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Direct estimation of household production functions

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THE DIRECT ESTIMATION OF HOUSEHOLD PRODUCTION FUNCTIONS

By

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Household production (HP) is the services and goods that households produce for themselves which they alternatively could have purchased on the market. Economists have attempted to value HP because previous studies have estimated the magnitude of HP to be between one-third and two-thirds of Gross National Product as governmentally measured in the United States.

One way of estimating the value of HP is to estimate household production functions. These functions also allow examination of household production behavior. Recently, empiricists have assumed the functional form of household production functions and have indirectly measured the variables necessary for estimating production functions. This study directly measures the necessary variables and consequently, avoids assumptions about the functional form of household production functions and the bias that may occur from using indirect measurements.

Several findings emerge from this study. First, direct estimation of household production functions is possible. Second, the assumptions and indirect measurements used by previous empiricists are inherently flawed, and their estimates should not be used to examine household production behavior. Third, unlike business firms, capital typically is not a significant input in household production functions. Fourth, while capital is often an insignificant input, capital tends to be a necessary input for most HP. For example, some capital is necessary to produce meals. Finally, the statistical evidence in this thesis indicates that households tend to operate according to economic principles provided by traditional neoclassical theories of the firm. Thus, perfectly competitive business firms and households tend to have similar production behavior even though their physical structures may differ.

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Acknowledgments

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Mr. Wicks deserves a tremendous amount of credit for the undivided attention he gave the project, this thesis, and me throughout the duration. His frequently heard booming voice used during our *brainstorming* sessions at our offices (including Stock's) not only improved my writing and communication skills, but provided me with an incentive to finish my thesis in a reasonable amount of time.

Finally, I wish to dedicate this thesis to my wife, Janelle. Although she did not provide the vocal attention and support that Mr. Wicks did, her patience and soft-spoken support proved invaluable in times of dire straits.

Chapter 1

OVERVIEW OF STUDY

The production of a good or service (output) involves combining current technology with a set of productive resources, e.g. labor and capital. A production function mathematically defines this production process in terms of a production possibility surface. Graphically, the production possibility surface is bounded, for example, by output on the vertical axis and capital and labor on the horizontal axes. Points lying on the surface depict the maximum attainable output given current technology and specified sets of resources. Points within the production possibility surface show situations where less than attainable output is being produced, i.e., resources are being used inefficiently and/or not at all. Points outside the surface represent unattainable quantities of output with the same technology and a set of resources. Therefore, any producing entity which combines productive resources with current technology has a production function defining a production possibility surface.

Households are producing entities. Hence, the previous description of production functions applies to households. Households combining productive resources with current technology produce output, or household production (HP). But what is household production? In 1934, Margaret Reid defined household production as:

> ...those unpaid activities which are carried on, by and for the members, which might be replaced by market goods, or paid services, if circumstances such as income, market conditions, and personal inclinations permit the service being delegated to someone outside the household group.[1]

This definition implies that HP is the production of goods or services at home which could be produced by a producing entity outside the home. For instance, laundry cleaning and clothing care could be done by a professional laundry service. Plumbing repairs such as changing the washer on a leaky faucet could be done by a plumber. We define HP as those goods and services produced at home for the household's *own consumption* which could alternatively have been purchased on the market. However, if a person builds a picnic table with intent to sell it on the market, that picnic table would not be HP.

One can measure HP directly or indirectly. Two indirect approaches, the opportunity cost and function cost approaches, measure HP based on labor hours spent engaging in HP.[2] The opportunity cost approach measures HP by multiplying total time spent on housework with average net-of-tax wages earned on the market. The function cost approach measures HP by multiplying time spent on various activities such as cooking, housekeeping, etc., by the market wages earned for those specific activities (e.g. cooking, housekeeping, etc.).

The direct approach measures HP by quantifying household output into physical units and multiplying those units by the prices of equivalent physical units

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[1]Reid (1934), P .11.

[2]See Chadeau (1985), Hawrylyshyn (1976), Gauger and Walker (1980), and Walker and Woods (1976).

available on the market.[3] For example, one can quantify the number of loads of clothing into physical units (e.g. ten loads of clothing) and multiply those units by the average charge per load by professional laundry services.

The above described approaches will most likely produce different values of HP.[4] Regardless of that fact, any estimated value of HP will show that HP has a significant impact on our total economy. In fact, current estimates indicate that the value of HP contributes an amount equal to one-third to one-half of measured Gross National Product (GNP) in our economy.[5] With such a large impact on GNP, we should be interested in the production behavior of households. The estimation of production functions allows us to make behavioral comparisons among different types of household members. We can also compare production behavior among different types of household activities. In addition, the direct estimation of household production functions allows us to substantiate which method of measuring HP is most appropriate.

Two economic schools of thought exist to explain household production behavior. The so-called "New Home Economics", founded by Gary S. Becker, argues that households behave rationally and according to traditional economic

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[3]John F. Fitzgerald and John H. Wicks, "Measuring the Value of Household Output: A Comparison of Direct and Indirect Approaches." Review of Income and Wealth, (forthcoming).

[4]Chadeau (1985) finds the opportunity cost approach yields lower estimates than the function cost approach, and argues the direct approach should yield even higher estimates than both indirect approaches. Alder and Hawrylyshyn (1978) find the two indirect approaches yield similar estimates while Murphy (1982) argues the opportunity cost approach will usually yield higher estimates than the function cost approach. However, Graham and Green (1984) argue the opportunity cost approach overstates the value of HP.

[5]see Chadeau (1985) or Murphy (1982).

principles.[6] In his article, "Theory of the Allocation of Time", he discusses how households maximize utility, given time and resource constraints. Becker argues households will maximize their utility by producing HP in accordance with cost minimization rules provided by neoclassical production theory of the firm.

The alternative school of thought argues households allocate resources towards the production of HP using a decision making process other than utility maximization and cost minimization.[7] Households may engage in HP activities because of traditional, biological, and socioeconomic reasons. Time constraints, physical limits on the size of households, and inherent values of household member types could cause an inefficient allocation of resources as defined by neoclassical theory. In addition, households produce goods and services which typically are not for sale on the market. Therefore, household goods and services will not be subjected to typical market conditions, and production behavior of households may be different from production behavior of firms as described by neoclassical production theory.

The research conducted for this thesis indicates that Becker's school of thought appears to apply to household production behavior. Neoclassical production theory requires producing entities to produce output where the marginal productivities of the inputs equal the prices of those inputs (assuming perfect competition). With household production, the husbands' and wives' labor are the most important inputs, and their market wage rates are the prices of their

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[6]See Becker (1965).

[7]See Green (1982).

labor. We find that the ratio of husbands' marginal productivity and wage rate is not significantly different from the ratio of wives' marginal productivity and wage rate for most HP activities. Thus, married couple households where both the husband and wife work appear to allocate resources according to rules provided by neoclassical theory of the firm.

Several other findings also emerge from this study. We find the marginal productivity of the husbands' labor is significantly greater than the marginal productivity of the wives' labor for a majority of HP. The law of diminishing marginal returns may explain this finding. According to the law of diminishing marginal returns, each additional unit of labor will add less and less to to total output. In the case of husbands and wives, the amount of HP the wives engaged in was significantly greater than the husbands' amount of HP for a majority HP activities. Therefore, the law of diminishing marginal returns requires wives to have smaller marginal products than husbands, ceteris paribus.

We also find married couple households tend to produce most HP in the range of constant returns to scale. Thus, if married couples double their productive inputs, e.g. labor and capital, then output will double. Furthermore, husbands and wives operate in Phase II of the short run production process for most HP activities, indicating positive but diminishing marginal products which are less than average products of labor. This latter finding also complies with rules provided by neoclassical theory of the firm.

Additional findings from this study indicate that using the direct approach for measuring the value of HP is more appropriate than indirect approaches. We find capital to be a necessary input for most HP activities. For example, we did not find any households that vacuumed without using a vacuum. Therefore, any measurement which does not include the value added by *all* inputs, including capital, will most likely be inaccurate. Previous empirical work estimate HP by using selected socioeconomic variables as a proxy for a householder's marginal productivity. Our study indicates virtually no relationship exists between a householder's marginal productivity and selected socioeconomic variables for a substantial majority of HP activities. Thus, the methodology of indirect approaches does not apply to household production behavior.

The previously stated empirical findings are the result of the following research procedures. First, we measured capital, labor, and output for a highly disaggregated array of household activities and several socioeconomic variables for each household member type.[8] Second, we conducted tests to determine which sample sets of our data were appropriate for estimating production functions. This procedure involved comparing production behavior among different household member types and household activities, and between married couple households with different socioeconomic characteristics. We wanted to avoid aggregating household member types who had entirely different production behavior, or aggregating types of output which are produced using a different production process.

We found that the socioeconomic status had no effect on the production process for husbands and wives. Therefore, we were able to aggregate all husbands together and all wives together.

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[8]We excluded children in our survey because other studies indicate children's contribution to total HP is relatively small.

Several interesting findings resulted from the previous procedure. For instance, we were able to see the effects of householder characteristics such as household member types and the socioeconomic status on the production process. However, these interesting findings are beyond the scope of this thesis and are not discussed in detail.

Using linear regression techniques on the appropriate sample sets, we directly estimated production functions of several possible forms and chose the form which best fit our data. The Cobb-Douglas production function appeared to have the best fit for most household member types and household activities. The estimated parameters associated with the Cobb-Douglas function provided us with measurements of marginal productivities of labor and capital, as well as returns to scale estimates. We then could compare husbands' and wives' marginal productivity and wage rate ratios for a significant difference.

In order to test phases of production, we first determined that the marginal products of labor were positive for all household member types by examining the estimated parameters of the Cobb-Douglas function. We then regressed household members' labor on their average products of labor (labor divided by output) and other socioeconomic variables. The sign (either positive or negative) associated with any significant estimated parameters indicated whether or not average products of labor were increasing or decreasing with respect to labor.

Regressing the marginal productivity of husbands' and wives' labor on selected socioeconomic characteristics allowed us to determine the validity of using indirect approaches for measuring the value of HP. Two procedures allowed us to determine the necessity of capital as an input in the HP process. First, we tested for a significant difference between the mean values of capital for those who engage in selected HP activities and those who do not. Second, we counted how many people engaged in specific HP activities without having any capital.

The most relevant problems with the above described procedures involved the measurement of capital and output, and the technique used to estimate productions functions directly.[9] First, capital is not an easy variable to measure and quantify.[10] We feel our survey technique allowed us to encompass a substantial portion of capital items that could be used for producing HP In addition, by making several assumptions about the use of capital for household production, we feel we overcame the problems of measuring capital for use in estimating household production functions.

Second, by disaggregating household activities into 148 individual HP activities, we were able to measure specific units of output for a substantial majority of household activities. We then could evaluate those units of output at prices of equal substitute goods available on the market, assuming market substitutes and corresponding household outputs provided equal utility to the consumer.

Third, the technique of estimating production functions directly produces some statistical problems.[11] The problems of multicollinearity, simultaneous-

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[9]Chapter 3 contains a detailed discussion about our measurement of capital and output. Chapter 4 discusses the techniques of estimation and the implications of those techniques.

[10]See Intriligator (1978), p. 263.

[11]See Intriligator (1978), p. 267.

equation estimation, and heteroskedasticity may cause biased results. However, as detailed in Section 3.5 of Chapter 3, these problems do not appear particularly applicable to HP. The questions we wish to answer in this thesis make the direct estimation approach more appropriate than indirect approaches.[12] Indirect approaches require assumptions about household behavior. For example, indirect approaches require assumptions about the functional form of the production function. We wanted to *estimate* the functional from of the production function. In addition, indirect approaches require accurate proxies for variables in the equations which may be unavailable in the case of HP. We measured our variables directly. We chose not to make any assumptions about household behavior or use any proxy variables.

The organization of this thesis is as follows. Chapter 2 contains a general review of literature pertaining to household production theory and past empirical approaches. The next chapter describes the data gathering process and the variables measured. Chapter 4 provides theoretical specification and estimation techniques of production functions utilized in this thesis. Chapter 5 includes the statistical results and an analysis of the empirical findings. Finally, Chapter 6 contains conclusive comments about the empirical findings and their implications, and provides ideas on further research in the area of household production.

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[12]Intriligator, p. 269.

Chapter 2

GENERAL REVIEW OF THE LITERATURE

2.1. Organization of the Chapter

This chapter contains theoretical and empirical groundwork conducted by economists involved with household production. Section 2.2 provides the theoretical framework created by Gary S. Becker. Section 2.3 details empirical work by Reuben Gronau. A discussion of John Graham and Carole Green's empirical work is presented in Section 2.4. Finally, Section 2.5 the criticizes past theoretical and empirical approaches.

2.2. Theoretical Work by Gary S. Becker

The theoretical work by Gary S. Becker provides the basis for most empirical work to date. Most economists who address the household production question refer to Becker's theories on time allocation and household utility maximization.

Becker defines household output as commodities, including leisure, which may provide households with utility.[13] For instance, attending a Broadway play, which involves one's time and the price of the ticket, provides utility. The attending of a Broadway play does not constitute household output according to our definition of HP. We did not measure leisure activities such as attending a

[13] Becker, p.495.

Broadway play because the definition of HP normally used by those who quantify HP excludes those types of activities. It appears appropriate to consider HP without simultaneously dealing with leisure, since that is how most economists deal with market employment.

The following equations and explanations summarize Becker's theoretical approach to household production.

$$U = U(Z_1, Z_2, \ldots, Z_n)$$

implies a utility function where Z_i's are defined by the production process

$$Z_i = f_i(X_i, T_i).$$

X_i is the vector of market goods or services purchased on the market, T_i is the vector of time inputs used in producing the i^{th} commodity, and Z_i is a vector of the household outputs.[14]

The previous equation constitutes Becker's production function. We can consider a portion of X_i as capital inputs and T_i as labor input. Households will combine time and capital market goods to produce household outputs, Z_i's, which satisfy household utility and are within a given set of time and resource constraints.[15]

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[14]The partial derivatives of Z_i with respect to both X_i and T_i are non-negatives which produces non-negative vectors for T_i, X_i, and subsequently, Z_i.

[15]The production function will not only produce household outputs, but household leisure as well. For example, households can combine a set of golf clubs with time and produce leisure. However, we do not consider leisure as a household product in this thesis.

The production of Z_i to maximize U_i has two constraints. The goods constraint is

$$\sum_{i=1}^{n} p_i X_i = I = V + T_w W$$

where p_i is a vector giving the unit prices of X_i, T_w is a vector giving the hours spent at work, W is a vector giving the earnings per unit of T_w, I is money income, and V is other income. The time constraint is

$$\sum_{i=1}^{m} T_i = T_c = T - T_w$$

where T_c is a vector giving total time spent at consumption and T is a vector giving the total time available. The production function, $f_i(X_i,T_i)$, can be expressed as two separate identity equations such that

$$T_i = t_i Z_i$$
$$X_i = b_i Z_i$$

where t_i is the time spent per unit of Z_i and b_i is that portion of X_i that is used to produce Z_i.

The goods and time constraint are not independent because one can convert his time into goods by working more on the market and spending less time engaged in HP or leisure. Thus, one constraint can be derived. Substituting the goods constraint into the time constraint provides this single constraint equation such that

$$\sum_{i=1}^{n} p_i X_i + \sum_{i=1}^{n} T_i W = V + TW.$$

This constraint can be written in terms of Z_i such that

$$\sum_{i=1}^{n} (p_i + t_i W) Z_i = V + TW$$

with $$\pi_i = p_i b_i + t_i W$$

$$S' = V + TW.$$

S′ represents money income achieved by household members, and π_i is the sum of the price of the market inputs and the time used per unit of Z_i. Hence, π_i is the full price of Z_i and is a function of the price of b_i and the price of a person's time, or W.

Households operating according to neoclassical economic theory will try to minimize the cost of producing HP and leisure, i.e., minimize π_i by setting the marginal productivities of b_i and t_i equal to the prices of b_i and t_i. In order to maximize utility, households will divide their time between work on the market (where wages are earned to purchase market inputs for production in the home) and time spent at home engaging in leisure or household production. The division of a person's time depends upon his utility function and his resource constraints.

Becker's theoretical framework adheres to neoclassical production theory of the firm. Instead of assuming profit maximizers, Becker assumes that households are utility maximizers. Becker recognizes that households operate much like a firm. "...that a household is truly a 'small factory': it combines capital goods, raw materials and labour to clean, feed, procreate, and otherwise produce useful commodities".[16]

2.3. Empirical Work by Gronau

With a previous lack of data available to estimate production functions directly for households, indirect methods have been designed. Reuben Gronau derives such an indirect method. He bases his production function on the estimation of the marginal productivity (MP) of labor using a set of socioeconomic characteristics for married coupled households. Gronau's data comes from a study called the Michigan Study of Income Dynamics.[17]

As with Becker, Gronau assumes that households maximize the following utility function.

$$U = U(X,L)$$

where L is leisure and X are goods and services that can either be purchased on the market or produced at home such that

$$X = X_h + Z.$$

Z represents goods produced at home and X_h are capital goods purchased on the

[16]Becker, p.496.

[17]Gronau (1980), p.410.

market. At this point, home production occurs by combining market inputs and time inputs such that

$$Z = f_H(X_h, H)$$

where H represents time spent engaged in HP and f_H is subject to decreasing marginal productivities for X_h and H. Two constraints, a budget and time constraint, exist. The budget constraint equals

$$X_m + X_h = WN + V$$

where X_m are capital goods produced at home that aid in the production of Z, W equals the wage rate, N equals work in the market, and V equals other sources of income. The time constraint equals

$$L + H + N = T.$$

T is the total time available for leisure, work, and HP. If a household member works in the market, then $N > 0$ and the following equilibrium results.

$$f_H = s = W$$

where f_H is the marginal productivity of work at home, s is the marginal rate of substitution between leisure and goods, and W is the wage rate. If a household member does not work in the market, then $N = 0$ and the equilibrium

$$f_H = s$$

exists. Figures 2-1 and 2-2 depict both equilibria situations where consumption goods and services are on the y-axis, and time is on the x-axis. In both figures, the production function crosses the x-axis where the total amount of time is available and the y-axis where the maximum attainable amount of goods can be produced or purchased. In Figure 2-1, the point of tangency, E_0, between the indifference curve, I_0, derived by a utility function and the production function, F_0, determines the amount of leisure time (the distance $0L_0$), the amount of time spent engaged in producing HP (the distance L_0T), and the amount of goods and services produced (the distance $0G_0$) by a non-working person. In Figure 2-2, the situation where the person is working, the production function can shift upward on the y-axis due to this person's ability to purchase more market inputs. Now a decision has to be made between working, leisure, and home production. I_2 represents the indifference curve derived by a utility function for a working person. The point of tangency, E_2, indicates the most preferred situation by this person. However, now less leisure time (the distance $0L_1$) is enjoyed. This person can buy goods and services on the market (the distance G_1G_2) by spending time working in the market (the distance L_1L_2). Home production is the distance $0G_1$ and time spent engaged in HP is the distance L_2T. Thus, the working person still can produce the same quantity of HP as a non-working person and additionally purchase more goods in the market, but must give up leisure time in order to work in the market.

