Human Capital, Effort, and the Sexual Division of Labor

Gary S. Becker, *University of Chicago and National Opinion Research Center*

Increasing returns from specialized human capital is a powerful force creating a division of labor in the allocation of time and investments in human capital between married men and married women. Moreover, since child care and housework are more effort intensive than leisure and other household activities, married women spend less effort on each hour of market work than married men working the same number of hours. Hence, married women have lower hourly earnings than married men with the same market human capital, and they economize on the effort expended on market work by seeking less demanding jobs. The responsibility of married women for child care and housework has major implications for earnings and occupational differences between men and women.

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I. Introduction

The labor force participation of married women in Western countries has increased enormously during the last 30 years. Initially, the increase was concentrated among older women, but it eventually spread to younger women with small children. Although this paper will not be primarily concerned with the causes of the increase, it will be useful first to sketch out briefly an "economic" explanation (based on Becker 1981, chap. 11) that can be tested against the evidence in other papers in this issue.

The major cause of the increased participation of married women during the twentieth century appears to be the increased earning power of married women as Western economies developed, including the rapid expansion of the service sector. The growth in their earning power raised the forgone value of their time spent at child care and other household activities, which reduced the demand for children and encouraged a substitution away from parental, especially mothers', time. Both of these changes raised the labor force participation of married women.

The gain from marriage is reduced, and hence the attractiveness of divorce raised, by higher earnings and labor force participation of married women, because the sexual division of labor within households becomes less advantageous. Consequently, this interpretation also implies the large growth in divorce rates over time. The decline in the gain from marriage is reflected also in the increased number of "consensual unions" (unmarried couples living together), the large increase in families headed by women, and even partly in the large growth in illegitimate birth rates relative to legitimate rates during recent decades.

Divorce rates, fertility, and labor force participation rates of women also interact in various other ways. For example, fertility is reduced when divorce becomes more likely, because child care is more difficult after a marriage dissolves. There is evidence that couples who anticipate relatively high probabilities of divorce do have fewer children (see Becker, Landes, and Michael 1977). The labor force participation of women is also affected when divorce rates increase, not only because divorced women participate more fully, but also because married women will participate more as protection against the financial adversity of a subsequent divorce.

One difficulty with this explanation is that economic progress and the growth in earning power of women did not accelerate in developed countries after 1950, yet both divorce rates and labor force participation rates of married women have risen far more rapidly since then. I tentatively suggest that threshold effects of increased female earning power on labor force participation rates, fertility, and divorce rates are responsible for much of the acceleration. As the earning power of

women continued to grow, fertility continued to fall until the time spent in child care was reduced enough so that married women could anticipate spending appreciable time in the labor force prior to their first child and subsequent to their last child. Women then had much greater incentive to invest in market-oriented human capital, which accelerated the increase in their earning power, participation, and divorce rates, and accelerated the reduction in fertility.

The modest increase in the hourly earnings of women relative to men during the last 30 years in the United States and many other Western countries (but not all; see Gregory, McMahon, and Whittingham [1985]; Gustafsson and Jacobsson [1985]) has been an embarrassment to the human capital interpretation of sexual earnings differentials, since this interpretation seems to imply that increased participation of married women would induce increased investment in earnings-raising market human capital. However, the increased participation may have temporarily reduced the earnings of women because increased supply generally lowers price, the average labor force experience of working women would be initially reduced, and observed earnings are temporarily reduced by increased on-the-job investments (see O'Neill 1985; Smith and Ward 1985).

Nevertheless, the evidence still suggests, although it does not demonstrate, that the earnings of men and women would not be equal even if their participation were equal. Some have inferred substantial discrimination in the marketplace against women, perhaps supported by the evidence in Zabalza and Tzannatos (1983) for Great Britain. This paper argues that responsibility for child care, food preparation, and other household activities also prevents the earnings of women from rising more rapidly.

Child care and other housework are tiring and limit access to jobs requiring travel or odd hours. These effects of housework are captured by a model developed in this paper of the allocation of energy among different activities. If child care and other housework demand relatively large quantities of "energy" compared to leisure and other nonmarket uses of time by men, women with responsibilities for housework would have less energy available for the market than men would. This would reduce the hourly earnings of married women, affect their jobs and occupations, and even lower their investment in market human capital when they worked the same number of market hours as married men. Consequently, the housework responsibilities of married women may be the source of much of the difference in earnings and in job segregation between men and women.

Section II sets out a model of the optimal division of labor among intrinsically identical household members who invest in different kinds of activity-specific human capital. Increasing returns from investments

in specific human capital encourage a division of labor that reinforces differences in market and household productivity of men and women due to other forces, including any discrimination against women.

Section III models an individual's optimal allocation of energy among different activities. Many implications are derived, including a measure of the value of time in different activities, the forces encouraging the production of energy, and especially a very simple equation for the optimal supply of energy per hour of each activity.

Section IV applies the analysis of specialized investment and of the allocation and production of energy to earnings and occupational differentials between married men and women. It shows that married women with responsibility for child care and other housework earn less than men, choose "segregated" jobs and occupations, and invest less in market human capital even when married men and women work the same number of market hours.

Section V provides a summary and concluding remarks.

II. Human Capital and the Division of Labor

The human capital approach has recognized from the beginning that the incentive to invest in human capital specific to a particular activity is positively related to the time spent at that activity (see Becker 1964, pp. 51–52, 100–102). This recognition was early used to explain empirically why married women have earned significantly less than married men since women have participated in the labor force much less than married men (see Oaxaca 1973; Mincer and Polachek 1974).

It was not recognized immediately, however, that investments in specialized human capital produce increasing returns and thereby provide a strong incentive for a division of labor even among basically identical persons. This is recognized in chapter 2 of my book on the family (1981), where economies of scale from investments in activity-specific human capital are shown to encourage identical members of a household to specialize in different types of investments and to allocate their time differently. I also suggest there that the advantages of specialized investments provide more insights into comparative advantage in international trade than does the conventional emphasis on differences in factor supplies. These increasing returns to scale and advantages of specialization are illustrated in this section with a simple model heavily influenced by discussions with and examples in Rosen (1982) and Gros (1983).

