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The Household and Business Sectors

The Measurement of Output of the Nonmarket Sector: The Evaluation of Housewives' Time

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ONE may agree with the group of economists calling for a drastic revision of the set of social accounts so as to reflect social welfare, or one may adopt a more conservative approach, designing the national accounts to yield merely a measure of output of all goods and services produced during a given period, but foremost on the agenda of both camps is the broadening of the current definition of the national accounts to include nonmarket production.

Very few economists ventured to estimate the importance of the nonmarket sector relative to the over-all economic activity, but those who tried are united in their claim that even in the most advanced economies the nonmarket sector contributes a considerable share of total output. Reconstructing the social accounts to generate a measure of economic welfare (MEW), Nordhaus and Tobin figured that the value of leisure and nonmarket work constituted in 1965 three-quarters of their measured MEW (the value of leisure accounting for about one-half and the value of labor inputs in home production accounting for one-quarter of MEW [15]). Morgan estimated [13, p. 5] that the inclusion of unpaid work in the national accounts would have increased gross national product in 1964 by 38 per cent.[1] Sirageldin, using the

NOTE: The empirical part of this paper is from my study, "The Labor Force Participation of Israeli Women," carried out at the Maurice Falk Institute for Economic Research, Jerusalem. I am indebted to Gary Becker, Giora Hanoch, Ruth Klinov, David Levhari, and Shlomo Yitzhaki for their comments, and to Jacob Ish-Shalom for the data he made available to me.

[1] Nordhaus and Tobin's MEW is almost twice the GNP in 1965. Thus, Morgan's estimate and the Nordhaus and Tobin estimate of the ratio of nonmarket work to GNP (38 and 48 per cent, respectively) are not too far apart.

same data as Morgan, states that had we measured the value of housework and home production, the average family's disposable income would have increased by 43 per cent [16, p. 55].

Given the large fraction of resources devoted to nonmarket production and given differences in this fraction among countries and changes in this fraction over time, it is difficult to make any meaningful international comparison of the level of economic activity or to make any accurate statement about national economic growth, ignoring the unmeasured economic activity taking place at home.

The measurement of this activity is hampered by both conceptual and technical difficulties. The large heterogeneity in the quality of the various home services (e.g., child care, meals, home decoration, etc.) produced by different households makes it difficult to provide a clear definition of the physical units of output in this sector. Moreover, the absence of an open market for these outputs outside the household impedes the evaluation of this product.

One would like to resort to a method applied in national accounting in some other cases where the outputs are nonmarketable (e.g., government services) and evaluate the output of the nonmarket sector according to its costs of production. However, even this method runs into two major stumbling blocks: the absence of data on physical inputs and the difficulty in assigning them a price. While the difficulties in the measurement and evaluation of the capital input in the nonmarket sector do not exceed those encountered in the case of their market counterparts, it is hard to overcome the obstacles imposed by the lack of data on physical inputs and prices of the labor services used in the home sector. The cure for the absence of information on time inputs in nonmarket activities lies in an intensive effort to collect time budget data. The difficulty in assigning these inputs a price is of a more conceptual character.

A common practice in pricing the time inputs in the nonmarket sector is to place on them the price they could charge if they were sold in the market. This criterion, however, is hard to apply when the person does not sell any of his time in the market. For one, it is difficult to know what is the price the market would have offered this person for his time, and secondly, it is just because this person found this price inadequate that he declined to sell any of his time in the market. Since over forty per cent of all the adult population do not participate in the labor force, and given that these nonemployed provide over 60 per cent of all time inputs in the home sector, and since labor's share in total nonmarket output is about 75 per cent,[2] it is important to generate some more accurate measures of the value of time for this population group.

The evaluation of the price of time of the unemployed and its comparison with the price of time of the employed are of particular importance when one attempts to measure the change in over-all economic activity over time or to compare the economic activity in two different economies at a point of time. For example, Denison estimated that over one-fourth of the annual growth in real GNP in the period 1929–59 can be explained by the growth of labor inputs [3, p. 41]. However, at least part of the increase of the labor inputs in the market was at the expense of the nonmarket sector, due to the increase in the labor force participation rates of women, and, in particular, of married women.[3] To obtain a measure of the rate of growth of the total U.S.

[2] The capital-labor ratio is obtained by dividing Nordhaus and Tobin's estimate of the value of consumer and government capital services by their estimate of the value of labor in home production (had we included in the denominator the value of labor in home production plus the value of leisure, the capital-labor ratio would have shrunk from 1:4 to 1:11). The estimate of the share of the not employed in the home-sector labor inputs is based on the following table:

	Male		Female			
		Not Em-ployed	Employed		Not Employed	
	Employed		Married	Single	Married	Single
Adults 14+ (1,000)	51,705	13,445	16,154	9,798	29,037	15,703
Daily hours of work at home per adult	1.9	1.9	4.8	3.7	7.8	6.1

SOURCE: Line 1: [18, pp. 31, 228], line 2: [17, Table 2.10]. It is assumed that employed and not employed males spend the same amount of time in home production.

[3] The data presented in note 2 and Table 1 indicate that employed women tend to spend less time in home production than housewives. However, it seems that at least part of the increased market supply of labor is at the expense of leisure. The increased labor force participation of women was therefore accompanied by a relative decline in time inputs in both home production and leisure. Over the past forty years, this tendency may have been accentuated by a reallocation of time of housewives and working men and women.

The only extensive time budget study in the United States in the thirties is the one reported by Lundberg *et al.* [11]. This study is based on a sample of 2,460 people reporting on 4,460 days and was conducted in Westchester County, New York, in 1932. The surprising aspect of the Lundberg results is the relatively economic activity one has to know the extent to which the increase in the labor force participation of married women affected home production, the extent to which this possible decline in labor inputs was compensated for by capital input increases in the nonmarket sector, and the rate of increase of labor productivity in the nonmarket sector relative to the market sector.

Another example, one which seems to be popular with politicians, is the comparison of U.S. and U.S.S.R. economic activity. Clearly, the focusing on GNP yields only a partial picture. However, to obtain a full account of the goods and services produced by the two nations it is not sufficient to know the amount of time spent in home production and males' and females' productivity in the market, but one has to take into account also the different degrees of specialization in home production in the two countries. Table 1 indicates that there is no great difference in the adult's average time inputs in home production in the two countries, but there is a significant difference in the way this production is distributed among the various members of the household. In the United States, the major burden of home production is borne by women not employed in the market, while in the U.S.S.R. this production is much more equally distributed among all adults. The lower incidence of unemployed married women in the U.S.S.R. is offset by the fact that on the average every Russian male and female (employed and not employed) spends 15–20 per cent more time in home production than his or her American counterpart. Thus, unless one knows the relationship between the productivities of the not employed in the market and nonmarket sectors one cannot produce an accurate answer to this beguiling question.

This paper addresses itself to the estimation of the price of time of a group that constitutes one-half of the not employed and contributes about 40 per cent of the time spent in home production,[4] namely, the housewives. As indicated earlier, the wife's rejection of the proposal

small amounts of time spent in home production. Employed women were reported to spend only 1.2–1.4 hours a day on household duties, child care, and shopping, while the corresponding figure for housewives was 4.2 hours. These figures are substantially below the 1965 figures presented in Table 1. Another striking feature of this report is the large amounts of time spent on physiological needs and free time. For most population groups it exceeded the corresponding 1965 figures by almost 2 hours (in the case of housewives the difference is almost 3 hours). It is difficult to believe that this difference can be fully explained by the admittedly biased nature of the sample.

[4] See note 2.

TABLE 1

Comparison of U.S. and U.S.S.R. Daily Time Budgets, Males and Females (hours)

	Market-related Work	Work at Home	Free Time and Physio-logical Needs	Physio-logical Needs	Free Time
All adults [a]					
U.S.	4.80	4.20	15.00	9.90	5.10
U.S.S.R.	6.50	4.10	13.40	9.20	4.20
U.S./U.S.S.R.	0.74	1.02	1.11	1.08	1.21
Married men, employed					
U.S.	7.55	1.90	14.55	9.70	4.85
U.S.S.R.	7.70	2.30	14.00	9.40	4.60
U.S./U.S.S.R.	0.98	0.83	1.04	1.03	1.04
All women [a]					
U.S.	2.65	6.15	15.20	10.10	5.10
U.S.S.R.	6.10	5.30	12.60	9.20	3.40
U.S./U.S.S.R.	0.43	1.16	1.21	1.10	1.50
Married women, employed					
U.S.	5.45	4.80	13.75	9.85	3.90
U.S.S.R.	6.80	5.50	11.70	9.10	2.60
U.S./U.S.S.R.	0.80	0.87	1.18	1.08	1.50
Married women, not employed					
U.S.	0.10	7.80	16.10	10.20	5.90
U.S.S.R.	0.10	8.90	15.00	10.30	4.70
U.S./U.S.S.R.	1.00	0.87	1.07	0.99	1.25

SOURCE: [17, Tables 2.9–2.11] The figures for the United States are a simple average of the data in Tables 2.10 and 2.11.

