higher for calories from meat and meat products and calories from vegetables and fruits. In general, calorie consumption increases as the ratio of wife's income to

[23] A quadratic term in the log of the value of consumption turned out to be insignificant. This is likely due to the fact that the sample is homogenous with respect to household wealth.

husband's income increases, with the exception of the calories consumed from meat and meat products for which the effect is insignificant.

Consumption of meat and meat products and vegetables and fruits increases with household size. Consumption of other food decreases with household size. However, household size does not influence total food consumption after controlling for household composition. Family composition, captured by the number of household members in different age and gender groups, significantly affects nutrition. Nutrition also depends on the spouses' years of schooling. Taken jointly, availability of health care in the village and access to electricity and sewage have a significant effect on the calorie demand equations. The coefficients of prices of food items are also jointly significant.

As discussed earlier, the identification strategy relies on the use of the treatment dummy variable representing eligible households in the treatment localities as an instrument for the endogenous right-hand side variables.

The spouses' family background information at the time of marriage provides additional instruments. The additional instruments include dummy variables indicating whether (i) the wife's father received any formal schooling, (ii) the wife's father and the husband's father were literate, (iii) the wife's father and the husband's father wore shoes (which is an indicator of social status in rural Mexico), (iv) the wife's father and the husband's father owned any land.

In the remaining of this subsection, I discuss the validity of the set of instruments selected for the 2SLS estimation of the unitary model (the base model), the restricted collective model (2.1) and the unrestricted collective model (2.2). I also draw attention to the strong correlation between the distribution factors and the instruments used in the estimation of the collective models. Precision of 2SLS estimates are related to the correlation between the endogenous variable and the instruments. The estimated variance covariance of the coefficients in the instrumental variables estimation is given below.

$$\text{Est.}Var(\beta^{IV}) = s^2[X'W(W'W)^{-1}W'X]^{-1}$$
$$\text{Est.}Var(\gamma^{IV}) = s^2[X'W(W'W)^{-1}W'X]^{-1}$$

β^{IV} is the IV estimate for the expenditures elasticity of calories
γ^{IV} is the IV estimate for the effect of the distribution factors
s^2 is the estimate for σ^2
X is the set of exogenous variables
W is the set of instrumental variables

A strong correlation between X and W is associated with more precise IV estimates of the coefficients of the endogenous regressors (here, the value of consumption and the distribution factors).

Different subsets of instruments are used in the estimation of the unitary model, the restricted model (2.1) and the unrestricted model (2.2).

In the 2SLS estimation of the unitary model, I instrument the value of consumption using the treatment dummy variable and the dummy variable indicating whether the wife's father received any formal schooling as instruments. I reject the null hypothesis that these instruments are uncorrelated with the value of consumption using a Wald test (Table A-4, first column). I also reject the null hypothesis of exogeneity using a Durbin-Wu-Hausman test for total calories and calories from each food group (Table A-5, first column). I cannot reject the null hypothesis that the instruments are uncorrelated with the error term in the equations for calories using a test of over-identifying restrictions (Table A-5, second column). [24]

The 2SLS estimation of the restricted collective model (2.1) requires instrumenting the value of consumption and the ratio of wife's income to husband's income. The treatment dummy variable and the dummy variables indicating whether the wife's father and the husband's father wore shoes are used as instruments. I reject the null hypotheses that these instruments are uncorrelated with the value of consumption and that they are uncorrelated with the ratio of wife's income to husband's income using a Wald test (Table A-4, second column). The strong correlation between the instruments and the ratio of wife's income to husband's income (χ^2 (3) = 5370) is mainly due to the treatment dummy variable. I also reject the null hypothesis of exogeneity using a Durbin-Wu-Hausman test (Table A-5, third column) for total calories and calories from each

[24] See Wooldridge (2002) p.93.

food group. I cannot reject the null hypothesis that the instruments are uncorrelated with the error term in the equations for calories using a test of over-identifying restrictions (Table A-5, fourth column).

The 2SLS estimation of the unrestricted collective model (2.2) requires instrumenting the value of consumption, the ratio of wife's income to husband's income and the wife's income. The treatment dummy variable and dummy variables indicating whether the wife's father and the husband's father were literate, whether the wife's father and the husband's father wore shoes, and whether the wife's father and the husband's father owned any land are used as instruments. I reject the null hypotheses that these instruments are uncorrelated with the three endogenous variables using a Wald test (Table A-4, third column). The strong correlation between the instruments and the ratio of wife's income to husband's income ($\chi^2(7) = 7756$) is mainly due to the treatment dummy variable. This is also the case for the strong correlation between the instruments and the wife's income ($\chi^2(7) = 12{,}691$). I reject the null hypothesis of exogeneity using a Durbin-Wu-Hausman test (Table A-5, fifth column) for total calories and calories from each food group. I cannot reject the null hypothesis that the instruments are uncorrelated with the error term in the equations for calories using a test of over-identifying restrictions (Table A-5, sixth column).