Assume that a person's earnings in each of m market activities are proportional to his time spent at the activity and to his stock of human capital specific to the activity:

$$I_i = b_i t_{w_i} h_i, \qquad i = 1, \ldots, m, \tag{1}$$

where h_i is capital completely specific to activity i. To simplify further, assume that h_i is produced only with investment time (t_{h_i}):

$$h_i = a_i t_{h_i}, \qquad i = 1, \ldots, m. \tag{2}$$

If the total time spent at all work and investment activities is fixed, then

$$\sum_{i=1}^{m} (t_{w_i} + t_{h_i}) = \sum t_i = T, \tag{3}$$

where $t_i = t_{w_i} + t_{h_i}$. By summing over earnings in all activities, and substituting from (2),

$$I = \sum I_i = \sum c_i t_{w_i} t_{h_i}, \tag{4}$$

where $c_i = a_i b_i$.

Since earnings in each activity are determined by the product of work and investment time, total earnings are maximized when these times are equal:

$$I = \frac{1}{4} \sum c_i t_i^2, \tag{5}$$

when $t_{h_i} = t_{w_i}$. The increasing returns from the total time allocated to an activity (t_i) arise from the independence between the cost of accumulating human capital and the amount of time spent using the capital. These increasing returns imply that earnings are maximized when all time is spent on just one activity:

$$I^* = \frac{c_k}{4} T^2, \tag{6}$$

where $c_k \geq c_i$, all i. Examples of complete specialization in human capital specific to a single "activity" include doctors, dentists, carpenters, economists, and so on.

The same formulation is applicable to time allocated among consumption activities produced under constant returns to scale, where the effective time input is proportional both to consumption-specific human capital and consumption time, as in

$$Z_i = b_i t_{z_i} h_i. \tag{7}$$

If $h_i = a_i t_{h_i}$, then

$$Z_i = c_i t_{z_i} t_{h_i}, \tag{8}$$

and the output of each commodity is maximized by equating the time spent on production and investment:

$$Z_i^* = \frac{c_i t_i^2}{4}, \tag{9}$$

where $t_i = t_{z_i} + t_{b_i}$.

If the utility function is a simple Leontief function of these commodities,

$$U = \min(Z_i, \ldots, Z_m), \tag{10}$$

and if $c_i = c$, for all i, utility would be maximized by allocating equal time to each commodity:

$$U^a = Z_i^* = \frac{cT^2}{4m^2}. \tag{11}$$

This indirect utility function depends positively on the total time available and negatively on the number of commodities produced and consumed in fixed proportion.

The link between production and consumption would be severed if other persons also produced these commodities. To eliminate any *intrinsic* comparative advantage, I assume that all persons are basically identical. Even though all commodity production functions have constant returns to scale in effective time, there is still a gain from trade because each person can concentrate his investment and production on a smaller number of commodities and trade for the others. By reducing the number of commodities produced, advantage can be taken of the increasing returns to the *total* time spent on a commodity (see eq. [9]). For example, if two persons each produce half the commodities and trade their excess production unit for unit, the output of each commodity would equal

$$\begin{aligned} Z_i^1 &= \frac{cT^2}{4(m/2)^2}, \qquad i = 1, \ldots, \frac{m}{2} \\ Z_j^2 &= \frac{cT^2}{4(m/2)^2}, \qquad j = \frac{m}{2} + 1, \ldots, m. \end{aligned} \tag{12}$$

Since they trade half the production, the indirect utility function of each person becomes

$$U^t = \frac{1}{2}\frac{cT^2}{4(m/2)^2} > \frac{cT^2}{4m^2} = U^a. \tag{13}$$

Increasing returns from investments in specialized human capital are

the source of the gains from increasing the "extent of the market." Trade permits a division of labor in investments that effectively widens the market and thereby raises the welfare even of basically identical traders. The gain from specialization and trade in this example is simply proportional to the number of traders; each of p traders, $p \leq m$, would specialize in m/p commodities, and produce

$$Z_j^k = \frac{c}{4}\frac{T^2}{m^2}p^2, \qquad j \in \frac{m}{p}, \qquad k = 1, \ldots, p \leq m. \tag{14}$$

If $(p-1)/p$th of the output were traded unit for unit, the level of utility would be proportional to the number of traders:

$$U^t = \frac{1}{p}Z_j^k = \frac{c}{4}\frac{T^2}{m^2}p, \qquad p \leq m. \tag{15}$$

The effect of specialization and trade on welfare is shown in figure 1 (suggested by John Muellbauer). A person without access to trade has a

