HOME PRODUCTION—A FORGOTTEN INDUSTRY

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I. Introduction

RECENT years have witnessed an awakened interest in the economic activity taking place outside the market, and in particular the activity taking place at home. This interest spurred by the new consumption theory of Becker and Lancaster and by the estimates of the Measure of Economic Welfare of Nordhaus and Tobin (1973) has taken two distinct forms: an increased number of studies on the economics of household behavior and a renewed effort to place a money value on the household home activity. However, while the major thrust of the first type of studies is in the field of microeconomics, the estimates of home production refer, in general, to the economy as a whole. These estimates, crude as they are, indicate that home production is far from being a negligible part of the economic activity. Even in an advanced economy such as the United States the value added generated by the home sector seems to account for over one third of the output produced at the market (Hawrylyshyn, 1976). In less advanced economies this fraction is presumably even higher. It seems, therefore, of interest to repeat the question in a microeconomic context and examine the role of home production at the household level, rather than in the aggregate.

In contrast to past studies which have focused on the labor inputs going into home production (Sirageldin, 1969; Walker and Gauger, 1973), the emphasis in this paper is on the measurement of productivity and total home output. The questions I try to answer are: What are the factors determining the wife's productivity at home? What is the value of home production and how does it compare with the family's money income? How does the value of home production differ among families with different socioeconomic backgrounds? How is it affected by the wife's labor force participation and by the existence of young children? How does it change over the family's life cycle?

It is found that the value of home production associated with the work at home of U.S. wives in 1973 exceeded 60% of the family's money income before taxes, and 70% of the family's money income after taxes. It was lower for families with no preschool children and almost equal to the family's money income after taxes when the family had young children. Home productivity increases with education but at a lower rate than market productivity. Home production is only slightly affected by the wife's employment in the market when the family does not have young children. However, when the family has young children, the loss of home output when the wife joins the labor force equals almost her increased money earnings. Finally, home production tends to peak at a younger age (35–39) than money income and drops significantly thereafter.

The paper opens with a discussion of the estimation of household productivity—the model, the data and the estimates. The role home output plays in comparison with other material resources is discussed in section III. The paper closes with some concluding remarks.

II. The Estimation of Home Productivity

Following conventional theory, it is assumed that welfare (U) is a function of consumption (X) and leisure (L),

$$U = U(X,L). \qquad (1)$$

Goods can be either purchased in the market (X_M) or produced at home (Z). Measuring the home-produced goods and services in terms of the price charged for them in the market,

$$X = X_M + Z. \qquad (2)$$

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Home goods are produced using market inputs (X_H) and time inputs (i.e., work at home H),

$$Z = f(X_H, H) \tag{3}$$

subject to decreasing marginal productivity $f_X > 0, f_H > 0, f_{XX} < 0$, and $f_{HH} < 0$. The maximization of welfare is subject to two constraints: (a) the budget constraint specifying that in this one-person, one-period model, market consumption cannot exceed money income.

$$X_M + X_H = WN + V \tag{4}$$

where W denotes the wage rate, N denotes work in the market, and V other sources of income; and (b) the time constraint specifying that time (T) is a scarce resource to be allocated among its three uses—work at home, work in the market and leisure:

$$L + H + N = T. \tag{5}$$

The maximization of welfare subject to these constraints yields two kinds of equilibria: (a) the case where the person works in the market ($N > 0$) in which case

$$f_H = s = W \tag{6}$$

where f_H is the marginal productivity of work at home and s denotes the marginal rate of substitution between leisure and goods $[s = (\partial U/\partial L)/(\partial U/\partial X)]$, and (b) the case where the person does not participate in the labor force ($N = 0$) where only the first of these equalities is satisfied:

$$f_H = s.^{1} \tag{7}$$

The estimation of the home goods production function (equation (3)) is abound with difficulties. Not only is the output Z unknown, but there is no direct way of separating X_M from X_H and measuring the market inputs (X_H) that are used in the process. An indirect approach is, therefore, clearly needed. The point of departure of this indirect approach is equation (6) rather than equation (3). Its purpose is to estimate the marginal productivity of time in home production, and generate the value of home production by integrating the marginal productivity function.