Reviewing the test results for the instruments used in the estimation of the unitary model and the collective models suggests that the instruments are valid ones. In addition, the strong correlation between the distribution factors and the instruments used for the estimation of the collective models produces precise estimate of the effect of the distribution factors on calorie consumption.

B. *Testing the income pooling restriction and the Pareto-efficiency assumption for the nutrition decisions*

Testing the income pooling restriction

Table 3 provides results from testing the income pooling restriction in the restricted collective model (column 1) and the unrestricted collective model (column 2) for total calories and calories from each food group. The income pooling restriction is rejected in all cases.

Table 3: Testing income pooling in the restricted collective model and the unrestricted collective model.

	Restricted collective model t-statistic (p-value)	Unrestricted collective model F-statistic (p-value)
Total calories	2.52	3.85
	(0.012)	(0.02)
Vegetable and fruits calories	1.74	3.81
	(0.082)	(0.022)
Cereals and grains calories	1.82	3.40
	(0.068)	(0.033)
Meat and meat products calories	-1.60	2.47
	(0.111)	(0.08)
Other food calories	3.67	7.67
	(0.0001)	(0.0005)

Testing the Pareto-efficiency assumption

Using the unrestricted collective model with two distribution factors, I reject the Pareto-efficiency assumption for all pairs of goods except in two instances. These consist of the pair "vegetables and fruits calories / other food calories" and the pair "cereals and grains calories / meat and meat products calories". The results are presented in Table 4.

Table 4: Testing Pareto-efficiency in the unrestricted collective model for pairs of goods.

χ^2-statistic (p-value)	Vegetable and fruits calories	Cereals and grains calories	Meat and meat products calories
Cereals and grains calories	3.09	–	–
	(0.07)		
Meat and meat products calories	2.97	0.25	–
	(0.08)	(0.62)	
Other food calories	1.08	4.67	3.19
	(0.29)	(0.03)	(0.07)

The joint hypothesis of equality of the ratio has a chi-square statistic equal to 6.42 that corresponds to a p-value of 0.09. I reject at the 10% level the Pareto-efficiency assumption on the allocation of resources within the household with respect to the nutrition decisions.

C. *How is nutrition affected by changing the wife's income?*

After providing statistical evidence of an effect of the distribution of power within the household on nutrition, I discuss the substantive importance of this effect.

The ratio of wife's income to husband's income has a mean of 0.19 in the sample. Suppose that the ratio is doubled to 0.38, maintaining everything else constant (Table 5, first column). According to the estimates from the restricted collective model, a 100 percent change in the ratio of wife's income to husband's income is associated with less than 1 percent change in total calories consumed. The effect is a little higher for calories from vegetables and fruits, but still in the 1 percent range.

Setting the ratio of wife's income to husband's income to 1 (i.e. moving to an equal distribution of income within the couple) is associated with a 2 to 5 percent change in food calories consumed (Table 5, second column). Despite the magnitude of the change in the ratio of wife's income to husband's income, the effect on nutrition is minor.

Reversing the allocation of income in the couple is associated with a 20 to 30 percent change in the levels of calorie consumption (Table 5, third column). This effect is quite large but the change in the spouses' relative incomes is unrealistic. In addition, although the effect of the ratio of wife's income to husband's income is likely to be non-linear as this ratio increases, there is not enough variation in the data to identify any non-linearity.

Table 5: Measuring the effect of varying the value of the ratio of wife's income to husband's income on the percent change in calories consumed using the restricted collective model.

	$WF = 2\times\overline{WF}$	$WF = 1$	$WF = 1/\overline{WF}$
Percent change in:			
Total calories	+0.7%	+2.98%	+18.69%
Vegetable and fruits calories	+1.2%	5.11%	+32.04%
Cereals and grains calories	+0.7%	+2.98%	+18.69%
Meat and meat products calories	-1%	-4.26%	-26.7%
Other food calories	+1%	+4.26%	+26.7%

I find that the effects of changes in wife's income are small in a substantive sense. This is consistent with recent results in the literature: "The key issue in the context of testing models of decision-making is their [statistical] significance" (Thomas 2002). Does this finding imply that the unitary model may hold approximately? I discuss this question further in the following sub-section.

D. *How does neglecting the distribution of power within the household affect the expenditures elasticity?*

Neglecting the effect of the distribution of power when modelling household nutrition choices affects the value of the expenditures elasticity of calories.

