Time-Intensity and the Composition of Consumption

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Abstract

Becker's theory of home production was the first to systematically incorporate time in economic models, and the theory generated much empirical research in a wide variety of areas. However, the direct applications of Becker's home production theory in empirical research are scarce because of the innate immeasurability of commodities. In this paper, I recover unobservable commodities from the cost functions under certain assumptions about production technologies. Then, using the Philippine Bukidnon panel study of rural households, I test for the core of the Becker model: negative substitution effects between a time-intensive and a goods-intensive commodity arising from wage increases. The estimates of the structural form as well as the reduced form relative demand between childcare, which represents a time-intensive commodity, and meal consumption, which represents a goods-intensive commodity, support the major predictions of the model (JEL: D13, J13, J22).

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1 Introduction

Almost all consumption behaviors require time expenditures apart from monetary expenditures. Buying foods, for example, does not complete consumption of eating unless time is spent for cooking and eating, while buying a ticket does not translate into the consumption of movies unless time is spent in the theater watching movies.

In his groundbreaking work, Becker (1965) proposes that "the household combines time and market goods to produce more basic commodities that directly enter their utility functions," such as a home cooked meal or a pleasant evening. Based on differential time-intensities across commodities, Becker's theory predicts the substitutions from time-intensive towards goods-intensive commodities with compensated wage increases. The theory of home production has been embraced by economists across fields and generated much empirical research.[1]

Despite the growing number of empirical research that is based on Becker's theory of home production, the direct applications of the theory are scarce due to the unobservability of commodities. As is noted by critics of Becker's theory of home production (Pollak and Wachter 1975), in the absence of direct measurement of commodities, the major contribution of the theory remains conceptual rather than empirically verifiable. Given that all the implications of the home production theory regarding time and market goods can be translated into implications of the derived utility functions (Michael and Becker 1973), the theory of home production could not avoid the criticism that it is only a reformulation of well-known statements with slightly different terminologies. The distinction between consumption and production, which Michael and Becker (1973) call "the separation of objects of choice from the means used to produce them," might be useful in an analytical sense, but can hardly be a guideline for empirical investigations (Gronau 1986).

[1] The theory has enabled a better understanding of household behaviors both in the market and non-market sectors (Apps and Rees 1996, Brown and Meghir 1991, Foster 2002, Rosenzweig and Schultz 1983). It has also contributed to improving the performance of standard macroeconomic models (Baxter and Jerman 1999, Aguiar and Hurst 2005, Hurd and Rhowedder 2003, Benhabib, Rogerson, and Wright 1991).

In this paper, I empirically separate consumption from production and apply the model's predictions directly on commodities. Under certain assumptions about production technologies, I recover commodities from cost functions. Then, I test for the substitution effects between child care, representative of a time-intensive commodity, and meal consumption, representative of a goods-intensive commodity, using the Philippine Bukidnon panel study of rural households. The estimates of the structural form as well as the reduced form relative demand between the two commodities suggest that there is a substitution from child care towards meal consumption when women's wages increase.

Furthermore, by empirically separating consumption from production, I disentangle the two substitution effects associated with wage increases. Increases in wage induce two substitution effects: one between commodities on the consumption side depending on their time-intensities, and the other between time and market goods on the production side. Using the recovered commodities and the estimated parameters of production technologies, I separate the two substitution effects and find out how these effects are translated into the eventual allocations of time and market goods.

The empirical results in this paper verify the core of the Becker model, which so far has had only an intuitive appeal. The empirical verification that agents systematically take into account the time cost in their consumption decisions reemphasizes the importance of the study of home production in economic analysis.

The traditional labor-leisure dichotomy model, for example, aggregates various sub-time categories into home time and does not give any insights regarding how these sub-time categories are affected when an agent changes her labor supply in response to wage changes. The empirical results in this study imply that labor supply decisions interact with home production technologies: time categories which are used for relatively time-intensive activities and for which market goods are highly substitutable, such as time for child care, are likely to be greatly affected by the wage increases. The latter production side substitution between market goods and time has also been empirically verified by other home production analysis

(Aguiar and Hurst 2005). However, given that time use is affected by both consumption and production side substitution effects, ignoring one effect might lead us to draw a wrong conclusion about the overall effects.[2] The current paper contributes to existing literature by providing empirical evidence on the consumption side substitution effects.

The verification that the nature of home production is a binding constraint on time allocation has serious policy implications especially for women in developing countries. In developing countries where the majority of home production activities fall in the women's sphere, backwardness in home production technology might be a particularly important obstacle to women's labor force participation or education acquisition. Any policy efforts to empower women through more education or better access to labor markets might not be effective, if poor home production technology prevents efficient and flexible use of home time. Even if the policy interventions are effective, they might bring undesirable outcomes if women have to bear excessive labor burdens in addition to home labor or sacrifice particular sub-time categories whose shortage might result in negative long term effects.[3] Therefore, a careful attention on the nature of home production has to precede any policy interventions.

