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A MODEL OF RESIDENTIAL LOCATION CHOICE AND COMMUTING BY MEN AND WOMEN WORKERS

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It has often been noted in the empirical literature that working women—both married and single—make shorter commuting journeys than working men.[1] Various explanations, mostly sociological rather than economic, have been presented to explain this difference. Kain [5], for example, suggests that working women often are secondary wage earners who take a "more casual attitude toward job seeking than that of the primary wage earner." Women therefore select places of employment which are close to their residences. This turns around the usual direction of causation in urban economic theory, which often assumes that workers have fixed employment locations but that they vary their places of residence. Thus workers trade off higher commuting costs against lower housing prices at locations more distant from their jobs.

Another explanation of women's shorter commuting trips relates to their home responsibilities. Women who work must also keep house, cook dinner, and perhaps be at home when their children arrive from school. Thus women are thought to place a higher value than men on time spent commuting, and they choose either their jobs or their residences so as to shorten the journey.

This paper is an attempt to present an economic theory explaining why women commute less. I restrict the scope of investigation to married women who work, or to households in which there are two wage earners. I assume that the household acts according to the rules of economic rationality with respect to both jobs, rather than with respect to just the husband's job. The theory suggests that in a city of mixed two-worker and one-worker households, the two-worker households choose their residential locations so that the wife's commuting journey is shorter than the husband's. The wife's journey is also shorter than that made by workers in single-job households.

Section 1 of the paper considers the general predictions of economic theory with respect to men's versus women's commuting distances. Section 2 develops a household utility model of married women's labor supply in an urban context. It also considers some discrepancies between the theoretical predictions and empirical evidence concerning the value of time spent commuting. Section 3 develops an urban model composed of both one- and two-worker households and considers its implications for men's and women's commuting distances.

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[1] The Appendix presents data which support this assertion.

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1. THE ECONOMICS OF COMMUTING

Standard economic theory yields ambiguous predictions when applied to the question of commuting distances for men versus women workers. The cost of commuting is normally divided into two separate elements: the actual monetary outlay for the trip and the value of time. The monetary outlay is the fare if the trip is by bus or subway or the outlay for gasoline and depreciation if the trip is by car. The value of time spent commuting is generally assumed to be related to the commuter's wage. Thus since women workers usually earn lower wages than men, the theory predicts that they should value their commuting time at a lower rate than men. They should therefore be willing to undertake longer commuting trips. On the other hand, the monetary costs of commuting have an opposite effect. Women workers' total earnings are generally lower than men's. Thus the monetary cost of commuting a given distance takes up a larger fraction of women workers' incomes. This should cause women to commute shorter distances. Reasoning of a similar sort is often used to explain the fact that poor people tend to live closer to their jobs than those with higher incomes.

Thus the influence of commuting costs on the length of women versus men workers' commuting journeys is ambiguous and could go either way. It is possible however to draw some testable hypotheses from the theory. For example, we would expect women workers to make shorter commuting journeys than men by car, since each extra mile requires extra monetary outlay on gasoline and depreciation. However, we would expect women workers to make longer commuting journeys by public transportation, if a flat fare is charged regardless of distance. Then the marginal monetary outlay of travelling an extra mile is zero. This should induce women to travel further than men since their time costs are lower.

2. A HOUSEHOLD LABOR SUPPLY MODEL

Suppose in a metropolitan area employment is offered at two locations: in the central business district and at a suburban ring located u' miles from the center. The central firms might be office headquarters and service activities, while the suburban firms could be manufacturing plants or retailing firms. For purposes of the model I assume that married women work only at the suburban firms, while men, married or not, work at the CBD. This assumption is made since data presented in the Appendix suggest that married women workers are in fact more likely to work in the suburbs than either men or single women workers. However, the model could also be used to predict relative commuting distances when job location assumptions are reversed.