The first step is to compare the elasticity of calories in the unitary model and the restricted collective model (Table 6, columns 1 and 2). In most of the cases except for the demand for calories from meat and meat products, omitting the distribution factors leads to an upward bias in the elasticity of calories. In the case of meat and meat products, the elasticity of calories in the unitary model is lower than the elasticity of calories in the restricted collective model.

Recall that increasing the ratio of wife's income to husband's income has a positive effect on calorie demands in all cases except the demand for calories from meat and meat products for which the effect is negative. Supposing that richer households are also the households where women have high bargaining power, the elasticity of calories as estimated in the unitary model would also be capturing the effect of higher women's bargaining power.

Thus, omitting the distribution factors is expected to lead to an upward bias in the expenditure elasticity of calories, calories from vegetables and fruits, calories from grains and cereals and calories from other food. It is expected to lead to a downward bias in the expenditures elasticity of calories from meat and meat products.

Table 6: Expenditures elasticity of calories from the 2SLS estimation of the unitary model, the restricted collective model and the unrestricted collective model.

	Unitary model	Restricted collective model	Unrestricted collective model
Total calories	0.84***	0.44***	0.76***
	(0.16)	(0.11)	(0.18)
Vegetable and fruits calories	2.31***	1.41***	0.89**
	(0.48)	(0.31)	(0.36)
Cereals and grains calories	0.84***	0.64***	1.15***
	(0.13)	(0.16)	(0.26)
Meat and meat products calories	1.53***	1.82***	1.60***
	(0.24)	(0.30)	(0.38)
Other food calories	1.29***	0.21	-0.04
	(0.28)	(0.17)	(0.23)

Note: Robust standard errors in parentheses.

However, the elasticities of calories estimated from the two collective models are different (Table 6, columns 2 and 3).

Testing the Pareto-efficiency assumption requires the inclusion of at least two distribution factors in the model equation. However, in practice, the number and nature of the distribution factors that determine the distribution of power within the household are not clearly defined. As mentioned in Section 2, although the distribution of income is likely to affect the distribution of power within the household, other factors could also have a role.[25] Omitting these factors might not affect the testing of the income pooling restriction and Pareto-efficiency assumption, but it could explain the discrepancy between estimates from the two different specifications that include different distribution factors (Table 6, columns 2 and 3).

[25] For example, current assets and assets brought at time of marriage have been found to influence the distribution of power within the household in developing countries.

Conclusion

How does the distribution of power within the household affect the nutrition of its members? I explore this question using a unique dataset collected for the evaluation of the largest social program in rural Mexico. For the purpose of the evaluation, poor households in randomly selected control localities were denied program benefits. I exploit data from this social experiment to (1) test models of household decision-making, (2) provide some insights on how much nutrition is affected by changing the distribution of income within the household, (3) discuss whether neglecting the distribution of power within the household can lead to misleading results on the expenditures elasticity of calories, a parameter of interest to policy-makers.

Focusing on the nutrition decision, I reject the income pooling restriction underlying the unitary model of the household. The distribution of power, captured by the distribution of income between husband and wife, matters for the allocation of resources towards nutrition. In addition, I reject the Pareto-efficiency underlying the collective model of the household for the nutrition decisions. There is an allocation of resources towards consumption of the various food groups that is Pareto-superior to the one collectively chosen in the household. This result is consistent with the separate sphere bargaining model (Lundberg and Pollak 1993) for which gender roles assign responsibility to each partner for certain decisions.

Doubling the wife's income is found to be associated to only minor changes in nutrition levels –around one percent. Although the direct effect of the distribution factors is small, omitting them from the demand equation leads to a bias in the estimate of the expenditures elasticity of calories. Neglecting the distribution of power within the household can lead to misleading results.

References

Adato, Michelle, Bénédicte de la Brière, Dubravka Mindek and Agnes Quisumbing. 2000. "Final report: the impact of PROGRESA on women's status and intrahousehold relations." Report submitted to PROGRESA. International Food Policy Research Institute, Washington D.C.

Attanasio, Orazio and Valérie Lechène. 2002. "Tests of income pooling in household decisions." *Review of Economic Dynamics*. 5: 720-748.

Behrman, Jere and Anil Deolalikar. 1987. "Will developing country nutrition improve with income? A case study for rural south India." *Journal of Political Economy*. 95(4): 492-506.

Behrman, Jere and Petra E. Todd. 1999. "Randomness in the Experimental Samples of PROGRESA (Education, Health, and Nutrition Program)." Report submitted to PROGRESA. International Food Policy Research Institute, Washington, D.C.

Bhalotra, Sonia and Cliff Attfield. 1998. "Intrahousehold resource allocation in rural Pakistan: a semi-parametric analysis." *Journal of Applied Econometrics* 13: 463-480.

Bouis, Howarth. 1994. "The effect of income on demand for food in poor countries: Are our food consumption databases giving us reliable estimates." *Journal of Development Economics*. 44: 199-226.