The insights of the home production theory are not confined to time allocations and expand to market good consumption. The empirical results in this paper demonstrate that market good consumption is affected by the two substitution effects at the consumption as well as the production level. Similar insights are established by Grossbard-Schechtman (2003) in her household model that incorporates both home production and bargaining. In her model, the elasticity of demand for market goods depends on the home production technologies. The elasticity of demand for certain market goods will be larger, the higher

[2]Suppose, for example, that the price of market goods for child care decreases due to subsidy for children's educational costs. The production side substitution effect suggests a decrease in time for child care because mother's time is now a more expensive input. The overall effect on time for child care, however, is ambiguous because the consumption side substitution effects are likely to be positive due to a decline in the implicit price of child care which is a function of both price of market goods and time cost.

[3]For example, the results in this paper suggests that time for child care will exhibit large negative effects to increases in women's wages due to its high time-intensity and high substitutability with market goods. If this arguably leads to negative results in terms of long term child health or cognitive ability, some complementary measures will be necessary to prevent them.

the substitutability between market goods and spousal domestic labor is and the higher an agent's reliance on spousal domestic labor given the substitutability. This has further implications such as gender differences in consumption patterns driven by gender differences in reliance on spousal domestic labor. In developing countries where males' higher reliance on female home labor is a common practice, larger gender differences in consumption patterns are expected. Although data unavailability restricts further investigation in such a subject, this is certainly another important issue raised by home production approach and requires further empirical research.

The rest of the paper proceeds as follows. In Section 2, I provide an expanded home production model in the multiple commodities setting, and derive testable implications of the model. Descriptions of the data, commodity construction, and the examination of relative goods/time intensities among commodities are given in Section 3. In Section 4, I conduct empirical tests of the model and present the results. Section 5 provides discussion of other issues, and Section 6 concludes.

2 Model

2.1 Household Optimization Problem

The household is assumed to maximize utility over commodities that are produced at home combining market goods and time. On the consumption side, it is assumed that the utility function is homothetic, all the commodities are net substitutes of each other, and the compensated cross-price elasticities are the same for all commodities.[4] On the production side, each commodity is produced by a separate production function with constant returns to scale and no jointness. Under the assumptions, the household's optimization problem is

[4]The assumption that the compensated cross-price elasticities are the same for all commodities implies $\zeta_{ji} = \zeta_{hi}$ for $i, j, h = 1..., n, i \neq j, i \neq h$, where ζ_{ji} stands for the compensated cross-price elasticity of commodity Z^j with respect to the price of Z^i. The three assumptions - homotheticity, net substitutability, and the same cross-price elasticity - are all satisfied when the utility function takes the CES form.

summarized as follows:

$$Max\ U(Z^1, Z^2, ..., Z^{n-1}, Z^n)$$
$$s.t.\ \sum_{i=1}^{n} \pi^i Z^i = w_w T_w + w_h T_h + m$$

where $Z = \{Z^i\}_{i=1}^n$ is a vector of commodities, π^i is the implicit price of each commodity, w is the opportunity cost of time (hourly market wage), subscript w and h stand for wife and husband respectively, T is the total time endowment, m is the household nonlabor income.

The implicit prices of commodities are determined within the household by the home production technology. Under the assumptions on the production side, each implicit price is equal to the unit cost of production defined by:

$$\pi^i = \pi^i(w_w, w_h, p^i) \quad i = 1..., n \tag{1}$$

where p^i is the price index of market goods used for production of Z^i.

Therefore, the reduced-form demand functions derive as follows:

$$Z^i = Z^i(w_w, w_h, p, m) \quad i = 1..., n \tag{2}$$

where p is a vector of n price indices.

2.2 Substitution Effect of Wage on the Relative Demand

When there are only two commodities, Becker's theory of home production generates a clear-cut prediction about the substitution effects: negative effects on the time-intensive commodity and positive effects on the goods-intensive commodity. When there are more than two commodities, the substitution effects on the most time-intensive commodity are negative, while the effects on the most goods-intensive commodity are positive similar to the two commodity case. However, the effects on the middle commodities are ambiguous. It

is because assuming three commodities, the middle commodity is time-intensive relative to the most goods-intensive commodity but goods-intensive relative to the most time-intensive commodity. Even if we restrict our attention to a relationship between two commodities, the implicit price of the irrelevant other commodity will still affect the comparative statics of our interest, making the relevant substitution effect ambiguous. Under the assumptions about the utility function enumerated in Section 2.1, however, a clear relationship between any two commodities can be established by constructing relative demands even in the multiple commodities setting.

Suppose now we have three commodities, Z^i, Z^h, and Z^j, whose relative time-intensities make the following inequality:

$$\frac{\pi_k^{i\prime}}{\pi^i} > \frac{\pi_k^{h\prime}}{\pi^h} > \frac{\pi_k^{j\prime}}{\pi^j} \tag{3}$$

where $\pi_k^{n\prime} = \frac{\partial \pi^n}{\partial w_k}, n = i, j, k = w, h.$

$\frac{\pi_k^{i\prime}}{\pi^i}$ measures the percentage change in the implicit price of Z^i due to change in wages. Therefore, if the percentage change in the implicit price of Z^i due to wage increases are greater than that of Z^h, Z^i is more time-intensive than Z^h.