To estimate the marginal productivity function f_H one can proceed in one of two ways: assume a certain form of the home production function f (e.g., Cobb-Douglas or constant elasticity of substitution (CES)), derive f_H and estimate it, or alternatively make an explicit assumption about the functional form of f_H and derive f. I adopted the second of these methods.

It is assumed that the marginal productivity of the home production function is of the semi-log variety[2]

$$\ln f_H = \alpha_0 - \alpha_1 H + \alpha_2 Y \tag{8}$$

where Y denotes a vector of variables affecting the value of marginal productivity at home. Given this specific function and the equilibrium condition (6) one can derive the work at home function for labor force participants:

$$H = (\alpha_0 - \ln W + \alpha_2 Y)/\alpha_1. \tag{9}$$

Estimating this function,

$$H = a_0 - a_1 \ln W + a_2 Y, \tag{10}$$

one derives the estimates of the parameters α_i:

$$\begin{aligned} (1/a_1) &= \text{est}(\alpha_1), \\ (a_0/a_1) &= \text{est}(\alpha_0), \\ (a_2/a_1) &= \text{est}(\alpha_2). \end{aligned} \tag{11}$$

Using these parameters one can estimate the value of home production

$$\begin{aligned} Z &= \int_0^H f_H(t)dt \\ &= \int_0^H \exp(\alpha_0 - \alpha_1 t + \alpha_2 Y)dt \\ &= \{\exp(\alpha_0 + \alpha_2 Y)[1 - \exp(-\alpha_1 H)]\}/\alpha_1, \end{aligned} \tag{12}$$

assuming there is no home production when there is no work at home.

Data on time use are hard to come by, and sources where such data are accompanied by adequate information on the household's socio-economic characteristics are even more scarce. One of the few sources that satisfies our require-

[1] The qualifications and ramifications of a similar model are discussed at length in Gronau (1977), and so I shall not discuss them here. It is sufficient to say that the optimum conditions (6) and (7) could have been generated also by other structures and, hence, my method of estimation is not crucially dependent on the validity of this model. Two crucial assumptions are that there is no joint use of time for work at home and leisure activities, and that work at home and work in the market generate the same direct utility.

[2] The assumption on the semi-log form follows Heckman (1974). Tests indicate that this functional form is superior to the linear and double log form. A more elaborate test of consistency is described in the appendix.

ments is the Michigan Study of Income Dynamics. In this study the head of the household was asked about the number of weeks the head and his wife worked in the market in the previous year and the number of hours worked per week. People were also asked how much time they and their wives spent on housework in an average week. Housework was not very strictly defined and the examples mentioned in the questionnaire such as cooking, cleaning and other work around the house allow for a lot of ambiguity. Thus, it is not clear whether the respondents included in their answers time spent on activities such as shopping (which does not take place within the home) or childcare (which may not be regarded as housework). The reported annual hours spent in housework may, therefore, underestimate the extent of work at home.

At this stage of the analysis I focused on white married couples, and since husbands reported relatively few hours spent in work at home (less than 200 hours in the case of employed males and about 350 hours in the case of the not employed), I narrowed the analysis even further to married women. The Michigan Study of Income Dynamics is a panel study encompassing seven years, 1968–1974. In this paper I shall report the findings relating to 1973.[3]

The set of explanatory variables Y includes the wife's age and education, the 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. Education and on-the-job training (i.e., age) are expected to increase the wife's marginal productivity at home the same way they affect productivity in the market. Children increase the value assigned to the wife's services and, hence, should increase her marginal productivity at home, though this increase may taper off as the child grows older. Similarly, the value of marginal productivity may increase with the size of the house as measured by the number of rooms. The husband's wage and education and the family's non-earned income are proxies for the other inputs in the home production process.