Bouis, Howarth and Lawrence Haddad. 1992. "Are estimates of calorie-income elasticities too high? A recalibration of possible range." *Journal of Development Economics*. 39: 333-364.

Bourguignon, François, Martin Browning, Pierre-André Chiappori and Valérie Lechène. 1993. "Intra household allocation of consumption: A model and some evidence from French data." *Annales d'Economie et de Statistique*. 29: 137-157.

Browning, Martin and Pierre-Andre Chiappori. 1998. "Efficient intra-household allocations: a general characterization and empirical tests". *Econometrica*. 66(6): 1241-1278.

Chiappori, Pierre-André. 1988. "Rational household labor supply." *Econometrica.* 56(1): 63-90.

Deaton, Angus. 1997. "The analysis of household surveys: a microeconometric approach to development policy." Johns Hopkins University Press. 26-32.

Doss, Cheryl. 1996. "Testing among models of intrahousehold resource allocation." *World Development*. 24(10): 1597-1609.

Duflo, Esther. 2003. "Grandmothers and granddaughters: Old age pension and intrahousehold allocation in South Africa". *World Bank Economic Review*. 17(1): 1-25.

Fortin, Bernard and Guy Lacroix. 1997. "A test of the unitary and collective models of household labour supply." *The Economic Journal.* 107: 933-955.

Haddad, Lawrence. 1999. "The income earned by women: impacts on welfare outcomes". *Agricultural Economics*. 20: 135-141.

Haddad, Lawrence and John Hoddinott. 1994. "Women's income and boy-girl anthropometric status in the Cote-d'Ivoire". *World Development*. 22: 543-553.

Hoddinott, John and Lawrence Haddad. 1995. "Does female income share influence household expenditures? Evidence from Cote-d'Ivoire". *Oxford Bulletin of Economics and Statistics*. 57(1): 77-95.

Hoddinott, John, Emmanuel Skoufias and Ryan Washburn. 2000. "The impact of PROGRESA on consumption: a final report", Report submitted to PROGRESA. International Food Policy Research Institute, Washington D.C.

Lundberg, Shelly and Robert A. Pollak. 1993. "Separate spheres bargaining and the marriage market." *Journal of Political Economy* 101(6): 988-1010.

Lundberg, Shelly and Robert A. Pollak. 1996. "Bargaining and distribution in marriage." *Journal of Economic Perspectives* 10(4): 139-158.

Lundberg, Shelly, Robert A. Pollak and Terence J. Wales. 1997. "Do husbands and wives pool their resources? Evidence from the United Kingdom child benefit." *Journal of Human Resources*. 32(3): 463-480.

Muñoz de Chávez , Miriam, José Antonio Roldán, José Angel Ledesma, Eduardo Mendoza, Adolfo Chávez, Fernando Perez-Gil, Sonia Hernández and Alejandra Chaparro. 1996. "Tablas de Valor Nutritivo de los Alimentos de Mayor Consumo en México". Edición Internacional. 330 pp.

Phipps, Shelley A. and Peter S. Burton. 1998. "What's mine is yours? The influence of male and female incomes on patterns of household expenditures." *Economica.* 65(260): 599-613.

Rosenzweig, Mark. 1986. "Program intervention, household distribution and the welfare of individuals: modeling household behavior." World Development. 14(2): 233-243.

Schultz, T. Paul. 1990. "Testing the neoclassical model of family labor supply and fertility." *Journal of Human Resources*. 25(4): 599-634.

Skoufias, Emmanuel. 2001. "PROGRESA and its impacts on the human capital and welfare of households in rural Mexico: A synthesis of the results of an evaluation by IFPRI". International Food Policy Research Institute, Washington D.C.

Stiglitz, Joseph E. 1976. "The efficiency wage hypothesis, surplus labour, and the distribution of income in L.D.C.s." *Oxford Economic Papers*. 1976. 28: 185-207.

Strauss, John and Duncan Thomas. 1990. "The shape of the calorie expenditure curve." Discussion paper No. 595. Economic Growth Center, Yale University.

Subramanian, Shankar and Angus Deaton. 1996. "The demand for food and calories" *Journal of Political Economy* 104(1): 133-162.

Thomas, Duncan. 1990. "Intrahousehold resource allocation: an inferential approach." *Journal of Human Resources.* 25(4): 635-664.

Thomas, Duncan. 1993. "The distribution of income and expenditure within the household." *Annales d'Economie et de Statistique.* 29: 109-135.

Thomas, Duncan. 1994. "Like Father, Like Son; Like Mother, Like Daughter: Parental Resources and Child Height." *Journal of Human Resources.* 29(4): 950-988.