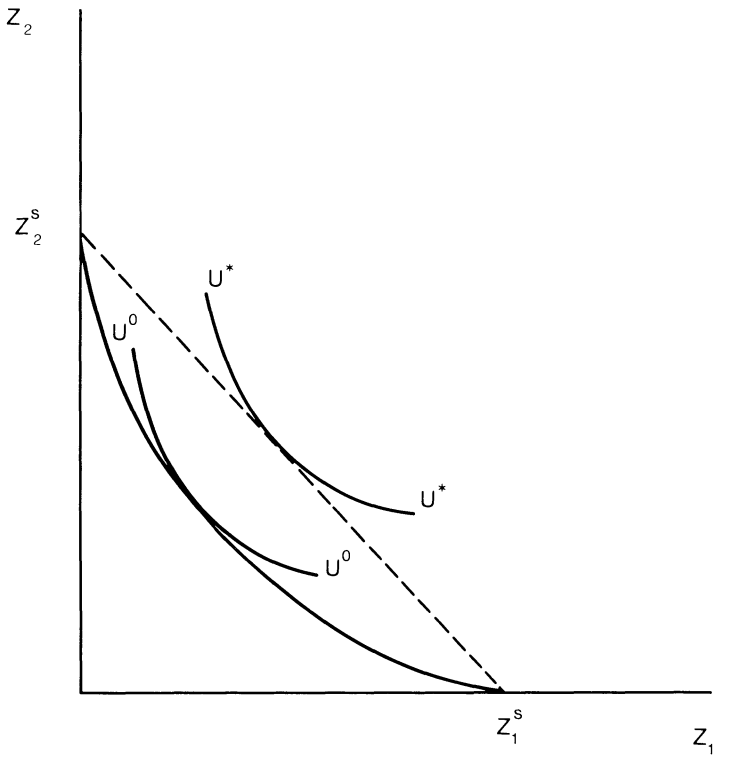

FIG. 1.—The gains from specialization and trade

convex opportunity boundary between Z_1 and Z_2 because of increasing returns from specific investments; his utility is maximized at the point of tangency with an indifference curve (U^0). A market with many basically identical persons has better opportunities and can obtain by specialization and trade any point on the straight line joining the intercepts, Z_1^s and Z_2^s. If b persons specialize completely in Z_1 and $n - b$ specialize in Z_2, trading provides each person with $(b/n)Z_1^s$ units of Z_1 and $(1 - b/n)Z_2^s$ units of Z_2. This defines a straight-line opportunity boundary between Z_1^s and Z_2^s as b varies from zero to n. The improvement in welfare from trade (U^*/U^0) is determined by the degree of increasing returns or by the convexity of the opportunities for a person without trade.

The analysis is readily generalized to permit substitution among a continuum of commodities. The number of commodities consumed along with the degree of specialization in production by any trader would then also depend on the extent of the market (see the analysis in Gros [1983]). Moreover, goods and services as well as time can be inputs into the production of commodities and human capital. The following proposition survives all reasonable generalizations.

PROPOSITION:—If n basically identical persons consume in equilibrium $m << n$ commodities produced under constant or increasing returns to scale with specific human capital, each person will completely specialize in producing only one commodity and accumulate only the human capital specific to that commodity. The other $m - 1$ commodities will be acquired by trades with other specialized producers. If $n > 1$ is smaller or not much larger than m, or with decreasing returns to scale, specialization may be incomplete, but *some* commodities *must* be produced by only one person.[1]

This analysis is applicable to the division of labor and specialization within households and families because the production of children, many aspects of child care and investments in children, protection against certain risks, altruism, and other "commodities" are more efficiently produced and consumed within households than by trades among households (see Becker [1981] for a further discussion). Most societies in all parts of the world have had a substantial division of labor, especially by age and sex, in the activities of household members. Although the participation of women in agriculture, trade, and other nonhousehold activities varies greatly throughout different parts of the world, women are responsible for the lion's share of housework, especially child care and food preparation, in essentially all societies. Moreover, even when they participate in market activities, women tend to engage in different

[1] This proposition essentially combines theorems 2.2, 2.3, and 2.4 in Becker (1981, chap. 2).

activities than men do (see Boserup [1970] for evidence from less developed countries that supports these statements).

The advantages of investments in specific human capital encourage a sharp division of labor among household members but do not in and of themselves say anything about the *sexual* division of labor. I suggested in my book on the family that men and women have intrinsically different comparative advantages not only in the production of children, but also in their contribution to child care and possibly to other activities (Becker 1981, pp. 21–25). Such intrinsic differences in productivity would determine the direction of the sexual division by tasks and hence sexual differences in the accumulation of specific human capital that reinforce the intrinsic differences.

Some have objected to the presumption that intrinsic differences in comparative advantage are an important cause of the sexual division of labor, and have argued instead that the sexual division is mainly due to the "exploitation" of women. Yet a sexual division of labor according to intrinsic advantage does not deny exploitation. If men have full power both to determine the division of labor and to take all household output above a "subsistence" amount given to women (a competitive marriage market would divide output more equally), men would impose an efficient division of labor because that would maximize household output, and hence their own "take." In particular, they would assign women to child care and other housework *only if* women have a comparative advantage at such activities.[2]

This argument is suggestive but not conclusive because it assumes that sexual differences in comparative advantage are independent of the exploitation of women. Yet exploited women may have an "advantage" at unpleasant activities only because the monetary value of the disutility tends to be smaller for exploited (and poorer) persons, or because exploited persons are not allowed to participate in activities that undermine their exploitation.[3]

No definitive judgment has to be made for the analysis in this paper (and in my book on the family), because it does not depend on the *source* of the comparative advantage of women at household activities, be it discrimination or other factors. It only requires that investments in specific human capital reinforce the effects of comparative advantage. Indeed, the analysis does not even require that the initial difference in comparative advantage between men and women be large: a small initial

[2] Presumably, the advantages to slaveowners of an efficient division of labor explain why slaves have sometimes been assigned to highly skilled activities (see Finley 1980).

[3] However, Guity Nashat pointed out to me that even slaves sometimes had major military responsibilities (see, e.g., Inalcik [1970] for a discussion of the Janissaries).

difference can be transformed into large observed differences by the reinforcing effects of specialized investments.

This conclusion is highly relevant to empirical decompositions of earnings differentials between men and women. Suppose, for example, that men and women have the same basic productivity, but that discrimination reduces the earnings of women 10% below their market productivity. Given the advantage of specialization, such discrimination would induce a sexual division of labor, with most women specialized to the household and most men specialized to the market. As a result, earnings of the average woman would be considerably less than those of the average man, say only 60%. A decomposition of the 40% differential would show that sexual differences in investments in human capital explain 30 percentage points, or 75%, and that only 25% remains to be explained by discrimination. Yet in this example, the average earnings of men and women would be equal without discrimination, because there would be no sexual division of labor. More generally, discrimination and other causes of sexual differences in basic comparative advantage can be said to explain the *entire* difference in earnings between men and women, even though differences in human capital may appear to explain most of it.