[a] Including single persons.

to enter the labor force indicates that the wage offer facing the woman falls short of the value that she places on her time. However, it is unknown whether the source of this discrepancy lies in a low wage offer or in her high valuation of her time. We do not know the value assigned to a person's time and if this person happens not to work we do not know the wage offers he rejected. This leaves the door open to two interpretations: according to the first, the fraction of those women who do not work are those who are the most efficient in the home sector (i.e., those who have the highest value of time), while according to the second, those who abstain from entering the labor force are those who are the least efficient in the market sector (i.e., those who face the lowest wage offers). If one adopts the first interpretation, one tends to conclude that the value of time of housewives exceeds the average wage of working women with similar market qualifications. The second assumption leads, on the other hand, to the conclusion that the average price of time of housewives falls short of the average wage of women who work in the market. The two alternative hypotheses give rise, naturally, to two alternative estimates of the housewives' average price of time.

The paper opens with a brief discussion of the factors affecting the wife's price of time. This discussion is followed by a description of a method to estimate this price of time and the paper ends with a report on the data and the results. It is found that under the first assumption the housewives' average value of time exceeds the average wage rate of working women by no more than 5 per cent. Given the second assumption, the lower limit of the housewives' average price of time is about 80 per cent of women's average wage rate. The housewives' mean price of time increases with the husbands' income, the elasticity of the price of time with respect to income ranging between 0.30 and 0.50. Differences in income tend to offset the effect of the existence of young children. Thus, we could not find any evidence that in the aggregate the price of time of housewives with young children exceeds that of housewives without young children.

THE VALUE OF TIME OF MARRIED WOMEN

The analysis of the factors affecting the price of time of a single person is well established in economic literature (see [1], [9], [14]). The incorporation of this analysis within a model of multiperson households calls for only minor modifications.

Let us assume, for simplicity, a two-person household trying to maximize family welfare:

$$U = U(Z_1^c, \ldots, Z_n^c, Z_1^W, Z_2^W), \tag{1.1}$$

where U denotes utility, Z_i^c denotes the ith consumption activity, and Z_j^W denotes the activity work in the market by person j.[5] Using the terminology developed by Becker [1] and Lancaster [10], a consumption activity is a combination of goods (X^c) and consumption time of the husband and/or his wife (T_1^c and T_2^c, respectively)

$$Z_i^c = F_i(X_i^c, T_{1i}^c, T_{2i}^c); \qquad (i = 1, \ldots, n); \tag{1.2}$$

where X and T_j are vectors of different goods and different units of time (e.g., different hours of the day).[6] Similarly, the activity work in the market by person j consists of a combination of goods (X_j^W), e.g., commuting services, and jth working time (T_j^W)

$$Z_j^W = G_j(X_j^W, T_j^W); \qquad (j = 1, 2). \tag{1.3}$$

The maximization of utility is subject to two kinds of constraints. The first (a) is the budget constraint, which states that expenditures on goods cannot exceed total income:[7]

$$\sum_{i=1}^{n} P_i^c X_i^c + \sum_{j=1}^{2} P_j^W X_j^W \leqslant W_1(Z_1^W) + W_2(Z_2^W) + V, \tag{1.4}$$

where P is a price vector, $W_j(Z_j^W)$ are the earnings of person j, and V denotes other sources of income. The second (b) contains two separate time constraints,

$$\sum_{i=1}^{n} T_{ji}^c + T_j^W \leqslant T_0; \qquad (j = 1, 2); \tag{1.5}$$

where T_0 is a vector of all the time units available. The maximization of the welfare function (1.1) subject to the budget and time constraints

[5] For simplicity we ignore the multidimensions of Z_j^W. Work is a heterogeneous activity, and the utility derived from work depends not only on the amount of work performed but also on the occupation the person is in. This topic has been discussed recently by Diewart [4].

[6] This paper does not distinguish between leisure time and time spent in work at home. This distinction is discussed in more detail in [7].

[7] This is a one-period model. One can easily adapt the discussion to an intertemporal model by defining one of the consumption activities as saving. For a discussion of the allocation of time and goods over time, see [5].

[(1.4) and (1.5)] yields the values placed by the family on its members' time, i.e., the optimal trade-off between time and goods.

Analyzing the price of a specific unit of time (i.e., a specific element of T_j) one has to distinguish between two cases: (a) the case where some units of this element of time are traded in the market (i.e., the corresponding elements in T_j^W are positive); and (b) the case where no unit of this element is sold by the family in the market (i.e., the corresponding element in T_j^W equals zero). In the first case, the price of this unit of time is determined by the marginal wage rate, in the second by the time scarcity.

Formally, the optimum combination of goods and time of person j in the production of activity Z_i^c is determined by the equality,

$$\frac{\partial Z_i^c/\partial T_{ji}^c}{\partial Z_i^c/\partial X_i^c} = \frac{\mu_j/\lambda}{P_i^c} = \frac{K_j}{P_i^c}; \qquad (j = 1, 2); \tag{1.6}$$

where μ_j is the marginal utility of the time of j, λ is the marginal utility of income, and K_j is the price placed by the family on the time of j. For those units of time for which the elements of $T_j^W > 0$

$$K_j = \left[\frac{\partial W_j(Z_j^W)}{\partial T_j^W} - P_j^W \frac{\partial Z_j^W/\partial T_j^W}{\partial Z_j^W/\partial X_j^W}\right] + \frac{\partial U/\partial T_j^W}{\lambda} = W_j + (U_j^W/\lambda), \tag{1.7}$$

where W_j is the net marginal wage rate (i.e., the remuneration person j receives for selling the marginal unit of time in the market minus any money costs involved), and U_j^W is the marginal utility the family derives from a unit of j's time in work in the market. For those units of time which are freely substitutable for work in the market the value of time depends on the net marginal wage rate. It equals W_j to the extent that work does not yield any direct marginal utility or disutility.

If a person does not sell any amount of a specific unit of time in the market, and in particular if he does not sell any time in the market (e.g., a housewife), the wage rate he could have received in the market constitutes merely a lower boundary for his value of time. The shadow price assigned to his time depends on the demand and supply of time in the nonmarket sector. The supply of time for nonmarket uses is in this case completely inelastic and the price of time is demand determined. The demand for time can be considered as a derived demand for an input. Any change that affects the final demand for activities, such as a change in income or a change in tastes due to the acquisition of children, and any change that affects the productivity of time, such as the acquisition of home durables, would change the value placed by the family on its members' time.[8]

ESTIMATION OF THE PRICE OF HOUSEWIVES' TIME

It has been shown in the previous section that if one ignores the marginal utility (or disutility) and the cost incurred as the result of work and if one assumes that the marginal wage rate does not change with the amount of time spent in the market then the average wage rate (net of taxes) can serve as a close approximation for the value of those elements of time sold in the market. However, if certain elements of time are not sold in the market or as in the case of housewives when no unit of time is sold in the market, the potential wage rate can serve only as a lower limit for the estimate of the price of time. The evaluation of the price of time depends in this case on the answer to two questions: (a) by how much does the price of time of people not employed exceed their potential wage rate, and (b) to what extent does the potential wage rate of those not employed differ from the actual wage rate of those employed. It will be shown in this section that at least partial answers to these questions can be obtained by comparing the rates of participation and the average wage rates of married women belonging to different age-education-income groups.

If the wife's price of time were determined solely by her family income, and if all women in, say, a given age-education group expected the same potential wage rate, one would expect all women in the given age-education-income group to act in the same way. Thus, one should observe that either all the wives in a given age-education-income group participate in the labor force, or that none of them do. The dispersion in the working habits of women belonging to the same group indicates that the women either differ in terms of their potential wage rate or in terms of their value of time or both.[9]

Let us assume that the potential wage rate W and the housewife's price of time W^* are jointly distributed within an age-education-income group with a joint density function $f(W, W^*)$. The percentage (P) of wives participating in the labor force in a given group equals the per-

[8] For a more formal discussion of this case, see [7]. Note that a change in income may affect one's price of time even if one works and the wage stays constant, inasmuch as it leads to a change of the money equivalent of the marginal (dis)utility of work (u_j^W/λ).