Thomas, Duncan and Chien-Liang Chen. 1994. "Income shares and shares of income: empirical tests of models of household resource allocations." Labor and Population Program. Working Paper Series 94-08. 29(4): 950-988.

Thomas, Duncan, Dante Contreras and Elizabeth Frankenberg. 2002. "Distribution of power within the household and child health." UCLA and Universidad de Chile. Mimeo.

Udry, Christopher. 1996. "Gender, Agricultural Production and the theory of the household." *Journal of Political Economy*, 104(5): 1010-1046.

Wooldridge, Jeffrey M. 2002. "Econometric analysis of cross-section and panel data." The MIT Press. 93.

Table A-1: Descriptive Statistics

Variable	N	Mean	Std. Error
Dependent Variables			
Logarithm of per mouth daily calorie consumption	5920	7.56	.40
Logarithm of per mouth daily calorie consumption from vegetables and fruits	6302	3.40	.97
Logarithm of per mouth daily calorie consumption from grains and cereals	6428	7.22	.56
Logarithm of per mouth daily calorie consumption from meat and meat products	5969	4.36	.98
Logarithm of per mouth daily calorie consumption from other food	6440	5.70	.63
Endogenous Explanatory Variables			
Logarithm of per capita value of consumption	6411	5.09	.51
Logarithm of the ratio of wife's income to husband's income	6257	-3.25	2.77
Logarithm of the wife's income	6562	3.24	2.39
Instrumental Variables			
Dummy indicating whether household is in a treatment locality	6562	.65	.47
Dummy indicating whether the wife's father received any formal schooling at the time of marriage of his daughter	5728	.57	.49
Dummy indicating whether the wife's father was literate at the time of marriage of his daughter	5728	.61	.48
Dummy indicating whether the wife's father owned any land at the time of marriage of his daughter	5728	.61	.48
Dummy indicating whether the wife's father wore shoes at the time of marriage of his daughter	5728	.38	.48
Dummy indicating whether the husband's father was literate at the time of marriage of his son	5728	.31	.46
Dummy indicating whether the husband's father owned any land at the time of marriage of his son	5728	.57	.49
Dummy indicating whether the husband's father wore shoes at the time of marriage of his son	5728	.56	.49
Exogenous explanatory variables			
Logarithm of household size	6562	1.72	.39
Number of children 4 years old and younger	6562	1.19	1.09
Number of children between 5 and 10 years old	6562	1.4	1.13
Number of boys aged 11-14	6562	.35	.60
Number of girls aged 11-14	6562	.34	.59
Number of boys aged 15-19	6562	.20	.48
Number of girls aged 15-19	6562	.26	.53
Number of adult males aged 20-34	6562	.49	.51
Number of adult females aged 20-34	6562	.64	.53
Number of adult males aged 35-54	6562	.43	.49
Number of adult females aged 35-54	6562	.36	.48
Number of adult males aged 55 or more	6562	.14	.35
Number of adult female aged 55 or more	6562	.14	.36
Husband's number of years of schooling	6562	3.23	2.73
Wife's number of years of schooling	6562	3.05	2.75

Variable	N	Mean	Std. Error
Husband is an agricultural worker	6562	.73	.44
Dummy indicating access to a sewage system in the village	6562	.12	.32
Dummy indicating access to electricity in the village	6562	.65	.47
Dummy indicating access to some permanent health care facilities in the village	6562	.84	.36
Dummy indicating access to mobile health squad in the village	6562	.79	.40
Median local price per kg of tomatoes	6562	10.73	1.52
Median local price per kg of onions	6562	7.03	1.44
Median local price per kg of potatoes	6562	7.09	1.54
Median local price per kg of oranges	6562	3.71	0.95
Median local price per kg of plantains	6562	3.41	0.95
Median local price per kg of maize tortillas	6562	3.41	.65
Median local price per kg of corn	6562	2.97	.76
Median local price per kg of noodles	6562	2.17	.60
Median local price per kg of rice	6562	6.63	1.07
Median local price per kg of beans	6562	11.25	2.00
Median local price per kg of eggs	6562	10.29	1.80
Median local price per kg of chicken	6562	21.71	3.60
Median local price per kg of coffee	6562	5.74	.77
Median local price per kg of sugar	6562	10.14	1.08
Median local price per kg of oil	6562	9.92	3.07

Table A-2: 2SLS estimation of the restricted collective model.

(1) The dependent variable is the logarithm of per mouth daily calorie consumption.
(2) The dependent variable is the logarithm of per mouth daily calorie consumption from vegetables and fruits.
(3) The dependent variable is the logarithm of per mouth daily calorie consumption from grains and cereals.
(4) The dependent variable is the logarithm of per mouth daily calorie consumption from meat and meat products.
(5) The dependent variable is the logarithm of per mouth daily calorie consumption from other food.