In order to estimate the production function, Gronau assumes a functional

Figure 2-1: Preference by a Non-Working Person

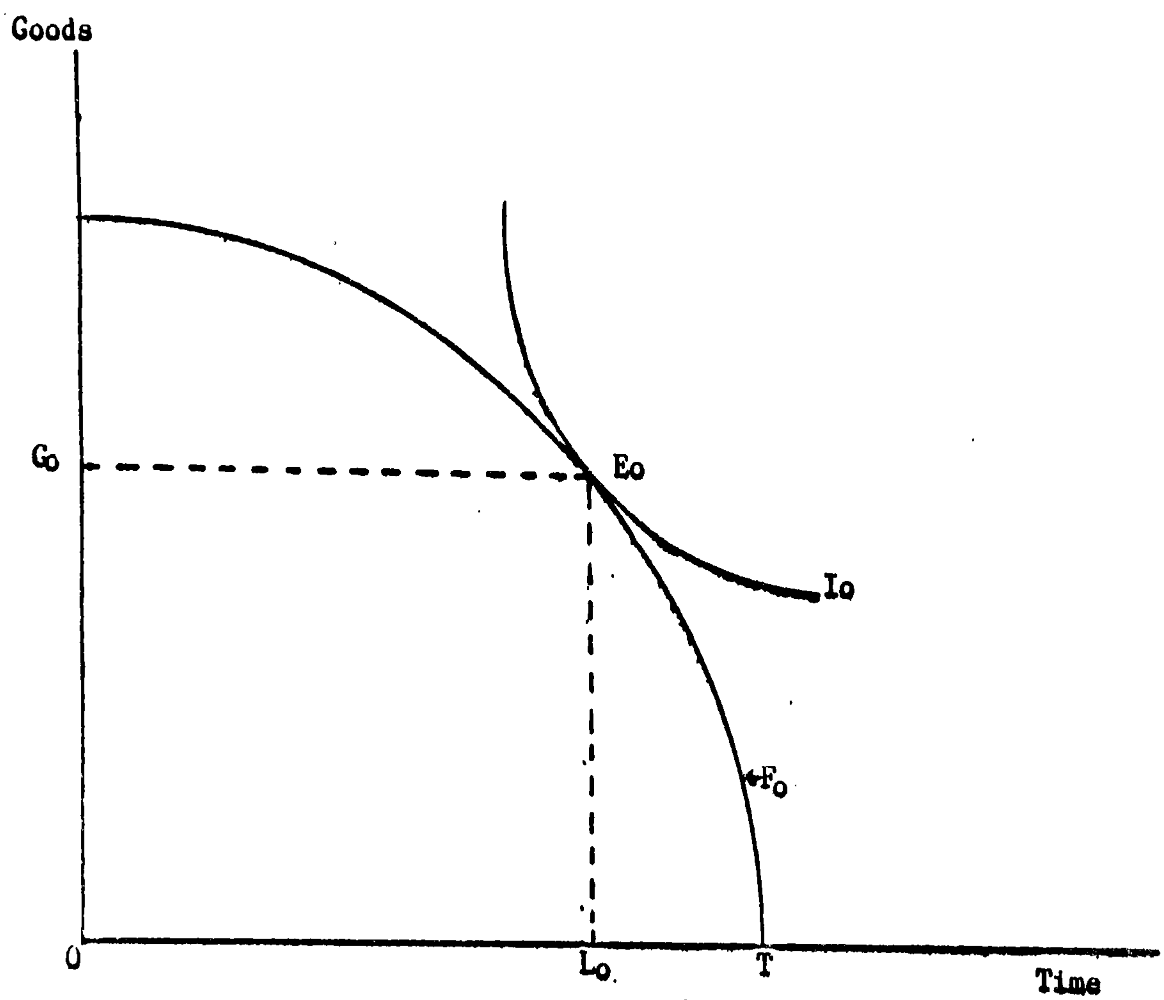
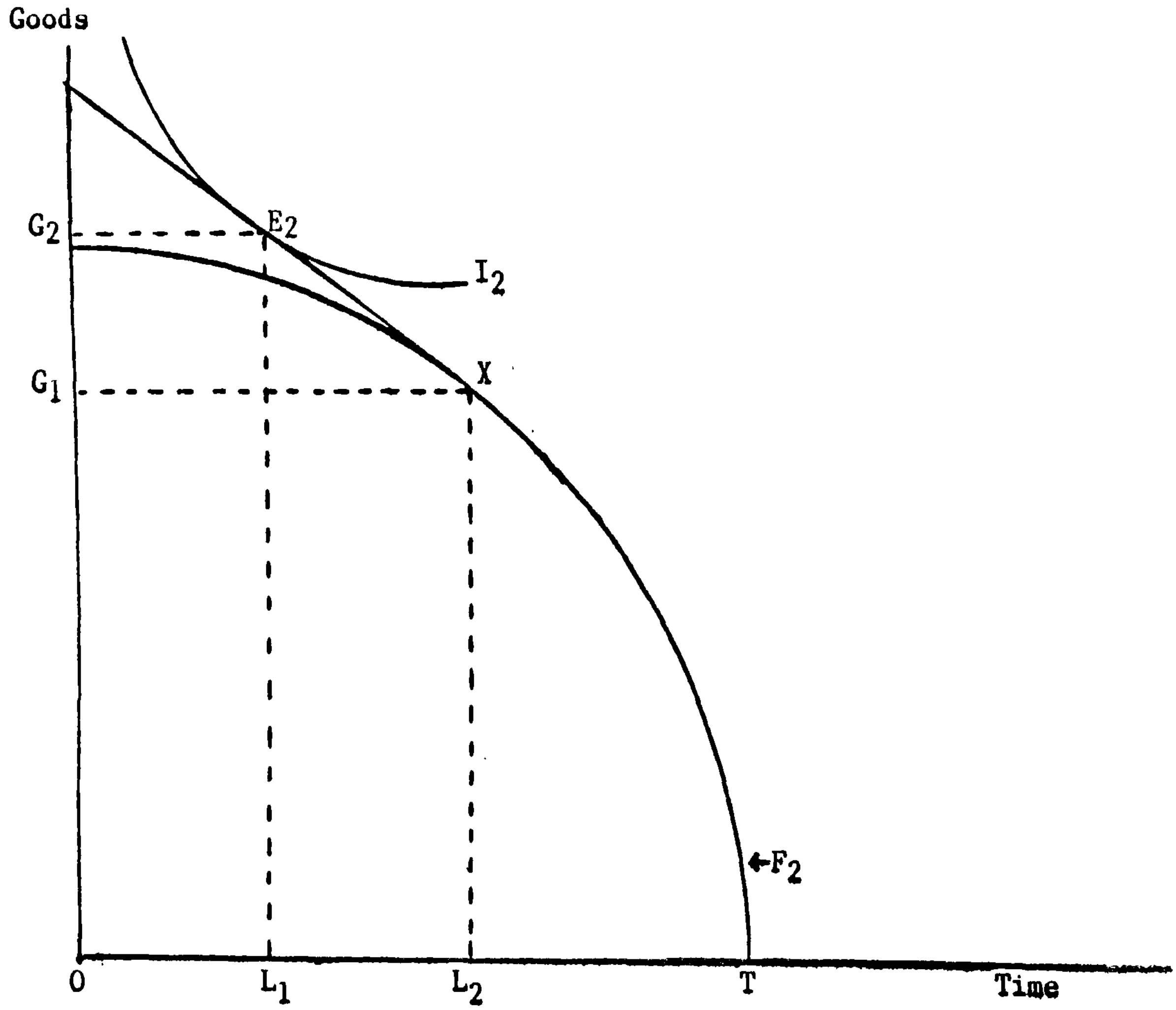


Figure 2-2: Preference by a Working Person



form of f_H.[18]

$$\ln f_H = \alpha_0 - \alpha_1 H + \alpha_2 Y$$

where Y denotes the socioeconomic effects on f_H and H denotes work done at home. Y includes the following variables: wife's age and education, husband's education and wage rate, the family's non-earned income, the number of children, the age of the youngest child, and the number of rooms in the house. Gronau then estimates HP by integrating f_H such that

$$Z = \{\exp(\alpha_0+\alpha_2 Y)[1-\exp(-\alpha_1 H)]\}/\alpha_1$$

where Z is the value of home production with the assumption that no home production exists when there is no work at home.

Gronau argues that work at home produces goods that are substitutes for market goods. His model implies that household production is simply a function of time spent engaged in HP and the socioeconomic variables that affect one's marginal productivity.

Gronau's model has some critical assumptions. The first involves the functional form of f_H. This function represents the marginal productivity of labor for home production. The vector Y, or the socioeconomic effects on the marginal productivity of labor at home, determines the function. Hence, Gronau implicitly assumes the vector Y will accurately determine the value of the marginal productivity of household labor.

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[18]Gronau, p.409.

The second assumption is that household capital is not a factor of production. The value added by employing capital to produce HP does not enter into Gronau's function. His estimate of HP is based solely on a person's labor hours and selected socioeconomic variables.

Finally, Gronau assumes, as do we, that home production time provides no utility as leisure. Physic utility derived from engaging in HP is beyond the scope of this study as well.

Gronau says, "Not only is the output Z unknown, but there is no direct way of separating X_M from X_H and measuring inputs (X_H) that are used in the process."[19] In the absence of directly measurable data -- e.g. Z and X_H -- Gronau uses indirect estimation techniques.

2.4. Empirical Work by Graham and Green

John W. Graham and Carole A. Green, in response to Gronau's method, developed another production function that is slightly more direct than Gronau's.[20] Utilizing Becker's theories, Graham and Green assume a utility function of the form

$$U = U(C, M_h L_h, M_w L_w)$$

where C equals goods and $M_h L_h$ and $M_w L_w$ are "effective" leisure of husband and wife, respectively. M_h and M_w represent a measure of productivity of labor and L_h and L_w measure leisure hours for the husband and wife, respectively.

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[19] Gronau, p. 409.

[20] See Graham and Green (1984).

The term "effective" comes from the notion that "since all human capital is embodied capital, an individual will carry it into all activities-work, leisure, and home production."[21] Thus, Graham and Green assume that the marginal productivity of leisure and the marginal productivity of labor at home are the same.

One can buy goods on the market or produce them at home such that

$$C = X_m + Z$$

where X_m are goods purchased in the market and Z represents goods produced at home.

The production of Z has the relationship

$$Z = Z(X_z, M_h^a H_h, M_w^a H_w)$$

where X_z represents market purchased inputs and $M_h^a H_h$ and $M_w^b H_w$ are the effective home production time for the husband and wife, respectively. H_h and H_w measure the time spent engaging in home production for the husband and wife, respectively.

Household have constraints on their time such that

$$l_i + H_i + N_i = T, \quad i = h,w$$

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[21]Graham and Green (1984) derive this notion by using an argument about embodied capital provided by Robert Michael (1972).

where T equals total time and ι_h and ι_w represent time spent neither engaged in HP nor work in the market, respectively. Thus, leisure would be defined as $\iota_h+\iota_w$. However, Graham and Green allow leisure to also occur when a person is engaged in HP such that leisure, L, is defined as

$$L_i = \iota_i + g(H_i), \quad i = h,w$$

where g(H) satisfies

$$0<=g'(H)<=1$$

$$g''(H)<0$$

$$\lim_{H \to 0} g'(H)=1$$

$$\lim_{H \to T} g'(H)=0.$$

As a person's time spent engaging in HP increases, i.e., as H→T, leisure experienced from engaging in HP decreases and vice versa. Hence, each additional hour of HP will add less and less to the value of leisure.

Households also have a budget constraint. The budget constraint is represented by

$$X_m + X_z = W_hN_h + W_wN_w + v$$

where v is nonlabor income, W_h and W_w are the hourly wages of the husband and wife, respectively, and N_h and N_w are the hours of work in the market for the husband and wife.

Graham and Green then assume the Cobb-Douglas production form such that

$$Z = A(M_h^a H_h)^{\lambda_h}(M_w^b H_w)^{\lambda_w} X_z^{\beta}$$

where Z is HP, A is a scale parameter, X_z equals the market purchased inputs, and $(\lambda_h+\lambda_w+\beta)$ is the returns to scale parameter. $M_h^a H_h$ and $M_w^b H_w$ represent the home-oriented skills of human capital for the husband and wife, respectively. The positive parameters, a and b, can be less than, equal to, or greater than 1, depending on how productive an individual is at home compared to work.

In order to estimate this function, the first order-conditions are derived and equated to the wage rate of the inputs (taking into consideration that time spent on home production can be total leisure, no leisure, or part leisure and part HP). Thus, three equations are derived such that

$$\frac{\partial z}{\partial X_z} = 1$$

$$\frac{\partial z}{\partial H_h} = W_h\left(\frac{H_h}{T}\right)^{\delta_h}$$

$$\frac{\partial z}{\partial H_w} = W_w\left(\frac{H_h}{T}\right)^{\delta_w}$$

The above partial derivatives are then simultaneously solved in terms of H_w and expressed in a log-linear form such that

$$\ln H_w = c' + \frac{1}{q}\ln A + \left\{\left(\frac{\gamma_h}{1+\delta_h}+\beta-1\right)\ln W_w\right\}/q$$

$$-\left\{\left(\frac{\gamma}{1+\delta_h}\right)\ln W_h\right\}/q + \frac{b\gamma_w}{q}\ln M_w$$

$$+\frac{a\gamma_h}{q}\ln M_h$$

where c′ is a constant and

$$q = (1-\beta)(1+\delta_w) - \gamma_w - \frac{\gamma_h(1+\delta_w)}{1+\delta}.$$

At this point, Graham and Green estimate the following equation using cross-sectional data.

$$\ln H = c + k\ln A + \iota\ln W_w + m\ln W_h + n\ln M_w + o\ln M_h$$

is the log-linear equation which will provide estimates for δ_h, δ_w, β, λ_h, λ_w, a, and b.

From the previous equation, Graham and Green obtain five equations with seven unknowns by substituting the estimates of the log-linear equation into the equation estimated by solving the partial derivatives simultaneously in terms of H_w. The five equations are

$$a\gamma_h = o/k$$

$$b\gamma_w = n/k$$

$$\frac{\gamma_h}{1+\delta_h} = -m/k$$

$$\beta = (k+\iota+m)/k$$

$$b = -n/\{1+\iota(1+\delta_w)\}$$

with γ_h, γ_w, β, δ_h, δ_w, a, and b representing the seven unknowns. Thus, they have a system underidentified by two. To alleviate this problem, Graham and Green variously assume values for two or more of the unknowns. For example, they assume constant returns to scale, i.e., $\lambda_h + \lambda_w + \beta = 1$, and $\delta_h = 0$. This allows the five equations to be solved simultaneously with five unknowns.

In order to estimate the value of HP, Graham and Green needed to estimate the value added by capital, or X_z in their Cobb-Douglas production function. However, they did not have a direct measurement of capital. Therefore, Graham and Green imputed a total value of market goods used in home production by using personal consumption expenditures provided by the July 1977 *Survey of Current Business.*

Graham and Green assume that the education of the husband and the age and education of wife can indirectly determine the marginal productivities of the husband and wife, respectively. They also assume that their indirect measure of capital accurately estimates the true value of households' capital.

2.5. Criticisms of Past Empirical Approaches

Previous empirical work attempts to estimate HP by using assumptions about the functional of the HP function, by using indirect measurements of the variables used to estimate the models, and/or by excluding important variables in the HP process. Gronau and Graham and Green assume the functional form of their models. The functional form of a production function should be estimated and not assumed if one is to learn the complete production behavior of households, and that estimation is possible.

The previous authors also use proxies for variables used to estimate their production functions. Graham and Green use a person's age and level of education as a proxy for her marginal productivity of labor. Section 5.4 of Chapter 5 shows no relationship exists among a person's age, education, and her marginal productivity. A likely reason for this empirical result is because of the simplistic nature of most HP activities. For instance, a person's age and education would have very little effect on his ability to vacuum a floor. If a person is not mentally or physically incapacitated and has reached an age where she is able to operate a vacuum cleaner, then she can effectively vacuum a floor regardless of her age and educational attainment.

While Graham and Green include an indirect measurement of capital as an HP input, Gronau excludes capital in his estimation of the value of HP If capital is a necessary input in the HP process, the conceptually correct measurement of HP should include the value added by all inputs, including capital. Section 5.6 of Chapter 5 indicates capital is a necessary input in the HP process

Previous empirical attempts to estimate production functions represent the best approaches thus far. However, directly measuring all the variables used to estimate household production functions facilitates more precise explanation of household behavior. The research for this thesis allows us to exclude uncertainties resulting from relying on assumptions and using proxies for production function variables.

Chapter 3

THEORETICAL FRAMEWORK OF PRODUCTION FUNCTIONS

3.1. Chapter Organization

The main purpose of this thesis is to estimate household production functions using directly measured data. We chose to examine several commonly used production functions: the constant elasticity of substitution production function (CES), the Cobb-Douglas production function, the transcendental production function, and the translog production function.[22] Section 4.2 examines the CES product function using the two input model. The next section formulates the Cobb-Douglas production function using the two input model. Section 4.4 introduces the transcendental production function and the translog production function. Section 4.5 addresses the econometric implications of different estimation techniques used to estimate the Cobb-Douglas function. The last section addresses the criteria used to determine the best fitting model.

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[22] See Intriligator (1978), pp. 266-280.

3.2. Specification and Estimation of the CES Production Function

3.2.1. Theoretical form of the Function

A commonly used production function, the CES (constant elasticities of substitution) production function, assumes homogeneity (as defined in Section 3.3) and varying elasticities of substitution for inputs such that

$$Y = A[\delta L^{-\beta} + (1-\delta)K^{-\beta}]^{-\eta/\beta}$$

where A is a scale parameter, δ is the parameter indicating the relative distribution of the inputs L and K, β is the substitutability of inputs parameter, and η indicates the returns to scale.[23] $\eta = 1$ implies constant returns to scale, i.e., for every increase in the quantities of inputs we get an equal increase in quantity of output. $\eta > 1$ implies increasing returns to scale, and $\eta < 1$ implies decreasing returns to scale. Holding $A>0$, $0<\delta<1$, and $\beta>=-1$, the CES satisfies two reasonable conditions for production functions, that the marginal productivity (MP) of inputs be positive and that these marginal products are diminishing. In mathematical form,

$$\frac{\partial Y}{\partial L}, \frac{\partial Y}{\partial K} > 0$$

and

$$\frac{\partial \partial Y}{\partial L}, \frac{\partial \partial Y}{\partial K} > 0.$$

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[23]See Arrow, Chenery, Minhas, and Solow (1961).

Interpreting β, the substitutability parameter, may best be done by graphical example.[24] For instance, let β equal the extreme value of −1. The elasticity of substitution for inputs approaches infinity and the CES function reduces to

$$Y = A[\delta L + (1-\delta)K]$$

which represents the perfectly linear isoquant in Figure 3-1. If β approaches positive infinity and the elasticity of substitution for inputs approaches zero, then the CES function approaches the input/output production function depicted by the L-shaped isoquant in figure 3-1. Finally, if β approaches zero, the elasticity of substitution for inputs approaches one and the CES function reduces to

$$Y = AL^{\delta}K^{(1-\delta)},$$

the curved isoquant in Figure 3-1. This last case approaches the Cobb-Douglas production function which will be explored in detail later in this chapter.

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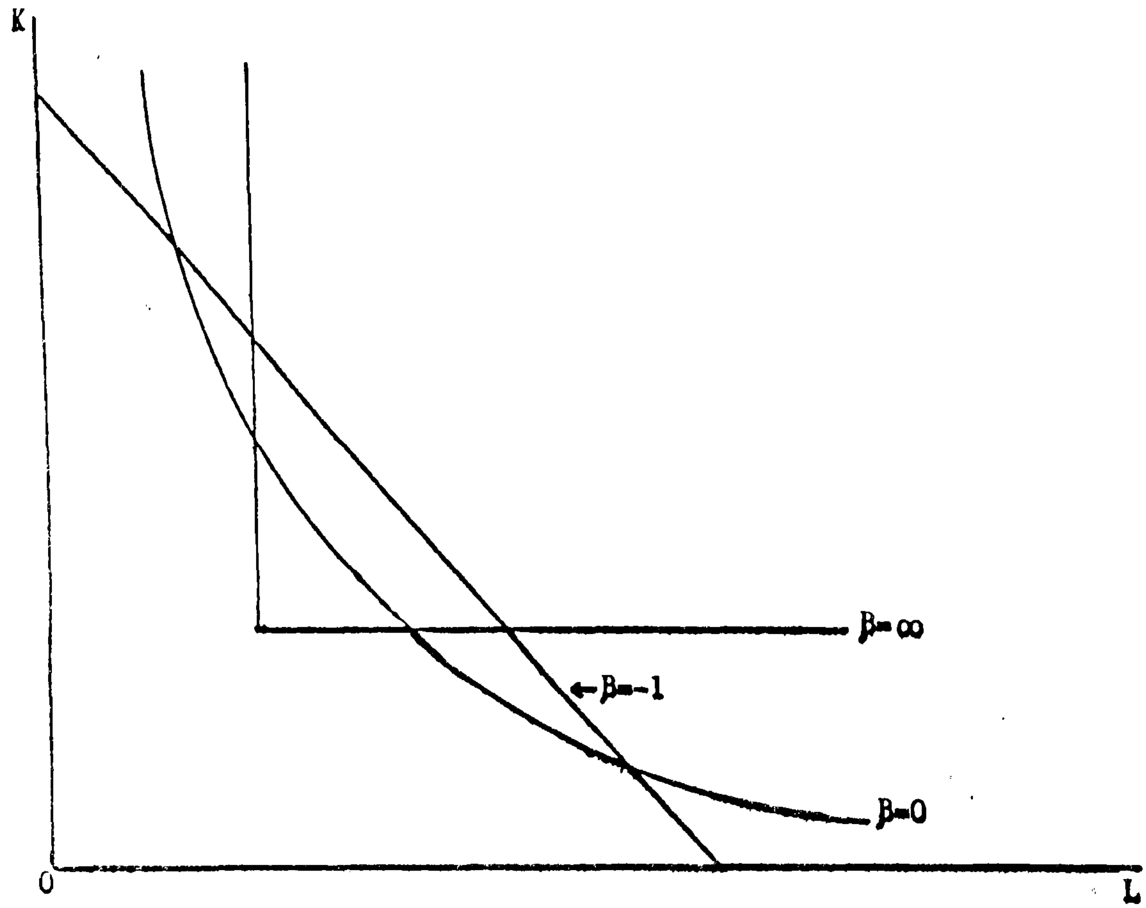
[24]This example assumes constant returns to scale.

Figure 4-1: Isoquants of the CES Function Using Different Values of β



3.2.2. Estimating the CES Function Using Assumptions

One can estimate the CES production function by assuming a profit maximization situation or directly by employing non-linear regression techniques. If one assumes constant returns to scale and profit maximization, the marginal productivity of labor can be written as

$$\frac{\partial Y}{\partial L} = A'\left(\frac{Y}{L}\right)^{1+\beta}$$

where A′ is a constant. Setting marginal product equal to the real wage rate implies

$$A'\left(\frac{Y}{L}\right)^{1+\beta} = w/p.$$

By solving for Y/L (labor productivity),

$$\frac{Y}{L} = A''\left(w/p\right)^{1/1+\beta}.$$

We can perform a linear transformation on the CES production function such that

$$\ln(Y/L) = a + \frac{1}{1+\beta}\ln(w/p) = a + \sigma\ln(w/p), \quad a = \ln A''.$$

This equation relates output per worker to the real wage. a and σ are constants with σ being the coefficient of ln(w/p). Through least-squares regression analysis, we can estimate a and σ based on empirical measurement of Y, L, and w/p. Assuming constant returns to scale, β can be estimated by equating $\sigma = 1/(1+\beta)$.

3.2.3. Estimation of the CES Function Directly

Unfortunately, the previous method of estimation requires significant assumptions. The purpose of this thesis involves direct estimation without having to make heroic assumptions. Direct estimation is made possible by using non-linear regression (or maximum likelihood) techniques.[25] This method involves four steps. First, we calculate a linear approximation of the CES function with respect to β using a Taylor series formula. Using linear regression techniques, we can estimate the parameters associated with the approximated linear equation. Third, we take the estimated parameters of the approximated linear equation and substitute them back into our original equation. This step provides us with the initial starting values necessary for non-linear regression estimation. The last step simply takes the initial values and substitutes them into the non-linear equation. A computer that does non-linear regression will iterate around the initial values until a solution to the CES function is obtained.