[9] Ben-Porath [2] reaches somewhat similar conclusions. However, his analysis is carried out in the framework of a single-person household and in terms of "taste for work" rather than the value of time.

centage of wives whose value of time falls short of their potential wage rate [10]

$$P = \text{Prob}\ (W > W^*) = \int_{-\infty}^{\infty} \int_{W^*}^{\infty} f(W, W^*) dW dW^*. \qquad (2.1)$$

The average wage rate of the women who work ($\bar{W}$) equals the conditional expectation of W where W exceeds W^*:

$$\bar{W} = E(W | W > W^*) = \frac{1}{P} \int_{-\infty}^{\infty} \int_{W^*}^{\infty} W f(W, W^*) dW dW^*; \qquad (2.2)$$

and the average price of time of women who do not work ($\bar{W}^*$) equals the conditional expectation of W^* where W^* exceeds W:

$$\bar{W}^* = E(W^* | W^* > W) = \frac{1}{1 - P} \int_{-\infty}^{\infty} \int_{W}^{\infty} W^* f(W, W^*) dW^* dW. \qquad (2.3)$$

In particular, if one assumes that the potential wage rate and the price of time within each group are independent and have a bivariate normal distribution,[11] then

$$f(W, W^*) = \frac{1}{2\Pi\sigma_W\sigma_{W^*}} \exp\left\{-\frac{1}{2}\left[\left(\frac{W - \mu_W}{\sigma_W}\right)^2 + \left(\frac{W^* - \mu_{W^*}}{\sigma_{W^*}}\right)^2\right]\right\} \qquad (2.4)$$

$$= \frac{1}{2\Pi\sigma_W\sigma_{W^*}} \exp\left[-\frac{1}{2}(x^2 + y^2)\right],$$

where μ_W and μ_{W^*} are the mean values, and σ_W and σ_{W^*} are the standard deviations of the marginal distribution of W and W^*, respectively, and where $x = (W - \mu_W)/\sigma_W$ and $y = (W^* - \mu_{W^*})/\sigma_{W^*}$ are standardized normal variables. The women's labor force participation rate is

$$\text{Prob}\ (W = \mu_W + x\sigma_W > \mu_{W^*} + y\sigma_{W^*} = W^*) \qquad (2.5)$$

$$= \text{Prob}\ (x > A + By = y^*)$$

$$= \frac{1}{2\Pi} \int_{-\infty}^{\infty} \int_{y^*}^{\infty} e^{-(1/2)(x^2+y^2)} dx dy,$$

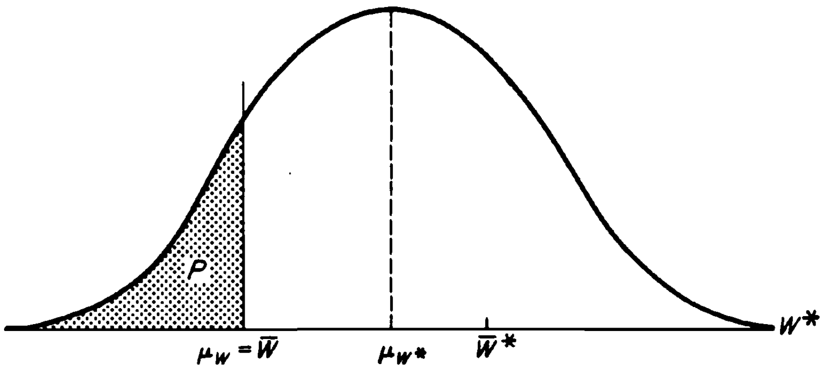
where $A = (\mu_{W^*} - \mu_W)/\sigma_W$ and $B = \sigma_{W^*}/\sigma_W$. The average wage rate $\bar{W}$ is

$$\bar{W} = \mu_W + \bar{x}\sigma_W, \qquad (2.6)$$

[10] This analysis assumes implicitly that the wives react to actual wage offers rather than to expected ones as suggested by the theory of search (see for example [6]). The incorporation of the theory of information in our framework may not change the major conclusions but would have complicated the estimation procedure considerably.

[11] This assumption rules out any intragroup dependence of the value of time on age and education. Thus, we ignore the possible positive correlation between the price of time and the potential wage rate due to natural ability.

FIGURE 1



where

$$\bar{x} = E(x|x > y^*) = \frac{1}{2\Pi P} \int_{-\infty}^{\infty} \int_{y^*}^{\infty} x e^{-(x^2+y^2)/2} dx dy \tag{2.7}$$

$$= \frac{1}{P} \left(2\Pi \frac{\sigma_W^2 + \sigma_{W*}^2}{\sigma_W^2} \right)^{-1/2} \exp \left[-\frac{1}{2} \frac{(\mu_{W*} - \mu_W)^2}{\sigma_W^2 + \sigma_{W*}^2} \right].$$

Finally, the average price of time of housewives equals

$$\bar{W}^* = \mu_W^* + \bar{y}\sigma_{W*}, \tag{2.8}$$

where [12]

$$\bar{y} = E(y|y^* > x) = \frac{P}{1 - P} \frac{\sigma_{W*}}{\sigma_W} \bar{x}. \tag{2.9}$$

Given the above assumptions, the participation rate and the average wage rate of a given group are a function of the mean values and the dispersions of the price of time and wage offer (i.e., potential wage) distributions. To estimate the mean value of time of housewives one has to reduce the number of parameters of the joint distribution.

Assuming that the standard deviation of the wage offer distribution is zero ($\sigma_W = 0$), i.e., that all women in a given age-education group expect the same wage rate μ_W, differences in participation behavior reflect differences in the price of time (see Figure 1). The rate of participation P within a given age-education-income group equals

$$P = \text{Prob } (W^* < \mu_W) \tag{2.10}$$

$$= \text{Prob} \left(y = \frac{W^* - \mu_{W*}}{\sigma_{W*}} < \frac{\mu_W - \mu_{W*}}{\sigma_{W*}} = -\frac{A}{B} = Z \right).$$

[12] For a fuller explanation of (2.7) and (2.9), see the mathematical appendix.

Moreover, since $\sigma_W = 0$, the average wage rate of working women equals the mean value of the wage offer distribution $\bar{W} = \mu_W$. Thus

$$Z = -\frac{A}{B} = \frac{\mu_W - \mu_{W*}}{\sigma_{W*}} = \frac{\bar{W} - \mu_{W*}}{\sigma_{W*}}$$

or alternatively

$$\bar{W} = \mu_{W*} + Z\sigma_{W*}. \tag{2.11}$$

Observing that in income group i, P_{ij} per cent of the women belonging to potential wage group j (i.e., age-education group j) participate in the labor force, one can (using the tables of the normal distribution) generate the values of Z_{ij} satisfying Prob $(y < Z_{ij}) = P_{ij}$. Given a sufficient number of potential wage groups and assuming that the mean value of the price of time μ_{W*} and the standard deviation σ_{W*} do not vary with age and education[13] one can estimate within each group i

$$\bar{W}_{ij} = a_i + b_i Z_{ij}, \tag{2.12}$$

the constant a_i serving as the estimate of the mean value of time $\mu_{W_i^*}$ in this income group and the regression coefficient b_i serving as an estimate of the standard deviation $\sigma_{W_i^*}$.

Inserting (2.7) in (2.9) and assuming $\sigma_W = 0$,

$$\begin{aligned} \bar{y} &= \frac{1}{(1-P)\sqrt{2\Pi}} \exp\left[-\frac{1}{2}\left(\frac{\mu_{W*} - \mu_W}{\sigma_{W*}}\right)^2\right] \\ &= \frac{1}{(1-P)\sqrt{2\Pi}} \exp\left(-\frac{1}{2} Z^2\right). \end{aligned} \tag{2.13}$$

Given the values of P_{ij} and Z_{ij} one can generate the value of $\bar{y}_{ij}$, and given the estimated values of $\mu_{W_i^*}$ and $\sigma_{W_i^*}$ one can estimate the average value of the housewives' time

$$\bar{W}_{ij}^* = \mu_{W_i^*} + \bar{y}_{ij}\sigma_{W_i^*} = a_i + b_i\bar{y}_{ij}. \tag{2.14}$$

Alternatively, one can assume that differences in participation behavior originate in differences in wage offers, i.e., the standard deviation of the value of time distribution within a given income group

[13] The assumption of intergroup independence of W and W^* is a much stronger assumption than the assumption of intragroup independence, ignoring the effect of education on the wife's nonmarket productivity (an effect discussed by [12]). Fortunately, it is not necessary for the estimation procedure. Its removal is discussed in the concluding section.