Dependent Variables	(1)	(2)	(3)	(4)	(5)
Logarithm of per capita value of consumption	.44***	1.41***	.64***	1.82***	.21
	(.11)	(.31)	(.16)	(.3)	(.17)
Logarithm of wife's income to husband's income	.007**	.012*	.007*	-.01	.01***
	(.002)	(.007)	(.004)	(.008)	(.004)
Logarithm of household size	-.11	.44**	.007	.51**	-.53***
	(.07)	(.2)	(.11)	(.21)	(.11)
Number of children 4 years old and younger	.02**	.0033	.02**	.05**	.01
	(.009)	(.025)	(.01)	(.02)	(.01)
Number of children between 5 and 10 years old	.007	-.04*	.007	.007	-.02
	(.009)	(.024)	(.01)	(.02)	(.01)
Number of boys aged 11-14	.02**	-.08***	.03*	-.05	.01
	(.01)	(.029)	(.01)	(.03)	(.01)
Number of girls aged 11-14	.02**	-.09***	.04***	-.04	.01
	(.01)	(.029)	(.01)	(.03)	(.01)
Number of boys aged 15-19	-.006	-.073***	-.01	.005	.007
	(.01)	(.032)	(.01)	(.03)	(.02)
Number of girls aged 15-19	.01	-.005	.004	.01	-.002
	(.01)	(.029)	(.01)	(.03)	(.01)
Number of adult males aged 20-34	.02	.001	.04*	-.03	.03
	(.01)	(.045)	(.02)	(.04)	(.03)
Number of adult females aged 20-34	.0006	-.013	-.002	-.06	.02
	(.01)	(.03)	(.02)	(.04)	(.02)
Number of adult males aged 35-54	.003	-.012	.02	-.04	.01
	(.01)	(.05)	(.02)	(.05)	(.03)
Number of adult females aged 35-54	.02*	-.01	.03	.01	.02
	(.01)	(.042)	(.02)	(.04)	(.02)
Number of adult males aged 55 or more	.02	.0025	.01	.07*	.005
	(.01)	(.05)	(.02)	(.05)	(.03)
Number of adult female aged 55 or more	.01	-.028	.03	.08	-.003
	(.01)	(.04)	(.02)	(.05)	(.02)
Husband's number of years of schooling	-.009***	.01**	-.01***	-.006	-.0001
	(.002)	(.005)	(.002)	(.005)	(.003)
Wife's number of years of schooling	-.006***	-.007	-.01***	.002	-.004
	(.002)	(.005)	(.003)	.006	(.003)
Husband is an agricultural worker	.01	-.035	.04***	.01	.004
	(.01)	(.035)	(.018)	(.03)	(.02)
Access to electricity in the village	-.03***	.007	-.05***	-.02	-.02
	(.01)	(.02)	(.01)	(.03)	(.01)
Access to a sewage system in the village	-.04***	.0093	-.06***	-.02	.03
	(.01)	(.04)	(.02)	(.04)	(.02)
Access to permanent health care facilities in the village	.02	-.02	.06**	.08	.01
	(.01)	(.05)	(.02)	(.05)	(.02)
Access to mobile health squad in the village	-.003	-.06	-.006	-.01	-.006
	(.01)	(.03)	(.01)	(.03)	(.02)

Table A-2: 2SLS estimation of the restricted collective model (continued).

	(1)	(2)	(3)	(4)	(5)
Median local price per kg of tomatoes	.0003	-.025**	.006	-.014	.02***
	(.004)	(.01)	(.007)	(.01)	(.007)
Median local price per kg of onions	.003	-.004	.01*	.02*	-.01
	(.004)	(.01)	(.006)	(.01)	(.006)
Median local price per kg of potatoes	.008***	-.0019	.003	-.01	.01*
	(.004)	(.009)	(.005)	(.01)	(.005)
Median local price per kg of oranges	-.009***	.009	-.01***	.008	.003
	(.001)	(.005)	(.002)	(.005)	(.003)
Median local price per kg of plantains	-.01*	-.02**	-.01*	-.0009	.005
	(.005)	(.012)	(.008)	(.01)	(.008)
Median local price per kg of maize tortillas	.01	-.016	.01	-.02	.05***
	(.008)	(.017)	(.01)	(.01)	(.009)
Median local price per kg of corn	.03***	.06***	.02*	.01	.02**
	(.007)	(.017)	(.01)	(.02)	(.01)
Median local price per kg of noodles	-.001	.06***	-.02	.05**	-.007
	(.009)	(.02)	(.01)	(.02)	(.01)
Median local price per kg of rice	-.01***	.005	-.01**	-.02*	.01**
	(.004)	(.011)	(.006)	(.01)	(.007)
Median local price per kg of beans	.003	-.004	.009**	-.02***	.006
	(.003)	(.006)	(.004)	(.008)	(.004)
Median local price per kg of chicken	-.005***	-.003	-.007***	.008*	-.01***
	(.001)	(.004)	(.002)	(.004)	(.002)
Median local price per kg of eggs	.004	-.023***	.009**	-.02***	.008*
	(.002)	(.006)	(.003)	(.007)	(.004)
Median local price per kg of coffee	-.005***	-.00088	-.005**	-.002	-.006**
	(.001)	(.004)	(.002)	(.004)	(.003)

Notes: Robust standard errors in parentheses.
* Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level.