The following example will make more clear the procedure used for non-linear estimation of the CES function. The CES production function is of the form

$$Y = A[\delta L^{-\beta}+(1-\delta)K^{-\beta}]^{-\eta/\beta}$$

By using a Taylor series formula, we can express an approximate linear equation of the form

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[25] See Kmenta (1986).

$$\ln Y = \alpha_1 + \alpha_2 \ln K + \alpha_3 \ln L + \alpha_4 [\ln K - \ln L]^2 + \varepsilon.$$

We estimate the α's using linear regression techniques. The initial starting values of the parameters of the CES can be expressed in terms of the estimated α's such that

$$A = \alpha_1,$$

$$\delta = \frac{\alpha_2}{\alpha_2 + \alpha_3},$$

$$\eta = \alpha_2 + \alpha_3,$$

$$\beta = \frac{-2\alpha_4(\alpha_2 + \alpha_3)}{\alpha_2 \alpha_3}.$$

If the estimate of α_4 is not significantly different from zero, then β approximates zero and the CES function approaches the Cobb-Douglas and further non-linear estimation is not required. Otherwise, we substitute the initial values above into the CES function and estimate the population parameters of the CES function using non-linear regression techniques. This technique allows us to determine directly whether or not the CES function fits our data better than other functions.

3.3. Specification and Estimation of the Cobb-Douglas Production Function

3.3.1. Theoretical Form of the Cobb-Douglas Production Function

The CES function is actually a generalized form of another common production function, the Cobb-Douglas production function.[26] The Cobb-Douglas model involves the following equations and explanations:

$$Y = AK^{\alpha}L^{\beta}$$

$$\alpha, \beta > 0$$

where Y is output, A is a shift parameter, K is the capital input, L is the labor input, and α, β are the returns to scale parameters. If $\alpha+\beta$ equals 1, we have constant returns to scale. If $\alpha+\beta>1$, we have increasing returns to scale and vice versa. The Cobb-Douglas function assumes unit elasticities of substitution for inputs and constant elasticity of output with respect to each input everywhere on the production surface. Another assumption is that of homogeneity, i.e., $\alpha + \beta = k$ (the returns to scale parameter), exists everywhere on the production surface. These assumptions cause the curvature of the isoquant in Figure 3-1 where $\beta = 0$.

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[26] See Douglas (1948) or Nerlove (1965).

3.3.2. Estimation of the Cobb-Douglas Using Assumptions

As with the case of the CES function, we can estimate the Cobb-Douglas function by assumption or by direct estimation. Several estimation by assumption techniques exist. One method assumes perfect competition and profit maximization which equates the marginal productivity of inputs with the price of those inputs. We can express this relationship as

$$\frac{\partial Y}{\partial L} = \alpha \frac{Y}{L} = \frac{w}{p}.$$

$$\frac{\partial Y}{\partial K} = \beta \frac{Y}{K} = \frac{r}{p}.$$

α and β equal the elasticity of output with respect to labor and capital, respectively. w/p and r/p are the real prices of labor and capital, respectively. Rewritten in terms of α and β,

$$\alpha = (w/L)/(pY),\ \beta = (r/K)/(pY).$$

pY is the value of the output while wL and rK are the payments to labor and capital, respectively. The total value of output equals the sum of labor's and capital's payments which implies

$$pY = wL + rK.$$

This satisfies the condition that $\alpha+\beta=1$. The Cobb-Douglas can then be expressed in log-linear form such that

$$\ln Y = \ln A + \alpha \ln L + (1-\alpha)\ln K + u.$$

In turn, we can express the log-linear Cobb-Douglas function in a form that will yield an equation relating output per worker to the capital-labor ratio.

$$\ln\left(\frac{Y}{L}\right) = a+(1-\alpha)\ln\left(\frac{K}{L}\right)+u.$$

We can now estimate a and $(1-\alpha)$, where α is the elasticity of labor and $(1-\alpha)$ is the elasticity of capital, using linear regression techniques. Empirical measurement of Y, L, and K is necessary for this estimation technique and is used primarily to avoid the problems associated with direct estimation discussed in Section 3.5.

Another indirect approach also estimates by assumption and has the advantage of not requiring measurements of capital. Again, assuming constant returns to scale, profit maximization, and perfect competition, we can express the share of labor income in output such that

$$\alpha = \frac{wL_i}{pY_i} = s_L, \quad \beta = 1 - \alpha$$

where s_L is the share of labor in total output. With the assumption of constant returns to scale, the share of labor in total output provides estimates of both α and β.

A third indirect approach again assumes profit maximization, perfect competition, and constant returns to scale such that the Cobb-Douglas in log-linear form is

$$\ln\frac{Y}{L} = \ln\frac{w}{p} - \ln\alpha.$$

The constant intercept estimated using linear regression provides an estimate of α. Assuming constant returns to scale, $\beta = 1 - \alpha$. Again, one only needs empirical measurement of Y and L to use this estimation technique.

3.3.3. The Direct Estimation of the Cobb-Douglas Function

The direct approach simply estimates the log-linear form of the Cobb-Douglas such that

$$\ln Y = \ln A + \alpha \ln L + \beta \ln K + u$$

where u, the stochastic error term, will account for variations in the technical or productive capabilities of different producing entities. This transformation allows us to use linear regression to estimate the parameters α and β based on actual measurements of Y, L, and K without assuming constant returns to scale, perfect competition, or profit maximization.

3.4. Specification and Estimation of Generalized Forms of the Cobb-Douglas Production Function

The CES function, as mentioned before, represents a generalization of the Cobb-Douglas. Other generalizations of the Cobb-Douglas exist as well. One generalization is the transcendental production function of the form

$$Y = AL^{\alpha}K^{\beta}e^{\alpha' L + \beta' K}$$

where A>0 and α', $\beta' < 0$.[27] The log-linear form is

$$\ln Y = a + \alpha \ln L + \beta \ln K + \alpha' L + \beta' K$$

which reduces to the Cobb-Douglas if α' and β' are not significantly different from zero. This function relaxes the assumptions of unit elasticity of substitution and constant elasticity of output. By relaxing these assumptions, we can examine the degree for which household members can substitute their labor for capital, or for each other's labor if more than one person engages in HP within a household.

Another generalized form of the Cobb-Douglas, the translog production function, is represented in log-linear form as

$$\ln Y = a + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta (\ln L)^2 + \varepsilon (\ln K)^2,$$

where this function approaches the Cobb-Douglas as γ, δ, and ε approach zero. This function allows non-unitary elasticity of substitutions as well.[28]

Again, we can directly estimate the parameters for either the transcendental or translog production functions using linear regression techniques. The generalized forms allow more freedoms in terms of the assumptions required when estimating the Cobb-Douglas and allow one to see whether or not the Cobb-Douglas is more appropriate. Other generalized forms exist, but are not considered in this thesis.

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[27]See Intriligator (1978), p. 279.

[28]See Intriligator (1978), p. 280.

3.5. Econometric Implications of Direct Estimation Techniques

Intriligator (1978) points out several econometric problems associated with direct estimation techniques. First, lnL and lnK tend not to be independent of one another, causing possible problems with multicollinearity.[29] Another problem lies in the interdependence of lnL and lnK with lnY, i.e., lnL and lnK are endogenous variables jointly determined by lnY. This can lead to problems of simultaneous-equation estimation.[30] In addition, the variance of the stochastic error term may not be constant due to variables left out of the equation. This can lead to problems associated with heteroskedasticity.[31] Green (1982) also argues variables such as unknown variations in quality, variations in technology from producing unit to producing unit, different factors of production, and unpredicted inputs such as weather can can cause the problems associated with heteroskedasticity and simultaneous-equation estimation.[32]

If we assume that household production is used specifically to fulfill the needs and desires of the people who produce HP, then we argue that variations in quality will not be a factor in determining the relationship between inputs and output. In addition, if we estimate production functions for similar household member types living in a given, quite homogeneous area, then the variations in

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[29]See Koutsoyiannis (1985), pp. 233-256.

[30]Koutsoyiannis, pp. 331-336.

[31]See Koutsoyiannis (1985), pp. 181-196.

[32]Green (1982), p. 47.

weather, productive factors and their capabilities, and technologies will be minimized. Hence, the effects of heteroskedasticity and simultaneous-equations estimation are minimized.

Table 3-1 contains the coefficients of determination between the independent variables of labor and capital for the Cobb-Douglas production equation applied to the categories of output described in Table 4-1 in Chapter 4 by household member type (as described in Table 4-2 in Chapter 4). As Table 3-1 indicates, the degree of multicollinearity is relatively low in most cases. In addition, the effects of multicollinearity (based on varying degrees of multicollinearity) have not been theoretically established.[33] Hence, we argue multicollinearity is not a problem with our model.

Both the direct estimation and the estimation by assumption methods have their pros and cons. As Intriligator points out: "None of these methods dominates the other. Each is appropriate in particular situations, depending on what can be assumed and what is to be investigated."[34] We measured the necessary variables directly in order to estimate production functions directly without making any assumptions. Therefore, we argue that direct estimation is appropriate in this situation.

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[33] See Koutsoyiannis (1985), p. 233.

[34] Intriligator (1978), p.269.

Table 3-1: Coefficients of Determination, (r^2_{LK}), between Labor and Capital for the Cobb-Douglas Production Function

(Household Member Type)

Category	01*	02*	03*	04*	05*	06*
inside cleaning	.0003	.0331	.1347	.1998	.3306	.2694
outside cleaning	.0384	.0437	.1884	.1267	.2153	.0294
child care	-	.0259	-	-	-	-
meal prep.	.0108	.0256	.0123	.0123	.0022	.1452
clothing care	-	.1089	.6889	.0380	.4160	-
repairs & maintent.	.0428	.0225	-	-	.0713	-
harvest nature	.2285	.0428	.2652	-	.0864	.3832
home furnish.	.0130	.0196	-	.0595	-	-
repairs & improve.	.1096	.0123	-	.0045	-	-

- denotes less than 20 cases observed.
* refer to Table 4-2 on page 50 for household member type descriptions.

3.6. Criteria Used to Determine the Best Model

The criteria used to select the best fitting model is simply based on the statistical significance of the estimated parameters and the goodness of fit (R^2 adjusted) of the models. A t-test determines the statistical significance of the estimated parameters and an F-test determines the significance of the R^2 adjusted.[35] The t-test is given the most weight in the selection process due to the nature of the models tested. If the t-test does not indicate the best model, then the size and significance of the R^2's adjusted becomes the deciding factor. The results reported in the next chapter indicate the Cobb-Douglas is the best fitting model and is used throughout the rest of this thesis.

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[35] See Koutsoyiannis (1985) for definition and examples of t-tests and F-tests.

Chapter 4

THE DATA COLLECTION PROCESS

4.1. Chapter Overview

Chapter 2 described empirical approaches used to estimate household production functions. Most of the criticism concerning past approaches evolved because of the data used for analysis. Our data collection process allowed us to avoid the problems encountered by past empiricists. This chapter discusses how we measured the variables essential for estimating production functions. Section 4.2 describes the origins of the sample. The third section discusses the variables measured by the survey which are used for estimating household production functions. Section 4.4 describes the categories of household output we created for analysis and the household member types whom we examined. Section 4.5 discusses how we placed values on some of the variables allowing us to create the categories of output described in Section 4.4. The last section focuses on the survey method used to gather the variables essential for estimating household production functions.

4.2. Origins of the Sample

The focus region of our study was the Missoula, Montana urban area. The Missoula urban area had a population of approximately 65,062 people with approximately 26,009 housing units as of the 1980 Census. There existed around 2.5 persons per household in 1980. Median household income was $19,473 in 1979. The 1980 census defined 48 area neighborhoods of which we sampled 44. The remaining four neighborhoods were dissimilar to the other 44, i.e. were located a considerable distance from Missoula's city limits or contained largely University of Montana dormitories.

4.3. The Variables Used for Estimating Production Functions

4.3.1. Introduction

The most important variables measured were household output, labor, and capital. The output variable measured the number units of production completed by a household member. For example, cleaning the garage one time represented one unit. When two or more members of a household produced the same type of output, we obtained a separate output estimate for each member. Household labor measured the total time spent by each household member engaged in a given activity, e.g., a husband spent *twelve* hours cleaning the garage last year. The capital variable measured the total amount of capital items households had for use in their homes. In our example of garage cleaning, a household may have had a shop vacuum in addition to a broom to use for cleaning the garage.

As mentioned in Chapter 1, household output and capital are typically harder to measure than labor. Thus, further discussion about the procedures we used to measure household output and capital is required.

4.3.2. Disaggregation Procedure used to Measure Output

In order to measure output in units, we disaggregated household production into specific household activities. We disaggregated household output for two reasons. First, disaggregation allowed the surveyor to prompt the memory of the person interviewed about a substantial portion of HP activities the person interviewed may have done in the past. Second, disaggregation allowed us to measure household activities in specific physical units. Thus, we could distinguish between a physical unit of vacuuming and a physical unit of mowing the lawn. Engaging in an activity until the activity was completed represented one unit of HP for that specific activity. Appendix A contains a copy of the survey form which includes the disaggregation of household activities.

4.3.3. Process Used to Measure Capital

We measured capital by creating a capital inventory check list that included as many capital items we could identify that could be used for household production. Appendix B contains the check list. The person interviewed checked those capital items she had available within the household. Each item was valued as explained in Section 4.5. We then determined which of the capital items would likely be used to produce each type of HP output and summed the values of these items.[36] Many household capital items, e.g screwdrivers, are quite versatile and were thus included in the capital value sums for a number of different outputs.

We simplified the survey by excluding measurements of the precise number of capital items available to households. This procedure implicitly assumes that a household can use only one of a given type of capital at a time, e.g. use only one shovel to dig a post hole even though the household owned two shovels. We also assumed that if a household indicated it owned a capital item, then that item would be used in the HP process. For instance, if a household had a microwave, then the household member that engaged in preparing meals would use that microwave to help prepare meals. In addition, we assumed capital items 1 through 118 in Appendix B were homogeneous in terms of their productive capabilities. Thus, a $2 screwdriver was considered as productive as a $4 screwdriver.

4.3.4. The Socioeconomic Variables

We obtained a number of the socioeconomic characteristics for each household, e.g. the number of children living at home and for each adult member the age, years of education, weekly hours of market employment, and average two-week take home pay. Appendix A lists all of the measured socioeconomic variables.

The above socioeconomic variables allowed us to select households with predetermined characteristics. For instance, we could examine only those households that have more than three children or those households that earn

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[36]For example, a person can use a broom, a mop, and a scrub bucket to clean a kitchen floor or a person can use a hydraulic jack, a tire iron, and a compressor to change a flat tire.

more than $20,000 per year. Hence, we could disaggregate the sample according to the socioeconomic criteria we felt necessary for analysis.

We used the socioeconomic variables listed above to check the validity of the sample sets analyzed in this thesis. For example, we found we could aggregate all husbands together and all wives together regardless of their socioeconomic status. We also used the socioeconomic variables to answer questions concerning married couple households. First, do married couple households with both the husband and wife working in the market equate their marginal productivities of labor at home to their market wage rates? Second, can selected socioeconomic characteristics accurately serve as a proxy for a husband's or wife's marginal productivity at home? Chapter 5 provides these results.

4.4. The Aggregation of Categories of Output and Disaggregation of Household Member Types

Clearly, not all HP activities are produced using the same types of capital or the same labor (in terms of skills required). Therefore, we created nine different categories of output, with each category containing household activities that require essentially the same types of capital and labor to produce them. From a production viewpoint, each category contains homogeneous outputs, i.e., outputs which are similar in nature, how they are produced, etc. Table 4-1 describes those categories of output.

In addition, we hypothesized that all household member types did not have similar production behavior. Tests in Chapter 5 substantiate this hypothesis. Thus, we separately analyzed six household member types. Table 4-2 describes those household member types. Most analysis involves husbands and wives due to the paucity of observations for the other member types.

4.5. Valuing the Capital and Output Variables

In order to aggregate household activities into the categories of output described in Table 4-1, we needed to express the different types of output and capital items within each category in similar terms. One possible method involves expressing output and capital in terms of their market values.[37] HP can be expressed in market value terms by multiplying the number of physical units produced per year by the average market value of each individual output. We determined the average market value per unit for each HP activity specified in our questionnaire by surveying a sample of local vendors which produced equivalent products. For example, to price washing loads of laundry, we obtained the prices that different laundry services in the Missoula area typically charged for washing and drying one load of laundry. We used the mean of those prices. The value of any significant inputs purchased from other firms -- e.g. parts for auto repairs, food for meal preparation -- was subtracted from the total price to obtain a net market price.

Some units of output required a different pricing scheme. For instance, the price of vacuuming was included in the total price of cleaning a house. We multiplied the total amount a firm charged for cleaning a house by the percentage of time spent just vacuuming.

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[37]See Intriligator (1978), pp. 262-263 for a discussion of measuring output, labor, and capital.

Table 4-1: Categories of Household Production

Category Name	Description
Category A cleaning inside house	Household activities such as vacuuming, bed making, kitchen cleaning, etc.; outputs 1-12 in Appendix A.
Category B cleaning outside house	Activities such as garage cleaning, lawn raking, etc.; outputs 13-20 in Appendix A.
Category C child care	Activities such as feeding, bathing, and changing children; outputs 21-24 in Appendix A.
Category D meal preparation	Activities such as grocery shopping, setting the table, dish washing, etc.; output 25 in Appendix A.
Category E clothing care	Activities such as washing, drying, and mending clothing; outputs 26-29 in Appendix A.
Category F repairs & maintenance	Activities such as electrical and plumbing repairs, vehicle tune-up, etc.; outputs 30-39 in Appendix A.
Category G harvest from nature	Activities such as hunting, fishing, berry gathering, etc.; outputs 40-44 in Appendix A.
Category H home furnishings	Activities such as building bookshelves, knitting an afghan, sewing a sweater, etc.; outputs A-KK in Appendix A.
Category I home repairs & improvements	Activities such as building a new deck, fixing a broken window, etc.; outputs 42A-43P in Appendix A.

Table 4-2: Household Member Types

Identification #	Description
01	Husbands living with their wives
02	Wives living with their husbands
03	Single male heads of households
04	Single female heads of households
05	Male roommates
06	Female roommates

Calculating the value of a person's output for an activity simply involved multiplying the number units produced by a person by the equivalent market price for that activity. Hence, we now could aggregate different output activities into the categories described in Table 4-1.

Calculating the value of capital involved a similar procedure. We visited local sellers of the capital items on the inventory check list to obtain the retail price of those capital items. We assumed that already purchased capital items in households were worth less than the original market value. Thus, we depreciated the value of capital items 1-118 in Appendix B by 50 percent.[38] Major household capital items (the first eight items in Appendix B) were not depreciated because they had a used market value for them which we obtained from the survey of local vendors. As with output, we aggregated capital items into the categories of output specified in Table 4-1.

4.6. Survey Method

Two survey methods exist for measuring the important variables of home production: the recollection approach and the daily diary approach.[39] The daily diary approach is the traditionally used survey method, especially for the labor value method.[40] This approach surveys people on a daily basis and includes

[38] 50 percent was chosen arbitrarily. However, if household A has a gross market value of capital equal to $500 and household B has a gross market value of capital equal to $250, then household A has twice the value of capital than household B. Therefore, the depreciation used will not effect the value relationship between the two households.

[39] See Martha S. Hill (1985), pp. 210-211.

[40] Hill, p. 211.

information on time spent in various activities on a given day or set of days. The accuracy level should be high for frequently done activities. However, many major household output activities are not done or completed during short periods of time. The building of a front porch may take weeks, depending on the time constraint of the individual. If the porch was not completed during the daily dairy survey, then estimation of the portion of the project completed on a given day would be necessary and difficult at best. Furthermore, many infrequent activities would be missed during the survey period.

The recollection approach asks people surveyed to recall, for a given time period, the number of units of output produced and the time spent producing those units. The time period to recall could be daily, weekly, monthly, or yearly. For instance, the respondent could recall that he typically spent thirty minutes a day making three beds. On the other hand, she could recall spending approximately thirty hours building a front porch ten months ago. Those outputs that are done on a daily basis, such as bed making, seem likely to be recalled accurately. Those outputs that are done infrequently may be forgotten and not stated during the interview. This could cause some output categories to be understated and total HP underestimated.[41] However, as long as both output and time spent are commensurably understated, the relationship between output and labor will be unaffected. In addition, this underestimation concern was the main reason we highly disaggregated household output as previously described. The high degree of disaggregation creates a reminder list for the respondent so that frequent and infrequent activities would have more chances of being recalled.

[41]Hill, p. 219.

We used the recollection approach in this study. The reasons for this were threefold. First, we wanted to minimize any wrong estimation of HP for projects that take a considerably long time to complete. Second, we wanted to capture those activities which are done infrequently. Third, the daily diary approach would have been impractical due to the large time commitment required by both the person interviewed and the surveyor.

Chapter 5

ANALYSIS OF THE EMPIRICAL WORK

5.1. Chapter Organization

This chapter contains the empirical results obtained using the production function estimations methods described in Chapter 3. Section 5.2 reviews the sample sets used for analysis and contains descriptive statistics about those sample sets. The next section provides tests to determine the validity of the sample sets. Section 5.4 reports the results of the production function equations tested and discusses which production functions have the best overall fit when applied to the sample sets. The following section theoretically interprets the estimated parameters of the Cobb-Douglas production function. Finally, Section 5.6 analyzes the empirical findings as applied to married couple households.