The wage is imputed as a function of the wife's education (*EDUCW*), her labor force experience since the age of 18 (*EXPRNW*), the experience variable squared and the husband's education (*EDUCH*). The estimated equation is of the semi log form:

$$\begin{aligned} \ln W = &-.4237 + .0827\, EDUCW \\ &\ (3.83) \quad\ (8.34) \\ &+ .0186\, EDUCH + .0331\, EXPRNW \\ &\ (2.25) \qquad\qquad (5.48) \\ &- .0006 (EXPRNW)^2 \\ &\ (3.39) \\ &\qquad\qquad R^2 = .16 \end{aligned} \tag{13}$$

where the values in parentheses are the corresponding t-values.[4]

The estimated work at home function of employed wives is

$$\begin{aligned} H = &\ 852.51 + 7.526\, AGEW \\ &\ (4.63) \quad (3.35) \\ &+ 46.168\, EDUCW + 25.813\, EDUCH \\ &\ (2.25) \qquad\qquad (2.58) \\ &- 4.614\, WAGEH - 1.879\, OTINCM \\ &\ (0.56) \qquad\qquad (1.22) \\ &+ 190.080\, CLD - 17.494\, AGEYC \\ &\ (9.58) \qquad\qquad (3.56) \\ &+ 30.617\, ROOMS \\ &\ (1.80) \\ &- 1009.743\, EXPWAGE \\ &\ (5.18) \\ &\qquad\qquad R^2 = .158 \end{aligned} \tag{14}$$

where *AGEW* denotes wife's age, *WAGEH*—husband's wage, *OTINCM*—non-earned income, *CLD*—number of children, *AGEYC*—age of youngest child, *ROOMS*—number of rooms, and *EXPWAGE*—the imputed wage (in ln).

The estimate confirms our expectations. The wife's age and education have a positive effect on the wife's work at home. The wife's work at home tends to increase with her husband's education but seems to be insensitive to changes in his wage rate and non-earned income.[5] Children

[3] The data are derived from the 1974 panel. Estimates based on the 1972 panel yield results that are very similar to the ones reported here. An attempt to apply my method to the 1969 panel was less successful. The 1974 sample contained 1,990 observations, out of which 1,022 wives reported that they were employed in 1973.

[4] The imputation should reduce the measurement error in wage. However, I ignore throughout this paper the effect of selectivity biases in the wage and labor supply functions (Gronau, 1974; Heckman, 1974).

[5] The husband's education may stand for his long-term earnings and market inputs (and in particular consumer durables), but it may also serve as a proxy for the wife's ability (allowing for selective mating). A third explanation ties the sign of the husband's education with substitution between the husband's and the wife's time in the production of home

are associated with an increase in work at home, but this effect diminishes with the age of the youngest child. Similarly, the number of rooms in the house exerts a positive effect on work at home.

III. The Value of Home Production

To estimate the structural parameters of f_H, I used the estimates of the restricted simultaneous equations method described in the appendix[6]

$$\begin{aligned}\ln f_H = {} & 0.599 + .005467\, AGEW \\ & + .05829\, EDUCW + .02358\, EDUCH \\ & - .004990\, WAGEH \\ & - .004250\, OTINCM + .1934\, CLD \\ & - .01875\, AGEYC + .05546\, ROOMS \\ & - .000926\, H. \end{aligned} \tag{15}$$

My method does not allow the estimation of the standard errors, but it seems that our expectations are confirmed—education has a positive effect on marginal productivity at home (its effect is about 70% of that it has on productivity in the market, as reflected by the wage function (13)).[7] Children and the number of rooms in the house have a positive effect on the value of marginal productivity, but the effect of children dissipates with their age.