Table A-3: 2SLS estimation of the unrestricted collective model.

(1) The dependent variable is the logarithm of per mouth daily calorie consumption.
(2) The dependent variable is the logarithm of per mouth daily calorie consumption from vegetables and fruits.
(3) The dependent variable is the logarithm of per mouth daily calorie consumption from grains and cereals.
(4) The dependent variable is the logarithm of per mouth daily calorie consumption from meat and meat products.
(5) The dependent variable is the logarithm of per mouth daily calorie consumption from other food.

Dependent Variables	(1)	(2)	(3)	(4)	(5)
Logarithm of per capita value of consumption	.76***	.89**	1.15***	1.6***	-.04
	(.18)	(.36)	(.26)	(.38)	(.23)
Logarithm of wife's income to husband's income	.2**	-.314**	.25**	-.25*	-.13
	(.08)	(.15)	(.11)	(.16)	(.09)
Logarithm of wife's income	-.21**	.34**	-.26**	.25	.16
	(.09)	(.15)	(.11)	(.16)	(.1)
Logarithm of household size	.02	.14	.25	.37	-.69***
	(.11)	(.23)	(.17)	(.24)	(.15)
Number of children 4 years old and younger	.04***	-.01	.05**	.05	.005
	(.01)	(.03)	(.02)	(.03)	(.01)
Number of children between 5 and 10 years old	.01	-.05*	.02	-.005	-.02
	(.01)	(.02)	(.02)	(.03)	(.01)
Number of boys aged 11-14	.02*	-.07**	.04*	-.05*	.01
	(.01)	(.03)	(.02)	(.03)	(.02)
Number of girls aged 11-14	.03**	-.07**	.05**	-.03	.01
	(.01)	(.03)	(.02)	(.03)	(.02)
Number of boys aged 15-19	-.02	-.05	-.03	.01	.01
	(.01)	(.03)	(.02)	(.04)	(.02)
Number of girls aged 15-19	.01	-.005	-.0006	.006	-.002
	(.01)	(.03)	(.02)	(.03)	(.02)
Number of adult males aged 20-34	.04	-.02	.06*	-.05	.02
	(.02)	(.05)	(.03)	(.05)	(.03)
Number of adult females aged 20-34	-.01	.02	-.02	-.03	.04
	(.02)	(.04)	(.03)	(.04)	(.02)
Number of adult males aged 35-54	.01	-.04	.03	-.03	.01**
	(.03)	(.05)	(.04)	(.05)	(.03)
Number of adult females aged 35-54	.002	.03	-.003	.04	.06
	(.02)	(.05)	(.03)	(.05)	(.03)
Number of adult males aged 55 or more	.01	.01	.01	.15***	.01
	(.03)	(.06)	(.04)	(.06)	(.03)
Number of adult female aged 55 or more	.0001	.03	.005	.1***	.04
	(.02)	(.05)	(.03)	(.05)	(.03)
Husband's number of years of schooling	-.01***	.01**	-.01***	-.003	-.0003
	(.002)	(.005)	(.004)	(.005)	(.003)
Wife's number of years of schooling	-.005*	-.01*	-.005	-.002	-.005
	(.003)	(.006)	(.004)	(.006)	(.003)
Husband is an agricultural worker	.17**	.29**	.27***	-.15	-.12
	(.07)	(.12)	(.09)	(.13)	(.08)
Access to electricity in the village	.0002	-.06	.02	-.08	-.04
	(.02)	(.04)	(.03)	(.05)	(.03)
Access to a sewage system in the village	-.05**	.04	-.08**	-.03	.03
	(.02)	(.04)	(.03)	(.04)	(.02)
Access to permanent health care facilities in the village	.02	-.02	.05	.07	.01
	(.02)	(.05)	(.04)	(.05)	(.03)
Access to mobile health squad in the village	-.01	-.04	-.01	-.02	.01
	(.01)	(.03)	(.02)	(.04)	(.02)

Table A-3 (continued): 2SLS estimation of the unrestricted collective model.