5.2. Sample Sets Used for Analysis

5.2.1. Introduction

As reported in Chapter 4, our survey measured a household member's output and labor hours, a household's capital inventory, and several socioeconomic variables for each person. We developed 71 sample sets from the data. These sets include categories of output A through I (as described on page 49) and 62 individual output activities (e.g. floor vacuuming, lawn mowing) where at least twenty people of a given member type engaged in HP. Each production function model discussed in Chapter 3 was tested separately for each of the 71 sample sets for various household member types. These tests determined which model had the best overall fit as detailed in Section 3.6.

The following analysis only includes the categories of outputs for each household member type and not the individual activities. There are several reasons for this limitation. First, when disaggregating by specific household activities, sample sizes became too small for most household member types. Thus, comparisons among household member types were not possible. Second, the production of many individual activities was similar to the production of the categories into which the individual activities fell. For example, cleaning the bathroom and cleaning the kitchen require similar types of labor and capital. The results for the specific activities were not much different from the results obtained using the sample sets of the categories of outputs. Also, as Appendix A indicates, our survey consisted of 148 different individual household activities of which 62 had more than 20 people in the sample set. Analysis of the individual sample sets would have entailed more effort and reporting (in terms of tables needed) than we felt worthwhile for this thesis.

5.2.2. Descriptive Statistics for the Sample Sets

Tables 5-1 through 5-10 report the means, standard deviations, and cell counts of household output (in $ terms) for all outputs combined and each category of output for each household member type. Tables 5-11 through 5-20 provide the same statistics for household labor hours, while Tables 5-21 through 5-30 contain the statistics for household capital (in $ terms). The means and standard deviations are calculated using only those people who engaged in a category or categories of HP activities.

Wives produce the most output at an average of $12,658 per year. They also devote the most time to HP, a yearly average of 1,779 hours. Male roommates produce the least output, an average of $3,710 per year. Married couple households contain the highest average value of capital stock, $3,665. Female roommate households have the least average capital stock value, $1,794. Meal preparation accounts for 42 percent of the total value of HP for all people combined; its value averages $4,378 per year per household.

Table 5-1: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(All HP Activities Combined (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$7,676	$10,141	443
Husbands	4,857	14,336	142
Wives	12,658	7,649	142
Single Male Heads	5,283	2,624	36
Single Female Heads	8,924	6,026	40
Male Roommates	3,710	1,922	50
Female Roommates	5,478	4,019	33

Table 5-2: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category A: Inside Cleaning (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$1,471	$1,363	396
Husbands	400	562	101
Wives	2,530	1,455	139
Single Male Heads	1,283	780	36
Single Female Heads	1,818	965	40
Male Roommates	675	473	49
Female Roommates	1,249	1,026	31

Table 5-3: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category B: Outside Cleaning (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$438	$750	352
Husbands	655	779	135
Wives	331	708	101
Single Male Heads	228	270	26
Single Female Heads	604	1,201	33
Male Roommates	106	172	36
Female Roommates	128	261	21

Table 5-4: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category C: Child Care (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$3,938	$4,739	42
Husbands	1,552	1,729	11
Wives	5,382	5,063	28
Single Male Heads	-	-	0
Single Female Heads	2,190	948	3
Male Roommates	-	-	0
Female Roommates	-	-	0

Table 5-5: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category D: Meal Preparation (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$4,3781	$3,600	325
Husbands	2,803	2,621	34
Wives	6,539	4,221	138
Single Male Heads	2,467	968	35
Single Female Heads	3,955	2,454	40
Male Roommates	2,175	962	46
Female Roommates	2,522	935	32

Table 5-6: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category E: Clothing Care (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$1,306	$1,406	245
Husbands	389	321	14
Wives	1,623	1,244	138
Single Male Heads	545	369	24
Single Female Heads	1,454	2,287	29
Male Roommates	545	246	23
Female Roommates	1,337	2,013	17

Table 5-7: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category F: Repairs & Maintenance (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$535	$1,256	210
Husbands	432	549	111
Wives	478	936	39
Single Male Heads	1,053	2,780	17
Single Female Heads	178	174	10
Male Roommates	644	2,145	22
Female Roommates	1,081	1,789	11

Table 5-8: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category G: Harvest from Nature (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$185	$364	213
Husbands	232	450	91
Wives	122	224	56
Single Male Heads	135	180	22
Single Female Heads	83	72	12
Male Roommates	275	468	26
Female Roommates	78	94	6

Table 5-9: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category H: Home Furnishings (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$1,421	$12,740	158
Husbands	4,607	26,303	37
Wives	430	511	65
Single Male Heads	300	263	11
Single Female Heads	533	1,085	24
Male Roommates	268	260	7
Female Roommates	583	1,755	14

Table 5-10: Means, Standard Deviations, and Cell Counts for the Value of Household Member Type's Output

(Category I: Home Repairs & Improvements (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$1,124	$2,396	265
Husbands	1,788	3,443	111
Wives	663	1,048	84
Single Male Heads	720	739	19
Single Female Heads	700	658	23
Male Roommates	630	963	17
Female Roommates	293	216	11

Table 5-11: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(All HP Activities Combined (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	896	963	443
Husbands	339	373	142
Wives	1,779	931	142
Single Male Heads	785	458	36
Single Female Heads	1,207	580	40
Male Roommates	492	241	50
Female Roommates	747	862	33

Table 5-12: Means, Standard Deviations, and Cell Counts Household Member Type's Labor

(Category A: Inside Cleaning (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	295	358	396
Husbands	81	112	101
Wives	535	466	139
Single Male Heads	199	145	36
Single Female Heads	319	203	40
Male Roommates	102	137	49
Female Roommates	238	271	31

Table 5-13: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category B: Outside Cleaning (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	32	42	396
Husbands	50	47	135
Wives	24	40	101
Single Male Heads	15	19	26
Single Female Heads	34	40	33
Male Roommates	9	18	36
Female Roommates	8	14	21

Table 5-14: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category C: Child Care (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	294	425	352
Husbands	93	95	11
Wives	387	493	28
Single Male Heads	-	-	0
Single Female Heads	162	35	3
Male Roommates	-	-	0
Female Roommates	-	-	0

Table 5-15: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category D: Meal Preparation (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	584	450	325
Husbands	372	408	34
Wives	834	467	138
Single Male Heads	424	295	35
Single Female Heads	636	417	40
Male Roommates	266	145	46
Female Roommates	292	178	32

Table 5-16: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category E: Clothing Care (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	200	216	245
Husbands	82	68	14
Wives	261	250	138
Single Male Heads	118	144	24
Single Female Heads	164	129	29
Male Roommates	79	44	23
Female Roommates	149	180	17

Table 5-17: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category F: Repairs & Maintenance (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	21	35	210
Husbands	20	27	111
Wives	18	20	39
Single Male Heads	26	59	17
Single Female Heads	6	6	10
Male Roommates	29	64	22
Female Roommates	23	43	11

Table 5-18: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category G: Harvest from Nature (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	88	174	213
Husbands	120	225	91
Wives	56	82	56
Single Male Heads	80	85	22
Single Female Heads	38	37	12
Male Roommates	85	202	26
Female Roommates	63	116	6

Table 5-19: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category H: Home Furnishings (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	61	167	158
Husbands	19	33	37
Wives	77	122	65
Single Male Heads	22	20	11
Single Female Heads	42	65	24
Male Roommates	39	45	7
Female Roommates	173	479	14

Table 5-20: Means, Standard Deviations, and Cell Counts of Household Member Type's Labor

(Category I: Home Repairs & Improvements (in Hours))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	23	56	265
Husbands	38	78	111
Wives	12	21	84
Single Male Heads	26	64	19
Single Female Heads	7	7	23
Male Roommates	7	9	17
Female Roommates	2	2	11

Table 5-21: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(All HP Activities Combined (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$3,085	$1,451	443
Husbands	3,665	1,267	142
Wives	3,665	1,268	142
Single Male Heads	2,417	1,672	36
Single Female Heads	1,904	907	40
Male Roommates	2,067	826	50
Female Roommates	1,794	1,120	33

Table 5-22: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category A: Inside Cleaning (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$100	$60	396
Husbands	108	63	101
Wives	110	63	139
Single Male Heads	84	42	36
Single Female Heads	99	58	40
Male Roommates	78	53	49
Female Roommates	73	56	31

Table 5-23: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category B: Outside Cleaning (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$292	$314	352
Husbands	371	345	135
Wives	353	321	101
Single Male Heads	290	362	26
Single Female Heads	153	94	33
Male Roommates	90	93	36
Female Roommates	62	80	21

Table 5-24: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category C: Child Care (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$6	$1	42
Husbands	6	1	11
Wives	6	1	28
Single Male Heads	-	-	0
Single Female Heads	6	0	3
Male Roommates	-	-	0
Female Roommates	-	-	0

Table 5-25: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category D: Meal Preparation (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$1,263	$464	325
Husbands	1,304	369	34
Wives	1,447	437	138
Single Male Heads	1,050	520	35
Single Female Heads	1,027	369	40
Male Roommates	1,182	334	46
Female Roommates	1,073	556	32

Table 5-26: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category E: Clothing Care (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$419	$224	245
Husbands	491	266	14
Wives	440	213	138
Single Male Heads	392	214	24
Single Female Heads	416	231	29
Male Roommates	323	196	23
Female Roommates	362	284	17

Table 5-27: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category F: Repairs & Maintenance (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$229	$196	210
Husbands	261	196	111
Wives	283	210	39
Single Male Heads	181	190	17
Single Female Heads	70	41	10
Male Roommates	162	171	22
Female Roommates	71	39	11

Table 5-28: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(for Category G: Harvest from Nature (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$745	$693	213
Husbands	849	699	91
Wives	859	723	56
Single Male Heads	717	739	22
Single Female Heads	216	418	12
Male Roommates	275	468	26
Female Roommates	588	697	6

Table 5-29: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category H: Home Furnishings (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$539	$420	158
Husbands	724	456	37
Wives	650	418	65
Single Male Heads	393	434	11
Single Female Heads	273	116	24
Male Roommates	310	331	7
Female Roommates	218	172	14

Table 5-30: Means, Standard Deviations, and Cell Counts of the Value of Household Member Type's Capital

(Category I: Home Repairs & Improvements (in $'s))

Household Member Type	Mean	Standard Deviation	Cell Count
All People	$595	$521	265
Husbands	719	533	111
Wives	697	513	84
Single Male Heads	510	547	19
Single Female Heads	111	75	23
Male Roommates	334	271	17
Female Roommates	141	153	11

5.3. Tests to Determine the Validity of the Sample Sets Used for Analysis

5.3.1. Introduction

Table 5-1 shows the value of output for all household member types and HP activities combined. When estimating production functions, several problems arise when aggregating household members types and household outputs together. First, if different household member types have different skill levels, productive capabilities, etc., then problems of heteroskedasticity and simultaneous-equation estimation as discussed in Section 3.5 of Chapter 3 are likely. These problems may also occur within a particular household member group. For example, husbands with differences in age, education, income, etc. may have different production behavior. We want to minimize these problems by grouping household members with similar production behavior. Second, not all HP activities are produced using the same types of labor skills and/or capital. Therefore, we want to aggregate only those activities which require essentially the same types of labor skills and capital to produce them. Section 4.4 of Chapter 4 discusses the aggregation procedure and describes the categories of output we use for analysis.

5.3.2. Test to Determine Differences in Capital among Different HP Activities

To consider further whether or not we aggregated HP activities appropriately with respect to the types of capital used, we use an Analysis of Variance (ANOVA) test.[42] The ANOVA tests the hypothesis that the mean values of capital vary more among the categories of output than within each category of output. A F-Ratio of 246.00 results when we apply the ANOVA test to our data set. The mean values of capital statistically vary more among the categories of output than within the categories of output. Assuming the value of capital is associated with the types of capital used, the ANOVA results indicate that our output categorization described in Table 4-1 on page 50 was appropriate.

5.3.3. Test to Determine Differences in Production Behavior among Household Member Types

We hypothesize that the different household member types described in Table 4-2 on page 51 have different production behavior and thus should not be aggregated together. A quasi analysis of variance following the technique of Graybill[43] provides a test for our hypothesis. Graybill's technique tests whether or not the estimated regression equations (these are reported in Tables 5-61 through Tables 5-69) significantly vary more among household member types than within each household member type.[44] Table 5-31 reports the results. In seven output

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[42]See Koutsoyiannis (1985), pp. 140-151 for ANOVA discussion.

[43]See Graybill (1976), pp. 284-294.

[44]It will be later shown that the estimated equations in Tables 5-61 through 5-69 are most appropriate in explaining household production behavior.

categories for which there were sufficient data to test, the production functions differ significantly more among the household types than within each household member type.[45] Therefore, our analysis involves each household member type separately.

5.3.4. Test to Determine Differences in Production Behavior within Household Member Types

In addition to the tests conducted above, we also want to see if differences in HP behavior as measured by the estimated parameters of production function equations (listed in Tables 5-61 and 5-69) exist within household member types having different socioeconomic characteristics. A F-Ratio test provided by Chow[46] allows us to test for any differences within household member types having different socioeconomic characteristics. This analysis is restricted to husbands and wives only because of the lack of sufficient sample sizes for other member types. We hypothesize that five socioeconomic variables may effect the estimated parameters of production function equations for husbands and wives: level of education, income, age, work in the market, and the number of children living in the household. Each socioeconomic variable is divided into the following two groups, both of which contain a roughly equal number of observations.

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[45]The F-Ratio used in this analysis shows that more variation exist among the all the household member types than within the household member types. However, this test does not provide conclusive evidence that among the household member types, any two household member types do not have similar production behavior.

[46]See Chow (1960), pp. 591-605.

Table 5-31: F-Ratio Results to Determine Different Estimated Production Function Equations among Household Member Types

Category of Output	SSE_T	SSE_1	SSE_2	SSE_3	SSE_4	SSE_5	SSE_6	F-Ratio
Inside Cleaning	202.16	69.43	40.30	12.83	4.28	17.03	4.75	27.23***
Outside Cleaning	470.24	95.99	146.39	18.79	39.66	37.82	12.14	22.75***
Meals	112.59	11.38	37.30	13.39	12.71	7.65	4.30	18.31***
Clothing Care	87.36	4.13	45.08	5.53	12.93	3.09	3.83	10.65***
Repairs & Mainten.	168.70	95.20	25.74	7.27	2.38	10.26	12.82	3.52**
Home Furnish	302.46	69.66	97.28	5.54	35.71	9.63	16.17	8.19***
Repairs & Improve.	163.84	67.11	57.38	6.21	7.49	5.50	2.69	5.89***

** indicates significance at the 5% level.
*** indicates significance at the 1% level.

SSE_T equals the sum of the squared residuals for all household types
SSE_1 equals the sum of the squared residuals for husbands
SSE_2 equals the sum of the squared residuals for wives
SSE_3 equals the sum of the squared residuals for male single heads
SSE_4 equals the sum of the squared residuals for female single heads
SSE_5 equals the sum of the squared residuals for male roommates
SSE_6 equals the sum of the squared residuals for female roommates

high school degree or less	*or*	greater than a high school degree
income of $15,000 per year or less for husbands	*or*	income greater than $15,000 per year
income of $25,000 per year or less for wives	*or*	income greater than $25,000 per year
47 years of age or less	*or*	older than 47 years.
30 hours of work per week or less for wives	*or*	more than 30 hours of work per week
20 hours of work per week or less for husbands	*or*	more than 20 hours of work per week
no children living at home	*or*	at least one child living at home

Tables 5-32 and 5-33 list the results of the Chow test as applied to husbands and wives, respectively. Table 5-32 indicates the previously mentioned socioeconomic variables do not significantly affect on the production behavior of husbands, since no F-Ratios are significant at the 95 percent confidence level or above. Thus, we aggregate all husbands together for analysis regardless of their socioeconomic status.

Table 5-33 suggests that the socioeconomic status of wives has some effect on their production behavior. At least one socioeconomic variable is significantly associated with production behavior in five of the seven categories tested. Age is significant for three categories, education and market employment are significant for two, and the number of children is significant for one. However, closer examination of the effects of these socioeconomic variables reveals a less consistent pattern than the number of significant t-values Table 5-33 suggests.

Table 5-32: Chow-test Results for Differences in Production Behavior between Husbands with Different Socioeconomic Characteristics

Category of Output	Socioeconomic Variable	SSE_T	SSE_1	SSE_2	F-Ratio
Inside Cleaning	Education	69.43	40.85	27.23	.6279
	Income	69.43	32.52	35.19	.8044
	Age	69.43	31.05	36.23	1.0120
	Work	69.43	14.32	54.07	.4816
	Children	69.43	48.23	15.91	2.6068
Outside Cleaning	Education	95.99	51.04	40.79	1.9479
	Income	95.99	35.29	58.95	.7985
	Age	95.99	50.13	43.95	.8730
	Work	95.99	29.72	65.44	.3751
	Children	95.99	73.02	21.89	.4893
Child Care			N<20		
Meal Preparation			N<20		
Clothing care		N<20			
Repairs & Maintenance	Education	95.20	43.58	48.76	1.0840
	Income	95.20	38.27	53.57	1.2805
	Age	95.20	54.35	37.65	1.2174
	Work	95.20	20.90	71.50	1.0606
	Children	95.20	63.87	29.36	.7433
Harvest from Nature	Education	85.68	47.13	38.47	.0265
	Income	85.68	35.65	49.18	.2839
	Age	85.68	48.33	36.17	.3424
	Work	85.68	23.60	58.71	1.1600
	Children	85.68	48.08	33.03	1.7053
Home and Hobby Production			N<20		
Home Repairs & Maintenance	Education	67.11	23.35	42.17	.8494
	Income	67.11	26.14	37.66	1.8158
	Age	67.11	33.62	31.62	.9076
	Work	67.11	17.84	49.00	.1414
	Children	67.11	43.71	19.44	1.5050

Table 5-33: Chow-test Results for Differences in Production Behavior between Wives with Different Socioeconomic Characteristics

Output Type	Variable	SSE_T	SSE_1	SSE_2	F-Ratio
Inside Cleaning	Education	40.30	22.69	16.37	1.4073
	Income	40.30	10.65	28.69	1.0819
	Age	40.30	26.45	13.12	.8178
	Work	40.30	15.41	23.05	2.1209
	Children	40.30	29.16	11.11	.0330
Outside Cleaning	Education	146.39	85.90	56.51	.8850
	Income	146.39	64.03	79.34	.7068
	Age	146.39	83.48	48.88	3.3567***
	Work	146.39	80.07	60.17	1.3887
	Children	146.39	105.73	38.76	.4142
Meal Prep	Education	37.30	17.76	18.31	1.5004
	Income	37.30	14.60	21.95	.9029
	Age	37.30	24.17	8.72	5.9000***
	Work	37.30	17.78	19.22	.3568
	Children	37.30	23.59	6.98	9.6722***
Clothing Care	Education	45.08	22.04	19.72	7.4080***
	Income	45.08	16.83	26.27	2.0213
	Age	45.08	22.55	21.74	.7847
	Work	45.08	23.33	21.03	2.2330
	Children	45.08	33.82	9.72	1.0577

** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-33 Continued

Output Type	Variable	SSE_T	SSE_1	SSE_2	F-Ratio
Harvest from Nature	Education	124.17	52.84	66.57	.6644
	Income	124.17	19.48	102.43	.3090
	Age	124.17	84.34	37.13	.3705
	Work	124.17	44.35	61.46	2.8920**
	Children	124.17	53.26	63.50	1.0577
Home Furnishings	Education	97.28	41.79	53.46	.6767
	Income	97.28	32.39	61.30	.7536
	Age	97.28	64.42	28.93	.8280
	Work	97.28	53.16	42.67	.2976
	Children	97.28	64.72	31.82	.4635
Home Repairs & Maintenance	Education	57.38	23.39	26.13	4.1268***
	Income	57.38	35.82	19.24	1.0955
	Age	57.38	21.31	29.81	3.1839**
	Work	57.38	22.33	26.95	4.2735***
	Children	57.38	38.00	13.51	2.5742

** indicates significance at the 5% level
*** indicates significance at the 1% level

Labor is a regularly significant variable in the estimated production functions (see Tables 5-61 through 5-69). Output's responsiveness to changes in labor hours is greater for older than for younger wives when producing outside cleaning. Conversely, the responsiveness of output to changes in labor hours is greater for younger than older wives for meal preparation and house repairs. Wives with more than a high school degree have greater output responsiveness to changes in labor hours when engaging in clothing care than wives with a high school degree or less. The opposite is true for home repairs. Working wives have greater output responsiveness to changes in labor hours than non-working wives in the harvest from nature category; visa versa for home repairs.

The previous inconsistencies suggest that the effects of socioeconomic variables on wives' production behavior is random. If the socioeconomic variables influence wives' production behavior, that influence has no discernible pattern. Thus, we aggregated all wives together for analysis.

5.4. Results of the Production Function Equations Tested

5.4.1. Introduction

The previous section provided statistical evidence that the sample sets we use for analysis are valid. Using the sample sets, we directly test the production function models discussed in Chapter 3. This section contains the statistical estimates of the production function equations discussed. The empirical and theoretical analysis that follow in Section 5.6 are based upon the statistical estimates contained in this section.

5.4.2. Results of the CES Production Function Equation

Tables 5-34 through 5-42 report the regression results for the partial linear equation of the CES production function for each category of output for each household member type. As explained in Chapter 3, further non-linear estimation is required only if the estimated parameter, α_4, is significantly different from zero.[47] The categories consisting of outside cleaning, clothing care, home furnishings, and house repairs all indicate that the CES production function approaches the Cobb-Douglas form for all household member types. Only eight out of 38 estimated regression equations indicate further CES estimation is required. These include: wives, single male heads, and female roommates for inside cleaning (Table 5-34), wives for child care (Table 5-36), single male and female heads for meal preparation (Table 5-37), male roommates for repairs and maintenance (Table 5-39), and single male heads for harvest from nature (Table 5-40).