Proposition 1 *When commodities are net substitutes to each other, show the same cross-price elasticities and are separately produced by production functions that exhibit constant returns to scale and no joint productions AND when the utility function is homothetic, with increases in wages, there is a substitution from a more time-intensive commodity towards a more goods-intensive commodity between any two commodities.*

Proof. Suppose now we are interested in the wage effect on the relative demand between Z^i and Z^h, whose time-intensity follows (3). Taking log of the relative demand, the comparative statics with respect to the wage derive in the following:

$$\frac{\partial}{\partial w_k} \ln\left(\frac{Z^i}{Z^h}\right) = \frac{\pi_k^{i\prime}}{\pi^i}\left(\frac{S_{ii}\pi^i}{Z^i} - \frac{S_{hi}\pi^i}{Z^h}\right) + \frac{\pi_k^{h\prime}}{\pi^h}\left(\frac{S_{ih}\pi^h}{Z^i} - \frac{S_{hh}\pi^h}{Z^h}\right) + \frac{\pi_k^{j\prime}}{\pi^j}\left(\frac{S_{ij}\pi^j}{Z^i} - \frac{S_{hj}\pi^j}{Z^h}\right) \quad k = w, h \tag{4}$$

Note that given the homotheticity of the utility function, the two income effects are cancelled out, making the non-compensated wage effect the same as the compensated effect. Following the assumption that the cross-price elasticities are the same for all commodities, and

$$S_{ii}\pi^i + S_{ih}\pi^h + S_{ij}\pi^j = 0 \tag{5}$$

(4) reduces to:

$$\frac{\partial}{\partial w_k} \ln\left(\frac{Z^i}{Z^h}\right) = \left(\frac{\pi_k^{i\prime}}{\pi^i} - \frac{\pi_k^{h\prime}}{\pi^h}\right)\left(\frac{S_{ii}\pi^i}{Z^i} - \frac{S_{hi}\pi^i}{Z^h}\right) < 0 \quad k = w, h \tag{6}$$

where the inequality follows from (3) and the net substitutability of Z^i and Z^h $(S_{hi} > 0)$. ■

Therefore, between any two commodities whose relative time-intensities can be defined, there is a substitution from the time-intensive to the goods-intensive commodity when wages increase.

3 Data Description

3.1 Bukidnon Data and Commodity Construction

This study uses the data from a survey conducted by the International Food Policy Research Institute and the Research Institute for Mindanao Culture in the southern Bukidnon province on Mindanao in the Philippines. The questionnaire was administered in 4 rounds between 1984 and 1985 at four month intervals to 488 households in the southern Bukidnon. The data set contains information on the two main inputs in commodity production. It provides household expenditures over 16 categories and the wife's 24 hour recall on the time allocation over 28 different activities, amounting to 24 hours. It is unfortunate that we do not have other family members' time uses, especially that of the husband. However, this shortcoming can be mitigated to some extent by the fact that the wife is the main provider of the home production activities in this rural context.

Out of 16 expenditures and 28 time uses, 12 expenditure categories and 22 different time uses are assigned to the construction of 7 different commodities: SLEEP, LODGING, APPEARANCE, MEALS, CHILDCARE, LEISURE, and HEALTH. Time devoted to income generating activities was excluded from home production, because it was transformed into money and put to use for commodity production as market expenditures. The classification of commodities follows the commodity set suggested by Gronau and Hamermesh (2006).[5] The detailed time allocation and expenditures for each commodity are presented in Table 1.

3.1.1 Relative Goods Intensity of Commodities and Selection

Following Gronau and Hamermesh (2003), the relative goods-intensity was defined by the ratio of goods to time inputs for a given commodity, to the ratio of total amount of goods and time allocated to commodity production as a whole:

$$RGTI^i = \frac{\text{expenditure}^i/\text{time}^i}{\sum_i \text{expenditure}^i / \sum_i \text{time}^i}$$

Table 2 presents the mean household monetary expenditures (pesos per day) on goods, the mean of the wives' time expenditures (minutes per day) for commodity production, and relative goods-intensity for each commodity. The intensity was calculated based on the means. Among the seven commodities, HEALTH was the most goods-intensive commodity, followed by MEALS, LODGING, APPEARANCE, CHILDCARE, LEISURE, and SLEEPING.[6] Even if the calculation was based only on the wife's time use without the time inputs of other family members, especially that of the husband, Table 2 presents the order of goods-intensities

[5] Out of 9 commodities defined by them, TRAVEL and MISCELLANEOUS are excluded due to lack of time use data on them.