$\sigma_{W^*} = 0$ (see Figure 2). The rate of participation within a given age-education-income group is

$$P = \text{Prob}\,(W > \mu_{W^*}) = \text{Prob}\left(x = \frac{W - \mu_W}{\sigma_W} > \frac{\mu_{W^*} - \mu_W}{\sigma_W} = A\right). \quad (2.15)$$

By equations (2.6) and (2.7) the average wage of working women is $\bar{W} = \mu_W + \bar{x}\sigma_W$ where

$$\bar{x} = E(x|x > y^* = A) \quad (2.16)$$

$$= \frac{1}{P\sqrt{2\Pi}} \int_A^\infty x e^{-x^2/2}\, dx = \frac{1}{P\sqrt{2\Pi}}\, e^{-A^2/2}$$

since $B = 0$.

Given the value of P_{ij}, one can generate the value of A_{ij} and compute the value of $\bar{x}_{ij}$. Since $\mu_W = \mu_{W^*} - A\sigma_W$

$$\bar{W}_{ij} = \mu_{W_j} + \bar{x}_{ij}\sigma_{W_j} \quad (2.17)$$

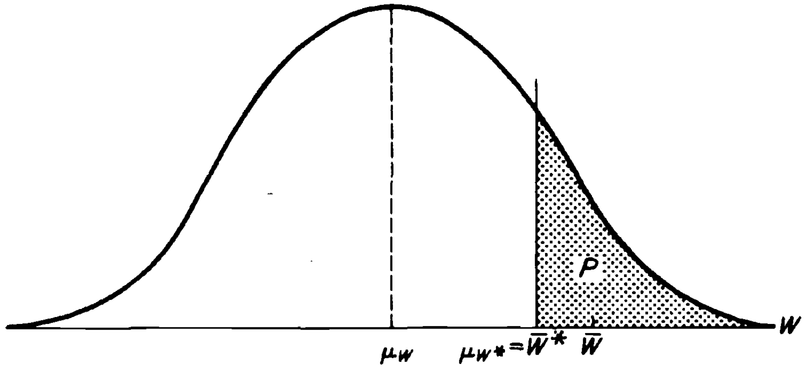
$$= \mu_{W_i^*} + (\bar{x}_{ij} - A_{ij})\, \sigma_{W_j} = \mu_{W_i^*} + Z_{ij}^*\sigma_{W_j}.$$

Assuming that the standard deviation of the wage offer distribution does not vary among potential wage groups, one can estimate within each income group

$$\bar{W}_{ij} = a_i + bZ_{ij}^*, \quad (2.18)$$

again, the constant is an estimate of the mean value of time μ_{W^*} and the regression coefficient b is an estimate of the standard deviation of the wage offer distribution σ_W. Since it is assumed that all women within a given group have the same price of time the average price of time of housewives equals the mean price of time $\bar{W}^* = \mu_{W^*}$.

FIGURE 2



It is worth noting the difference between our two assumptions. According to the first assumption ($\sigma_W = 0$), women who work are those who have the lowest price of time, i.e., are the least productive at home, while by the second assumption ($\sigma_{W*} = 0$), women who work are those who have received the highest wage offers, i.e., are the most productive in the market. This difference carries over to the relationship between housewives' average price of time and the average market wage rate. According to the first assumption one would expect the housewives' average value of time to exceed the average wage rate of working women belonging to the same age-education-income group $[\bar{W}^* = E(W^*|W^* > \mu_W = \bar{W}) > \bar{W}]$, while by the second assumption $\bar{W}^*$ falls short of $\bar{W}[\bar{W} = E(W|W > \mu_{W*} = \bar{W}^*) > \bar{W}^*]$. Actually it can be shown at least in the second case that it yields a lower limit for the mean value of time.

Finally, if the size of the sample does not allow a very detailed classification of potential wage groups, the number of observations might be too small to allow reliable estimates of equations (2.12) and (2.18). In this case the relationship between the mean value of time μ_{W*} and income I [i.e., $\mu_{W_i^*} = g(I_i)$] must be prespecified. Thus, if, for example, one assumes that there exists a linear relationship

$$\mu_{W_i^*} = \alpha_0 + \alpha_1 I, \tag{2.19}$$

one can estimate

$$\bar{W}_{ij} = a + b_1 I_i + b_2 Z_{ij} \tag{2.20}$$

$$\bar{W}_{ij} = a + b_1 I_i + b_3 Z_{ij}^*,$$

where $a = \text{est}\ (\alpha_0)$, $b_1 = \text{est}\ (\alpha_1)$, $b_2 = \text{est}\ (\sigma_{W*})$, and $b_3 = \text{est}\ (\sigma_W)$.

Furthermore, if one assumes that the standard deviation of the price of time varies linearly among income groups

$$\sigma_{W_i^*} = \beta_0 + \beta_1 I_i, \tag{2.21}$$

one can estimate

$$\bar{W}_{ij} = a + b_1 I_i + b_4 Z_{ij} + b_5 (Z_{ij} I_i), \tag{2.22}$$

where $a = \text{est}\ (\alpha_0)$, $b_1 = \text{est}\ (\alpha_1)$, $b_4 = \text{est}\ (\beta_0)$, and $b_5 = \text{est}\ (\beta_1)$.

THE DATA AND THE RESULTS

The data used to estimate the value of time of housewives consists of a sample survey conducted during the months January–March 1969 by the Manpower Planning Authority of the Israeli Ministry of Labor. The purpose of the study was to investigate the labor force participation of Israeli married women and the sample contained about 1,200 observations of Jewish married women aged 18–65 living in urban areas.

The sample was investigated by Ish-Shalom [8] who fitted a linear probability function to the disaggregated observations. Ish-Shalom reports that among all the variables examined he found only four that played a significant role in explaining participation. These are (in descending order of importance): wife's potential wage rate, husband's income, monthly debt payments, and the presence in the household of a child less than three years old.[14] As expected, husband's income and the presence of a young child had a discouraging effect on women's labor force participation, and participation increases with the potential wage rate and the burden of debt repayment.

To estimate the price of time, the data were classified according to 12 age-education groups [four ages (18–30, 31–40, 41–50, 50+) by three education groups (primary, secondary, and higher)] [15] and six income groups (husband's regular monthly income in Israeli pounds, IL: 0–200, 201–400, 401–600, 601–800, 801–1,000, 1,001+).[16]

Finally, since the presence of young children seems to have a significant bearing on the wife's productivity at home and the value assigned to her time, the data were subdivided into two additional groups according to whether the household did or did not include children below the age of three.

There were too few potential wage groups and income groups to allow definite conclusions from the results of regressions (2.12) and (2.18). Thus equation (2.20) was estimated by adopting two alternative assumptions: (a) that the mean price of time (μ_{W*}) varies linearly with income (I), and (b) that the mean price of time varies linearly with the natural logarithm of income ($\ln I$). A weighted regression was estimated separately for all married women, for women with a child less than three years old, and for women with no child below three (the weights being the number of working women in each cell). The results are reported in Tables 2 and 3.

[14] Ish-Shalom defined the potential wage rate as the expected wage rate of women belonging to a given age-education group. He did not attempt, however, to include in his regression both the potential wage variable and the age-education variable. Thus, part of the estimated wage effect may be attributable to tastes.

[15] It was found that age and education explain 42 per cent of the dispersion of wage rates among women who work full time. This classification of age-education groups differs somewhat from that used by Ish-Shalom.

[16] Increasing the number of income groups from six to eight (0–200, 201–400, 401–600, 601–800, 801–1,000, 1,001–1,200, 1,201–1,400, 1,400+) did not affect the results.

TABLE 2

Estimate of the Relationship Between Housewives' Value of Time and Income, Where $\mu_{W^*} = \alpha_0 + \alpha_1 I$

	Adj. R^2	Constant a	Constant t	Income I b_1	Income I t	$Z(Z^*)$ b_2	$Z(Z^*)$ t
	Assumption I ($\sigma_W = 0$): $\bar{W} = a + b_1 I + b_2 Z$						
Total	.55	337.0	9.10	.261	5.70	75.79	4.63
Child <3	.41	379.8	6.07	.209	2.73	65.00	4.14
No child <3	.50	303.5	7.14	.287	5.44	61.99	3.11
	Assumption II ($\sigma_{W^*} = 0$): $\bar{W} = a + b_1 I + b_2 Z^*$						
Total	.48	234.9	5.08	.278	5.71	103.72	3.62
Child <3	.38	288.7	4.11	.215	2.74	96.86	3.89
No child <3	.45	232.0	4.34	.298	5.41	76.70	2.27

$\bar{W}$ = average monthly gross earnings of women who worked full time.
I = average monthly gross earnings of the husband.
Z and Z^* – see text (it is assumed that $Z = Z^* = 3$ when $P = 1$).