Upon further estimation, only one estimated equation is significant: the equation for single male heads cleaning inside of the house. However, because most of our analysis includes only married couple households and the previous results indicate the CES approaches the Cobb-Douglas function for most cases, the CES results obtained for this one case will not be analyzed.

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[47]We conduct further non-linear estimation only if α_4 is statistically different from zero at the 95 percent confidence level or above.

Table 5-34: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4(\ln K - \ln L)^2$

(Y = Category A: Inside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	2.1523**	.9208	2.338	.7785***
	lnL	.9154***	.0883	10.368	
	lnK	-.0807	.2044	-.395	
	$(\ln K - \ln L)^2$	-.0192	.0263	-.730	
Wives	Constant	4.4577***	.5347	8.338	.4081***
	lnL	.6518***	.0919	7.091	
	lnK	-.1022	1393	-.734	
	$(\ln K - \ln L)^2$	-.0831**	.0364	-2.284	
Single Male Heads	Constant	5.5422***	.6726	8.239	.5981***
	lnL	.6390***	1002	6.375	
	lnK	-.3545**	.1410	-2.517	
	$(\ln K - \ln L)^2$	- 1812***	.0476	-3.803	
Single Female Heads	Constant	4.1330***	.5417	7.630	.5143***
	lnL	.5897***	.2011	2.933	
	lnK	.0137	.2498	.055	
	$(\ln K - \ln L)^2$	-.0537	.0775	-.693	
Male Roommates	Constant	3.7484***	.5904	6.349	.4456***
	lnL	.8815***	.1565	5.634	
	lnK	-.3496*	.1762	-1.984	
	$(\ln K - \ln L)^2$	- 1818*	.0943	-1.927	
Female Roommates	Constant	3.4038***	.4165	8.172	.7029***
	lnL	-.0038	.2173	-.017	
	lnK	.7721***	.2448	3.154	
	$(\ln K - \ln L)^2$	.2202**	.0934	2.358	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-35: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4(\ln K - \ln L)^2$

(Y = Category B: Outside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.5292**	.5642	2.710	.6485***
	lnL	.8357***	.1459	5.728	
	lnK	.2617*	.1472	1.777	
	$(\ln K - \ln L)^2$	.0013	.0224	.060	
Wives	Constant	1.7880*	.9512	1.880	.5913***
	lnL	.5864**	.2915	2.012	
	lnK	.3559	.3006	1.184	
	$(\ln K - \ln L)^2$	-.0497	.0414	-1.201	
Single Male Heads	Constant	2.3762**	.9973	2.383	.7293***
	lnL	.7783	.5129	1.518	
	lnK	.1965	.5283	.372	
	$(\ln K - \ln L)^2$	-.0141	.0760	-.185	
Single Female Heads	Constant	1.4580	.8939	1.631	.6619***
	lnL	1.1237***	.3045	3.690	
	lnK	.0899	.2442	.368	
	$(\ln K-\ln L)^2$	.0058	.0588	.098	
Male Roommates	Constant	1.6202**	.6049	2.678	.4479***
	lnL	-.3815	4166	-.916	
	lnK	1.0571**	4014	2.634	
	$(\ln K - \ln L)^2$	-.1467**	.0667	-2.200	
Female Roommates	Constant	2.9668***	.6885	4.309	.8110***
	lnL	-.9904	.5877	-1.685	
	lnK	2.0443***	.5212	3.923	
	$(\ln K - \ln L)^2$	1745	.1161	1.502	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-36: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4(\ln K - \ln L)^2$

(Y = Category C: Child Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	3.8417***	1.1905	3.227	.7144***
	lnL	.8852***	.2256	3.923	
	lnK	-.1889	.6555	-.288	
	$(\ln K - \ln L)^2$	-.0164	.0386	-.423	
Single Male Heads			N<20		
Single Female Head			N<20		
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-37: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4 (\ln K - \ln L)^2$

(Y = Category D: Meal Preparation)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	-1.8826**	2.6903	-.700	.8890***
	lnL	.6705***	.1492	4.494	
	lnK	.8231**	.4026	2.044	
	$(\ln K - \ln L)^2$	-.0204	.0162	-1.257	
Wives	Constant	3.0647***	1.1345	2.701	.3768***
	lnL	.6065***	1466	4.136	
	lnK	.2152	.1764	1.220	
	$(\ln K - \ln L)^2$	-.0033	.0717	-.046	
Single Male Heads	Constant	4.9239**	1.8428	2.672	.5413***
	lnL	-.0175	.2016	-.087	
	lnK	.4651**	.2082	2.234	
	$(\ln K - \ln L)^2$	-.1269***	.0331	-3.835	
Single Female Heads	Constant	5.3338	1.95562	2.727	.1325**
	lnL	.5525***	.1876	2.945	
	lnK	-.1110	.2714	-.409	
	$(\ln K - \ln L)^2$	.0765**	.0324	2.359	
Male Roommates	Constant	3.4867**	1.6472	2.117	.4001***
	lnL	.1003	.3504	.286	
	lnK	.5549	.3780	1.468	
	$(\ln K - \ln L)^2$	-.1204	.0890	-1.352	
Female Roommates	Constant	8.3845***	1.0419	8.047	.1976**
	lnL	-.2830	.3590	-.788	
	lnK	.2053	.3415	.601	
	$(\ln K - \ln L)^2$	-.2077	.1247	-1.665	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-38: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4 (\ln K - \ln L)^2$

(Y = Category E: Clothing Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	3.8456***	4570	8.415	.5917***
	lnL	.5839***	.0881	6.629	
	lnK	.0461	.0992	464	
	$(\ln K - \ln L)^2$	1.0198	.0255	-.775	
Single Male Heads	Constant	3.0237***	.6388	4.734	.7747***
	lnL	.5069*	.2442	2.076	
	lnK	.1484	.2519	.589	
	$(\ln K - \ln L)^2$	.0134	.0725	.185	
Single Female Heads	Constant	2.3315	2.0267	1.150	.5854***
	lnL	.9906***	.2508	3.949	
	lnK	-.0744	.3698	-.201	
	$(\ln K - \ln L)^2$	.0248	.0475	.522	
Male Roommates	Constant	2.5183***	.4961	5.076	.7056***
	lnL	1.0211***	.2081	4.907	
	lnK	-.1669	.1383	-1.207	
	$(\ln K - \ln L)^2$	.1141*	.0630	1.812	
Female Roommates	Constant	3.7052***	.6100	6.074	.6167***
	lnL	.4945	.4019	1.231	
	lnK	.1556	.3428	454	
	$(\ln K - \ln L)^2$	-.0053	.1586	-.033	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-39: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4 (\ln K - \ln L)^2$

(Y = Category F: Repairs & Maintenance)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	3.7759***	.6772	5.576	.5314***
	lnL	.8650***	.2055	4.210	
	lnK	-.1165	.2228	-.523	
	$(\ln K - \ln L)^2$	.0199	.0282	.706	
Wives	Constant	4.3571***	1.1897	3.662	.4842***
	lnL	.6151	.3683	1.670	
	lnK	-.0743	4073	-.182	
	$(\ln K - \ln L)^2$	.0127	.0479	.265	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates	Constant	6.6325***	1.1178	5.934	.7621***
	lnL	1.3195***	.2738	4.819	
	lnK	-1.1182**	.3909	-2.860	
	$(\ln K - \ln L)^2$	.1061**	.0471	2.251	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-40: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4(\ln K - \ln L)^2$

(Y = Category G: Harvest from Nature)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.5016**	.6244	2.405	4872***
	lnL	.6631**	.2544	2.607	
	lnK	.0810	.2563	.316	
	$(\ln K - \ln L)^2$	-.0099	.0539	-.184	
Wives	Constant	1.6000	1.2765	1.253	.1597***
	lnL	.8015*	.4456	1.798	
	lnK	-.1332	.4439	-.300	
	$(\ln K - \ln L)^2$	.0337	.0687	.491	
Single Male Heads	Constant	1.1750	1.1702	1.004	.4341***
	lnL	-.8523	.6304	-1.352	
	lnK	1.3995**	1.1702	2.366	
	$(\ln K - \ln L)^2$	-.3599**	.1313	-2.740	
Single Female Heads			N<20		
Male Roommates	Constant	1.6005	1.0800	1.482	.6686***
	lnL	1.3988***	.3185	4.392	
	lnK	-.4407	.3127	-1.409	
	$(\ln K - \ln L)^2$	.1013*	.0532	1.905	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-41: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4(\ln K - \ln L)^2$

(Y = Category H: Home Furnishings)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.6960	2.3342	.727	.5338***
	lnL	.3846	.6092	.631	
	lnK	.6669	.6302	1.058	
	$(\ln K - \ln L)^2$	-.0897	.0723	-1.240	
Wives	Constant	2.3746	1.7797	1.334	4068***
	lnL	.2370	.3519	.674	
	lnK	.4402	.4434	.993	
	$(\ln K - \ln L)^2$	-.0757	.0540	-1.401	
Single Male Heads			N<20		
Single Female Heads	Constant	-.8291	1.9865	-.417	.4681***
	lnL	.9698	.7538	1.286	
	lnK	.5315	.7839	.678	
	$(\ln K - \ln L)^2$	.0052	.1306	.040	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-42: Regression Results for the Partially Linear CES Equation of the Form: $\ln Y = \alpha_1 + \alpha_2 \ln L + \alpha_3 \ln K + \alpha_4 (\ln K - \ln L)^2$

(Y = Category I: Home Repairs & Improvements)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	2.9994***	.6680	4.491	.6801***
	lnL	.3519*	.1863	1.889	
	lnK	.5547***	.2074	2.675	
	$(\ln K - \ln L)^2$	-.0443*	.0239	-1.856	
Wives	Constant	4.0029***	1.0614	3.771	4671***
	lnL	.5386*	.2727	1.975	
	lnK	.1616	.3074	.526	
	$(\ln K - \ln L)^2$	-.0064	.0259	-.249	
Single Male Heads			N<20		
Single Female Heads	Constant	4.4100***	.7064	6.243	.5960***
	lnL	.5638	.3516	1.603	
	lnK	.3134	.2502	1.253	
	$(\ln K - \ln L)^2$	-.0495	.0492	-1.007	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

5.4.3. Results of the Transcendental and Translog Production Function Equations

Tables 5-43 through 5-51 contain the results of the regression analysis for the transcendental production function. The results of the transcendental equation indicate the Cobb-Douglas function is more appropriate for most household members. As stated in Chapter 4, if α' and β' are not significantly different from zero, then the the transcendental function approaches the Cobb-Douglas function in form. In only one instance, inside cleaning for male roommates, are both α' and β' significantly different from zero. In addition, only three other cases show α' or β' significant at the 95 percent confidence level or above.

In the case of the translog production function equation, we see similar results. As Tables 5-52 through 5-60 indicate, there are no instances where γ, δ, and ε are all significantly different from zero. In only ten cases do either γ, δ, or ε show statistical significance. Those cases represent only nine percent of the total number of times γ, δ, and ε were estimated. These findings indicate that the translog function approaches the Cobb-Douglas function, strongly suggesting that the Cobb-Douglas function is more appropriate.

It would be questionable whether or not we could use the estimated parameters of the transcendental or translog production functions for analysis. Note the size and significance of the adjusted R^2's which appear throughout Tables 5-43 through 5-60. In many cases, the adjusted R^2's are relatively large and highly significant, but relatively few of the estimated parameters are significant. This type of situation implies a problem with multicollinearity. We would expect multicollinearity to occur given the relationship between the independent variables. For instance, the natural log of labor (lnL) will likely be highly correlated with labor

(L) itself in both the transcendental and translog production function equations. As a result, it is questionable to use linear regression techniques to estimate these two production functions.

5.4.4. Results of the Cobb-Douglas Equation

Tables 5-61 and 5-69 contain the regression results using the Cobb-Douglas production function equation. The adjusted R^2's are highly significant for every estimated equation except one (single female heads for meal preparation), indicating the independent variables (labor and capital) in the equations explain most of the variation of the dependent variable (output). The estimated parameter, α, is statistically significant at the 95 percent confidence level in very case except one (single female heads for meal preparation). This finding means that labor has a significant impact on the HP process for most household member types. However, the estimated parameter, β, is significant in only three cases: for female roommates engaged in inside cleaning and for husbands engaged in outside cleaning and home repairs and improvements. Variations in capital do not yield significant output variations in most cases.

5.4.5. The Best Fitting Production Function Equation

When compared to the CES, transcendental, and translog production functions, the Cobb-Douglas appears to have the best fit when applied to our sample sets. The consistent significance of the α and the high adjusted R^2's demonstrate that Cobb-Douglas has significant explanatory power. Examination of the results of the Cobb-Douglas function by itself does not produce overwhelming evidence that the Cobb-Douglas is the best fitting model. For instance, the

Table 5-43: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category A: Inside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	.3300*	2.7746	1.921	.7800***
	lnL	1.0299***	.0836	12.325	
	lnK	-1.0002	.7200	-1.389	
	L	-.0011	.0012	-.852	
	K	.0060	.0049	1.222	
Wives	Constant	3.7792**	1.7383	2.174	.3855***
	lnL	.5530***	.0897	6.162	
	lnK	.1533	.4243	.362	
	L	-.0002	.0002	-1.030	
	K	-.0003	.0029	-.107	
Single Male Heads	Constant	1.9515**	.8883	2.197	.6067***
	lnL	1.2300***	.1852	6.642	
	lnK	-.0712	.1989	-.358	
	L	-.0049***	.0012	-4.032	
	K	.0019	.0040	477	
Single Female Heads	Constant	4.4197***	1.2664	3.490	.5019***
	lnL	.4650*	.2592	1.794	
	lnK	.0556	.1860	.299	
	L	.0000	.0009	-.043	
	K	.0014	.0020	.739	
Male Roommates	Constant	2.2349**	.8814	2.536	.5016***
	lnL	1.2315***	.2551	4.828	
	lnK	-.4031**	.1561	-2.583	
	L	-.0042**	.0018	-2.360	
	K	.0063**	.0026	2.388	
Female Roommates	Constant	5.1683***	.8544	6.049	.6816***
	lnL	.0906	.2007	.451	
	lnK	.2290*	.1223	1.873	
	L	.0013**	.0006	2.091	
	K	.0007	.0023	.324	

* indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level

Table 5-44: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category B: Outside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1085	.9686	.112	.6567***
	lnL	.9129***	.0916	9.972	
	lnK	.5436***	1954	2.782	
	L	-.0032	.0026	-1.222	
	K	-.0007	.0004	-1.604	
Wives	Constant	2.0237	1.5112	1.339	.5952***
	lnL	1.0754***	.1137	9.456	
	lnK	.0356	.3073	.116	
	L	-.0081*	.0044	-1.842	
	K	.0000	.0007	-.050	
Single Male Heads	Constant	2.2378**	1.0337	2.165	.7229***
	lnL	.9428***	.2082	4.528	
	lnK	.1824	.2550	.716	
	L	-.0093	.0170	-.545	
	K	-.0004	.0008	-.513	
Single Female Heads	Constant	.4507	1.1989	.376	.6840***
	lnL	1.3013***	.1980	6.574	
	lnK	4339	.3967	1.094	
	L	-.0104	.0072	-1.445	
	K	-.0045	.0051	-.894	
Male Roommates	Constant	3.3686***	.8617	3.909	.3880***
	lnL	.4013**	.1899	2.113	
	lnK	-.1816	.3423	-.531	
	L	.0056	.0152	.368	
	K	.0069	.0054	1.277	
Female Roommates	Constant	2.3563*	1.1172	2.109	.7732***
	lnL	1.3148***	.2347	5.602	
	lnK	-.1787	.4585	-.390	
	L	-.0026	.0240	-.110	
	K	.0008	.0072	.110	

* indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level

Table 5-45: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category C: Child Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	3.7349**	1.5200	2.458	.7029***
	lnL	.8516***	.1465	5.812	
	lnK	-.1065	2.6387	-.040	
	L	-.0002	.0004	-.493	
	K	-.0011	.6313	-.002	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-46: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category D: Meal Preparation)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	-20.7905	15.4334	-1.347	.8955***
	lnL	.9021***	.0648	13.930	
	lnK	3.7470	2.5220	1.486	
	L	-.0005*	.0003	-1.737	
	K	-.0024	.0020	-1.215	
Wives	Constant	7.8435	5.1071	1.536	.3828***
	lnL	.7762***	.1688	4.597	
	lnK	-.6990	.8140	-.859	
	L	-.0002	.0002	-1.032	
	K	.0006	.0006	1.127	
Single Male Heads	Constant	-1.2571	4.3325	-.290	.7061***
	lnL	.9570***	.1199	7.985	
	lnK	.6360	.7048	.902	
	L	-.0015***	.0005	-2.836	
	K	-.0003	.0006	-.465	
Single Female Heads	Constant	3.1663	7.1007	.446	.0415
	lnL	.0164	.1353	.121	
	lnK	.7686	1.1892	.646	
	L	.0005	.0003	1.391	
	K	-.0007	.0011	-.631	
Male Roommates	Constant	6.5048	7.2006	.903	.4093***
	lnL	1.0195***	.2688	3.793	
	lnK	-.6779	1.2206	-.555	
	L	-.0021*	.0012	-1.847	
	K	.0007	.0011	.698	
Female Roommates	Constant	5.0486	3.3601	1.503	.1394*
	lnL	.5553*	.2980	1.864	
	lnK	.0419	.5658	.074	
	L	-.0011	.0011	-.942	
	K	-.0003	.0005	-.636	

* indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level

Table 5-47: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category E: Clothing Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	3.6116***	.6116	5.905	.5890***
	lnL	.6880***	.0770	8.932	
	lnK	.0040	.1293	.031	
	L	-.0002	.0003	-.810	
	K	-.0000	.0004	-.097	
Single Male Heads	Constant	2.7725**	1.0881	2.548	.7640***
	lnL	.4453**	.2019	2.205	
	lnK	.2743	.3542	.774	
	L	-.0000	.0013	-.003	
	K	-.0004	.0012	-.358	
Single Female Heads	Constant	9.1060	5.7395	1.587	.5913***
	lnL	.8986***	.2451	3.666	
	lnK	-1.3393	1.1185	-1.197	
	L	.0002	.0019	.102	
	K	.0028	.0022	1.274	
Male Roommates	Constant	1.2786	.9256	1.381	.7005***
	lnL	1.2451***	.3554	3.504	
	lnK	.1236	.1845	.669	
	L	-.0089*	.0051	-1.759	
	K	-.0009	.0010	-.855	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-48: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category F: Repairs & Maintenance)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	4.5370***	1.2478	3.636	.5333***
	lnL	.8048***	.1033	7.787	
	lnK	-.2261	.2829	-.799	
	L	-.0049	.0054	-.909	
	K	.0011	.0011	1.004	
Wives	Constant	3.5511	2.6775	1.326	.4721***
	lnL	.5710***	.1540	3.707	
	lnK	.1741	.6014	.289	
	L	-.0058	.0127	-.453	
	K	-.0006	.0020	-.283	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates	Constant	6.6111**	2.5611	2.581	.7320***
	lnL	.5541***	1580	3.508	
	lnK	-.6410	.6411	-1.000	
	L	.0067	.0040	1.660	
	K	.0009	.0023	.336	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-49: Regression Results for the Transcendental Production Function Equation of the Form: $\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$

(Y = Category G: Harvest from Nature)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.9698	1.2183	1.617	.4835***
	lnL	.6651***	.1162	5.725	
	lnK	-.0298	.2412	-.124	
	L	.0003	.0006	.529	
	K	.0001	.0004	.338	
Wives	Constant	3.6867	2.3246	1.586	1688***
	lnL	.3687	.2975	1.240	
	lnK	-.3096	.4451	-.695	
	L	.0041	.0044	.935	
	K	.0007	.0007	.965	
Single Male Heads	Constant	3.5834	2.4695	1.451	.2060*
	lnL	.9412*	.5240	1.796	
	lnK	-.5750	.4991	-1.152	
	L	-.0038	.0072	-.530	
	K	.0009	.0009	1.082	
Single Female Heads			N<20		
Male Roommates	Constant	4.6795**	1.8294	2.558	.6630***
	lnL	.9631***	.1683	5.724	
	lnK	-.7263*	.4165	-1.744	
	L	-.0009	.0014	-.642	
	K	.0019	.0009	2.558	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-50: Regression Results for the Transcendental Production Function Equation of the Form:

$$\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$$

(Y = Category H: Home Furnishings)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	2.6274	5.3201	.494	.4982***
	lnL	1.1822***	.2986	3.959	
	lnK	-.0165	.9874	-.017	
	L	-.0038	.0125	-.301	
	K	-.0000	.0014	-.005	
Wives	Constant	6.9581	5.0014	1.391	.3889***
	lnL	.7938***	.1611	4.927	
	lnK	-.8141	.9234	-.882	
	L	-.0014	.0020	-.711	
	K	.0011	.0013	1.391	
Single Male Heads			N<20		
Single Female Heads	Constant	3.7988	4.5500	.835	.4985***
	lnL	1.3200***	.3832	3.444	
	lnK	-1.0534	1.3366	-.788	
	L	-.0078	.0071	-1.102	
	K	.0119	.0094	1.262	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-51: Regression Results for the Transcendental Production Function Equation of the Form:

$$\ln Y = a + \alpha \ln L + \beta K + \alpha' L + \beta' K$$

(Y = Category I: Home Repairs & Improvements)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	2.8371**	1.1492	2.469	.6733***
	lnL	.7493***	.0714	10.502	
	lnK	.3406	.2160	1.577	
	L	-.0018	.0014	-1.301	
	K	-.0002	.0003	-.634	
Wives	Constant	5.3350***	1.6081	3.318	.4697***
	lnL	.5523***	.1060	5.212	
	lnK	-.1270	.3058	-.415	
	L	.0059	.0066	.903	
	K	.0003	.0005	.750	
Single Male			N<20		
Single Female Heads	Constant	3.6150***	1.1339	3.188	.5674***
	lnL	.9789***	.3159	3.098	
	lnK	.3190	.3088	-.185	
	L	-.0075	.0403	-.185	
	K	-.0028	.0040	-.694	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-52: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = \alpha + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$