[6] Contrary to the usual expectations, LODGING is time-intensive relative to the average commodity and no more goods-intensive than APPEARANCE. This relative time-intensity can be explained by the fact that more than 85% of the households reported that they have at least one house and do not pay any rent or mortgage. Given that rent or mortgage payments would comprise relatively large shares of expenditures compared to time spending, high household ownership percentages and a lack of mortgage payments explain why LODGING is classified as a relatively time-intensive commodity to the average commodity. Therefore, it is very likely that LODGING will be considered to be a relatively goods-intensive commodity, if we include the monetary value of accommodating services from a house.

among commodities reasonably well. Relative goods-intensities of commodities in other countries for which both husband and wife's time uses were taken into account for commodity production exhibit a similar relationship: in the United States and Israel, HEALTH was the most goods-intensive commodity, followed by LODGING, EATING, APPEARANCE, CHILDCARE, LEISURE and SLEEP (Gronau and Hamermesh 2006, p.5).

The prediction of equation (6) applies to any two commodities for which the relative goods/time intensities can be defined. For n commodities, $\frac{n(n-1)}{2}$ relative demands can be constructed and tested. For the empirical analysis of this study, however, only two commodities that mainly require the wife's time were selected: CHILDCARE and MEALS. Between these two commodities, CHILDCARE is time-intensive relative to MEALS.

The data set provides the survey results of 448 households over 4 rounds, which comprise 1,792 total observations. The number of observations reduces to 1,687 due to missing values either in time use and expenditures on MEALS and CHILDCARE or other demographic variables. Further, in order to avoid a possible substitution by other females for the wife's time for meal preparation and child care, only those households that do not have women older than 15 other than the wife herself were selected. This reduces the total observations to 1,196.

4 Empirical Specification

4.1 Empirical Construction of Zs

For empirical research, an additional assumption was made on the production side. The wife is a sole provider of the time for home production activities in the household.[7] Therefore, the

[7] The assumption that only women contribute to home production activities might be rather restrictive, given that we can easily imagine that husbands will provide appreciable amount of time for home production activities such as repairing and gardening. However, the household time allocation data of another Phillippine rural province, Laguna (Evenson 1978) show that as far as child care and food preparation are concerened, the assumption is not too excessive. In average, women spend 11 hours for child care and 20 hours for cooking per week, whereas men spend only 3 hours for child care and 1.5 hour for food preparation.

two inputs to each commodity production is expenditure on market goods and the relevant wife's time.

The major obstacle to the research is that Zs are unobservable. That is, the two inputs, market goods and time are observable, whereas the outputs are not. However, assuming that each commodity production technology exhibits constant returns to scale with no jointness, Z^i can be obtained by dividing the total cost with its unit cost of production:

$$Z^i = \frac{TC^i}{\text{Unit Cost}^i} \tag{7}$$

where superscript i stands for each commodity i.

The empirical specification proceeds with the assumption that the total cost function of each commodity Z^i is a translog. Imposing constant returns to scale, the total cost function of a commodity Z^i is defined by:

$$\ln TC^i = \alpha_0^i + \ln Z^i + \sum_l \alpha_l^i \left(d^i\right) \ln \tau_l^i + \frac{1}{2} \sum_l \sum_k \alpha_{lk}^i \ln \tau_l^i \ln \tau_k^i \tag{8}$$

where l and k denote inputs such as market goods and wife's time, α_0^i, α_l^i, and α_{lk}^i are parameters, d^i is a vector of demographic variables that affect cost of Z^i, and τ_l^i is a price of input l for Z^i. Symmetry implies $\alpha_{lk}^i = \alpha_{kl}^i$, and linear homogeneity in prices implies $\sum_l \alpha_l^i = 1$ and $\sum_k \alpha_{lk}^i = 0$.

The implicit price of the commodity Z^i is then defined as the exponent of the unit cost function:

$$\pi^i = \exp\left(\alpha_0^i + \sum_l \alpha_l^i \left(d^i\right) \ln \tau_l^i + \frac{1}{2} \sum_l \sum_k \alpha_{lk}^i \ln \tau_l^i \ln \tau_k^i\right) \tag{9}$$

Then, the commodity Z^i is derived by dividing the total cost of production, which is the sum of market expenditure and time costs (women's hourly wage[8] multiplied by the time

[8]Women's hourly wages are calculated by dividing their daily wages by the number of hours of outside work. For those women who do not have hourly wages either because they do not work, or they do not report, hourly wages are imputed. In doing so, first, wages of those women who work but do not report the data are predicted based on their demographic variables and the local labor market situations, such as age,

spent for production), by (9).

By differentiating (8) with respect to the input prices and applying the Shepherd's lemma, we extract the input share equations. Given the unobservability of the total output Z^i, only share equations can be estimated. Using the parameter estimates of the share equations, we can construct the predicted marginal cost up to a constant term α_0^i. Then, the $\hat{Z}$ is derived from equation (7) using the predicted marginal cost.