Two worker families are assumed to have household utility functions defined over housing, H, a composite good, X, the husband's leisure time, L_M, and the wife's leisure time, L_W. Their utility function is

$$U = H^a X^b L_M{}^c L_W{}^d \tag{1}$$

The household maximizes utility subject to budget and time constraints. The budget constraint is

$$P_H(u)H + X + fu' = E_W r_W + E_M r_M \tag{2}$$

where $P_H(u)$ is the price of housing as a function of distance from the city center and the price of other goods is unity. Assuming for the moment that the household lives between its two jobs, fu' is the constant total monetary outlay on commuting, where u' is the distance between the husband's and the wife's jobs and f is the monetary outlay on commuting per two miles (one mile in each direction). E_M and E_W are the husband's and wife's working hours and r_W and r_M are their hourly wages.

The time constraints are

$$L_M + E_M + u/s = k \tag{3}$$

and

$$L_W + E_W + (u' - u)/s = k \tag{4}$$

Here (3) is the husband's time constraint, where u is the husband's commuting distance and s is the speed of commuting. Hours devoted to leisure plus work plus commuting must add up to some constant number of hours, k. Equation (4) for the wife is analogous, where her commuting distance is $(u' - u)$.

Equations (2) through (4) reflect the assumption that the household lives between its two jobs. However, given a low price of suburban housing, the household might choose to live beyond the wife's job at some $u > u'$. In that case Equations (2) and (4) become

$$P_H H + X + f(2u - u') = E_W r_W + E_M r_M \tag{5}$$

and

$$L_W + E_W + (u - u')/s = \kappa \tag{6}$$

Equation (3) remains unchanged.

Substituting (3) and (4) into (2), we get the full income constraint

$$\begin{aligned} k(r_M + r_W) = P_H H + X + fu' + r_M L_M \\ + r_W L_W + r_M\left(\frac{u}{s}\right) + r_W \frac{(u' - u)}{s} \end{aligned} \tag{7}$$

Forming a Lagrangean expression, we maximize the utility function (1) subject to (7). The wife's marginal rate of substitution between leisure and goods, $MRS_{L_W,X}$ is

$$\frac{dX}{bL_W} = r_W \tag{8}$$

Substituting (2) and (4) into (8), we can derive an expression for the number of hours worked by the wife

$$E_W = \left(\frac{b}{d+b}\right)\left(k - \frac{(u' - u)}{s}\right) - \left(\frac{d}{d+b}\right)\left(\frac{E_M r_M - P_H H - fu'}{r_W}\right) \tag{9}$$

In (9) the wife's hours of work are negatively related to the husband's wage rate $(\partial E_W/\partial r_M < 0)$ and the husband's working hours $(\partial E_W/\partial E_M < 0)$ and positively related to the wife's own wage rate $(\partial E_W/\partial r_W > 0)$. The latter is composed of a positive substitution effect and a negative income effect, where in this formulation the substitution effect is larger in magnitude.[2] Also as the valuation placed on the wife's leisure relative to goods or to the husband's leisure increases, the wife's working hours fall ($\partial E_W/\partial d < 0$).

From an urban viewpoint, it is interesting to note the spatial properties of the hours of work equation. The wife's supply of labor increases with the speed of commuting ($\partial E_W/\partial s > 0$), since the time cost of working declines. However her labor supply decreases if the monetary cost of commuting falls ($\partial E_W/\partial f > 0$), since the income effect of a decline in commuting cost on labor supply is negative. Finally, an increase in the wife's commuting distance ($u' - u$) has an indeterminate effect on her working hours. From (9)

$$(10) \qquad \frac{\partial E_W}{\partial u} = \frac{1}{d+b}\left[\frac{d}{r_W} H \frac{\partial P_H}{\partial u} + \frac{b}{s}\right]$$

An increase in the wife's commuting distance implies that the household moves closer to the center of the city and u declines. The first term in (10) is negative since $\partial P_H/\partial u$ is negative, while the second term is positive. As u declines, the increase in the wife's commuting time decreases her working hours, but the negative income effect of an increase in the price of housing causes her to work more.