(Y = Category A: Inside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	11.4041	8.1836	1.394	.7783***
	lnL	1.3679**	.6841	2.000	
	lnK	-4.2073	3.3806	-1.245	
	lnLlnK	-.0528	.1480	-.356	
	$(\ln L)^2$	-.0247	.0277	-.890	
	$(\ln K)^2$	.4349	.3515	1.394	
Wives	Constant	9.7683	6.4902	1.505	.4025***
	lnL	.1426	.7029	.203	
	lnK	-1.6963	2.2107	-2.114	
	lnLlnK	.2688*	.1530	1.757	
	$(\ln L)^2$	-.0795**	.0376	-2.114	
	$(\ln K)^2$	.0156	.2006	.078	
Single Male Heads	Constant	3.4325	2.9028	1.182	.6364***
	lnL	1.7572**	.7630	2.303	
	lnK	-.7840	.7771	-1.009	
	lnLlnK	.2439	.1588	1.535	
	$(\ln L)^2$	-.2542***	.0557	-4.568	
	$(\ln K)^2$	-.0325	.0854	-.380	
Single Female Heads	Constant	8.2208*	4.1107	2.000	.5249***
	lnL	4402	1.2832	.343	
	lnK	-1.6314	1.0184	-1.602	
	lnLlnK	.4030*	.2339	1.723	
	$(\ln L)^2$	-.1620	.1519	-1.066	
	$(\ln K)^2$	-.0491	.0785	-.625	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

(Table 5-52 Continued)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Male	Constant	2.7885	2.4909	1.119	.5618***
Roommates	lnL	2.4629**	1.0205	2.413	
	lnK	-1.9981***	.5136	-3.891	
	lnLlnK	.3296**	.1903	2.047	
	$(\ln L)^2$	-.3701***	.1148	-3.224	
	$(\ln K)^2$	.0473	.1060	.446	
Female	Constant	5.6124*	3.0335	1.850	.6898***
Roommates	lnL	-.8144	.9455	-.861	
	lnK	.7520	.6827	1.102	
	lnLlnK	-.3623	.2300	-1.575	
	$(\ln L)^2$	.2651**	.1080	2.454	
	$(\ln K)^2$	.1715	.1132	1.515	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-53: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = \alpha + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta (\ln L)^2 + \varepsilon (\ln K)^2$$

(Y = Category B: Outside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	-3.4242	2.2264	-1.538	.6599***
	lnL	1.5307***	.4070	3.761	
	lnK	1.6765**	.7427	2.257	
	lnLlnK	-.1169	.0727	-1.607	
	$(\ln L)^2$	-.0119	.0258	-.460	
	$(\ln K)^2$	-.0915	.0678	-1.350	
Wives	Constant	1.4888	3.2916	.452	.5845***
	lnL	.2699	.5705	.473	
	lnK	.5699	1.2166	.468	
	lnLlnK	.1494	1143	1.307	
	$(\ln L)^2$	-.0386	.0454	-.852	
	$(\ln K)^2$	-.0783	.1173	-.667	
Single Male Heads	Constant	2.4155	2.4071	1.003	.7104***
	lnL	.9585	.5831	1.644	
	lnK	.2248	1.0898	.206	
	lnLlnK	.0087	.1610	.054	
	$(\ln L)^2$	-.0464	.0953	-.486	
	$(\ln K)^2$	-.0185	.1213	-.153	
Single Female Heads	Constant	-.4140	.1463	-.676	.6522***
	lnL	1.6877**	.6021	2.803	
	lnK	.8555	1.3300	.643	
	lnLlnK	-.0988	.1463	-.676	
	$(\ln L)^2$	-.0366	.0812	-.450	
	$(\ln K)^2$	-.0662	.1646	-.402	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

(Table 5-53 Continued)

Male Roommates	Constant	3.0812**	1.3210	2.333	.4639***
	lnL	-.5942	.5313	-1.118	
	lnK	.1436	.8945	.161	
	lnLlnK	.3156**	.1416	2.229	
	$(\ln L)^2$	-.1013	.0824	-1.229	
	$(\ln K)^2$	-.0253	.1335	-.190	
Female Roommates	Constant	1.5293	2.2933	.667	.7950***
	lnL	2.4687***	.7501	3.291	
	lnK	-.2217	1.3618	-.163	
	lnLlnK	-.4559	.2770	-1.646	
	$(\ln L)^2$	.1479	.1333	1.109	
	$(\ln K)^2$	.0878	.1894	464	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-54: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = \alpha + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$

(Y = Category C: Child Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	.4347	21.3877	.020	.6888***
	lnL	1.8746	6.0892	.308	
	lnK	.4044	5.8267	.069	
	lnLlnK	-.5227	3.4144	-.153	
	$(\ln L)^2$	-.0155	.0407	-.382	
	$(\ln K)^2$	.7154	4.5914	.156	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-55: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = \alpha + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$

(Y = *Category D: Meal Preparation*)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	-82.8401	62.4764	-1.326	.8926***
	lnL	2.7634	1.6444	1.681	
	lnK	22.1073	17.4844	1.264	
	lnLlnK	-.2317	.2133	-1.086	
	$(\ln L)^2$	-.0398*	.0230	-1.730	
	$(\ln K)^2$	-1.4149	1.2262	-1.154	
Wives	Constant	10.1582	21.3462	.476	.3904***
	lnL	3.9663**	1.7190	2.307	
	lnK	-4.7373	5.5880	-.848	
	lnLlnK	-.3495	.2350	-1.487	
	$(\ln L)^2$	-.0673	.0771	-.872	
	$(\ln K)^2$	.4999	.3905	1.280	
Single Male Heads	Constant	-26.7749	20.1007	-1.332	.7919***
	lnL	4.6876**	1.7531	2.674	
	lnK	5.5733	4.8396	1.152	
	lnLlnK	-.4790*	.2789	-1.717	
	$(\ln L)^2$	-.0918**	.0337	-2.723	
	$(\ln K)^2$	-.1850	.3029	-.611	
Single Female Heads	Constant	39.1158	39.1098	1.00	.1543*
	lnL	-5.1465	3.4519	-1.491	
	lnK	-4.8189	9.4503	-.510	
	lnLlnK	.5798	.4473	1.296	
	$(\ln L)^2$	.1277**	.0452	2.825	
	$(\ln K)^2$	.0911	.6069	.150	

* indicates significance at the 10% level

** indicates significance at the 5% level

*** indicates significance at the 1% level

(Table 5-55 Continued)

Male Roommates	Constant	16.2341	32.1506	.505	.4003***
	lnL	3.1211	2.5727	1.213	
	lnK	-5.3903	8.8194	-.611	
	lnLlnK	-.0191	.0364	-.062	
	$(\ln L)^2$	-.2333*	.1212	-1.924	
	$(\ln K)^2$	.4036	.6190	.652	
Female Roommates	Constant	-2.4909	11.9388	-.209	.1661*
	lnL	.8320	1.9911	.418	
	lnK	2.4546	3.3421	.734	
	lnLlnK	.2756	.3237	.851	
	$(\ln L)^2$	-.2237	.1423	-1.572	
	$(\ln K)^2$	-.3115	.2826	-1.102	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-56: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = a + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta (\ln L)^2 + \varepsilon (\ln K)^2$$

(Y = Category E: Clothing Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	4.0324***	1.3754	2.932	.5857***
	lnL	.4760	.5104	.933	
	lnK	.0682	.4747	.144	
	lnLlnK	.0545	.0864	.630	
	$(\ln L)^2$	-.0178	.0275	-.649	
	$(\ln K)^2$	-.0276	.0636	-.433	
Single Male Heads	Constant	5.6711*	3.0129	1.882	.7824***
	lnL	1.7787**	.8315	2.139	
	lnK	-1.5128	1.6561	-.914	
	lnLlnK	-.3198	.2329	-1.373	
	$(\ln L)^2$	.0528	.0769	.687	
	$(\ln K)^2$	.2541	.2195	1.158	
Single Female Heads	Constant	12.3240	22.9553	.537	.5878***
	lnL	6.0570	5.1654	1.173	
	lnK	-7.2784	6.5585	-1.110	
	lnLlnK	-.6467	.6225	-1.039	
	$(\ln L)^2$	-.1320	.1663	-.794	
	$(\ln K)^2$	.8481	.5913	1.434	
Male Roommates	Constant	-1.5285	1.9704	-.776	.7480***
	lnL	1.7695	1.2004	1.474	
	lnK	1.2452	.8905	1.398	
	lnLlnK	-.2975	1998	-1.489	
	$(\ln L)^2$	.0489	.2503	.195	
	$(\ln K)^2$	-.0144	.0811	-.178	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-57: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = \alpha + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$

(Y = Category F: Repairs & Maintenance)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	4.6093*	2.5612	1.800	.5300***
	lnL	1.2875**	.5232	2.461	
	lnK	-.6214	.9157	-.679	
	lnLlnK	-.0944	.0928	-.1017	
	$(\ln L)^2$	-.0125	.0382	-.326	
	$(\ln K)^2$	.0820	.0856	.959	
Wives	Constant	.0443	8.0718	.005	.4627***
	lnL	.9568	.6784	1.410	
	lnK	1.4678	2.9860	.492	
	lnLlnK	-.0798	.1285	-.621	
	$(\ln L)^2$	-.0074	.0631	-.118	
	$(\ln K)^2$	-.1212	.2725	-.445	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates	Constant	10.1941*	5.5178	1.847	.7443***
	lnL	1.6798**	.6224	2.699	
	lnK	-2.6680	2.2318	-1.195	
	lnLlnK	-.2739*	.1422	-1.929	
	$(\ln L)^2$	.0973*	.0499	1.950	
	$(\ln K)^2$	.2682	.2225	1.206	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-58: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = a + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$

(Y = Category G: Harvest from Nature)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.8127	3.2316	.561	.4772***
	lnL	.4222	.4964	.851	
	lnK	.1162	1.1596	.100	
	lnLlnK	.0412	.1148	.358	
	$(\ln L)^2$	.0041	.0602	.068	
	$(\ln K)^2$	-.0190	1104	-.172	
Wives	Constant	7.0398	6.2613	1.124	.1486**
	lnL	-.5388	1.4711	-.366	
	lnK	-1.2772	2.0851	-.613	
	lnLlnK	.0444	.1785	.249	
	$(\ln L)^2$	.1252	.1209	1.035	
	$(\ln K)^2$	.0997	.1863	.535	
Single Male Heads	Constant	5.9468	5.5626	1.069	.4361**
	lnL	.2020	1.4448	.140	
	lnK	-.9513	1.9384	-.491	
	lnLlnK	.7823***	.2660	2.941	
	$(\ln L)^2$	-.5542**	.2304	-2.405	
	$(\ln K)^2$	-.1758	.1957	-.898	
Single Female Heads			N<20		
Male Roommates	Constant	5.6531	4.6788	1.208	.6509***
	lnL	1.0861*	.6125	1.773	
	lnK	-1.7680	1.6204	-1.091	
	lnLlnK	-.1120	.1592	-.703	
	$(\ln L)^2$	.0743	.0625	1.189	
	$(\ln K)^2$	.1956	.1410	1.387	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-59: Regression Results for the Translog Production Function Equation of the Form:

$$\ln Y = a+\alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$

(Y = Category H: Home Furnishings)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	5.2224	15.0615	.347	.5463***
	lnL	-2.4561	1.7784	-1.384	
	lnK	.3368	4.7784	.070	
	lnLlnK	.5964**	.2839	2.101	
	$(\ln L)^2$	-.0205	.0821	-.250	
	$(\ln K)^2$	-.1265	.3829	-.330	
Wives	Constant	18.3048	16.1069	1.136	4119***
	lnL	-1.0458	1.0858	-.963	
	lnK	-3.8954	5.0757	-.767	
	lnLlnK	.3332	+(*)	.1753	1.901
	$(\ln L)^2$	-.0556	.0592	-.939	
	$(\ln K)^2$	.2129	4011	.531	
Single Male Heads			N<20		
Single Female Heads	Constant	-.7909	21.5887	-.037	.4488***
	lnL	5.1535	5.0412	1.022	
	lnK	-2.1870	7.9577	-.275	
	lnLlnK	-.6350	.8685	-.731	
	$(\ln L)^2$	-.0856	1581	-.541	
	$(\ln K)^2$	.4514	.7746	.583	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-60: Regression Results for the Translog Production Function Equation of the Form:
$$\ln Y = a + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta(\ln L)^2 + \varepsilon(\ln K)^2$$
(Y = Category I: Home Repairs & Improvements)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	.0377	2.9654	.013	.6794***
	lnL	.7875*	.4165	1.891	
	lnK	1.3817	.9423	1.466	
	lnLlnK	.0258	.0696	.370	
	$(\ln L)^2$	-.0500*	.0274	-1.827	
	$(\ln K)^2$	-.1006	.0765	-1.316	
Wives	Constant	5.8930	4.7269	1.247	.4548***
	lnL	.4751	.7267	.654	
	lnK	-.4494	1.5747	-.285	
	lnLlnK	.0236	.1044	.226	
	$(\ln L)^2$	-.0063	.0362	-.173	
	$(\ln K)^2$	.0420	.1297	.324	
Single Male Heads			N<20		
Single Female Heads	Constant	6.0929*	3.4816	1.750	.5620***
	lnL	-.3638	1.4006	-.260	
	lnK	-.0213	1.1858	-.018	
	lnLlnK	.2466	.2575	.958	
	$(\ln L)^2$	.0140	.1221	.114	
	$(\ln K)^2$	-.0481	.1226	-.392	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-61: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category A: Inside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	2.0856**	.9140	2.282	.7795***
	lnL	.9678***	.0513	18.854	
	lnK	-.1227	.1957	-.627	
Wives	Constant	4.3322***	.5400	8.023	.3898***
	lnL	.4781***	.0524	9.120	
	lnK	.1015	.1086	.934	
Single Male Heads	Constant	4.0922***	.6575	6.223	.4341***
	lnL	.6021***	.1184	5.087	
	lnK	-.0348	.1342	-.259	
Single Female Heads	Constant	4.0308***	.5176	7.788	.5211***
	lnL	.4661***	.0925	5.040	
	lnK	.1710	.1035	1.652	
Male Roommates	Constant	3.2118***	.5357	5.996	4129***
	lnL	.7232***	.1370	5.278	
	lnK	-.0814	.1110	-.732	
Female Roommates	Constant	3.6750***	.4317	8.513	.6546***
	lnL	4625***	.0972	4.760	
	lnK	.2247**	.0840	2.676	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-62: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category B: Outside Cleaning)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.5294***	.5620	2.721	.6511***
	lnL	.8277***	.0558	14.824	
	lnK	.2681***	.1000	2.680	
Wives	Constant	2.0184**	.9337	2.162	.5895***
	lnL	.9234***	.0788	11.722	
	lnK	.0572	.1692	.338	
Single Male Heads	Constant	2.4963***	.7419	3.365	.7407***
	lnL	.8707***	.1174	7.408	
	lnK	.1032	.1560	.662	
Single Female Heads	Constant	1.4908*	.8155	1.828	.6731***
	lnL	1.0976***	.1469	7.473	
	lnK	.1057	.1812	.583	
Male Roommates	Constant	2.4274***	.5082	4.777	.3836***
	lnL	.4843***	.1443	3.356	
	lnK	.2260	.1434	1.577	
Female Roommates	Constant	2.2648***	.5230	4.330	.7978***
	lnL	1.2897***	.1437	8.974	
	lnK	- 1335	.1464	-.912	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-63: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category C: Child Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	3.9451***	1.1459	3.443	.7238***
	lnL	.7988***	.0946	8.446	
	lnK	-.1212	.6252	-.194	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates					
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-64: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category D: Meal Preparation)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	-1.4958	2.6975	-.555	.8870***
	lnL	.8462***	.0524	16.148	
	lnK	.6199*	.3722	1.666	
Wives	Constant	3.0534***	1.1044	2.765	.3814***
	lnL	.6125***	.0692	8.847	
	lnK	.2109	.1495	1.410	
Single Male Heads	Constant	.9591	1.8232	.526	.6469***
	lnL	.7028***	.0874	8.037	
	lnK	.3878	.2477	1.566	
Single Female Heads	Constant	6.4007***	2.0166	3.174	.0254
	lnL	.1627*	.0942	1.726	
	lnK	.1030	.2712	.380	
Male Roommates	Constant	3.5961**	1.6609	2.165	.3886***
	lnL	.5546***	.1005	5.520	
	lnK	1365	.2192	.623	
Female Roommates	Constant	8.2209***	1.0685	7.694	.1486**
	lnL	.2869**	.1113	2.578	
	lnK	-.2964*	.1655	-1.791	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-65: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category E: Clothing Care)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands			N<20		
Wives	Constant	3.7959***	4518	8.402	.5929***
	lnL	.6412***	.0478	13.405	
	lnK	-.0009	.0784	-.012	
Single	Constant	3.0375***	.6197	4.902	7850***
Male	lnL	4669***	1110	4.208	
Heads	lnK	.1830	1649	1.110	
Single	Constant	2.2576	1.9932	.5970***	
Female	lnL	.8812***	.1358	6.491	
Heads	lnK	.0373	.2974	.125	
Male	Constant	2.8426***	.4884	5.820	.6720***
Roommates	lnL	.7463***	.1504	4.962	
	lnK	.0360	.0857	.420	
Female Roommates			N<20		

indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-66: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category F: Repairs & Maintenance)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	3.6104***	.6339	5.695	.5336***
	lnL	.7276***	.0659	11.035	
	lnK	.0155	.1210	.128	
Wives	Constant	4.2213***	1.0595	3.984	4976***
	lnL	.5201***	.0838	6.209	
	lnK	.0198	.1968	.101	
Single Male Heads			N<20		
Single Female Heads			N<20		
Male Roommates	Constant	5.2856***	1.0402	5.081	.7111***
	lnL	.7387***	.1009	7.320	
	lnK	-.3658	.2233	-1.638	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-67: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category G: Harvest from Nature)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	1.5261**	.6067	2.516	4928***
	lnL	.7071***	.0869	8.134	
	lnK	.0383	.1084	.353	
Wives	Constant	1.3972	1.1991	1.165	.1717***
	lnL	.5998***	.1717	3.493	
	lnK	.0644	.1857	.347	
Single Male Heads	Constant	1.9561	1.3151	1.487	.2401**
	lnL	.7485**	.2747	2.725	
	lnK	-.1134	.2461	-.461	
Single Female Heads			N<20		
Male Roommates	Constant	1.6726	1.1394	1.468	.6308***
	lnL	.8409***	.1322	6.362	
	lnK	.0204	.2090	.098	
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-68: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category H: Home Furnishings)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	2.4701	2.2670	1.090	.5264***
	lnL	1.1099***	.1725	6.433	
	lnK	.0189	.3553	.053	
Wives	Constant	3.0425*	1.7279	1.761	.3976***
	lnL	.7067***	.1076	6.566	
	lnK	-.0465	.2775	-.167	
Single Male Heads			N<20		
Single Female Heads	Constant	-.8562	1.8230	-.470	4934***
	lnL	.9411***	.2285	4.119	
	lnK	.5596	.3409	1.642	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-69: Regression Results for the Cobb-Douglas Production Function of the Form: $\ln Y = \ln A + \alpha \ln L + \beta \ln K$

(Y = Category I: Home Repairs & Improvements)

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	3.5634***	.6015	5.924	.6729***
	lnL	.6846***	.0511	13.390	
	lnK	.2160**	.0995	2.172	
Wives	Constant	4.1836***	.7695	5.437	.4733***
	lnL	.6041***	.0704	8.582	
	lnK	.0915	.1222	.748	
Single Male Heads			N<20		
Single Female Heads	Constant	4.3376***	.7030	6.170	.5957***
	lnL	.8835***	1509	5.856	
	lnK	1076	.1442	.746	
Male Roommates			N<20		
Female Roommates			N<20		

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

estimated parameter, β, is significant in only a few cases. However, the results obtained from estimating generalized forms of the Cobb-Douglas provide further statistical evidence that the Cobb-Douglas function is more appropriate for our sample sets. In most instances, the results obtained using generalized forms of the Cobb-Douglas indicate that the generalized forms approach a more specific case example, i.e., the Cobb-Douglas. Thus, analysis throughout the rest of this thesis will focus primarily on the estimated parameters derived using the Cobb-Douglas production function.

5.5. Theoretical Interpretation of the Cobb-Douglas Function Regression Results

5.5.1. Elasticities

The estimated parameters, α and β, measure the elasticities of output with respect to labor and capital, respectively.[48] In other words, α is the ratio of the percentage change in output to the percentage change in labor causing that output change, holding all other inputs constant. The same applies to β for capital. The higher the elasticity of output with respect to an input, the more households produce out of additional increases in the input. The Cobb-Douglas function assumes the elasticity of output with respect to all inputs will be constant for all levels of output and inputs.