This magnification of small differences in comparative advantage into large differences in earnings distinguishes differences between men and women from those between blacks and whites or other groups. A little market discrimination against blacks would not induce a large reduction in their earnings, because there is no racial division of labor between the market and household sectors. (However, even slightly greater market discrimination against black men compared with black women could be magnified into much larger reduction in the earnings of black men than black women, because black women would be induced to spend more time in the labor force than white women, and black men would spend less time than white men.) Consequently, the empirical decomposition of earnings differences into discrimination and other sources should be interpreted more cautiously for men and women than for other groups because of the division of labor between men and women.

III. The Allocation of Effort

The huge increase in the labor force participation of married women in developed countries should have encouraged much greater investment by women in market capital, which, presumably, would raise their earnings relative to men's. Yet sexual differences in earnings are very large (perhaps 40%) in the Soviet Union, where women participate almost as much as men (see Ofer and Vinokur 1981), and they have not declined much in the United States. The persistence of these large differences may be evidence of substantial market discrimination against women

(see the evidence for Great Britain in Zabalza and Tzannatos [1983]) or of a countervailing temporary depression in the earnings of women due to the entrance of many women with little market experience (see Mincer 1983; O'Neill 1985; Smith and Ward 1985).

An additional factor is the continuing responsibility of women for housework. For example, married women in the Soviet Union have responsibility for most of the child care and other housework even though they participate in the labor force almost as much as married men, and Ofer and Vinokur (1981) argue that the earnings of married Soviet women are much lower than the earnings of married men in good part because of these responsibilities. O'Neill (1983) has a similar argument regarding the lower earnings and segregated occupations of married women in the United States. Time budget studies clearly show that women have remained responsible for a large fraction of the child care and other housework even in advanced countries (see, e.g., Gronau [1976] for Israel, Stafford [1980] for the United States, and Flood [1983] for Sweden).

The earnings of women are adversely affected by household responsibilities even when they want to participate in the labor force as many hours as men, because they become tired, must stay home to tend to sick children or other emergencies, and are less able to work odd hours or take jobs requiring much travel. Although many effects of these responsibilities on the earnings and occupations of women have been frequently recognized, apparently the only systematic analysis is in my unpublished paper (Becker 1977). A model of the allocation of energy (or effort) among various household and market activities is developed there, and many implications are obtained, including some relating to differences in earnings and the allocation of time between husbands and wives.

This section further develops that model, and shows how the allocation of energy is affected by the energy intensities of different activities, and also how its allocation interacts with the allocation of time and with investments in market and nonmarket human capital. The incentive to increase one's supply of energy is shown to depend positively on market human capital and other determinants of wage rates.

Firms buy a *package* of time and effort from each employee, with payment tied to the package rather than separate payments for units of time and effort. Earnings depend on the package according to

$$I = I(t_m, E_m) \tag{16}$$

with $\partial I/\partial E_m$ and $\partial I/\partial t_m > 0$, and $I(0, t_m) = I(E_m, 0) = 0$, where E_m is effort and t_m is time. By entering E_m explicitly, I am assuming that firms can monitor the effort supplied by each employee, perhaps indirectly

(see, e.g., Mirrlees 1976; Shavell 1979). If firms were indifferent to the distribution of hours among identical workers, earnings would be proportional to hours worked for a given effort per hour:

$$I = w(e_m)t_m, \tag{17}$$

with $w' > 0$ and $w(0) = 0$, where $e_m = E_m/t_m$ is effort per hour. A simple function that incorporates these properties is

$$I = \alpha_m e_m^{\sigma_m} t_m = \alpha_m E_m^{\sigma_m} t_m^{1-\sigma_m} = \alpha_m t'_m, \tag{18}$$

with $t'_m = e_m^{\sigma_m} t_m$, and $\alpha_m = \beta_m h_m$, where h_m is market human capital, and σ_m, the effort intensity of work, is assumed to be constant and measures the elasticity of earnings with respect to effort per hour.

Clearly, an increase in hours would raise earnings when total effort (E_m) is held constant only when $\sigma_m < 1$. However, $\sigma_m < 1$ implies that equal effort (e_m) is used with each hour, because increases in effort per hour then have diminishing effects on earnings. Equation (18) implies that earnings are proportional to an "effective" quantity of time (t'_m) that depends on effort per hour as well as number of hours.

Each firm chooses σ_m and α_m to maximize its income, subject to production functions, competition from other firms, the methods used to monitor employees, and the effect of σ_m and α_m on the effort supplied by employees. An analysis of these decisions and of market equilibrium is contained in Becker (1977). Here I only indicate that the trade-off between α_m and σ_m depends on the cost to firms of monitoring effort (perhaps indirectly), and by the effect of these parameters on the effort supplied by employees.

Time and effort not supplied to firms are used in the household (or nonmarket) sector. Each household produces a set of commodities with market goods and services, time, and effort:

$$Z_i = Z_i(x_i, t_i, E_i), \qquad i = 1, \ldots, n. \tag{19}$$

If time and effort in the household sector also combine to produce "effective" time, the production function for Z_i can be written as

$$Z_i = Z_i(x_i, t'_i), \tag{20}$$

with $t'_i = w_i(e_i)t_i = \alpha_i e_i^{\sigma_i} t_i = \alpha_i E_i^{\sigma_i} t_i^{1-\sigma_i}$, with $0 < \sigma_i < 1$, and $\alpha_i = \beta_i h_i$, where h_i is human capital that raises the productivity of time spent on the ith commodity, and σ_i is the effort intensity of that commodity. The sum of the time spent on each commodity and the time spent at market activities must equal the total time available:

$$\sum_{i=1}^{n} t_i + t_m = t_h + t_m = t, \tag{21}$$

where t_h is the total time spent in the household sector.

The total energy at the disposal of a person during any period can be altered by the production of energy and by reallocation of energy over the life cycle. I first assume a fixed supply of energy that must be allocated among activities during a single period:

$$\sum_{i=1}^{n} E_i + E_m = E, \tag{22}$$

where E is the fixed available supply. This equation can be written as

$$\sum_{i=1}^{n} e_i t_i + e_m t_m = \bar{e}t = E, \tag{23}$$

where $\bar{e}$ is the energy spent per each of the available hours. Since the decision variables, e_j and t_j, enter multiplicatively rather than linearly, the allocation of time directly "interacts" with the allocation of energy.