Given these parameters of the household production function α_i, I estimated for each woman in the sample her value of home production (using equation (12)). The findings are summarized in table 1, where households are classified by the husband's education and the existence of preschool children. The first four rows of this table follow conventional accounting methods, describing the husband's and wife's earnings and the family's money income before and after taxes. The fifth line contains my estimates of the value of home production. As these figures indicate, this value is far from negligible. According to these estimates, the average value of home production of a U.S. household in 1973 was over \$7,500. It was close to \$6,500 when the family did not have preschool children, and reached almost \$10,000 when it had. On the average, it equaled two-thirds of total family money income and reached 86% of family money income for families with preschool children.[8] This value by far exceeded the wife's money earnings, and at least in the case of families headed by a person with elementary education, it is almost as large as the earnings of the husband. Home production is, of course, tax exempt, and the importance of home production, therefore, is even greater when we compare it with the family's money income after taxes (the two are almost of equal importance when the family has preschool children).

Given the positive correlation between the husband's and the wife's education, it is observed that the value of home production increases with the husband's education (the increase in productivity due to the increase in the wife's education more than offsets the decline in the number of hours she works at home). It increases, however, at a much slower rate than the family's money income. The value of home production equals almost 80% of money income in families headed by males with less than eight years of schooling but is less than 60% of the money income of families whose head had 13 years of schooling or more.

It has been observed (Gronau, 1977) that employed married women work less at home than the not employed. It is worth examining, therefore, how much market employment affects home production. As tables 2 and 2A indicate, the value of home production in families where the wife is not employed exceeds that where the wife is employed by over 20%. Given the difference in income, home production equals about 80% of money income when the wife is not employed but only 50% when she is employed. The increase in money earnings due to the wife's work in the market exceeds by far the loss of home production when there are no young children at home, but this difference almost disappears when the family has preschool children (the not employed spending much more time in work at home and the employed working relatively few hours in the market). It is worth noting, however, that even in the case of employed

services. It is surprising, however, in this case that the husband's wage has no significant effect on the wife's work at home.

[6] These estimates should be more efficient than those derived from the unrestricted OLS estimates of equation (14).

[7] This estimate is consistent with Michael's estimates of the effect of education on the efficiency of consumption (Michael, 1972, pp. 324–325).

[8] My measure ignores the value of home production due to the work at home of other members of the household (specifically, the husband). However, given the small number of hours husbands report they work at home, this bias should be relatively small.

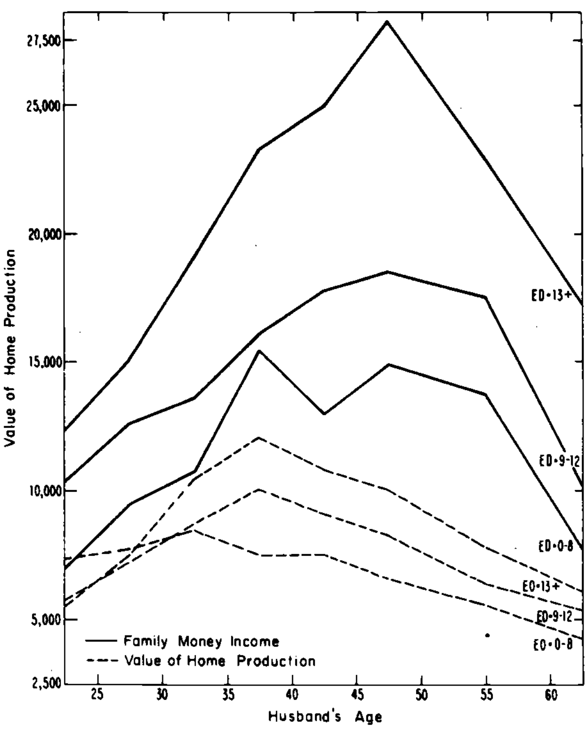
TABLE 1.—EVALUATION OF U.S. HOUSEHOLD PRODUCTION IN 1973 BY EDUCATION OF HUSBAND AND AGE OF YOUNGEST CHILD