The fact that the Cobb-Douglas is the best fitting equation implicitly assumes that the elasticity of substitution (σ) of labor for capital is essentially one

[48]See Douglas (1948).

and vice versa. The elasticity of substitution is defined as the percentage rate of change in the input ratio (L/K) when the marginal rate of technical substitution (e.g. marginal productivity of L/marginal productivity of K) is increased at a rate of one percent, holding output constant.[49] In other words, σ measures how easy or difficult it is for households to substitute labor for capital (or vice versa) and still maintain a given level of output. An σ equal to zero implies households cannot substitute labor for capital (or vice versa) without changing the current level of output. An σ which approaches infinity means that household inputs are perfect substitutes, i.e., households can substitute one input for another at will without giving up the current level of output. Thus, the Cobb-Douglas function implies households can substitute inputs in a degree between these two extremes, but the specific difficulty or ease of input substitution is not intuitively obvious.

5.5.2. Marginal Productivities of Inputs

Another measure of output with respect to an input, the marginal productivity (MP) of an input, is defined as the change in output resulting from a one unit increase in that input, holding all other inputs constant.[50] Mathematically, it is the partial first derivative of the production function with respect to an input. Unlike the elasticity of input, the marginal productivity is dependent upon what levels of output are being produced and what levels of all inputs are used to produce a given level of output.

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[49] See Russell and Wilkinson (1979), pp. 144-145.

[50] See Russell and Wilkinson (1979), pp.140-141.

We can estimate the average marginal productivity of labor and capital for households using the estimates provided by the Cobb-Douglas function. Recall that the Cobb-Douglas is of the form

$$Y = AL^{\alpha}K^{\beta}$$

The MP of labor is the first derivative of the function Y with respect to L such that

$$MPL = \frac{\partial L}{\partial Y} = A\alpha L^{\alpha-1}K^{\beta}$$

If we multiply both sides of this equation by Y and then divide both sides by $AL^{\alpha}K^{\beta}$, the equation reduces to

$$\alpha\frac{L}{Y}$$

.

Similarly, the MP of capital is $\beta\frac{K}{Y}$. We can evaluate the MP of labor (capital) for each person in our sample by multiplying α (β) with the ratio of a person's output and labor hours (capital value).

If the estimates of α and/or β do not statistically differ from zero, then the marginal productivity of that particular input is essentially zero, implying any additional input used will not add to total output. As Tables 5-61 through 5-69 indicate, the MP of capital is essentially zero for most cases. On the other hand, the MP of labor is positive for most cases. This finding implies that HP is mostly a function of household labor and not household capital. However, we hypothesize that capital is an essential input for most HP activities, and Section 5.6 will provide a statistical test which substantiates this hypothesis.

We also observe that differences exist between the estimated parameter α for husbands' and wives'. Does this imply that the marginal productivities of husbands' and wive's labor differ? We hypothesize that husbands' and wive's marginal productivities will differ because of the law of diminishing marginal returns defined in Chapter 1. Section 5.6 provides the necessary tests to determine statistically whether different marginal productivities do exist and what may cause those differences.

5.5.3. Returns to Scale Interpretation

Using the estimates of α and β in Tables 5-61 through 5-69, we can derive the returns to scale parameter for married couple households. As mentioned in Chapter 3, the returns to scale parameter, $\alpha + \beta$, measures how much output will change when we change the level of household inputs. If we have constant returns to scale, i.e. $\alpha + \beta = 1$, then output will double if we double *both* inputs. If increasing returns to scale ($\alpha + \beta > 1$) exist, output will more than double if we double both inputs and vice versa.

Tables 5-70 and 5-71 provides the estimates of α, β, $\alpha + \beta$, and 95 percent confidence intervals for husbands and wives for each category of a output. The confidence intervals allow us to determine whether or not the returns to scale parameter, $\alpha + \beta$, includes one. If the confidence interval indicates that $\alpha + \beta$ is not significantly different from one, then we cannot rule out the possibility of constant returns to scale.

In Table 5-70, the 95 percent confidence interval includes one for every category of output except repairs & maintenance and harvest from nature for husbands. In both cases, decreasing returns to scale exist. In Table 5-71, wives appear to operate in the range of constant returns to scale for every category except inside cleaning, clothing care, and home repairs & improvements. Again, decreasing returns to scale exist for those three category types. However, because capital does not appear as a significant variable in any of the equations where decreasing returns to scale appears, we still cannot rule out the possibility of constant returns to scale.

5.6. Implications of the Empirical Findings

5.6.1. Introduction

The previous section discussed the theoretical meaning of the estimated parameters, α and β, of the Cobb-Douglas function. In addition, α and β were used to derive the marginal productivity of labor and capital. This section utilizes the estimates of the marginal productivity of labor and capital to analyze capital as a necessary input in the HP process, to determine the validity of previous empirical work, and to analyze the production behavior of married couple households.

5.6.2. Test to Determine the Necessity of Capital as an Input

In Tables 5-61 through 5-69, we observe that the coefficient of capital does not significantly differ from zero in most output categories for most household member types. Consequently, the marginal productivity of household capital is essentially zero. However, we hypothesize that capital is still a necessary input in the production process.

Table 5-70: Husbands' Estimated Returns to Scale for Each Category of Output

Category of Output	α	β	Returns to Scale	95% C.I.
Inside Cleaning	.9678*** (.0513)	-.1227 (.1957)	.8451*** (.2015)	(.4502, 1.2400)
Outside Cleaning	.8277*** (.0558)	.2681*** (.1000)	1.0958*** (.1046)	(.8907, 1.3009)
Child Care		N<20		
Meal Prep	.8462*** (.0524)	.6199* (.3722)	1.4661*** (.3812)	(.7190, 2.2140)
Clothing Care		N<20		
Repairs & Maint.	.7276*** (.0659)	.0155 (.1210)	.7431*** (.1253)	(.4976, .9886)
Harvest Nature	.7071*** (.0893)	.0383 (.1084)	.7454*** (.1015)	(.5463, .9444)
Home Furn.	1.1099*** (.1725)	.0189 (.3553)	1.1288*** (.3769)	(.3901, 1.8675)
Home Rep. & Improv.	.6846*** (.0511)	.2160** (.0995)	.9006*** (.1040)	(.6967, 1.1045)

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level
( ) includes the standard error

Table 5-71: Wives' Estimated Returns to Scale for Each Category of Output

Category of Output	α	β	Returns to Scale	95% C.I.
Inside Cleaning	.4781*** (.0524)	.1015 (.1086)	.5796*** (.1117)	(.3607, .7985)
Outside Cleaning	.9234*** (.0788)	.0572 (.1692)	.9806*** (.1710)	(.6455, 1.3157)
Child Care	.7988*** (.0946)	−.1212 (.6252)	.6776 (.6170)	(−.5318, 1.8870)
Meal Prep	.6125*** (.0692)	.2109 (.1495)	.8234*** (.1544)	(.5208, 1.1260)
Clothing Care	.6412*** (.0478)	−.0009 (.0784)	.6403*** (.0771)	(.4891, .7915)
Repairs & Maint.	.5202*** (.0830)	.0198 (.1968)	.5400*** (.2100)	(.1441, 1.0800)
Harvest Nature	.5998*** (.1717)	.0644 (.1857)	.6642*** (.2253)	(.2227, 1.1057)
Home Furn.	.7067*** (.1076)	−.0465 (.2775)	.6602** (.2786)	(.1142, 1.2062)
Home Rep. & Improv.	.6041*** (.0704)	.0915 (.1222)	.6956*** (.1341)	(.4327, .9585)

See Table 5-70 for footnotes

The first test of our hypothesis involves t-testing the difference between the mean values of capital for those that engage in HP activities with those who do not. We hypothesize that those who engage in HP activities will have a significantly greater value of capital than those who do not. Table 5-72 provides the results. Only for inside cleaning are the mean values of capital not greater by a significant amount. The result for inside cleaning may be due to fact that this output requires relatively little capital to produce. Thus, capital should not greatly influence the production of inside cleaning. In any case, the t-test results indicate capital is typically available to those who engage in HP, perhaps by necessity.

A second procedure used to test our hypothesis involves examining the number of people who engaged in specific HP activities without having any capital. We examined 48 out of the total 148 measured individual activities for two reasons. First, we examined only individual activities where more than 20 people engaged in the activity. Second, for some activities, by their very nature, capital appears irrelevant e.g. bed making, child changing. After the screening process, 48 output types remained.

We find no one in our sample who engaged in meal preparation without some capital. This activity alone makes up 42 percent of the total HP for all householders. The same applies to vacuuming, and lawn mowing and raking. Overall, only 11 percent of the time did people engage in HP without having any capital. Capital does appear necessary for a majority of the HP activities measured by our survey. Hence, any measurement of HP that does not include capital's added value will most likely be inaccurate.

Table 5-72: Results of t-test for Differences between the Mean Values of Capital for:

Those Who Engage in Household Activities and Those Who Do Not

Category of Output	Mean Values of Capital with no Output	Mean Values of Capital with Output	t-value	Sig. of t
Inside Cleaning	110	99	1.10	.271
Outside Cleaning	197	292	-2.59	.010
Meal Prep.	1,263	1,476	-4.24	.000
Repairs & Maintenance	153	229	-4.41	.000
Harvest from Nature	334	745	-7.29	.000
Home Furnishings	447	539	-2.22	.028
Home Repairs & Improvements	383	595	-4.44	.000

The indivisible nature of capital may influence the results appearing in Tables 5-61 through 5-69. For example, households tend to be small producing units relative to business firms. Typically, there are only a few members living in one household. In addition, capital tends to come in relatively large units such as vacuum cleaners and table saws whose capacity is likely far to exceed the needs of the household. Households cannot purchase one-half of a vacuum cleaner, etc. Purchasing additional units of capital to increase output would most likely create redundant capital for households because there are a limited number of members to not only utilize the additional capital, but to consume the additional output. The marginal productivity of capital would be zero. On a cross sectional basis among households, capital varies considerably less than labor. Overall in our sample, the average coefficient of variation for capital is 76 percent compared to an average coefficient of variation for labor of 131 percent. Linear regression estimation relies heavily upon variations among the variables of the equations estimated. This may be a reason why capital is not as significant as labor in most of the estimated equations.

5.6.3. Test of the Relationship between Socioeconomic Variables and the Marginal Productivity of Labor

As mentioned in Section 2.5 of Chapter 2, previous empirical work by Gronau and by Graham and Green rely on the assumption that a person's age and education can serve as a proxy for that person's marginal productivity. Our direct estimation of household production functions provides a direct marginal productivity measurement for each person in our sample. If one is to use age and education as a proxy for marginal productivity, then age and education should have a significant relationship with marginal productivity. For example, as a person becomes more educated, his marginal productivity should increase. We use linear regression techniques to test this relationship which Gronau and Graham-Green assumed. Gronau and Graham-Green examined only husbands and wives; thus this analysis will only include those household member types.

Table 5-73 reports the results from regressing the marginal productivity of labor on the age and education of husbands and wives for three major categories of output; inside cleaning, outside cleaning, and meal preparation. In only two instances do the socioeconomic variables show statistical significance, the age of the wives for inside cleaning and the age of the husbands for cleaning outside of the house. However, the extremely small, non-significant adjusted R^2 for each estimated equation means that age and education do very little in explaining the behavior of the marginal productivity of labor. Thus, Gronau and Graham-Green's assumption required for their estimations appears inappropriate.

5.6.4. Test for Marginal Productivity Differences between Husbands and Wives

Again using our measurement of the husbands' and wives' marginal productivity, we examine if there are any differences in the production behavior between husbands and wives. We hypothesize that the husbands' marginal productivity of labor should be greater than the wives' for most types of HP due to the law of diminishing returns. For example, Table 5-74 indicates a significant difference between the mean labor hours for every type of HP except repairs and maintenance. The mean labor hours for wives is significantly greater than the

Table 5-73: Marginal Productivities of Husbands' and Wives' Labor Regressed on Education and Age
Equation: $MPL = \alpha + \beta Education + \gamma Age$

Cleaning Inside of the House

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	5.6911	3.0266	1.880	-.0170
	Education	.0317	.1589	.200	
	Age	-.0138	.0300	-.461	
Wives	Constant	4.4615***	1.4738	3.027	.0094
	Education	-.0030	.0857	-.035	
	Age	-.0233*	.0133	-1.751	

Cleaning Outside of the House

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	37.6003	18.8781	1.992	-.0044
	Education	-.8698	.1791	-1.038	
	Age	-.1860**	.9924	-.876	
Wives	Constant	53.0220**	22.2508	2.383	.0121
	Education	-1.4757	1.3217	-1.117	
	Age	-.3236	.2000	-1.618	

Meal Preparation

Household Member	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Husbands	Constant	-.5013	9.2776	-.054	-.0210
	Education	.5624	.4894	1.149	
	Age	.0300	.0862	.348	
Wives	Constant	6.6590***	1.8782	3.545	.0476
	Education	.0713	.1098	.650	
	Age	-.0433	.0167	-2.591	

* indicates significance at the 10% level
** indicates significance at the 5% level
*** indicates significance at the 1% level

mean labor hours for husbands for inside cleaning, meal preparation, and home furnishings. On the other hand, the mean labor hours for husbands is significantly greater for outside cleaning, harvest from nature, and home repairs and improvements. Thus, the law of diminishing marginal returns requires husbands to have a greater marginal productivity than wives for all HP activities except outside cleaning, harvest from nature, and home repairs and improvements. In those three categories, the wives' marginal productivity should be greater.

Section 5.6 illustrates how we use the estimated parameter α to derive the marginal productivity of labor. In order to determine whether or not husbands and wives have different marginal productivities, we must establish that the α estimated for husbands is significantly different from the α estimated for wives. The Chow test described in Section 5.3 provides this test. Table 5-75 lists the results for the seven output categories having sufficient data. The estimated parameters of the production function equations are significantly different for five of the seven categories. Thus, we can use the estimated parameters for comparing marginal productivity differences for inside cleaning, outside cleaning, meal preparation, home furnishings, and home repairs and maintenance.

We hypothesize that the average marginal productivity of husbands will be significantly greater than the average marginal productivity of wives for inside cleaning, meal preparation, and home furnishings. The opposite should occur for outside cleaning and home repairs and improvements. Table 5-76 provides the t-test results. For inside cleaning, meal preparation, and home furnishings, the average marginal productivity of labor for husbands is significantly greater than the average marginal productivity of labor for wives. In the case of wives having

Table 5-74: Results of t-test for Differences between Mean Labor Hours of Husbands and Wives

Category of Output	Wives' Mean Labor Hours	Husbands' Mean Labor Hours	t-value	Sig. of t
Inside Cleaning	535	81	11.05	.000
Outside Cleaning	24	50	-4.50	.000
Meal Prep.	834	372	5.74	.000
Repairs & Maintenance	18	20	-.55	.582
Harvest Nature	56	120	-2.44	.016
Home Furnishings	77	19	5.59	.001
Home Repairs & Improve.	12	37	-3.29	.001

Table 5-75: Chow-test Results for Differences in Production Behavior between Husbands and Wives

Category of Output	SSE_T	SSE_1	SSE_2	F-Ratio
Inside Cleaning	143.39	69.43	40.30	23.8841***
Outside Cleaning	253.74	95.99	146.38	3.5966***
Meal Preparation	52.18	11.38	37.30	3.9897***
Repairs & Maintenance	125.15	95.20	25.74	1.6669
Harvest Nature	214.24	85.68	124.17	.9832
Home Furnish	188.33	69.66	97.28	4.1002***
Home Repairs & Maintenance	130.22	67.11	57.38	2.8998**

** indicates significance at the 5% level
*** indicates significance at the 1% level

SSE_T equals the sum of the squared residuals for both husband and wives
SSE_1 equals the sum of the squared residuals for husbands
SSE_2 equals the sum of the squared residuals for wives

greater marginal productivity than husbands, we do not find any evidence of a significant difference for outside cleaning or home repairs and improvements. The husbands' marginal productivity of labor may be greater than the wives' because husbands tend to produce a wider variety of outputs in each of these two categories. For example, an average of 45 percent of the husbands engaged in all of the individual activities within inside cleaning compared to only an average of 19 percent of wives. Thus, husbands most likely will use a wider variety of tools such as table saws, sanders, wood working equipment, shop vacuums, etc. We find capital to be a significant input for both of these output categories for husbands. Utilization of a wider variety of capital may increase the husbands' marginal productivity, assuming capital is a complementary input to labor.

5.6.5. Test for Neoclassical Allocation of Resources within Married Couple Households

Neoclassical theory dictates that producing entities will produce output where the ratio of input marginal productivities equals the ratio of the prices of these inputs. In the case of working married couple households, the husbands' and wives' labor are the primary inputs and their wage rates are the prices of the inputs. We examine only husbands and wives for several reasons. First, we have a large enough sample size to examine most HP outputs. Second, certain biological needs (e.g. meals, minimum cleaning, etc.) have to be fulfilled within a married couple household. Typically, households do not purchase the services or goods necessary to fulfill these biological needs. Therefore, excluding children as producing members, either the husband or wife must engage in the HP necessary

Table 5-76: Results of t-test for Differences between Average Marginal Productivities of Labor for Husbands and Wives

Category of Output	Wives' Ave. MP of Labor	Husbands' Ave. MP of Labor	t-value	Sig. of t
Inside Cleaning	3.32	5.45	-4.53	.000
Outside Cleaning	17.94	16.16	42	.676
Meal Prep.	5.55	9.26	-4.41	.000
Repairs & Maintenance	26.04	27.90	-.250	.805
Harvest Nature	2.23	2.15	.150	.883
Home Furnishings	9.06	72.35	-1.79	.077
Home Repairs & Improve.	53.48	67.10	-1.27	.205

to fulfill those needs. In addition, both the husband and wife have access to essentially the same technology and capital which will likely exclude marginal productivity differences due to technological or capital differences.

If both parents work in the market, we hypothesize that average ratio of the marginal productivity of husbands and their wage rate will not differ significantly from the average ratio of the marginal productivity of wives and their wage rate. The reason for this hypothesis is that even though husbands have a higher marginal productivity than wives for most HP activities, a t-test indicates that husbands' wage rate is significantly greater than wives'. Thus, households minimize the cost of HP by having husbands do more work in the market and wives do more work at home.

Equating the previous ratios is mathematically the same as equating the ratio of husbands' and wives' marginal productivities with the wage rates ratio of husbands and wives. However, because we estimate α separately for husbands and wives, we must assume different variances for each. The t-test we conduct to test our hypothesis assumes separate variances. Thus, we t-test the difference between the MP of husbands' labor divided by the husbands' wage rate and the MP of wives' labor divided by the wives' wage rate.

Table 5-77 contains the results of the t-tests for a significant difference between the average ratio of husbands' marginal productivity and their wage rates and the ratio of wives' marginal productivity and their wage rates. For only inside cleaning do we see a significant difference between the previously described averages, and that t-value is only significant at the 90.6 percent confidence level. Therefore, married couple households appear to behave rationally and according to rules provided by neoclassical theory. In this respect, Becker's theoretical work seems to apply to our sample sets of husbands and wives.

5.6.6. Test for Phases of Production

In neoclassical production theory, there exist three *short-run* stages of production; phase I where average productivity of labor (output/labor) is rising and the marginal productivity of labor is positive, phase II where average productivity of labor is falling and marginal productivity of labor is positive, and phase III where average productivity of labor is falling and marginal productivity of labor is negative. Neoclassical theory states that operating in phase II is most optimal for producing entities. For example, if a firm was producing in phase III, output could be increased by using less labor. If a firm were operating in phase I, perfect competition would compel the firm to increase output by increasing labor. The additional output obtained would be greater than the cost of the additional labor, ceteras paribus. Thus, the optimal level of production would be in Phase II.

We hypothesize that husbands and wives, being rational producers, will operate in phase II of the short run production process. The estimated α's for husbands and wives in Tables 5-61 through 5-69 indicate that the marginal productivity of labor is positive for all HP categories. Thus, households are not operating in Phase III.

To determine if households are in phase I or phase II, we examine the relationship between the average productivity of labor and labor hours, including several socioeconomic variables to account for any *long-run* differences among the people in our sample. These long-run variables are listed at the bottom of

Table 5-77: Results of the t-test for Differences between the Marginal Productivity of Labor and Wage Rate Ratio for Husbands and the Marginal Productivity of Labor and Wage Rate Ratio for Wives

Category of Output	Mean of $MPL_w/Wage_w$	Mean of $MPL_h/Wage_h$	t-value	Sig. of t
Inside Cleaning	.698	1.138	-1.70	.094
Outside Cleaning	2.153	2.229	-.14	.890
Meal Prep.	1.170	1.650	-.71	.484
Repairs & Maintenance	4.318	6.884	-.93	.366
Harvest Nature	.256	.486	-1.62	.116
Home Repairs & Improve.	9.785	11.029	-.40	.688

Table 5-78. If the relationship between the average productivity of labor and labor hours is negative, then the average productivity of labor is falling and households are operating in phase II. If the relationship is positive, then households are operating in phase I.

Tables 5-78 and 5-79 report the results from regressing the average productivity of labor on labor hours and several socioeconomic variables for husbands and wives, respectively. For husbands, four out of seven categories of output significantly indicate that the average product of labor is falling. Even though the other categories do not show labor as significant, the estimated parameter is still negative, except for home furnishings. Therefore, husbands tend to operate in phase II of the production process. For wives, seven out of nine categories of output significantly indicate that the average productivity of labor is falling with respect to labor. Only outside cleaning and repairs & maintenance were not significant. Thus, wives also tend to operate in phase II of the short run production process. These results are what neoclassical theory tells us we should see if married couple households are operating rationally.