Total expenditures on market goods and services must equal money income:

$$\sum p_i x_i = w_m(e_m)t_m + v = I + v = Y, \tag{24}$$

where Y is money income and v is income from transfer payments, property, and other sources not directly related to earnings. Money income is affected not only by the time but also by the energy allocated to the market sector. Full income (S) is achieved when all time and energy is spent at work since earnings are assumed to be independent of the time and energy spent on commodities:

$$w_m(\bar{e})t + v = S. \tag{25}$$

Full income depends on four parameters: property income (v), the wage rate function (w_m), the available time (t), and the supply of energy per unit of time ($\bar{e}$).

Each household maximizes a utility function of commodities

$$U = U(Z_1, \ldots, Z_n), \tag{26}$$

subject to the full income constraint in equation (25) and to the production functions given by equation (20). The following first-order conditions are readily derived:

$$\frac{\partial U}{\partial x_i} \equiv U_{x_i} = \tau p_{x_i}$$

$$\frac{\partial U}{\partial t_i'} w_i \equiv U_{t_i} = \mu + \varepsilon e_i$$

$$\tau w_m = \mu + \varepsilon e_m \tag{27}$$

$$\frac{\partial U}{\partial t_i'}\left[t_i \frac{dw_i}{de_i}\right] \equiv U_{e_i} = \varepsilon t_i$$

$$\tau t_m \frac{dw_m}{de_m} = \varepsilon t_m,$$

where τ, μ, and ε are the marginal utilities of income, time, and effort, respectively.

The interpretation of these conditions is straightforward. The second and third indicate that the marginal utility of an additional hour spent at any activity must equal the sum of the opportunity cost of this hour in both time (μ) and effort (εe_j). An additional hour has an effort as well as a time cost because some effort is combined with each hour. The fourth and fifth conditions simply indicate that the marginal utility of effort per hour must equal the opportunity cost of effort (εt_j).

Each household selects the combination of goods and effective time that minimizes the cost of producing commodities. Effective time can be substituted for goods by reallocating either time or effort from work to commodities. Costs of production are minimized when the marginal rate of substitution between goods and effective time equals the cost of converting either time or effort into market goods.

On substituting the third into the second condition, one obtains

$$U_{t_i} = \tau\left[w_m - \frac{\varepsilon}{\tau}(e_m - e_i)\right] = \tau\hat{w}_i, \tag{28}$$

where $\hat{w}_i$ is the shadow price or cost of an additional hour at the ith activity. Another expression for the marginal cost of time is obtained by combining the last two conditions, and using the relation between U_{t_i} and U_{t_i}:

$$U_{t_i} = \frac{\tau w_m' \cdot w_i}{w_i'} = \frac{\tau w_m(1 - \sigma_m)}{(1 - \sigma_i)} = \tau\hat{w}_i, \tag{29}$$

where $w_j' = \partial w_j/\partial e_j$.

The marginal cost of time is below the wage rate for all activities with effort intensities less than the effort intensity of work because the saving

in energy from reallocating time away from work is also valued. Equation (28) shows that the marginal cost is the difference between the wage rate and the money value of the saving in (or expenditure on) energy: ε/τ is the value of an additional unit of energy, and $e_m - e_i$ is the saving in (or expenditure on) energy.

Consequently, the marginal cost of time would be least for commodities using the least energy per hour. Moreover, the marginal cost is not the same even for persons with the same wage rate, if the money value of energy and the saving in energy differ. Note also that the cost of time *exceeds* the wage rate for highly effort-intensive activities (e.g., the care of young children).

The second and fourth optimality conditions immediately imply that

$$e_i = \frac{\mu}{\varepsilon} \frac{\sigma_i}{1 - \sigma_i} \tag{30}$$

(I am indebted to John Muellbauer for pointing this out). The optimal amount of energy allocated to an hour of any activity is proportional to the marginal cost of time in terms of energy, and also is positively related to the effort intensity of the activity. The cost of time in terms of energy is a sufficient statistic for other variables, including effort intensities of other activities, investments in human capital, property income, and the allocation of time, because they can affect the energy allocation per hour of any activity only by affecting this statistic.

A remarkably simple relation for the ratio of the optimal allocation of energy to any two activities is immediately derived from (30), or from (29) and the fourth condition in (27):

$$\frac{e_j}{e_i} = \frac{\sigma_j(1 - \sigma_i)}{\sigma_i(1 - \sigma_j)}, \tag{31}$$

for all i, j, including m. The optimal ratio of energy per hour in any two activities depends only on their effort intensities, and will be constant as long as these intensities are constant, regardless of changes in other effort intensities, the utility function, the allocation of time, and so on.

The ratio of efforts per hour in equation (31) does not depend on utility, the allocation of time, and other variables, because it is a necessary condition to produce efficiently, that is, to be on the production possibility frontier between commodities in the utility function. A change in the effort intensity of an activity might change the absolute amount of energy per hour in all activities, but would not change the ratio between the energies per hour in any two other activities. The simple relations in equations (30) and (31) are of great use in determining the effects of different parameters on the allocation of energy.

A few things can be surmised about the ordering of effort intensities in different activities. Sleep is obviously closely dependent on time but not energy; indeed, sleep is more energy producing than energy using. Listening to the radio, reading a book, and many other leisure activities also depend on the input of time but less closely on energy. By contrast, many jobs and the care of small children use much energy. Available estimates of the value of time are usually much below wage rates, one-half or less, which suggests by equation (29) that the effort intensity of work greatly exceeds the intensities of many household activities.[4]

A change in property income, human capital, the allocation of time, or other variables that do not change effort intensities would change the effort per hour in all activities by the same positive or negative proportion, equal to the percentage change in the energy value of time (see eq. [30]). This proportionality, and constant energy ratios in different activities, is a theorem following from utility maximization (and other assumptions of our model) and should not be confused with the assumption of a constant effort per hour in each activity (an assumption made, for example, by Freudenberger and Cummins [1976]).