Education of husband:	Total			0–8			9–12			13+		
Age of youngest child:	Total	1–5	6+	Total	1–5	6+	Total	1–5	6+	Total	1–5	6+
Husband's earnings	10,692	11,283	10,409	6,035	7,577	5,727	9,847	9,925	9,803	14,278	14,118	14,311
Wife's earnings	2,129	1,479	2,443	1,409	1,324	1,426	1,996	1,416	2,322	2,686	1,512	3,275
Total family money income	15,606	14,011	16,379	11,071	10,162	11,253	14,292	12,379	15,365	19,840	17,398	21,178
Family money income after taxes	13,519	12,260	14,129	9,842	9,360	9,939	12,626	11,094	13,486	16,692	14,716	17,774
Value of home production	7,587	9,863	6,488	5,745	8,956	5,103	7,462	9,010	6,594	8,691	11,376	7,220
Value of home production / Total family money income	0.66	0.86	0.56	0.79	1.14	0.72	0.67	0.86	0.57	0.57	0.80	0.44
Value of home production / Family income after taxes	0.71	0.94	0.60	0.82	1.19	0.75	0.73	0.92	0.62	0.63	0.90	0.49
Labor inputs in home production	4,052	4,877	3,653	3,123	3,875	2,973	3,957	4,364	3,729	4,656	5,893	3,979
Labor inputs in home production / Total family money income	0.35	0.43	0.32	0.42	0.50	0.41	0.36	0.42	0.33	0.31	0.43	0.25
Sample size	1,990	648	1,342	330	55	275	996	358	638	664	235	429

women with young children whose husbands have a college education, the value of home production exceeds the wife's earnings.

Given the important effect of young children and the wife's employment status on the value of home production, and the changes in these two factors over the family's life cycle, I compared in figure 1 the changes taking place over time in home production with the age-income profiles (the age is that of the husband). The age-home production profiles resemble in many respects those of age-income. They have the same inverted U shape, they are flatter the lower the husband's education, and they tend to funnel out with age. Still, there are some significant differences between the two profiles. The value of home production tends to increase with age at a faster rate than does money income during the early phases of life (at least when the husband has nine years of schooling or more), it peaks earlier (during the ages 35–39) and, usually, drops more sharply.[9]

FIGURE 1.—FAMILY MONEY INCOME AND THE VALUE OF HOME PRODUCTION OVER THE LIFE CYCLE



[9] Computing the ratio (value of household production)/(family money income) for each household and averaging over all the households in the age-education group, it is observed that this ratio increases up to ages 35–39 and declines thereafter. On the other hand, had I computed this ratio using the means in each group, one would not have observed an

TABLE 2.—EVALUATION OF U.S. HOUSEHOLD PRODUCTION IN 1973 BY EDUCATION OF HUSBAND, AGE OF YOUNGEST CHILD, AND THE EMPLOYMENT STATUS OF THE WIFE—EMPLOYED WIVES

Education of husband:	Total			0–8			9–12			13+		
Age of youngest child:	Total	1–5	6+	Total	1–5	6+	Total	1–5	6+	Total	1–5	6+
Husband's earnings	10,811	10,061	11,143	6,969	6,543	7,074	10,073	9,602	10,308	13,077	11,494	13,775
Wife's earnings	4,146	3,053	4,631	3,843	3,033	4,044	3,788	2,897	4,233	4,744	3,295	5,382
Total family money income	16,908	13,920	18,234	13,621	10,334	14,434	15,785	13,265	17,045	19,535	15,666	21,239
Family money income after taxes	14,602	12,244	15,648	12,018	9,521	12,636	13,805	11,767	14,825	16,547	13,539	17,872
Value of home production	6,849	8,517	6,109	5,748	8,132	5,158	6,654	7,872	6,045	7,475	9,579	6,548
Value of home production / Total family money income	0.52	0.73	0.42	0.60	0.89	0.52	0.52	0.68	0.44	0.49	0.76	0.37
Value of home production / Family income after taxes	0.57	0.80	0.47	0.63	0.94	0.56	0.57	0.75	0.48	0.55	0.84	0.42
Labor inputs in home production	3,564	4,213	3,276	2,928	3,174	2,868	3,420	3,794	3,233	3,970	5,068	3,487
Labor inputs in home production / Total family money income	0.27	0.36	0.23	0.29	0.36	0.27	0.27	0.32	0.24	0.26	0.40	0.20
Sample size	1,022	314	718	121	24	97	525	175	350	376	115	261