4.1.1 Share Equations for CHILDCARE Cost and MEALS Cost

Two inputs to each commodity production are the monetary expenditure and the wife's time spent for each commodity. With linear homogeneity in prices and symmetry, the share equations for MEALS cost are written as follows:

$$S_{kjt}^i = \alpha_k^i \left(d_{jt}^i\right) + \alpha_{kk}^i \ln \left(\frac{\tau_k^i}{\tau_l^m}\right)_{jt} + \omega_{ljt}^i \qquad i = c, m \tag{10}$$

where superscript c and m stand for CHILDCARE and MEALS, j is household, t is survey round, l and k are market expenditure and wife's time and $l \neq k$, ω_{ljt}^m is errors associated with cost-minimizing behavior. The disturbance term ω_{jt}^m includes a time invariant household specific random component as well as time varying error terms.

The demographic variables for CHILDCARE production include the age of the youngest child, the mother's monthly age, the average household monthly age, the number of children. The survey round dummies are also controlled. For MEALS production, additional controls are included such as the number of adults and the mother's nutritional knowledge score, of which the highest is 17 and the lowest is 1. The summary statistics of the explanatory variables are reported in Table 3.

After arbitrarily dropping the time input share equation in order to prevent singularity

weight by survey round, average height, body mass index, energy expenditure for work, population density in the municipality, and survey round dummies. Then, by pooling both types of women - those who work and those who do not work - the hourly wages of women are estimated irrespective of whether they were actually employed in the labor market after correcting self-selection with Heckman selection procedure. The selection equation includes a woman's age, and the age of her youngest child.

problem, the parameters are estimated with the random effect model. The results are reported Table 4. For CHILDCARE production,the age of the youngest child and number of children have statistically significant effects on the market expenditure share. As the relative price of market goods increases, the cost share of market goods decreases, although the effect is not statistically significant. Some observations have zero monetary expenditure or zero time expenditure for child rearing, which leads to market expenditure share of 0 and 1 respectively. In order to deal with this censoring problem, the random effect Tobit model was estimated and the results are reported in column (3) of Table 4. The coefficient estimates have the same sign as those of random effect estimation, and the two estimates do not show notable differences in terms of significance.

For MEALS production, except for the average household age, all the other demographic variables are significant at the conventional level. The own and cross price coefficients are also statistically significant (column (3) in Table 4). The share of market goods in the total cost of MEALS production increases with mother's age, number of children, number of adults, and the mother's nutritional knowledge. The positive effect of mother's nutritional knowledge on the market expenditure share reflects that most of the households in the data are semisubsistence households. Therefore, better knowledge of nutrition leads to more monetary spending on food to provide essential nutrients, rather than to improvement of taste and quality through increased food preparation time.

Using the parameter estimate of the relative price and the information on the cost shares, Allen elasticities of substitution were calculated. Evaluated at the sample mean shares, the cross elasticity of substitution between the time and market goods for CHILDCARE production is 1.19. The calculated elasticity is statistically significant. The two inputs for MEALS production are slightly substitutable (0.28) and the elasticity is statistically significant.

4.1.2 Reduced Form Relative Demand Estimation

The implicit prices of MEALS and CHILDCARE are constructed as in equation (9) up to the constant term using the parameter estimates reported in (2) and (3) in Table 4. After CHILDCARE ($\hat{Z}^c$) and MEALS ($\hat{Z}^m$) are obtained by dividing the total costs with each implicit price, the log relative demand between CHILDCARE and MEALS $\ln\left(\frac{\hat{Z}^c}{\hat{Z}^m}\right)$ is constructed. The summary statistics of $\hat{Z}^c$, $\hat{Z}^m$, and the implicit prices are reported in Table 3. The relative demand in the reduced form is estimated as follows:

$$\ln\left(\hat{Z}^c/\hat{Z}^m\right)_{it} = \beta_0 + \beta_1' \ln P_{it}^m + \beta_2 \ln \text{Wage}_{it} + \beta_{10} \ln \text{Wealth}_{it} + \beta_{11}' \text{Rounds} + \nu_{it} \qquad (11)$$

where $\beta_0 = \alpha_{e0}^c - \alpha_{e0}^m + \tilde{\beta}_0$, $\nu_{it} = (\xi^c - \xi^m)_{it} + \mu_{it}$, ξ^i is the disturbance term in the total cost for commodity Z^i, μ_{it} includes both time invariant random components as well as time varying error terms,[9] lnWage is the wife's log hourly market wage, lnWealth is the log mean wealth of the household for four rounds. The summary statistics of the explanatory variables are reported in Table 3.

The error term structure in the relative demand equation requires random effect estimation.[10] The estimation results are reported in Table 5. As is predicted by the theory, increases in wage both in levels and in logs have negative effects on the relative demand between CHILDCARE and MEALS. When a woman's opportunity cost of time increases by 10%, households decrease the consumption of CHILDCARE by 3% relative to MEALS.