	(1)	(2)	(3)	(4)	(5)
Median local price per kg of tomatoes	.01	-.04***	.02**	-.02*	.01**
	(.007)	(.01)	(.01)	(.01)	(.009)
Median local price per kg of onions	.002	.002	.008	.02*	-.008
	(.006)	(.01)	(.008)	(.01)	(.007)
Median local price per kg of potatoes	.009*	-.009	.009	-.02	.003
	(.005)	(.01)	(.008)	(.01)	(.007)
Median local price per kg of oranges	-.002	-.004	-.001	-.0006	-.001
	(.003)	(.007)	(.005)	(.007)	(.004)
Median local price per kg of plantains	-.004	-.03**	-.01	.005	-.0007
	(.007)	(.01)	(.01)	(.01)	(.009)
Median local price per kg of maize tortillas	.02**	-.05**	.02	-.05**	.03**
	(.01)	(.02)	(.01)	(.02)	(.01)
Median local price per kg of corn	.01	.08***	-.001	.03	.03**
	(.01)	(.02)	(.01)	(.02)	(.01)
Median local price per kg of noodles	-.01	.05*	-.009	.05**	-.02
	(.01)	(.02)	(.02)	(.02)	(.01)
Median local price per kg of rice	-.008	-.0008	-.01	-.01	.01
	(.006)	(.01)	(.009)	(.01)	(.008)
Median local price per kg of beans	.005	-.004	.005	-.02**	.007
	(.004)	(.007)	(.005)	(.008)	(.005)
Median local price per kg of chicken	-.009***	.008	-.014***	.01**	-.006
	(.003)	(.006)	(.004)	(.006)	(.003)
Median local price per kg of eggs	-.005	-.004	.003	-.009	.01**
	.006	(.01)	(.007)	(.01)	(.006)
Median local price per kg of coffee	-.005**	.0006	-.007**	-.001	-.006**
	(.002)	(.004)	(.003)	(.005)	(.003)

Notes: Robust standard errors in parentheses.
* Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level.

Table A-4: Wald tests for weak instruments for the 2SLS estimation of the unitary model, the restricted collective model and the unrestricted collective model.

Chi-square statistic (p-value)	Unitary model (1)	Restricted collective model (2)	Unrestricted collective model (3)
Value of consumption	35.7	74.1	77.3
	(0.0001)	(0.0001)	(0.0001)
Ratio of wife's income to husband's income	-	5370	7756
		(0.0001)	(0.0001)
Wife's income	-	-	12,691
			(0.0001)

Notes:

(1) The set of instrumental variables includes the treatment dummy along with a dummy indicating whether the wife's father received any formal schooling.

(2) The set of instrumental variables includes the treatment dummy along with two dummy variables indicating whether the wife's father wore shoes and the husband's father wore shoes at the time of marriage of their children.

(3) The set of instrumental variables includes all the variables specified in (2) along with dummy variables indicating whether the wife's father and the husband's father were literate and whether they owned any land at the time of marriage of their children.

Table A-5: Hausman test and test of over-identifying restrictions (OIR) for the 2SLS estimation of the unitary model, the restricted collective model and the unrestricted collective model.

	Total calories	Vegetables and fruits calories	Cereals and grains calories	Meat and meat products calories	Other food calories
Unitary model					
Hausman test	χ^2 (1) = 8.29 (0.004)	χ^2 (1) = 12 (0.0005)	χ^2 (1) = 6.94 (0.0085)	χ^2 (1) = 5.50 (0.019)	χ^2 (1) = 19.6 (0.0001)
Test of OIR	χ^2 (1) = 1.42 (0.23)	χ^2(1) = 0.003 (0.95)	χ^2 (2) = 3.59 (0.16)	χ^2 (2) = 4.02 (0.13)	χ^2 (1) = 0.004 (0.94)
Restricted collective model					
Hausman test	χ^2 (2) = 13.1 (0.001)	χ^2 (2) = 4.6 (0.1)	χ^2 (2) = 15.3 (0.0005)	χ^2 (2) = 9.24 (0.009)	χ^2 (2) = 6.86 (0.0325)
Test of OIR	χ^2 (1) = 0.38 (0.53)	χ^2(1) = 0.57 (0.44)	χ^2 (1) = 0.49 (0.48)	χ^2 (1) = 0.88 (0.34)	χ^2 (1) = 0.52 (0.46)
Unrestricted collective model					
Hausman test	χ^2 (3) = 18.3 (0.0004)	χ^2 (3) = 11.8 (0.0081)	χ^2 (3) = 25.2 (0.0001)	χ^2 (3) = 14.1 (0.002)	χ^2 (3) = 7.62 (0.0527)
Test of OIR	χ^2 (4) = 1.30 (0.86)	χ^2(4) = 2.37 (0.66)	χ^2 (4) = 1.59 (0.81)	χ^2 (4) = 1.36 (0.84)	χ^2 (4) = 5.80 (0.21)

Note: p-values in parentheses.