TABLE 2A.—EVALUATION OF U.S. HOUSEHOLD PRODUCTION IN 1973 BY EDUCATION OF HUSBAND, AGE OF YOUNGEST CHILD, AND THE EMPLOYMENT STATUS OF THE WIFE—NOT-EMPLOYED WIVES

Education of husband:	Total			0–8			9–12			13+		
Age of youngest child:	Total	1–5	6+	Total	1–5	6+	Total	1–5	6+	Total	1–5	6+
Husband's earnings	10,570	12,431	9,589	5,494	8,378	4,992	9,595	10,234	9,189	15,846	16,828	15,145
Wife's earnings	—	—	—	—	—	—	—	—	—	—	—	—
Total family money income	14,237	14,097	14,311	9,595	10,028	9,520	12,627	11,532	13,322	20,239	19,058	21,082
Family money income after taxes	12,380	12,275	12,435	8,583	9,236	8,469	11,312	10,449	11,860	16,881	15,843	17,622
Value of home production	8,367	11,129	6,912	5,743	9,594	5,073	8,363	10,098	7,261	10,278	13,098	8,264
Value of home production / Total family money income	0.80	0.99	0.71	0.90	1.34	0.83	0.84	1.02	0.73	0.67	0.84	0.55
Value of home production / Family income after taxes	0.86	1.06	0.75	0.93	1.39	0.85	0.90	1.09	0.77	0.74	0.94	0.60
Labor inputs in home production	4,567	5,502	4,075	3,236	4,417	3,030	4,556	4,910	4,331	5,552	6,685	4,743
Labor inputs in home production / Total family money income	0.45	0.50	0.42	0.50	0.60	0.48	0.46	0.52	0.43	0.38	0.46	0.32
Sample size	968	334	634	209	31	178	471	183	288	288	120	168

IV. Some Concluding Comments

This paper is a first expedition into an unexplored land. Thus, it naturally has its shortcomings. Several reservations may have been too easily brushed aside; others may have been completely overlooked. Selectivity biases may play a much more prominent role than admitted. Entry costs (e.g., search and transportation costs) have been completely ignored. So has an issue that has plagued followers of the new household economics for a long time, namely, joint production (in our case the simultaneous usage of time for work at home and leisure activities). Our data are far from ideal, and we tend to underplay the importance of husbands and other family members in home production.

Still I feel that the method described in this paper provides a powerful tool to identify and estimate the value of household production. My first attempts in this area are highly encouraging. At this stage I have focused on married white families. A lot still has to be done. One should be able to extend this work to compare the home production of married and single persons, whites and nonwhites. More important, the household sector (or the nonmarket sector) plays a much more important role in the less developed countries than in the developed countries. The application of the method to less developed countries should yield better measures and understanding of the process of growth and the gap in material resources between the developed and the less developed states.[10]

Finally, the focus of this paper was on productivity and the value of home production. A natural question that comes to mind is, What is the value added in this production process and what can be learned from our estimates on the estimates of the aggregate output of the home sector? Existing estimates of the contribution of the home sector to total output are based on two different approaches. According to the first approach (Walker and Gauger, 1973), the time inputs in home production are assigned the prices the household would have to pay had it purchased the services in the market. According to the second approach (Sirageldin, 1969; Gronau, 1973), the criterion used is the costs the household assigns to the marginal unit of its members' time. Both approaches seem equally unsatisfactory.