The positive effect of lnWealth on the relative demand suggests that agents' demand for CHILDCARE increases faster than the demand for MEALS as wealth increases, violating the homotheticity assumption. However, the fact that the gross wage effects including both substitution and income effects on the relative demand are negative implies a greater neg-

[9] The constant terms in the total cost functions for each commodity (α_0^c, α_0^m) are subsumed in the constant term in the relative demand equation. The disturbance terms from the cost minimizing behaviors $\xi^c - \xi^m$ are also included in ν_{it}.

[10] In addition, due to the way the relative demand is constructed, there are intrinsic heteroschedasticities across observations. The heteroschedasticities are corrected through Jackknife sampling.

ative 'compensated' substitution effect between CHILDCARE and MEALS, supporting the prediction of the model. Columns (5) and (6) present fixed effect estimation results. The wage variables still have negative effects on the relative demand but they are not any more statistically significant due to efficiency loss associated with fixed effect estimation. The Hausman test result in Table 5 suggests that the hypothesis that the individual effects are uncorrelated with the wage cannot be rejected.

The interpretation of the negative substitution effects of wage is made difficult because all the effects are in relative terms. In order to make the interpretation simpler, I assume that we fix the consumption of MEALS by compensating the income when wages increase. On the consumption side, a 10% increase in wages decreases the demand for CHILDCARE by 3%, which is decomposed into 3% decrease in time and 3 % decrease in expenditures respectively. On production side, a 10% increase in wages substitutes market expenditures for time, as time becomes a more expensive input. The substitution effects on the production side will decrease time by 5.7% and increase market expenditures by 3.5%. Therefore, the overall effects of a 10% increase in wages are 8.5% decrease in time and 0.4% increase in expenditures for CHILDCARE.[11]

4.1.3 Structural Form Relative Demand Estimation

As is mentioned in Section 2.1, CES utility function satisfies all the assumptions imposed on the utility function in the model. Therefore, this paper proceeds to assume that the household maximizes a CES utility function over commodities (Z^i) .Then, the effect of wage on the log relative demand between CHILDCARE and MEALS derives as follows:

$$\frac{\partial}{\partial w}\ln\left(\frac{Z^c}{Z^m}\right) = -\frac{\sigma}{w}[\alpha_e^m\left(d^m\right) - \alpha_e^c\left(d^m\right) - \alpha_{ee}^c \ln\left(\frac{P^c}{w}\right) + \alpha_{ee}^m \ln\left(\frac{P^m}{w}\right)] \tag{12}$$

[11]These decomposed effects are calcuated using equations (8) and (10). First, equations (8) and (10) are evaluated at the sample mean. Then, they are evaluated again by incorporating a 3% decrease in Z^c from the sample mean and a 10% increase in wages. These total changes are decomposed into the two substitution effects. The consumption side substitution effects are the changes in each input when only Z^c changes and wages are held constant. The production side substitution effects are the changes in each input when only wages change given Z^c.

where σ is the elasticity of substitution, subscript e denotes market goods expenditures.

Using (7), the log relative demand can be rearranged as (i) of equations (13). Combining (i) with the two share equations, the following system of nonlinear equations can be estimated with the seemingly unrelated regression method:

$$
\begin{aligned}
i)\ \ln\left(\frac{TC^c}{TC^m}\right) &= \sigma \ln\left(\frac{\delta^c}{\delta^m}\right) + (1-\sigma)\left[\alpha_e^c \ln\left(\frac{P^c}{w}\right) - \alpha_e^m \ln\left(\frac{P^m}{w}\right) + \alpha_{ee}^c F^c - \alpha_{ee}^m F^m\right] + \varepsilon_{jc} \\
ii)\ S_{ej}^c &= \alpha_{e0}^c + \alpha_e^{c\prime} x_j^c + \alpha_{ee}^c \ln\left(\frac{P^c}{w}\right)_j + \varepsilon_{je}^c \\
iii)\ S_{ej}^m &= \alpha_{e0}^m + \alpha_e^{m\prime} x_j^m + \alpha_{ee}^m \ln\left(\frac{P^m}{w}\right)_j + \varepsilon_{je}^m
\end{aligned}
\tag{13}
$$

where j is each observation, $F^c = [\frac{1}{2}\ln P^{c2} - \ln P^c \ln w + \frac{1}{2}(\ln w)^2]$, $F^m = [\frac{1}{2}\ln P^{m2} - \ln P^m \ln w + \frac{1}{2}(\ln w)^2]$ and $\varepsilon_j = \left\{\varepsilon_{jc}, \varepsilon_{je}^c, \varepsilon_{je}^m\right\} \sim N(0, \sum)$ is a vector of disturbance terms either associated with unknown preferences or with cost minimizing behaviors.[12]

The estimation results are reported in Table 6. The estimates of production technologies are similar with the results of separate estimations of each share equation, in terms of signs and significance.