TABLE 3

Estimate of the Relationship Between Housewives' Value of Time and Income, Where $\mu_{W^*} = \alpha_0 + \alpha_1 \ln I$

	Adj. R^2	Constant a	Constant t	Log of Income ($\ln I$) b_1	Log of Income ($\ln I$) t	$Z(Z^*)$ b_2	$Z(Z^*)$ t
	Assumption I ($\sigma_W = 0$): $\bar{W} = a + b_1 \ln I + b_2 Z$						
Total	.47	−280.8	−1.59 [a]	125.23	4.62	75.90	4.29
Child <3	.44	−286.7	−1.05 [a]	126.13	3.04	64.39	4.20
No child <3	.39	−326.1	−1.57 [a]	130.14	4.05	62.54	2.82
	Assumption II ($\sigma_{W^*} = 0$): $\bar{W} = a + b_1 \ln I + b_2 Z^*$						
Total	.39	−414.6	−2.21	132.66	4.60	99.12	3.19
Child <3	.40	−365.4	−1.29 [a]	125.33	2.92	94.24	3.84
No child <3	.33	−427.4	−1.97 [a]	136.45	4.09	74.26	1.98 [a]

[a] Not significant at the 5 per cent level.

The results of Table 2 confirm our expectations. The coefficients of I, Z, and Z^* are all positive and significant. An increase of 1 Israeli pound in the husband's gross earnings increases the value of his wife's time (if she does not work) by IL 0.2–0.3.[17] The standard deviation of the value of time, σ_{W^*}, is about IL 60–75 while that of the wage offer distribution, σ_W, is about IL 75–100. The assumption that the mean value of time changes linearly with the logarithm of income (Table 3) yields estimates which are somewhat inferior in terms of explanatory power (i.e., adjusted R^2). However, the estimates of the standard deviation (σ_{W^*} and σ_W) are almost identical to the ones obtained assuming a linear relationship between the mean price of time (μ_{W^*}) and income (I).[18]

Relaxing the assumption that the standard deviation of the price of time σ_{W^*} is constant, and allowing it to vary with income, I tried to estimate equation (2.22). Unfortunately, the results are somewhat ambiguous due to multicollinearity (the coefficient of correlation between Z and ZI exceeds 0.93). In all cases the coefficient of Z is found to be nonsignificant. Thus, assuming that the standard deviation σ_{W^*} varies proportionately with income, $\sigma_{W^*} = \beta_1 I$, we estimated

$$\bar{W} = a + b_1 I + b_2 ZI, \tag{3.1}$$

b_2 being an estimator of β_1. The results reported in Table 4 give some support to the hypothesis that the dispersion of the price of time within each income group increases with income, but leave intact the estimates of the effect of income on the mean price of time.

The discussion in the previous section asserts that if one assumes that all women belonging to a given age-education-income cell are homogeneous with respect to their potential wage rate (i.e., $\sigma_W = 0$) then the average price of time of housewives $\bar{W}^*$ exceeds the average wage rate of working women ($\bar{W}$) belonging to the same group. On the other hand, if all women belonging to the same group have the same price of time (i.e., $\sigma_{W^*} = 0$) then W exceeds W^*. The mean price of time in the absence of market opportunities (μ_{W^*}) exceeds the group's average wage rate ($\bar{W}$) if one adopts the first assumption for all those

[17] There exists almost no correlation between income (I) and both Z and Z^* (the correlation coefficients being about 0.1). Thus, one obtains the same income coefficient whether Z or Z^* are used in the regression.

[18] This is again an outcome of the small correlation between ln I and both Z and Z^*. Since $Z(Z^*)$ is uncorrelated with both I and ln I the coefficient of $Z(Z^*)$ should be the same whether I or ln I are included in the regressions. Thus, one obtains the same estimates (b_2) of the standard deviations.

TABLE 4

Estimate of the Relationship Between Housewives' Value of Time and Income, Where $\sigma_W = 0$ and $\sigma_{W^*} = \beta_1 I$

	Adj. R^2	Constant a	t	Income b_1	t	$Z \cdot I$ b_2	t
			$W = a + b_1 I + b_2(Z \cdot I)$				
Total	.57	328.9	9.13	0.267	6.00	.110	4.99
Child <3	.39	391.7	6.18	0.195	2.50	.082	3.95
No child <3	.53	306.3	7.40	0.278	5.39	.091	3.51
			$\bar{W} = a + b_1 \ln I + b_2(Z \cdot I)$				
Total	.49	−311.8	−1.82 [a]	129.44	4.91	.111	4.64
Child <3	.41	−224.5	−0.80 [a]	116.84	2.74	.080	3.94
No child <3	.43	−313.3	−1.56 [a]	127.53	4.11	.095	3.35

[a] Not significant at the 5 per cent level.

groups where the rate of participation is less than 50 per cent. It falls short of $\bar{W}$ if the second assumption is used. These relationships, however, need not necessarily hold if one estimates $\bar{W}$, $\bar{W}^*$, and μ_{W^*} for the population as a whole.

The average wage rate of all working women is obtained by averaging the wage rates of each group, where the weight given to the group is proportional to the number of working women in that group. To obtain an estimate of the mean price of time (μ_{W^*}) one has to estimate for each group

$$\hat{\mu}_{W^*} = a + b_1 I \tag{3.2}$$

and to average over all groups, where the weights are the number of women belonging to each group. To obtain an estimate of the housewives' average price of time one has to compute

$$\hat{\bar{W}}^* = \hat{\mu}_{W^*} + b_2 \hat{y} \tag{3.3}$$

if one adopts the first assumption, or uses the estimate of $\hat{\mu}_{W^*}$ [equation (3.2)] in the second case and averages over all groups where the weights are the number of women not participating in the labor force. The relationship between $\bar{W}$, $\bar{W}^*$, and μ_{W^*} in the population is affected by the relationship within each individual group[19] as well as by the difference in the weighting schemes.

[19] The estimated relationship between $\bar{W}$, $\bar{W}^*$, and μ_{W^*} may deviate from the theoretical one because of misspecifications in the assumed relationship between the mean price of time (μ_{W^*}) and income [i.e., equation (2.20)].

TABLE 5

Estimates of the Value of Housewives' Time
(pounds Israeli)

	Total	Child Younger than 3	No Child Younger than 3
Labor force participation rate, P	0.357	0.307	0.380
Average wage of working women, $\bar{W}_W$	536.2	562.6	524.8
Average potential wage, $\bar{W}_T$	489.3	499.0	486.9
Housewives' potential wage, $\bar{W}_H$	470.1	470.1	468.1
Assumption I ($\sigma_W = 0$):			
Mean price of time, $\hat{\mu}_{W^*}$	529.7	527.9	518.6
Price of time elasticity, $\hat{\epsilon}_{W^* \cdot I}$	0.36	0.28	0.41
Price of housewives' time, $\hat{\bar{W}}^*$	564.5	549.5	548.9
Price of time/wage rate ratio:			
$\hat{\bar{W}}^*/\bar{W}_H$	1.20	1.17	1.17
$\hat{\bar{W}}^*/\bar{W}_W$	1.05	0.98	1.05
Assumption II ($\sigma_{W^*} = 0$):			
Mean price of time, $\hat{\mu}_{W^*}$	441.0	440.3	457.2
Price of time elasticity, $\hat{\epsilon}_{W^* \cdot I}$	0.46	0.35	0.48
Price of housewives' time, $\hat{\bar{W}}^*$	438.2	437.2	455.4
Price of time/wage rate ratio:			
$\hat{\bar{W}}^*/\bar{W}_H$	0.93	0.93	0.97
$\hat{\bar{W}}^*/\bar{W}_W$	0.81	0.78	0.87

The estimates of $\bar{W}$, $\bar{W}^*$, and μ_{W^*} are presented in Table 5.[20] Comparing the average potential wage rate (using as the weights the number of women belonging to each group) with the estimates of the mean price of time in the absence of market opportunities ($\hat{\mu}_{W^*}$), it is found that the first assumption yields an estimate of $\hat{\mu}_{W^*}$ that exceeds the average potential wage rate by less than 10 per cent, while the second assumption yields an estimate that falls short of the average potential wage by a similar margin (these relationships are only slightly different if one estimates $\hat{\mu}_{W^*}$ separately for wives with young children and wives without young children).