A decrease in hours worked and an increase in "leisure," induced perhaps by a rise in property income, would save on energy and raise the energy value of time, because work is more effort-intensive than leisure.[5] Then the energy spent on each hour of work and other activities would increase by the same proportion, which would raise hourly earnings and the productivity of each hour spent on other activities. Conversely, a compensated increase in market human capital that raised hours worked would reduce the energy value of time, and hence also the energy spent on each hour of work.

The effect of increased market human capital on wage rates, a major determinant of the return to investments in market capital, is positively related to the energy spent on each hour of work. Therefore, the incentive to invest in market capital is greater when the energy per hour

[4] However, practically all estimates of the value of time refer to time spent on transportation. Beesley's estimates for commuting time (1965) rise from about 30% of hourly earnings for lower-income persons to 50% for higher-income persons; similar results were obtained by Lisco (1967) and McFadden (1974). Becker (1965) estimates the time spent in commuting at about 40 percent of hourly earnings. Gronau (1970) concludes that business time during air travel is valued at about the hourly earnings of business travelers, while personal air travel time is apparently considered free.

[5] By equation (23), $e_m t_m + e_h t_h = E$, where $e_h = E_h/t_h$. If $e_h = \gamma e_m$, where $\gamma < 1$ because $\sigma_m > \sigma_h$, then

$$\frac{\partial e_m}{\partial t_m} = \frac{-e_m(1-\gamma)}{\gamma t + t_m(1-\gamma)} < 0.$$

as well as number of hours of work (see Sec. II) is greater,[6] since costs of investing in human capital are only partly dependent on wage rates. The same conclusion applies to investments in capital specific to any other activity.

Earnings in some jobs are highly responsive to changes in the input of energy, while earnings in others are more responsive to changes in the amount of time. That is, some have larger effort intensities, and others have larger time intensities. Persons devoting much time to effort-intensive household activities like child care would economize on their use of energy by seeking jobs that are not effort intensive, and conversely for persons who devote most of their household time to leisure and other time-intensive activities.

The stock of energy varies enormously from person to person, not only in dimensions like mental and physical energy,[7] but also in "ambition" and motivation. Although equation (30) implies that an increase in the stock of energy, and hence in the energy value of time, increases the energy per hour by the same percentage in all activities, the productivity of working time would increase by a larger percentage if work is more effort intensive than the typical household activity. Then persons with greater stocks of energy would excel at work not only

[6] These variables have opposite effects when hours of work change if work is more effort intensive than the competing household activities. Since

$$MP = \frac{\partial I}{\partial h_{mi}} = w_{mi} t_{mi},$$

then

$$\frac{\partial MP}{\partial t_{mi}} = (1 + n_{mi}\sigma_{mi})w_{mi},$$

where

$$n_{mi} = \frac{\partial e_{mi}}{\partial t_{mi}} \frac{t_{mi}}{e_{mi}}.$$

Given that $0 < \sigma_{mi} < 1$, and that $-1 \leq n_{mi} \leq 1$, then $0 < \partial MP/\partial t_{mi}$ and $(\partial MP/\partial t_{mi}) \gtreqless w_{mi}$ as $n_{mi} \gtreqless 0$. A change in hours worked always changes the marginal product of human capital in the same direction (as argued in Sec. II), but the effect can be substantially attenuated if n_{mi} is quite negative, because work is *much* more effort intensive than the competing household activities, and conversely, if n_{mi} is positive, because work is less effort intensive than these activities.

[7] The inequality in energy is dramatically conveyed in the following preface to a biography of Gladstone: "Lord Kilbracken, who was once his principal private secretary, said that if a figure of 100 could represent the energy of an ordinary man, and 200 that of an exceptional man, Gladstone's energy would represent a figure of at least 1,000" (see Magnus 1954, p. xi). I owe this reference to George Stigler.

because their wage rates would be above average, but also because the productivity of their working time would be especially high.

If the (full) income effect of greater energy is weak,[8] persons with greater energy also tend to work longer hours and at more effort-intensive jobs because their time is relatively more productive at work than at household activities. Consequently, more energetic persons would both work longer hours and earn more per hour.

Since the elasticity of output with respect to energy per hour is less than unity ($\sigma_m < 1$), a given increase in the stock of energy would raise output by a smaller percentage if hours worked were unchanged. However, the induced increase in hours would raise output by more than the increase in the stock of energy. Several experimental studies do find that an increase in the consumption of calories by workers doing physically demanding work, where calories are an important source of "energy," apparently raises their output by a larger percent (see UN Food and Agriculture Organization 1962, pp. 14–15, 23–25).

Since a person's health affects his energy, ill health reduces hourly earnings (see the evidence in Grossman [1976]), because a lower energy level reduces the energy spent on each working (and household) hour. Ill health also reduces hours worked because work is relatively effort intensive; that is, sick time is spent at home rather than at work because rest and similar leisure activities use less energy than work. Therefore, more energetic persons can be said to work longer hours and earn more per hour partly because they are "healthier."

The energy available to a person changes not only because of illness and other exogenous forces, but also because of the expenditure of time, goods, and effort on exercise, sleep, physical check-ups, relaxation, proper diet, and other energy-producing activities. At the optimal rate of production, the cost of additional inputs equals the money value of additional energy:

[8] The sign of the income effect is ambiguous even when leisure is a superior good. The elasticity of working hours with respect to an increase in the stock of energy equals

$$\frac{\partial t_m}{\partial E}\frac{E}{t_m} = \eta_{t_{mE}} = R[x\delta_c(\sigma_m - \sigma_b) - \sigma_m(x - v)N_t + x\sigma_b N_x],$$

where t_b and x are the total time and goods used in the household ($p_x = 1$), N_t and N_x are the *full* income elasticities of t_b' and x respectively, δ_c is the elasticity of substitution between x and t_b' in the utility function, and R is positive. The substitution effect is essentially given by $x\delta_c(\sigma_m - \sigma_b) > 0$ if $\sigma_m > \sigma_b$. The income effect is given by $x\sigma_b N_x - \sigma_m(x - v)N_t \gtreqless 0$. It is greater than zero if $(\sigma_b/\sigma_m) > k_e(N_t/N_x)$, where k_e is the share of earnings in money income. This footnote is based on notes by H. Gregg Lewis.