It is interesting to note the difference in the effect of commuting on the husband's versus the wife's hours of work. By a procedure similar to the one above, an hours of work equation for the husband can be derived. Differentiating it with respect to u, we get

$$(11) \qquad \frac{\partial E_M}{\partial u} = \left(\frac{1}{r+b}\right)\left[\frac{c}{r_M} H \frac{\partial P_H}{\partial u} - \frac{b}{s}\right] < 0$$

For the husband, an increase in commuting distance unambiguously reduces his working hours and vice-versa. Thus as the household moves closer to the center, the husband tends to work longer hours but the change in total working hours is indeterminate. As it moves further away, the husband works less but the change in total working hours is again indeterminate.

Finally the model has interesting labor market implications. The utility maximization model assumes that workers can vary their supply of labor continuously. Given full variability, the marginal value of time spent working, commuting or in leisure all ought to be equal to the wage rate. The wife's marginal rate of substitution between leisure and income, for example, should be equal to her wage rate, r_W, and the husband's to his wage rate, r_M. In fact these conditions would hold literally only if there were no taxes on income. Friedman [4] has suggested that given exemptions, subsidies and deductions, the progressive American tax system has effects similar to a proportionate tax at the rate of 20 percent. This suggests

[2] This can be seen by expressing the wife's labor supply as a function of family income, $Y_F = E_W r_W + E_M r_M$, and her own wage rate, or

$$E_W = \left[k - \frac{(u'-u)}{s}\right] - \frac{d}{b}\left[\frac{Y_F(r_W) - P_H H - fu'}{r_W}\right]$$

Here an increase in the wife's wage rate increases working hours directly, holding family income constant, but decreases working hours indirectly by raising family income.

that the marginal rates of substitution between leisure and income ought to equal 80 percent of the relevant wage rate. That is, the tax on income should cause people to reduce their working hours to the point where nonwork activities are valued at the after-tax wage rate.

However empirical studies suggest the contrary: commuters at least do not consistently value their time spent commuting at their after-tax wage. Beesley's study [1] of London commuters shows that low wage clerical workers value their time commuting at about 31 percent of their wage rate, higher wage clerical workers at about 37 percent of their wage and professionals at 42 percent of their wage. Another study of Leeds commuters by Quarmby [6] suggests that time is valued at 20 to 30 percent of the relevant wage rate.

These results are perplexing on two counts. First, the average value of the figures seems low even for workers in Britain, where taxes are somewhat higher than in the U.S. Second, with a progressive rather than a proportionate tax system, high income workers should value their time at a smaller fraction of their wage rate than low income workers, the reverse of Beesley's result.[3]

What could explain the discrepancy? The obvious theoretical implication is that workers are not in equilibrium with respect to hours of work. Since they value commuting time at the margin at less than their wage, they must not be working enough. This suggests that the usual pattern of a fixed work week, normally 35 to 40 hours, leaves workers with too little income and too much nonwork time.

The results cited above also contradict the popular explanation for shorter commuting journeys by married women: that their time spent commuting is valuable because of their home responsibilities. In the context of the fixed work week, this would suggest that married women work too much rather than too little. For example, they might work full time due to a lack of available part-time jobs. However if this were so, married women should value their commuting time at a rate higher than their wage. But no empirical evidence has ever suggested that any group of workers values commuting time this highly.[4]

3. AN URBAN MODEL OF ONE- AND TWO-WORKER HOUSEHOLDS

In this section an urban model is developed in which two-worker households determine how much they are willing to pay for housing at each distance from the city center. They do so purely by a process of joint utility maximization; no extra-economic motivations are introduced.

Assume that two-worker and one-worker households are mixed in the metropolitan area. Two-worker households are willing to pay different amounts for

[3] A study by DeVany [3] of the value of air travellers' time suggests that they value their time on average at their wage rate. This seems logical since air travellers are mostly travelling on business on company time. DeVany's study suggests that while businesses value the time of their employees in a rational way, employees may not value their own time as rationally. Another perplexing result is obtained by Watson [7], who suggests that for inter-city social-recreational trips, people value their time at 68 percent of their wage, a higher figure than found by any of the studies of the value of commuting time.