Applying these estimates of the mean price of time to estimate the elasticity of the price of time with respect to income,

[20] The estimates in Table 5 are based on the assumption that the mean price of time is a linear function of income (i.e., the regression estimates presented in Table 2). Had I adopted any of the other assumptions the results would have been almost identical.

$$\epsilon_{W^*I} = b_1(\bar{I}/\ \mu_{W^*}), \tag{3.4}$$

it is found that an increase in the husband's income by 1 per cent increases his wife's value of time (if she does not work) by 0.30–0.40 per cent. A somewhat higher estimate of the elasticity is obtained (0.35–0.50) if one adopts the second assumption ($\sigma_{W^*} = 0$).

Comparing the housewives' average price of time with their potential wage rate ($\bar{W}_H$), it is found that under the first assumption ($\sigma_W = 0$) the price of time exceeds the wage rate by 20 per cent. Adopting the second assumption ($\sigma_{W^*} = 0$), the price of time falls short of the potential wage by 7 per cent.

The comparison of the housewives' average price of time with the average wage of working women is affected by the two different weighting schemes used in their computation. If one assumes $\sigma_W = 0$, $\bar{W}^*$ exceeds $\bar{W}$ by no more than 5 per cent ($\bar{W}^*$ falls short of $\bar{W}$ in the case of wives with young children). On the other hand, if it is assumed that $\sigma_{W^*} = 0$, then the estimated price of time of housewives falls short of the women's average wage rate by 13–22 per cent.

The income of wives with a young child is less than IL 710 while that of wives without a young child is IL 750 (the average for the population being about IL 740). These differences in income tend to offset the effect young children may have on housewives' price of time. Thus, there is almost no difference in our estimates of the average price of time of housewives with and without young children.

SOME CONCLUDING REMARKS

The results presented in the preceding section proved to be quite robust, not being much affected by changes in the assumptions about the relationships between the mean and the standard deviation of the price of time distribution (μ_{W^*} and σ_{W^*}) and income (I). However, one would like the estimates to pass some additional sensitivity tests before they are accepted at face value. For one, it seems advisable to remove the assumption of intergroup independence between the wage offers and the value of time (W and W^*, respectively). Allowing for an additive effect of age and education on the mean price of time, one can rewrite equation (2.19)

$$\mu_{W^*_{ij}} = \alpha_{0j} + \alpha_1 I_i \tag{4.1}$$

and estimate

$$\bar{W}_{ij} = \sum_{j=1}^{12} a_j D_j + b_1 I_i + b_2 Z_{ij} \tag{4.2}$$

and

$$\bar{W}_{ij} = \sum_{j=1}^{12} a_j D_j + b_1 I_i + b_3 Z^*_{ij},$$

where D_j is a dummy variable presenting potential wage group j, $b_1 =$ est (α_1), $b_2 =$ est (σ_{W^*}), $b_3 =$ est (σ_W), and $a_j =$ est (α_{0j}) measures the effect of age and education on the mean price of time. Secondly, one may wish to replace the normality assumption by some alternative form of distribution of W and W^* (say, the log normal).[21]

Even if the estimates passed all these sensitivity tests one would place more confidence in them if they could be compared with some other estimates in this field. Unfortunately, there are as yet no comparable studies against which the validity of the results can be tested. There is no remedy to this situation but further research.

The same procedure can of course be applied to other bodies of data. The kind of data investigated here is easily available (e.g., the 1/1,000 sample of the U.S. Bureau of the Census), and a more detailed classification should yield further insight into the factors determining the price of time. I used only the information on the rate of participation P and the average wage rate $\bar{W}$ to derive an interval estimate of the mean price of time. Additional information about the wage dispersion and the relationship between the average wage rate and income may narrow the range in which the mean price of time is to be found.

As mentioned, the housewife's price of time has considerable bearing on her purchasing, traveling, and recreational habits. One should therefore be able to find supporting evidence from studies of these areas. In evaluating such evidence, one limitation of the study must, however, be borne in mind. Throughout the study, I have ignored differences in the marginal utilities of work in the market and work at home. The possible effect of any such difference on labor force participation was attributed to the price of time. Thus, one would expect the estimates of the price of time obtained when the labor force participation decision is investigated to differ from those obtained when the investigation focuses on other decisions relating to the allocation of the housewife's time.

In summary, it is quite encouraging that the two estimates of the

[21] Note, however, that the assumption that within an age-education-income group W and W^* are independently normally distributed does not imply that the observed distribution of wages of working women (or the unobserved distribution of the price of time of housewives) within a group is normal (or even symmetrical). The distribution of W among working women (and the distribution of W^* among housewives within each group) are truncated distributions and hence positively skewed. Furthermore, clearly, the assumption of within-group normality does not imply over-all normality (or symmetry).

price of time of housewives did not differ too much from the average wage rate. Given our estimates, the average price of time of housewives should be found within a range of −20 to +5 per cent of the average wage of working women. The average wage rate of working women can, therefore, serve as a first approximation to the value of labor inputs in home production. However, given the importance of housewives in home production, and the share of nonmarket production in total output, one has to improve this estimate considerably to obtain reliable estimates of the imputed total economic activity. It is hoped that this paper can serve as a first step. Certain further improvements were suggested in this section. Admittedly, there is still a long way to go.

MATHEMATICAL APPENDIX

Assuming that the price of time and the potential wage rate are independently distributed with a bivariate normal distribution, the percentage of women participating in the labor force is

$$P = \text{Prob}\ (W > W^*) = \text{Prob}\ (x > A + By = y^*) \qquad \text{(A.1)}$$
$$= \frac{1}{2\Pi} \int_{-\infty}^{\infty} \int_{y^*}^{\infty} e^{-(x^2+y^2)/2} dx dy$$

where

$$x = (W - \mu_W)/\sigma_W,$$
$$y = (W^* - \mu_{W^*})/\sigma_{W^*},$$
$$A = (\mu_{W^*} - \mu_W)/\sigma_W,$$
$$B = (\sigma_{W^*}/\sigma_W).$$

The average wage of working women equals $\bar{W} = \mu_W + \bar{x}\sigma_W$ where

$$\bar{x} = E(x|x > y^*) = \frac{1}{2\Pi P} \int_{-\infty}^{\infty} \int_{y^*}^{\infty} x e^{-(x^2+y^2)/2} dx dy \qquad \text{(A.2)}$$
$$= \frac{1}{2\Pi P} \int_{-\infty}^{\infty} e^{-(y^2+y^{*2})/2} dy$$
$$= \frac{1}{2\Pi P} \int_{-\infty}^{\infty} \exp\left\{-\frac{1}{2}\,[A^2 + 2ABy + (B^2+1)y^2]\right\} dy$$
$$= \frac{1}{2\Pi P} \int_{-\infty}^{\infty} \exp\left\{-\frac{1}{2}\left[(B^2+1)\left(y + \frac{AB}{B^2+1}\right)^2 + \frac{A^2}{B^2+1}\right]\right\} dy$$

$$= \frac{1}{2\Pi P}\left(\frac{2\Pi}{B^2+1}\right)^{1/2} \exp\left\{-\frac{1}{2}\left[A^2/(B^2+1)\right]\right\}$$

$$= \frac{1}{P}\left[2\Pi(B^2+1)\right]^{-(1/2)} \exp\left\{-\frac{1}{2}\left[A^2/(B^2+1)\right]\right\}$$

$$= \frac{1}{P}\left[2\Pi\,\frac{\sigma_W^2+\sigma_{W^*}^2}{\sigma_W^2}\right]^{-(1/2)} \exp\left[-\frac{1}{2}\,(\mu_{W^*}-\mu_W)^2/(\sigma_W^2+\sigma_{W^*}^2)\right].$$

The average price of time of housewives equals $\bar{W}^* = \mu_{W^*} + \bar{y}\sigma_{W^*}$, where

$$\bar{y} = E(y|y^* > x) = E\left[y|y > \frac{1}{B}(x-A) = x^*\right] \tag{A.3}$$

$$= \frac{1}{2\Pi(1-P)}\int_{-\infty}^{\infty}\int_{x^*}^{\infty} y e^{-(x^2+y^2)/2}\,dy\,dx$$

$$= \frac{1}{2\Pi(1-P)}\int_{-\infty}^{\infty} e^{-(x^2+x^{*2})/2}\,dx$$

$$= \frac{1}{2\Pi(1-P)}\int_{-\infty}^{\infty} \exp\left\{-\frac{1}{2B^2}\left[A^2 - 2Ax + (B^2+1)x^2\right]\right\} dx$$

$$= \frac{1}{2\Pi(1-P)}\int_{-\infty}^{\infty} \exp\left\{-\frac{1}{2B^2}\left[(B^2+1)\left(x-\frac{A}{B^2+1}\right)^2 + \frac{A^2B^2}{B^2+1}\right]\right\} dx$$

$$= \frac{1}{2\Pi(1-P)}\left(\frac{2\Pi B^2}{B^2+1}\right)^{1/2} \exp\left(-\frac{1}{2}\,\frac{A^2}{B^2+1}\right)$$

$$= \frac{B}{1-P}\left[2\Pi(B^2+1)\right]^{-1/2} \exp\left[-\frac{A^2}{2(B^2+1)}\right]$$

$$= \frac{1}{1-P}\left(2\Pi\,\frac{\sigma_W^2+\sigma_{W^*}^2}{\sigma_{W^*}^2}\right)^{-1/2} \exp\left[-\frac{1}{2}\,\frac{(\mu_{W^*}-\mu_W)^2}{\sigma_W^2+\sigma_{W^*}^2}\right]$$

$$= \frac{P}{1-P}\,\frac{\sigma_{W^*}}{\sigma_W}\,\bar{x} = \frac{P}{1-P}\,B\bar{x}.$$