Using the parameter estimates of the nonlinear seemingly unrelated regression, the effects of wage on the relative demand defined by (12) are calculated for all 1,196 observations. The mean of the wage effects on the relative demand is -0.1086 and the standard deviation is 0.0981. The wage effect in the reduced form relative demand in Table 5 is -0.0843 and this is within one standard deviation of the mean effects of wage in the structural demand.

5 Other Issues

The prediction on the substitution effects between the two different commodities in a multiple commodity setting is based on strong assumptions on the utility function: that the utility function is homothetic, all the commodities are net substitutes of each other, and the

[12] For the identification purpose, $\alpha_0^c - \alpha_0^m$ in (i) is normalized to zero.

compensated cross-price elasticities are the same for all commodities. These strong assumptions might not always accord with reality. The comparison of the reduced form results and the structural form results in Section 4, however, suggest that the assumptions on the utility function are reasonably well met in the Bukidnon data set: the wage effects on the relative demand in both cases are fairly close to each other (-0.0843 vs. -0.1086).

However, there are other issues that were not addressed in this study. First, different gender roles in home production were not taken into account due to data unavailability. Questions such as how changes in male and female opportunity costs of time differentially affect their time allocations and consumption patterns depending on their roles in home production are important policy issues. However, incomplete information about time use of household members restricts the investigation of such a subject.

Second, the joint production and its implication were not considered. Given that both meal production and child care provision are predominantly women's duties, the two commodities could be jointly produced, making the interpretation of the empirical results difficult. There are possibilities that relative time-intensities among commodities might change when secondary time uses are taken into account in addition to the main time use. Also, the degree of joint production itself can change in response to wage changes. Given that joint production is a common practice in home production, incorporation of joint production in the analysis is necessary to draw correct inference on agents' response to time cost changes. Lack of information on the secondary time use in the current data set is another shortcoming that restrains further analysis.

The current study, therefore, suggests that adequate data collection is a critical prerequisite for further research. Specifically, collection of detailed data sets including but not limited to disaggregated time use of all the household members and both major and auxiliary time uses will be an essential task to undertake for future research.

6 Conclusion

In this study, I take advantage of a valuable data set that includes both time and market expenditures, the two inputs to home production and provide empirical evidence that verifies the core of the Becker model. The estimates of the structural form as well as reduced form relative demand between child care, representative of a time-intensive commodity, and meals, representative of a goods-intensive commodity, support the substitution effects from the former towards the latter with compensated wage increases.

Despite increasing consensus about the importance of home production in economic analysis, lack of appropriate data sets significantly limits empirical exploration of the theory. Given that the empirical evidence provided in this study is only one piece of numerous insights generated by the home production theory, it is vital to collect more appropriate data with a richer set of information to fully exploit the potential of the theory.

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Commodity	Time Use	Goods Expenditure
SLEEPING	sleeping	none
LODGING	cleaning, gathering wood, repairing, gardening, shopping for nonfood	fuel or light, household services[a] housing
APPEARANCE	laundry, personal care	personal care, non-durable[b] clothing/textile for adult[c]
MEALS	cooking, shopping for food, fetching water, eating	food, guest food
CHILDCARE	feeding, bathing, playing, breastfeeding,	education, clothing/textile for children[d]
LEISURE	visiting friends/relatives, attending meetings, church, fiesta, resting	recreation, cigarettes/alcohol
HEALTH	care for illness	health[e]

Note: [a]Expenditures on household services include wages to servants, drivers, launderers, guards and others.
[b]Non-durable household goods include detergent, soap, and matches.
[c,d]Predicted values based on the number of children (c), and the number of adults (d)
[e]Health expenses include medical care fees and drugs, traditional health fees (e.g., midwife, Seriyano, Mananambal, Hilot, Arbulario, Baylan) and drugs, and dental fees.

Table 1: Assignments of Inputs to Commodities

Commodity	Goods (peso/day)		Time (min/day)		RGTI
	Mean	S.D.	Mean	S.D.	
SLEEPING	0		538.72	75.78	0
LODGING	2.34	7.95	70.54	76.64	0.98
APPEARANCE	2.45	3.47	74.1	80.49	0.97
MEALS	32.22	22.15	237.39	108.02	4.00
CHILDCARE	2.28	4.93	71.84	100.63	0.94
LEISURE	3.11	5.9	255.25	168.46	0.36
HEALTH	0.97	3.56	3.67	44.23	7.79
TOTAL	42.45	35.64	1,251.49	192.23	1
TOTAL AVAILABLE	45.91	34.11	1,440		

Table 2: Relative Goods/Time Intensity of Commodities

Variables	**Obs**	**Mean**	**Std.**
Number of Adults	1,196	2.32	0.69
Age of Youngest Child	1,196	24.27	22.71
Number of Children	1,196	4.03	2.11
$\ln(P^m/\text{WAGE})^a$	1,196	0.005	0.58
lnWage	1,196	1.23	0.56
lnWealth	1,196	8.56	1.60
Mother's Age	1,196	377.44	78.72
Mean Household Age	1,196	183.46	54.29
Mother's Nutritional Knowledge	1,196	7.68	3.18
Wage	1,196	3.98	2.21
Z^c	1,196	3.37	4.08
Z^m	1.196	12.58	5.53
π^c	1,196	2.52	1.87
π^m	1,196	3.72	0.90