The market prices approach is deficient in the case of corner solutions—the case when the household does not consume the market services. In this case, the market prices approach assigns to home production prices which have been explicitly rejected by the household as a true measure of its productivity. The family could have bought the home services in the market but preferred not to do so, either because it found their prices too high, or because it found their quality wanting. The "opportunity costs" approach, on the other hand, ignores the fact that a person working at home is, in essence, self employed, contributing to the production process both his labor services and his entrepreneurial capacity. The "producer surplus" generated by homemakers is ignored in the conventional "opportunity costs" calculation.

To what extent can our estimates improve current estimates of the value added? The contribution of this paper to the improvement of the aggregate estimates can be only modest. To obtain estimates of the value added generated by the home production process, one has to subtract from the estimates of total output the value of market inputs. These inputs are, however, unknown. Still, for comparative reasons I listed in the tables my estimates of the value of labor inputs in home production according to the "opportunity costs" approach (the wage assigned to the woman's time was generated by equation (13)).[11] These estimates are only about one-half as large as our estimates of total output. They seem to underestimate the effect of young children on home production (in absolute as well as in relative terms). They understate the loss of home output when the woman works in the market (in particular when she has young children),

increase in this ratio over the first phases of the life cycle (hence, it is difficult to detect this tendency in figure 1).

[10] In some of the less developed countries the wage sector plays only a minor role. In this case, one should replace the wage variable by a variable representing the marginal productivity in marketable farm products (or in cottage industries), and the wage function by an agriculture production function.

[11] A recent survey of estimates of aggregate home production (Hawrylyshyn, 1976) has not found significant differences between the "market prices" and the "opportunity costs" estimates.

and the changes in home output over the life cycle.

The difference between our estimates of the value of home production and the labor inputs can be attributed to market inputs, the capital services of consumer durables and to the wife's entrepreneurial capacity. Casual observation indicates that the variability in market inputs with age of children and education is relatively small, the differences in home production originating presumably in the other two factors. Conventional measures tend, therefore, to understate considerably the value added, not giving sufficient credit to the entrepreneurial capacity required at home.[12]

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[12] To illustrate, assume that market inputs into home production are represented by the family's consumption of food. Under this assumption, when food and labor inputs are subtracted from home production the residual would, on the average, come to about one fifth of our estimate of home production; for a mother of preschool children the residual is around 30% (irrespective of education and employment status) and it is about 10% for women whose youngest child is aged 6 or more (the percentage increasing slightly with wife's education). Ignoring the services of consumer durables, this would imply that entrepreneurship at home is more important when there are young children, and the more schooling the wife has.

APPENDIX

To test the assumption that the marginal productivity-at-home function (equation (9)) is semi-log, let it be assumed that the marginal rate of substitution of goods for leisure s is also a semi-log function (of leisure and other variables)[1]

$$\ln s = \beta_0 - \beta_1 L + \beta_2 Y. \quad \text{(A1)}$$

Given the equilibrium condition (6)

$$L = (\beta_0 - \ln W + \beta_2 Y)/\beta_1, \quad \text{(A2)}$$

which can be estimated in the sample of employed women by the semi-log regression

$$L = b_0 - b_1 \ln W + b_2 Y \quad \text{(A3)}$$

where

$$(1/b_1) = \text{est}(\beta_1),$$
$$(b_0/b_1) = \text{est}(\beta_0), \quad \text{(A4)}$$
$$(b_2/b_1) = \text{est}(\beta_2).$$

Furthermore, when a person does not work in the market $N = 0$, $H + L = T$, and by equation (7),

$$H = [(\beta_1 T + \alpha_0 - \beta_0) + (\alpha_2 - \beta_2)Y]/(\alpha_1 + \beta_1). \quad \text{(A5)}$$