P is a function of A and B. An increase in A results in a decrease in P:

$$\frac{\partial P}{\partial A} = \frac{\partial}{\partial A}\left[\frac{1}{2\Pi}\int_{-\infty}^{\infty}\int_{A+By}^{\infty} e^{-(x^2+y^2)/2}\,dx\,dy\right] \tag{A.4}$$

$$= -\frac{1}{2\Pi}\int_{-\infty}^{\infty} e^{-[(A+By)^2+y^2]/2}\,dy = -P\bar{x} < 0.$$

since $\bar{x} > 0$. An increase in B results in an increase in P:

$$\frac{\partial P}{\partial B} = \frac{\partial}{\partial B}\left[\frac{1}{2\Pi}\int_{-\infty}^{\infty}\int_{A+By}^{\infty} e^{-(x^2+y^2)/2}dxdy\right] \tag{A.5}$$

$$= -\frac{1}{2\Pi}\int_{-\infty}^{\infty} ye^{-[(A+By)^2+y^2]/2}dy$$

$$= \frac{1}{(B^2+1)2\Pi} e^{-[(A+By)^2+y^2]/2}\Big|_{-\infty}^{\infty}$$

$$+ \frac{AB}{(B^2+1)2\Pi}\int_{-\infty}^{\infty} e^{-[(A+By)^2+y^2]/2}dy = \frac{AB}{B^2+1}P\bar{x} > 0,$$

since in general $A > 0$, P being smaller than 50 per cent.

Similarly, one can compute the changes of $\bar{x}$ with respect to A and B

$$\frac{\partial \bar{x}}{\partial A} = -\bar{x}\left(\frac{\partial P/\partial A}{P} + \frac{A}{B^2+1}\right) = \bar{x}\left(\bar{x} - \frac{A}{B^2+1}\right) \tag{A.6}$$

and

$$\frac{\partial \bar{x}}{\partial B} = -\bar{x}\left[\frac{\partial P/\partial B}{P} + \frac{B}{B^2+1} - \frac{A^2B}{(B^2+1)^2}\right]$$

$$= \frac{B\bar{x}}{B^2+1}\left(\frac{A^2}{B^2+1} - A\bar{x} - 1\right).$$

Finally, changes in A and B affect also $\bar{y}$:

$$d\bar{y} = \bar{y}\left[\frac{dP}{P(1-P)} + \frac{dB}{B} + \frac{d\bar{x}}{\bar{x}}\right]. \tag{A.7}$$

Given the values of P and $\bar{W}$, a change in the assumptions about B calls for a compensating change in the assumptions about A. For example, let us assume that σ_{W} is given and that the value of σ_{W^*} is overestimated by $d\sigma_{W^*}$. Since P is given,

$$dP = \frac{\partial P}{\partial \sigma_{W^*}} d\sigma_{W^*} + \frac{\partial P}{\partial(\mu_{W^*} - \mu_{W})} d(\mu_{W^*} - \mu_{W}) \tag{A.8}$$

$$= \frac{\partial P}{\partial B}\frac{\partial B}{\partial \sigma_{W^*}} d\sigma_{W^*} + \frac{\partial P}{\partial A}\frac{\partial A}{\partial(\mu_{W^*} - \mu_{W})} d(\mu_{W^*} - \mu_{W}) = 0.$$

Thus,

$$d(\mu_{W^*} - \mu_W) = -\frac{\dfrac{\partial P}{\partial B}\dfrac{\partial B}{\partial \sigma_{W^*}}}{\dfrac{\partial P}{\partial A}\dfrac{\partial A}{(\mu_{W^*} - \mu_W)}}\, d\sigma_{W^*} \tag{A.9}$$

$$= -\frac{\dfrac{AB}{B^2+1}\dfrac{P\bar{x}}{\sigma_W}}{-\dfrac{P\bar{x}}{\sigma_W}}\, d\sigma_{W^*} = \frac{AB}{B^2+1}\, d\sigma_{W^*}.$$

Given the overestimate in $d\sigma_{W^*}$ and the compensating overestimate in $d(\mu_{W^*} - \mu_W)$ the estimate of $\bar{x}$ should change by

$$d\bar{x} = \frac{\partial \bar{x}}{\partial \sigma_{W^*}}\, d\sigma_{W^*} + \frac{\partial \bar{x}}{\partial(\mu_{W^*} - \mu_W)}\, d(\mu_{W^*} - \mu_W) \tag{A.10}$$

$$= \left[\frac{\partial \bar{x}}{\partial B}\frac{\partial B}{\partial \sigma_{W^*}} + \frac{\partial \bar{x}}{\partial A}\frac{\partial A}{\partial(\mu_{W^*} - \mu_W)}\frac{d(\mu_{W^*} - \mu_W)}{d\sigma_{W^*}}\right] d\sigma_{W^*}$$

$$= \frac{d\sigma_{W^*}}{\sigma_W}\left[\frac{B\bar{x}}{B^2+1}\left(\frac{A^2}{B^2+1} - A\bar{x} - 1\right) + \frac{AB}{B^2+1}\bar{x}\left(\bar{x} - \frac{A}{B^2+1}\right)\right]$$

$$= -\frac{B\bar{x}}{B^2+1}\frac{d\sigma_{W^*}}{\sigma_W}.$$

Since $\bar{W}$ is given:

$$d\bar{W} = d\mu_W + \sigma_W d\bar{x} + \bar{x}\, d\sigma_W = d\mu_W + \sigma_W d\bar{x} = 0. \tag{A.11}$$

Hence an overestimate of σ_{W^*} by $d\sigma_{W^*}$ results in an overestimate of μ_W by

$$d\mu_W = -\sigma_W d\bar{x} = \frac{B\bar{x}}{B^2+1}\, d\sigma_{W^*} > 0, \tag{A.12}$$

and an overestimate of μ_{W^*} by

$$d\mu_{W^*} = d\mu_W + d(\mu_{W^*} - \mu_W) = \left(\frac{B\bar{x}}{B^2+1} + \frac{AB}{B^2+1}\right) d\sigma_{W^*} \tag{A.13}$$

$$= \frac{B}{B^2+1}(A + \bar{x})\, d\sigma_{W^*} > 0.$$

The same change affects the average price of time of housewives by

$$d\bar{W}^* = d\mu_{W^*} + \sigma_{W^*} d\bar{y} + \bar{y}\, d\sigma_{W^*}. \tag{A.14}$$

By equations (A.3), (A.7), and (A.9),

$$d\bar{y} = \bar{y}\left(\frac{\partial B/\partial\sigma_{w^*}}{B} + \frac{\partial\bar{x}/\partial\sigma_{w^*}}{\bar{x}}\right) d\sigma_{w^*} = \frac{P}{1-P}\,\frac{B\bar{x}}{B^2+1}\,\frac{d\sigma_{w^*}}{\sigma_{w^*}}. \quad \text{(A.15)}$$

and hence

$$d\bar{W}^* = \left[\frac{B}{B^2+1}\left(A + \frac{\bar{x}}{1-P}\right) + \bar{y}\right] d\sigma_{w^*} > 0. \quad \text{(A.16)}$$

Thus, an underestimate of σ_{w^*}, yields an underestimate of both μ_{w^*} and $\bar{W}^*$. In particular, the assumption $\sigma_{w^*} = 0$ yields an underestimate of the mean price of time and housewives' average price of time.