Note: [a] P^m is a price index for market goods for MEALS, which is equal to barrio median unit price of calories

Table 3: Summary Statistics of Demographic Variables, Wage, Prices, and Commodities

	CHILDCARE		MEALS
	(1)	(2)	(3)
Constant	-0.1712	-0.4025	0.3227
	(0.81)	(-1.27)	(6.25)**
Age of Youngest Child	0.0083	0.0127	—
	(12.44)**	(12.26)**	
Mother's Age	0.0003	0.0004	0.0003
	(0.66)	(0.69)	(2.36)*
Mean Household Age	0.0005	0.0007	0.0002
	(1.67)	(1.56)	(1.77)
Number of Children	0.0475	0.0631	0.0205
	(5.49)**	(4.86)**	(6.04)**
Number of Adults	—	—	0.0221
			(3.51)**
Mother's Nutritional Knowledge	—	—	0.0055
			(3.40)**
$\ln\left(\frac{P^c}{w}\right)$	-0.0148	-0.046	—
	(0.25)	(0.51)	
$\ln\left(\frac{P^m}{w}\right)$	—	—	0.1680
			(9.07)**
Elasticity of Substitution (Time)		-0.93	-0.48
		(3.27)*	(3.46)**
Elasticity of Substitution (Expenditure)		-1.52	-0.16
		(3.27)*	(3.46)**
Cross Elasticity of Substitution		1.19	0.28
		(3.27)*	(3.46)**
Round Dummy	Yes	Yes	Yes
Observation	1,196	1,196	1,196
No. Household	324	324	324

Note: t-statistics in parentheses. * significant at 5 percent; ** significant at 1 percent.
[a] P^c is a price index for market goods for CHILDCARE, which is normalized to 1.
[b] P^m is a price index for market goods for MEALS, which is equal to the barrio median unit price of calories.
Columns(1) and (3) use random effect estimation.
Column(2) uses random Tobit estimation.

Table 4: Parameter Estimates of CHILDCARE and MEALS Cost Functions

	Random Effect				Fixed Effect	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-2.223	-3.0643	-2.3920	-3.2968	-2.1808	-2.4573
	(6.37)**	(7.28)**	(5.29)**	(6.43)**	(4.41)**	(3.44)**
ln P^m	0.3058	0.3137	1.0736	0.4138	0.2341	0.8248
	(2.63)**	(2.70)**	(2.59)**	(2.65)**	(1.55)	(1.52)
lnWage	-0.0984	-0.0843	-.3769	-0.2997	-0.0656	-0.1583
	(3.75)**	(3.16)**	(4.04)**	(3.10)**	(1.3)	(0.52)
lnWealth	—	0.0878	—	0.0897	—	—
		(4.15)**		(4.28)**		
Round Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Hausman Test					0.19 (1)	0.24(1)
Observation	1,196	1,196		1,196	1,196	1,196
No. Household	324	324		324	324	324

Note: Robust t-statistics (Jackknife sampling) in parentheses.

* significant at 5 percent ** significant at 1 percent

Columns (1), (2), and (5) with P^m and wage in levels.

Columns (3), (4), and (6) with ln(P^m) and ln(wage)

Table 5: Parameter Estimates of the Reduced Form Relative Demand between CHILDCARE and MEALS

	(i) **Relative Cost**	(ii) **CHILDCARE**	(iii) **MEALS**
$\sigma \ln\left(\frac{\delta^c}{\delta^m}\right)$	0.2491	—	—
	(18.3)**		
σ	0.8359	—	—
	(51.44)**		
Constant	—	-0.2255	0.3012
		(1.46)	(6.16)**
Age of Youngest Child	—	0.0084	—
		(16.52)**	
Mother's Age	—	0.0003	0.0004
		(1.03)	(2.98)*
Mean Household Age	—	0.0005	0.0002
		(2.19)**	(2.42)**
Number of Children	—	0.0498	0.020
		(7.42)**	(8.25)**
Number of Adults	—	—	0.0292
			(5.52)**
Mother's Nutritional Knowledge	—	—	0.0048
			(4.24)**
$\ln\left(\frac{P^c}{w}\right)^{\text{a}}$	—	-0.0327	—
		(0.75)	
$\ln\left(\frac{P^m}{w}\right)^{\text{b}}$	—	—	0.1617
			(8.37)**
Round Dummy	Yes	Yes	Yes
Observation	1,196	1,196	1,196
No. of Household	324	324	324

Note: [a] P^c is a price index for market goods for CHILDCARE, which is normalized to 1.
[b] P^m is a price index for market goods for MEALS, which is equal to barrio median unit price of calories.

Table 6: Parameter Estimates of the Nonlinear Seemingly Unrelated Regression