Table 5-78: Results from Regressing AP of Labor (Output/Labor) on Labor and Several Socioeconomic Variables for Husbands

Equation: $APL = \alpha_0 + \alpha_1 L + \alpha_2 Time + \alpha_3 Age + \alpha_4 Educ + \alpha_5 Income + \alpha_6 Kids$ ###

Category of Output	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Inside Cleaning	Labor	-.0439	.0504	-1.631	.4332***
Outside Cleaning	Labor	-.1601***	.0614	-2.605	-.0069
Meal Prep.	Labor	-.1141	.0701	-1.627	.1009
Repairs & Maintenance	Labor	-.2750***	.0670	-4.101	.1510***
Harvest Nature	Labor	-.3158***	.0790	-4.001	.1474**
Home Furnishings	Labor	.1690	.1780	.952	.0406
Home Repairs & improve.	Labor	-.2962***	.0503	-5.890	.2303***

Time = Length of time household has existed at current address.

Income = Dummy variable for the following income groups: $0 through $7,000/yr, $7,001 though $15,000/yr, $15,001 through $25,000/yr, $25,001 through $35,000/yr, $35,001 though $50,000/yr, over $50,000/yr.

Kids = Dummy variable for the following children groups: no children living at home, one child living at home, two children living at home, three or more children living at home.

** indicates significance at the 5% level
*** indicates significance at the 1% level

Table 5-79: Results from Regressing AP of Labor (Output/Labor) on Labor and Several Socioeconomic Variables for Wives

Equation: $APL = \alpha_0 + \alpha_1 L + \alpha_2 Time + \alpha_3 Age + \alpha_4 Educ + \alpha_5 Income + \alpha_6 Kids$ ###

Category of Output	Variable	Estimated Parameter	Standard Error	t-value	R^2adj.
Inside Cleaning	Labor	-.5635***	.0557	-10.108	.4332***
Outside Cleaning	Labor	-.0662	.0785	-.844	.0050
Child Care	Labor	-.3614***	.1077	-3.357	.2127***
Meal Prep.	Labor	- 4525***	.0903	-6.736	.3140***
Clothing Care	Labor	.3780***	.0494	-7.658	.3069***
Repairs & Maintenance	Labor	.1322	1281	1.032	.2579
Harvest Nature	Labor	-.3573***	.1084	-3.295	.1553***
Home Furnishings	Labor	-.3013**	.1218	-2.473	.1720
Home Repairs & improve.	Labor	-.4183***	.0665	-6.285	.3592***

See Table 5-78 for variable definitions.

** indicates significance at the 5% level
*** indicates significance at the 1% level

Chapter 6

CONCLUSIONS AND IDEAS FOR FURTHER RESEARCH

6.1. Direct vs. Indirect Estimation Techniques

Using the direct measurement of household output, labor, and capital discussed in Chapter 4, direct estimation of household production functions was possible. Furthermore, by examining appropriate sample sets, the estimated parameters of household production functions were used to test several hypotheses concerning household production behavior. One of the most important hypothesis concerned the validity of previous empirical work. As discussed earlier, the lack of sufficient data caused past empiricists to use assumptions about the functional form of household production functions, and to develop proxies for variables used in their equations. Our direct estimation technique allowed us to test several functional forms of household production functions in order to see which form best fit our sample sets. Thus, we did not need to *assume* any functional form. In addition, the estimated parameters of directly estimated production functions allowed us to determine whether or not the proxy variables used by past empiricist were appropriate. The results in Section 5.6 of Chapter 5 showed that the chosen proxies did not exemplify the true behavior of the variable being replaced by the proxies. This implies past empirical work by Gronau and Graham-Green were inherently flawed.

6.2. Capital as an HP Input

Although the regression results of the previous chapter indicated capital was not a significant variable in the production functions for most households, the necessity of capital was established through both the t-test of the mean values of capital for those who engage in HP and those who do not, and close examination of the number of people who engaged in HP without having any capital available. The t-test provided statistical evidence while the other was an intuitive test. For instance, common sense tells us that one cannot vacuum a floor without a vacuum cleaner. One cannot mow the lawn without a manual or powered mower. Hence, any previous estimates of household production which did not include the value added by all inputs were likely inaccurate.

If household capital was necessary, then why was it an insignificant input in our estimated production functions? The typical business firm in the long-run can vary all inputs, including capital. If a business firm wishes to increase output to meet market demands, they can purchase new capital and/or employ more labor. Thus, if linear regression techniques were applied to business firm production functions, capital would be a significant input.[51] Households, however, do not have market demands for the goods and services they produce. The number of household members living at a one residence limits not only the demand for goods and services, but the labor necessary to produce additional output. Furthermore, capital tends not to come in easily divisible units. A household cannot purchase one-half of a microwave oven. Consequently, household capital

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[51] See Douglas (1948) for estimated business firm production functions.

varies substantially less than labor on a cross-sectional basis. The end result is additional capital becomes redundant for households and the marginal productivity of capital is essentially zero.

6.3. Household Production Behavior and Neoclassical Theory of the Firm

Becker argued that households behave rationally and adhere to rules provided by traditional neoclassical theory. The results in Chapter 5 are consistent with Becker's theoretical assessment of household production behavior. First, the law of diminishing marginal returns appeared to apply to married couple household production behavior. Second, married couple households where both the husband and wife work did not show a tendency to misallocate resources. The statistical evidence in Section 5.6 of Chapter 5 indicated that husbands and wives did equate their marginal productivities with their wage rates. This is what we would expect to find for a producing entity abiding by cost minimization rules of neoclassical theory. Third, neoclassical theory dictates that producing entities in a perfectly competitive market should operate in phase II of the short run production process. The results in Section 5.6 of Chapter 5 showed substantial evidence that husbands and wives did operate in phase II of the short run production process. All the previous results imply households operate according to traditional neoclassical theory.

6.4. Ideas for Further Research

6.4.1. Business Firms vs Households

Much of the previous analysis centered on determining whether or not households operate like business firms in a perfectly competitive market. One obvious way to directly test whether or not business firms and households have similar production behavior is to measure output, labor, and capital for business firms that produce services and goods households typically produce for themselves. This would allow a direct estimation of business firm production functions for inside cleaning, outside cleaning, meal preparation, etc. Estimated household and business firm production functions could then be compared for similarities or differences.

Currently, business firms in the Missoula, Montana area are being surveyed to gather the information necessary for estimating business firm production functions. We intend to use the information obtained to directly test our hypothesis that business firms and households have similar production behavior.

6.4.2. Estimating the Value of Household Production

Graham and Green estimated the value of household production using the estimated parameters of their production function and a proxy for capital. Our directly estimated production function also can be used to estimate the value of household production. However, our direct measurement of capital avoids possible bias which may occur when using proxies for variables. In addition, with a measurement of capital and several socioeconomic variables, one may be able to identify a significant relationship between capital and selected socioeconomic variables. If a relationship is identified, a previously determined production function can be integrated (using integral calculus techniques) at given quantities of labor and capital (using previously identified proxies for capital) to estimate the value of household production. This technique would avoid having to measure output and capital which are typically harder to measure than labor in order to estimate the value of HP.

6.4.3. Another Dimension of Household Behavior

Although we did not include leisure in this study, we are interested in the role leisure plays in household production behavior. Graham and Green tried to account for household production that provided not only goods and/or services, but leisure as well. For instance, a person may derive leisure enjoyment from engaging in meal preparation. If leisure has any value, the actual value of household production should include the value added by all inputs plus the value of leisure. Furthermore, activities such as attending a Broadway play, skiing, tennis, etc. all have value in terms of the leisure that those activities may provide people in society. Becker recognized these activities as being an important factor in determining the allocation of resources within a household. Becker also recognized that the production of leisure activities requires not only one's time, but capital items (e.g. ticket to the play, skis, tennis racquet, etc.) as well. By directly estimating the value of leisure, the time spent engaged in leisure, and the capital used to produce leisure, leisure production functions could be estimated. Thus, Becker's theoretical model could be tested in its entirety.

Currently, members of the Seminar in Empirical Research Design at the University of Montana's Economics Department are in the process of obtaining the value of a wide variety of leisure activities. If the value of leisure were obtained, it could also be used to determine net economic losses sustained by a person who is wrongfully injured or killed. For example, a wrongfully injured person may lose the value of her future market productivity, household production, and leisure. The value of a person's market productivity can be determined by his wage rate, or potential wage rate. The value of household production can be determined using the Fitzgerald/Wicks[52] direct output approach. The value of leisure may be obtained by determining how much a person is willing to pay for a leisure activity, or how much a person must be paid in order to give up that leisure activity. Thus, a heretofore unavailable total economic loss could be determined.

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[52]See Fitzgerald and Wicks, loc. cit.

APPENDIX A
SINGLE HEAD OF HOUSEHOLD

Name: ____________________ A. Household # ____________

Address: ____________________ Date: ____________

Phone: ____________________ Interviewer ____________

B. Principal occupation ____________ Checker ____________

C. Number of children living at home ______

D. Ages of children living at home ______

E. How long has this household existed with a single person as head? ______

F. Age ______

G. Years of education ______

H. Years of experience in principal occupation ______

I. Number of months employed during past 12 months ______

J. Hours worked per week when employed ______

K. If 1 or more months of unemployment during past 12, was it voluntary or involuntary? ______

L. Average 2-week's take-home pay (Please check appropriate box)

- ☐ 0 - $99
- ☐ $100 - $199
- ☐ $200 - $399
- ☐ $400 - $699
- ☐ $700 - $999
- ☐ $1,000 - $1,499
- ☐ $1,500 - $2,499
- ☐ $2,500 and over

Are there any other members of the household? If so, what is the age and relationship to the household of each? ____________

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HOUSEHOLD PRODUCTION

CLEANING - INSIDE HOUSE: Activity	Reporting Period for Activity (✓) Day	Week	Month	Year	Average Time Spent during Reporting Period Hours	Minutes	Output Unit	Number of Units Produced during Period Units	Tenths
1. Vacuuming							1 room, 1 time	.	
2. Floor mopping							1 floor, 1 time	.	
3. Basin, tub, tile, commode cleaning							bathroom cleanings	.	
4. Bed linen changing							changes	.	
5. Bed making							bed makings	.	
6. Garbage take-out							bags	.	
7. Stove cleaning: elements & oven							complete cleanings	.	
8. Defrosting: fridge OR freezer							defrostings	.	
9. Cupboard cleaning							cupboards cleaned	.	
10. Kitchen other surfaces cleaned							times all cleaned	.	
11. Other rooms' other surfaces cleaned							one room's surfaces	.	
12. General pick-up							rooms picked up	.	
CLEANING - OUTSIDE HOUSE:									
13. Window cleaning							windows cleaned	.	
14. Garage cleaning							cleanings	.	
15. Patio cleaning							cleanings	.	
16. Lawn mowing				✓			mowings	.	
17. Lawn raking				✓			rakings	.	
18. Yard litter pick-ups							pick-ups	.	
19. Snow shovelling				✓			times	.	
20. Chimney sweeping							times	.	
CHILD CARE:									
21. Child feeding (excl. meal preparation)							feedings	.	
22. Child changing							changings	.	
23. Child bathing							baths	.	
24. Child transporting							miles	.	
25. MEAL PREPARATION (including dish washing, food shopping)							meal for 1 person	.	

CLOTHING CARE: Activity	Reporting Period for Activity: Day	Week	Month	Year	Average Time Spent during Reporting Period: Hours	Minutes	Output Unit	Number of Units Produced during Period: Units Tenths
26. Washing & drying							load	.
27. Ironing							garments ironed	.
28. Mending							garments mended	.
29. Alteration							garments altered	.
REPAIRS & MAINTENANCE:								
30. Electrical repairs							job	.
31. Plumbing repairs							job	.
32. Interior painting							1 room	.
33. Exterior painting							whole house	.
34. Vehicle cleaning							times	.
35. Vehicle tune-up (plugs, points, timing)							tune-ups	.
36. Lubrication (incl. oil change)							lube jobs	.
37. Tire changing							tires changed	.
38. Other vehicle repair							job	.
39. Other appliance & equipment repair							job	.
HARVEST FROM NATURE & HOMEGROWN FOOD:								
40. Hunting				✓			pounds	.
41. Fishing				✓			pounds	.
42. Wild berry gathering				✓			pounds	.
43. Homegrown livestock				✓			pounds	.
44. Garden produce				✓			(List output on following page)	

GARDEN HARVEST DURING YEAR

Item	Pounds	Pints	Quarts	Gallons	Bushels	Grocery Sacks	Bunches	Heads	Number
1. Asparagus									
2. Beans, string									
3. Beans, other									
4. Beets									
5. Broccoli									
6. Brussels sprouts									
7. Cabbage									
8. Carrots									
9. Cauliflower									
10. Corn									
11. Cucumber									
12. Kohlrabi									
13. Lettuce									
14. Onions									
15. Peas									
16. Peppers									
17. Potatoes									
18. Pumpkins									
19. Radishes									
20. Rhubarb									
21. Spinach									
22. Squash, fall									
23. Squash, summer									
24. Swiss chard									
25. Tomatoes									
26. Apples									
27. Apricots									
28. Cherries									
29. Pears									
30. Plums									
31. Raspberries									
32. Strawberries									
33. Blackberries									
34. Currants									
35. Grapes									

41. HOBBY & HOME FURNISHINGS PRODUCTION

Reporting period for all items on this page: YEAR

HOME FURNISHINGS: Activity	Time Spent during Year: Hours	Minutes	Output Unit	Number of Units Produced during Year: Units	Tenth
A. Bookshelves			each	.	
B. Coffee table			each	.	
C. Desk			each	.	
D. Dresser			each	.	
E. Gun cabinet			each	.	
F. Refinish bed			each	.	
G. Refinish table & 4 chairs			each	.	
H. Re-upholster chair			each	.	
I. Re-upholster couch			each	.	
J. Re-upholster footstool			each	.	
K. Rocking chair			each	.	
L. Stereo cabinet			each	.	
M. Other (specify)			each	.	
CLOTHING:					
N. Afghan			each	.	
O. Baby blanket			each	.	
P. Bedspread			each	.	
Q. Curtains			each	.	
R. Embroidered pollowcase			each	.	
S. Jacket			each	.	
T. Muffler			each	.	
U. Nightgown			each	.	
V. Pillow			each	.	
W. Quilt			each	.	
X. Slacks			each	.	
Y. Sweater			each	.	
Z. T-shirt			each	.	
AA. Other (specify)			each	.	

41. HOBBY & HOME FURNISHINGS PRODUCTION

Reporting period for all items on this page: YEAR

MISCELLANEOUS: Activity	Time Spent during Year: Hours	Time Spent during Year: Minutes	Output Unit	Number of Units Produced during Year: Units Tenths
BB. Birdhouse			each	.
CC. Boutineer			each	.
DD. Doll			each	.
EE. Wall hanging			each	.
FF. Ornament			each	.
GG. Picture frame			each	.
HH. Potholder			each	.
II. Record box			each	.
JJ. Stained glass			each	.
KK. Other (specify)			each	.
42. HOUSE REPAIRS AND IMPROVEMENTS:				
A. Add basement			basement	.
B. Add cabinet			cabinet	.
C. Add carport			carport	.
D. Add ceiling tile			1 tile	.
E. Add pantry			pantry	.
F. Add railing to porch			railing	.
G. Add porch			porch	.
H. Add shelf			shelf	.
I. Add wall			wall	.
J. Build awning for porch			awning	.
K. Build dog run			dog run	.
L. Build porch roof			roof	.
M. Build skylight			skylight	.
N. Caulk window			window caulked	.
O. Clean carpet			carpet in 1 room	.
P. Fix broken window			1 window pane	.
Q. Fix door			job	.
R. Frame wall			wall	.

42. HOUSE REPAIRS AND IMPROVEMENTS cont. 2

Reporting period for all items on this page: YEAR

Activity	Time Spent during Year		Output Unit	Number of Units Produced during Year	
	Hours	Minutes		Units	Tenths
S. Hang door			door	.	
T. Install electrical outlet			outlet	.	
U. Install automatic garage door			door	.	
V. Install new flooring			1 room's floor	.	
W. Install window screen			screen	.	
X. Install wooden sidewalk			sidewalk	.	
Y. Insulate basement			basement	.	
Z. Insulate door			door	.	
AA. Insulate darage			garage	.	
AB. Lay carpet			1 room	.	
AC. Put up window drapes			window	.	
AD. Put in new ceiling joist			joist	.	
AE. Put metal siding on house			house	.	
AF. Put on new screen door			door	.	
AG. Re-shingle house			house	.	
AH. Remodel front entry			entry	.	
AI. Remodel garage			garage	.	
AJ. Remove oven vent			vent	.	
AK. Remove wall			wall	.	
AL. Repair drywall			wall	.	
AM. Repair foundation			job	.	
AN. Repair roof on outbuilding			roof	.	
AO. Repair screen door			door	.	
AP. Repair shower door			door	.	
AQ. Replace septic tank			septic tank	.	
AR. Replace door knob			knob	.	
AS. Replace insulation			job	.	
AT. Replace sink			sink	.	
AU. Re-side garage			garage	.	
AV. Tarring; roof repair			job	.	

42. HOUSE REPAIRS AND IMPROVEMENTS cont. 3

Reporting period for all items on this page: YEAR

Activity	Time Spent during Year: Hours	Time Spent during Year: Minutes	Output Unit	Number of Units Produced during Year: Units Tenths
AW. Wallpapering			room	.
AX. Wash house or trailer exterior			house	.
AY. Winterize house			house	.
				.

43. YARD REPAIRS & IMPROVEMENTS:

Activity	Hours	Minutes	Output Unit	Units Tenths
A. Build deck			deck	
B. Build deck roof (cover)			roof	
C. Build fence			fence for 1 side of yard	.
D. Build rock wall			wall	.
E. Build new flower bed			bed	.
F. Clean landscaping (rock; bark)			job	.
G. Install underground sprinkler			sprinkler head	.
H. Plant shrub			shrub	.
I. Plant tree			tree	.
J. Pour concrete			job	.
K. Repair deck			job	.
L. Repair fence			job	.
M. Tree or shrub removal			tree or shrub	.
N. Tree spraying for bugs			tree	.
O. Trim shrub or small tree			shrub	.
P. Trim tree			tree	.
				.

APPENDIX B
CAPITAL INVENTORY CHECKLIST

1. Household Capital Inventory Checklist

Description	Size			Age			
	Small	Medium	Large	New to 6 Months	6 Months to 3 Yrs.	3 to 8 Yrs.	Over 8 Yrs.
Range							
Refrigerator							
Dishwasher							
Freezer							
Microwave							
Washing Machine							
Clothes Dryer							
Vacuum cleaner							

If household has item, please check appropriate box. If not, then leave blank!

KITCHEN ITEMS

1. ________ Blender
2. ________ Canner
3. ________ Carving knives
4. ________ Charcoal barbecue
5. ________ Coffee maker
6. ________ Cooking utensils
7. ________ Crock pot
8. ________ Deep fat fryer
9. ________ Electric canopener
10. ________ Electric fry pan
11. ________ Electric griddle
12. ________ Electric knife
13. ________ Electric meatslicer
14. ________ Fondue pot
15. ________ Food dehydrator
16. ________ Food processor
17. ________ Garbage disposal
18. ________ Gas barbecue
19. ________ Ice cream maker
20. ________ Ice crusher
21. ________ Juicer
22. ________ Meat grinder
23. ________ Mixer
24. ________ Pasta maker
25. ________ Popcorn maker
26. ________ Pressure cooker
27. ________ Smoker
28. ________ Table settings
29. ________ Toaster
30. ________ Trash compactor
31. ________ Waffle iron
32. ________ Wok

LAWN & CLEANING

33. ________ Air broom
34. ________ Broom
35. ________ Chimney sweep
36. ________ Garden hose
37. ________ Garden rake
38. ________ Garden tractor
39. ________ Gas can
40. ________ Hoe
41. ________ Lawn fertilizer
42. ________ Lawn mower
43. ________ Lawn rake
44. ________ Lawn thatcher
45. ________ Lawn vac

46. ________ Mop
47. ________ Roto tiller
48. ________ Scrub bucket
49. ________ Shop vac
50. ________ Shovels
51. ________ Snow blower
52. ________ Sidewalk edger
53. ________ Sprinkler
54. ________ Weed eater
55. ________ Weed sprayer
56. ________ Wet vac

TOOLS

57. ________ Allen wrench
58. ________ Bench grinder
59. ________ Chain saw
60. ________ Crescent wrench
61. ________ Cutting torch
62. ________ Drill press
63. ________ Extension cord
64. ________ Files
65. ________ Grease gun
66. ________ Hack saw
67. ________ Hammer
68. ________ Hand planer
69. ________ Hand saw
70. ________ Hot glue gun
71. ________ Jointer
72. ________ Ladder
73. ________ Lathe
74. ________ Metric wrench set
75. ________ Oiler
76. ________ Pipe wrench
77. ________ Post hole digger
78. ________ Power drill
79. ________ Power planer
80. ________ Power sander
81. ________ Propane torch
82. ________ Screwdriver
83. ________ Skill saw
84. ________ Socket wrench set
85. ________ Standard wrench set
86. ________ Staple gun
87. ________ Sythe
88. ________ Table saw
89. ________ Tap & die set
90. ________ Vice
91. ________ Vice grips
92. ________ Welder
93. ________ Wire cutters
94. ________ Wire strippers
95. ________ Pliers
96. ________ Soldering gun

TOOLS FOR CARS

97. ________ Battery charger
98. ________ Buffer
99. ________ Car ramp
100. ________ Hydraulic jack
101. ________ Oil filter wrench
102. ________ Polisher
103. ________ Tire iron
104. ________ Torque wrench

PAINTING TOOLS

105. ________ Air brush
106. ________ Compressor
107. ________ Generator
108. ________ Paint brush
109. ________ Protective mask

WOOD TOOLS

110. ________ Axe and hatchet
111. ________ Hand pruner
112. ________ Splitting maul

HUNTING & FISHING

113. ________ Fishing boat
114. ________ Fishing pole
115. ________ Hunting rifle
116. ________ Shot gun

SEWING

117. ________ Serger
118. ________ Sewing machine

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