$$w'_m = \beta_m \sigma_m e_m^{\sigma_m - 1} h_m = \frac{\varepsilon}{\tau} = w'_m t_s \frac{de_s}{dE} + p_s \frac{dx_s}{dE} + w_m \frac{(1 - \sigma_m)}{1 - \sigma_s} \frac{dt_s}{dE}, \quad (32)$$

where e_s, x_s, and t_s are inputs into the production of energy.[9] The term on the right is the cost of inputs used to produce an additional unit of energy; the money value of an additional unit equals the effect on hourly earnings of an increase in energy per hour (see the last condition in [27]).

An increase in the marginal wage rate increases the optimal production of energy because marginal benefits increase relative to marginal costs. An increase in market human capital and a decrease in energy per hour of work (perhaps resulting from an increased number of working hours) both encourage the production of energy by raising benefits relative to cost of production; indeed, costs could decline when energy per hour decreased because the value of time would decrease. Increased production of energy would also improve health, given the positive relation between health and energy.

Many have argued that long hours of work substantially reduce productivity because of "fatigue."[10] This argument is questionable for differences among persons because more energetic persons work longer. Moreover, even if longer working hours by any given person directly reduce his energy (and productivity) per hour of work, longer hours also encourage his production of energy and of market human capital. Since more energy and market capital raise the productivity of each working hour, longer hours could even indirectly *raise* his productivity per hour.

The incentive to invest in energy varies over the life cycle as the stock of market human capital and other determinants of the value of energy vary. Therefore, hourly earnings rise at younger ages probably partly because of increased production of energy, and conversely for declines in earnings at older ages. The stock of energy at a particular age might also be augmentable by "borrowing" from other ages, perhaps with substantial penalty or interest. In extreme forms, borrowing and repayment of energy produce "overwork" and "burn-out."[11]

[9] I assume that inputs are devoted exclusively to the production of energy, but the analysis is readily extended to "joint production," where, say, a good diet produces both energy and commodities.

[10] In his classic study of the sources of economic growth in the United States, Denison (1962) assumed that each hour of work beyond 43 hours per week reduces productivity by at least 30%.

[11] Bertrand Russell claims that he worked so hard on *Principia Mathematica* that "my intellect never quite recovered from the strain" (1967, p. 230).

IV. Division of Labor in the Allocation of Effort between Husbands and Wives

Since more energetic persons have a comparative advantage at effort-intensive activities, efficient marriage markets match more energetic with less energetic persons (i.e., negative sorting by energy). A larger fraction of the time of energetic spouses would be allocated to effort-intensive activities like work where they have a comparative advantage, and a larger fraction of the time of sluggish spouses would be allocated to the household activities where they have a comparative advantage.

The evidence is much too scanty to argue that a division of labor by energy level helps explain the division of labor between married men and women. Therefore, I assume that women have responsibility for child care and other housework for reasons unrelated to their energy or to the effort intensity of housework. Nevertheless, differences in effort intensities have important implications for sexual differences in earnings, hours worked, and occupations.

To demonstrate this, I follow the brief discussion in the previous section suggesting that housework activities like child care are much more effort intensive than leisure-oriented activities and may be more or less effort intensive than market activities. Married women with primary responsibility for child care and other housework allocate less energy to each hour of work than married men who spend equal time in the labor force. A simple proof uses the assumption that housework is more effort intensive than leisure, and the implication of equation (31) that the ratio of the energy spent on each hour of any two activities depends only on the effort intensities of these activities.[12]

Since married women earn less per hour than married men when they spend less energy on each hour of work, the household responsibilities of married women reduce their hourly earnings below those of married men even when both participate the same number of hours and have the same market capital. These household responsibilities also induce occupational segregation because married women seek occupations and jobs that are less effort intensive and otherwise are more compatible with the demands of their home responsibilities. The same argument explains why students who attend class and do homework have lower hourly earnings than persons not in school when both work the same

[12] By equation (31), $e_c = \gamma_1 e_m$ and $e_\ell = \gamma_2 e_m$, where $\gamma_1 > \gamma_2$ because $\sigma_c > \sigma_\ell$, where c refers to housework and ℓ to leisure. Since $e_m t_m + e_c t_c + e_\ell t_\ell = E$, then $e_m(t_m + \gamma_1 t_c + \gamma_2 t_\ell) = E$, and

$$\left.\frac{de_m}{dt_c}\right|_{dt_m=0} = \frac{-e_m(\gamma_1 - \gamma_2)}{t_m + \gamma_1 t_c + \gamma_2 t_\ell} < 0.$$

number of hours and appear to have similar characteristics (see the evidence and discussion in Lazear [1977]).

Therefore, the traditional concentration on the labor force participation of women gives a misleading, perhaps a highly misleading, impression of the forces reducing the earnings and segregating the employment of married women. Nor is this all. Married women would invest less in market human capital than married men even when both spend the same amount of time in the labor force. Since the benefit from investment in market human capital is positively related to hourly earnings and hence to the energy spent on each hour of market work (see the previous section), the benefit is greater to married men even when they do not work longer hours than married women.

The lower earnings of married women due both to their lower energy spent on work and their lower investment in market human capital discourages their labor force participation relative to that of their husbands. Of course, their lower participation further discourages their investment in market capital (but see n. 6), and could even lower their energy spent on each hour of work if they substitute toward housework that is more effort-intensive than their market activities. A full equilibrium could involve complete specialization by wives in housework and other nonmarket activities.