This equation can be estimated in the sample of the not employed

$$H = c_0 + c_2 Y \quad \text{(A6)}$$

where

$$c_0 = \text{est}[(\beta_1 T + \alpha_0 - \beta_0)/(\alpha_1 + \beta_1)],$$

and

$$c_2 = \text{est}[(\alpha_2 - \beta_2)/(\alpha_1 + \beta_1)]. \quad \text{(A7)}$$

There is no way of isolating the parameters α_i and β_i from the estimates of c_0 and c_2. These estimates provide us, however, with a test of consistency. Deriving the estimates of α_i and β_i using equations (10) and (A3), then by equations (11) and (A4),

$$\hat{c}_0 = \frac{a_1 T + b_1 a_0 - a_1 b_0}{a_1 + b_1} = \text{est}\left(\frac{\beta_1 T + \alpha_0 - \beta_0}{\alpha_1 + \beta_1}\right),$$
$$\hat{c}_2 = \frac{b_1 a_2 - a_1 b_2}{a_1 + b_1} = \text{est}\left(\frac{\alpha_2 - \beta_2}{\alpha_1 + \beta_1}\right), \quad \text{(A8)}$$

and one can compare the coefficients of equation (A6) (the work at home equation of the nonparticipants) with their predicted values (equation (A8)) to generate a powerful test for the validity of the estimates and our assumption concerning the functional form.

[1] The vector Y in (A1) and (8) need not necessarily have the same components (i.e., some of the elements of α_2 and β_2 may be assumed to be zero).

Alternatively, one can pool the sample of participants and nonparticipants and estimate the following set of simultaneous equations

$$H = A_0 + A_2Y + I \times (A'_0 - A'_1 \ln W + A'_2Y)$$
$$L = B_0 + B_2Y + I \times (B'_0 - B'_1 \ln W + B'_2Y) \quad \text{(A9)}$$

where I is a dummy variable denoting that the person participates in the labor force. By equations (9), (A2), and (A5),

$$\begin{aligned}
&A_0 = \text{est}[(\beta_1 T_0 + \alpha_0 - \beta_0)/(\alpha_1 + \beta_1)],\\
&A_2 = \text{est}[(\alpha_2 - \beta_2)/(\alpha_1 + \beta_1)],\\
&A_0 + A'_0 = \text{est}(\alpha_0/\alpha_1),\\
&A'_1 = \text{est}(1/\alpha_1),\\
&A_2 + A'_2 = \text{est}(\alpha_2/\alpha_1),\\
&B_0 = \text{est}[(\alpha_1 T_0 + \beta_0 - \alpha_0)/(\alpha_1 + \beta_1)],\\
&B_2 = \text{est}[(\beta_2 - \alpha_2)/(\alpha_1 + \beta_1)],\\
&B_0 + B'_0 = \text{est}(\beta_0/\beta_1),\\
&B'_1 = \text{est}(1/\beta_1),\\
&B_2 + B'_2 = \text{est}(\beta_2/\beta_1).
\end{aligned} \quad \text{(A10)}$$

Hence,

$$A_0 + B_0 = T,\ A_2 + B_2 = 0,\ A'_0/A'_1 = B'_0/B'_1,$$
$$A'_2/A'_1 = B'_2/B_1. \quad \text{(A11)}$$

To derive the estimates of α_i and β_i one should estimate the two equations of (A9) simultaneously subject to the nonlinear restrictions imposed by (A11).

Comparing the explanatory power of the restricted simultaneous system with the unrestricted ordinary least squares (OLS) equations should yield an indication of how binding the theoretical restrictions are.

Applying the two consistency tests to our data it is found that they withstand these tests surprisingly well.[2] The estimates of equation (15) are derived from (A10):

$$\begin{aligned}
&1/A'_1 = \text{est}(\alpha_1),\\
&(A_0 + A'_0)/A'_1 = \text{est}(\alpha_0),\\
&(A_2 + A'_2)/A'_1 = \text{est}(\alpha_2).
\end{aligned} \quad \text{(A12)}$$

[2] For details see an earlier version of this paper (Gronau, 1976).