Assuming that σ_{w^*} is given and that the value of σ_w is overestimated by $d\sigma_w$, and since P is given

$$dP = \frac{\partial P}{\partial\sigma_w}\, d\sigma_w + \frac{\partial P}{\partial(\mu_{w^*} - \mu_w)}\, d(\mu_{w^*} - \mu_w) \quad \text{(A.17)}$$

$$= \left(\frac{\partial P}{\partial A}\frac{\partial A}{\partial\sigma_w} + \frac{\partial P}{\partial B}\frac{\partial B}{\partial\sigma_w}\right) d\sigma_w + \frac{\partial P}{\partial A}\,\frac{\partial A}{\partial(\mu_{w^*} - \mu_w)}\, d(\mu_{w^*} - \mu_w) = 0.$$

Thus,

$$d(\mu_{w^*} - \mu_w) = -\frac{\dfrac{\partial P}{\partial A}\dfrac{\partial A}{\partial\sigma_w} + \dfrac{\partial P}{\partial B}\dfrac{\partial B}{\partial\sigma_w}}{\dfrac{\partial P}{\partial A}\,\dfrac{\partial A}{\partial(\mu_{w^*} - \mu_w)}}\, d\sigma_w \quad \text{(A.18)}$$

$$= -\frac{\dfrac{P\bar{x}}{\sigma_w}\left(A - \dfrac{AB^2}{B^2+1}\right)}{-\dfrac{P\bar{x}}{\sigma_w}}\, d\sigma_w = \frac{A}{B^2+1}\, d\sigma_w.$$

Given the overestimate in $d\sigma_{w^*}$ and the compensating overestimate in $d(\mu_{w^*} - \mu_w)$ the estimate of $\bar{x}$ should change by

$$d\bar{x} = \frac{\partial\bar{x}}{\partial\sigma_w}\, d\sigma_w + \frac{\partial\bar{x}}{\partial(\mu_{w^*} - \mu_w)}\, d(\mu_{w^*} - \mu_w) \quad \text{(A.19)}$$

$$= \left\{\frac{\partial\bar{x}}{\partial A}\left[\frac{\partial A}{\partial\sigma_w} + \frac{\partial A}{\partial(\mu_{w^*} - \mu_w)}\,\frac{d(\mu_{w^*} - \mu_w)}{d\sigma_w}\right] + \frac{\partial\bar{x}}{\partial B}\,\frac{\partial B}{\partial\sigma_w}\right\} d\sigma_w$$

$$= \left[\bar{x}\left(\bar{x} - \frac{A}{B^2+1}\right)\left(\frac{A}{B^2+1} - A\right) - \frac{B^2\bar{x}}{B^2+1}\left(\frac{A^2}{B^2+1} - A\bar{x} - 1\right)\right]\frac{d\sigma_w}{\sigma_w}$$

$$= \frac{B^2\bar{x}}{B^2+1}\,\frac{d\sigma_w}{\sigma_w}.$$

Since $\bar{W}$ is given,

$$d\bar{W} = d\mu_W + \sigma_W d\bar{x} + \bar{x} d\sigma_W = 0.$$

Hence, an overestimate of σ_W by $d\sigma_W$ results in an underestimate of μ_W by

$$d\mu_W = -(\sigma_W d\bar{x} + \bar{x} d\sigma_W) = -\bar{x}\left(\frac{B^2}{B^2+1} + 1\right) d\sigma_W < 0 \quad \text{(A.20)}$$

and a change of μ_{W^*} of

$$\begin{aligned} d\mu_{W^*} &= d\mu_W + d(\mu_{W^*} - \mu_W) \qquad \text{(A.21)} \\ &= \left[-\bar{x}\left(\frac{B^2}{B^2+1} + 1\right) + \frac{A}{B^2+1}\right] d\sigma_W \\ &= [A - (2B^2 + 1)\bar{x}] \frac{d\sigma_W}{B^2+1}. \end{aligned}$$

$$d\bar{y} = \bar{y}\left(\frac{\partial B/\partial\sigma_W}{B} + \frac{\partial\bar{x}/\partial\sigma_W}{\bar{x}}\right) d\sigma_W = -\frac{\bar{y}}{B^2+1}\frac{d\sigma_W}{\sigma_W}. \quad \text{(A.22)}$$

Hence,

$$d\bar{W}^* = d\mu_{W^*} + \sigma_{W^*} d\bar{y} = [A - (2B^2 + 1)\bar{x} - B\bar{y}] \frac{d\sigma_W}{B^2+1}. \quad \text{(A.23)}$$

It seems to me that the terms in (A.21) and (A.23) are always negative and, hence, the estimates based on the assumption $\sigma_{W^*} = 0$ are upper limits of σ_{W^*} and $\bar{W}^*$, but I cannot prove it. Note, however, that when $\sigma_W = 0$

$$d\mu_{W^*} = d\bar{W}^* = -2\bar{x} d\sigma_W < 0, \quad \text{(A.24)}$$

i.e., μ_{W^*} and $\bar{W}^*$ are local maximums.

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COMMENT

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Gronau offers an ingenious and promising procedure for estimating an important but essentially unobservable variable, namely, the value of time of housewives. I applaud this attempt, and hope that in time the procedure will be implemented more widely, with different data sets, for other groups (for instance, teen-agers and retired persons) and with additional refinements.

Gronau proposes a procedure such that with only two data sets—data on labor force participation and the average wage rate—he can get estimates of the mean value of time of those who do not work.

Quite correctly, he calls to our attention that wives who work are either those who are the most productive in the market or those who are the least productive at home. According to the first interpretation, the mean price of time of housewives would be smaller than the average wage rate of working women, while according to the second, the mean price of time would exceed the average wage rate.

Structurally, the problem is the same as the following. Consider an industry producing a given product. For any given demand conditions, are those firms in the industry those which are the most efficient at producing this good, or are they the firms which are the least efficient at producing other goods?

There are several problems connected with the particulars of Gronau's application. In the first place, the sole income variable entered in the regressions to explain the price of time of housewives is the regular income of the husband. Presumably, this variable includes both his earnings and his portion of family nonwage income. These two components have, however, rather different effects on the price of time of housewives. Leaving aside intertemporal planning considerations, to which I will return in a moment, a 1 per cent difference in property income may have very different effects from a 1 per cent difference in the wage rate. Indeed, while a rise in property income would raise her price of time (as long as her home time were normal), a rise in his wage rate, aside from the income effect, would induce substitution toward or against her time depending on whether her home time and his were substitutes or complements. With a sufficient degree of complementarity between these nonmarket times, a rise in the husband's wage rate could even produce a negative effect on the price of time of the wife. The estimates produced by Gronau mix both the effect of changes in nonwage income and that of changes in the husband's wage rate. It would be desirable if in future work these effects could be disentangled.

My second comment relates to the need to embed the model in a general intertemporal planning framework. From that point of view, one would expect variations in the price of time independent of variations in the husband's wage rate or of the presence of children. Indeed, as long as all productivities and income streams were perfectly anticipated, a positive rate of interest (net of time preference) would in itself induce substitution toward future consumption, thereby raising the demand for future home time relative to present home time. In other words, it would have been appropriate to have an age variable in the regression to capture the effect of a positive rate of interest (net of time preference), as well as the effect of changes in nonmarket productivity which are not correlated with the presence of young children. Alternatively, it would have been better if the estimation was done for a given age group rather than over the whole population.

My third comment addresses itself to the treatment of children. The children variable is introduced as a control, and yet children themselves are not exogenous, but rather are produced by parents with a certain degree of control. In fertility studies we take the price of time (the wage rate) as exogenous, while in this study, as in labor force studies, one takes children as exogenous. Some day, I hope, a fully integrated model will be developed.

Fourth comment. The empirical procedure rules out all fixed costs resulting from engaging in market activities. There are no commuting costs, no time "lost" in switching activities. Were these incorporated into the analysis, the condition $W > W^*$ (with W^* evaluated at an income net of the fixed costs) would still be a necessary condition but would no longer be a sufficient condition for entry into the market. Sufficiently high transaction costs could make a potential participant better off by staying at home. Since these fixed costs vary in a systematic way across income groups, the estimates produced by Gronau are biased on this account. I hope this difficulty can be remedied in future work.

Finally, I find little comfort that ". . . the two estimates of the price of time of housewives did not differ too much from the average wage rate . . . ; the average price of time of housewives should be found within a range of -20 to $+5$ per cent of the average wage of working women," as Gronau puts it. That range in itself is not so narrow, and moreover the estimates were obtained under the implausible assumption that the price of time of a housewife is independent of her age and education. Although the evidence is still scanty, one may presume that investment in education by women raises not only their potential earnings but also their nonmarket efficiency. Some work has been done to estimate the nonmarket returns to males' education. Robert Michael estimates that the elasticity of real full income with respect to the education of males is positive, and may be as high as 0.5. Presumably, the effects are even stronger for housewives since they spend more time in the home than men do. May we soon have Gronau's revised estimates.