Table 1 (brought to my attention by June O'Neill) shows that even married women employed full-time in the United States work much

Table 1
Time Use of Married Men and Married Women in the United States by Hours per Week at Home and at Market Work, 1975–76

	Married Women			Married Men	
Type of Activity	Employed Full Time	Employed Part Time	All*	Employed Full Time	All†
Market work:	38.6	20.9	16.3	47.9	39.2
At job‡	35.7	18.9	15.0	44.0	36.0
Travel to/from job	2.9	2.0	1.3	3.9	3.2
Work at home:	24.6	33.5	34.9	12.1	12.8
Indoor housework	14.6	21.0	20.8	2.8	3.5
Child care	2.8	3.2	4.9	1.7	1.5
Repairs, outside work, gardening	1.6	1.7	2.2	3.8	3.9
Shopping, services	5.6	7.6	7.0	3.8	3.9
Leisure	21.0	25.5	26.7	23.0	27.1
Total work time	63.2	54.4	51.2	60.0	52.0
Sample size	101	51	220	236	307

SOURCE.—Hill (1981), based on data from a national sample of U.S. households collected by the Survey Research Center of the University of Michigan.

* Includes married women with no market work.

† Includes married men with part-time work and no market work.

‡ Includes lunch and coffee breaks.

more at home than do unemployed or part-time employed married men, let alone full-time employed married men. Moreover, married women employed full-time work many fewer hours (about 9 hours per week) in the market than do married men employed full-time, although total hours worked are a little higher for these women. There is considerable other evidence that the occupations and earnings of women are also affected by their demand for part-time employment and flexible hours (see Mincer and Polachek 1974, table 7; O'Neill 1983).

This analysis implies that the hourly earnings of single women exceed those of married women even when both work the same number of hours and have the same market capital because child care and other household responsibilities induce married women to seek more convenient and less energy-intensive jobs. The analysis also can explain why marriage appears to raise the health of men substantially and women's health only moderately (see Fuchs 1975). Since married men accumulate more market human capital and work longer hours than single men (see Kenny 1983), married men produce larger stocks of energy than single men, which improves their health. The effect of marriage on the energy of women is more ambiguous: the value of energy to women not working in the market is measured by the value of additional energy in the household, which can be sizable. However, the value of energy to working women is measured by its value at work, which has been below the value to men because women have invested less in market human capital and have chosen less energy-intensive work.

The large growth in the labor force participation of married women during the last 30 years has been accompanied by a steep fall in fertility and a sharp rise in divorce rates. The fall in fertility clearly raises the hourly earnings of married women because they have more energy and more flexible time to devote to market work instead of child care. The time spent in housework by married women in the United States apparently did decline significantly after 1965 (see Stafford 1980).

The effect of the growth in divorce on the hourly earnings of women is more ambiguous. On the one hand, married women invest more in market human capital when they anticipate working because they are likely to become divorced. On the other hand, since divorced women in the United States and other Western countries almost always retain custody of their children, the demands of child care on their energy and attention might exceed those of married women, for they have no husbands to share any of the housework.[13]

[13] Dustin Hoffman lost his job in *Kramer vs. Kramer* after he became responsible for the care of his child.

V. Summary and Concluding Remarks

This paper argues that increasing returns from specialized human capital is a powerful force creating a division of labor in the allocation of time and investments in human capital even among basically identical persons. However, increasing returns alone do not imply the traditional sexual division of labor, with women having primary responsibility for many household activities, unless men and women tend to differ in their comparative advantages between household and market activities. Whatever the reason for the traditional division—perhaps discrimination against women or high fertility—housework responsibilities lower the earnings and affect the jobs of married women by reducing their time in the labor force and discouraging their investment in market human capital.

This paper also develops a model of an individual's allocation of energy among different activities. More energy is spent on each hour of more energy-intensive activities, and the ratio of the energy per hour in any two activities depends only on their effort intensities and not at all on the stock of energy, utility function, money income, allocation of time, or human capital. Other implications are derived about the cost of time to different activities, the effect of hours worked on hourly earnings, the effect of earnings on investment in health, and the effect of an increase in the energy spent on each hour of work on the benefits from investment in market human capital.

Since housework is more effort intensive than leisure and other household activities, married women spend less energy on each hour of market work than married men working the same number of hours. As a result, married women have lower hourly earnings than married men with the same market human capital, and they economize on the energy expended on market work by seeking less demanding jobs. Moreover, their lower hourly earnings reduce their investment in market capital even when they work the same number of hours as married men.

Therefore, the responsibility of married women for child care and other housework has major implications for earnings and occupational differences between men and women even aside from the effect on the labor force participation of married women. I submit that this is an important reason why the earnings of married women are typically considerably below those of married men, and why substantial occupational segregation persists, even in countries like the Soviet Union where labor force participation rates of married men and women are not very different.

The persistence of these responsibilities in all advanced societies may only be a legacy of powerful forces from the past and may disappear or

be greatly attenuated in the near future. Not only casual impressions, but also evidence from time-budgets indicate that the *relative* contribution of married men to housework in the United States has significantly increased during the last decade (Stafford 1980; personal communication from Stafford about a 1981 survey). The frequency of partial or complete custody of children by divorced fathers has also increased. A continuation of these trends would increase the energy and time spent at market activities by women, which would raise their earnings and incentive to invest in market human capital. The result could be a sizable increase in the relative earnings of married women and a sizable decline in their occupational segregation during the remainder of this century.

Even if the process continued until married women no longer had primary responsibility for child care and other housework, married households would still greatly gain from a division of labor in the allocation of time and investments if specialized household and market human capital remained important, or if spouses differed in energy. This division of labor, however, would no longer be linked to sex: husbands would be more specialized to housework and wives to market activities in about half the marriages, and the reverse would occur in the other half.

Such a development would have major consequences for marriage, fertility, divorce, and many other aspects of family life. Yet the effect on the inequality in either individual or family earnings would be more modest since all persons specialized to housework would still earn less than their spouses, and the distribution of family earnings would still be determined by the division of labor between spouses, by the sorting of spouses by education and other characteristics, by divorce rates and the custody of children, and so forth.

However, a person's sex would then no longer be a good predictor of earnings and household activities. It is still too early to tell how far Western societies will move in this direction.

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