[4] Beesley gives no data on the sex or marital status of his sample of commuters. It is possible that his sample contained few married women and that his results would have shown higher valuation of time if it had included married women.

housing at various distances from the center than are single-worker households. All households are assumed to be renters. Landowners live outside the city. Since owners of land attempt to maximize their return, they sell or rent housing to the household offering the highest bid. Two-worker households must therefore outbid single-worker households to obtain housing. They maximize utility by locating at the point where the difference between their willingness to pay for housing at a given utility level and the amount offered by single-worker households is maximized.

Housing price offer curves must be separately determined for one-worker and two-worker households. Turning to one-worker households first, assume that their utility function has the same form as that of two-worker households, Equation (2), although parameter values may differ. Their income and time constraints are

$$P_H H_1 + X_1 + fu = r_{M1} E_{M1} \tag{12}$$

$$L_{W1} = k \tag{13}$$

and

$$L_{M1} + E_{M1} + \frac{u}{s} = k \tag{14}$$

where the subscript 1 refers to single-worker households. The first order condition with respect to u, solved for $\partial P_H/\partial u$, is the slope of single-worker households' bid function for housing or

$$\left(\frac{\partial P_H}{\partial u}\right)_S = -\frac{r_{M1}/s + f}{H_1(u)}. \tag{15}$$

Here r_{M1}/s is the value of time spent in extra commuting and f is the marginal monetary outlay on commuting.

Two-worker households' bid function for housing is derived by maximizing (1) with respect to distance, subject to (7). This yields

$$\left(\frac{\partial P_H}{\partial u}\right)_T = \frac{(r_{W2} - r_{M2})/s}{H_2(u)} \tag{16}$$

where the subscript 2 refers to two-worker households. In (16), r_{W2}/s and r_{M2}/s are the values of the wife's and the husband's extra time spent commuting as they move one mile further out. The two terms have opposite signs, since an increase in u moves the household closer to the wife's job but further from the husband's.

Equation (16) holds only if the household locates between its two job locations, $u = 0$ and u'. Beyond u', the household's bid function is derived by maximizing (2) subject to (3), (5) and (6), or

$$\left(\frac{\partial P_H}{\partial u}\right)_{T'} = -\left[\frac{(r_{M2} + r_{W2})/s + 2f}{H_2(u)}\right] \tag{17}$$

In (17) the time cost of commuting terms are negative for both husband and wife and an additional monetary outlay equal to $2f$ is incurred for each extra mile the household moves outward.

Equations (15) and (17) cannot be solved directly for $P_H(u)$. However, (16) can be solved by substituting the expressions $r_{M2} = c_2 P_H H_2/a_2 L_{M2}$ and r_{W2}

$= d_2P_HH_2/a_2L_{W2}$, to get

$$\frac{\partial P_H/\partial u}{P_H} = \frac{1}{s}\left[\frac{d_2}{a_2L_{W2}} - \frac{c_2}{a_2L_{M2}}\right] \tag{18}$$

where c_2, d_2 and a_2 are parameters of the two-worker household utility function. If we assume that working hours for the husband and wife are constant, (18) can be solved by substituting the time constraints (3) and (4) and integrating to get

$$P_H(u)_T = P_0[k - E_{W2} - (u' - u)/s]^{d_2/a_2}\left[k - E_{M2} - \frac{u}{s}\right]^{c_2/a_2} \tag{19}$$

where P_0 is a constant of integration.

Equation (19) has a different shape from conventional housing price offer curves. Its slope, rather than having the usual negative sign, is ambiguous. Taking the derivative of (19) and solving, the condition for a negative slope is

$$\frac{d_2}{c_2} < \frac{L_{W2}}{L_{M2}} \tag{20}$$

The housing price offer curve tends to become negatively sloped as the wife's leisure hours increase relative to the husband's and as the husband's leisure time contributes more heavily to household utility. In these cases the household is willing to pay more for accessibility to the husband's job than to the wife's. If the inequality is reversed, the bid function has a positive slope and accessibility to the wife's job is valued more highly.

The curvature of (19) depends on the household's valuation of space relative to its valuation of time.[5] It has the usual shape if $\partial^2P_H/\partial u^2 > 0$ or

$$2d_2c_2 < d_2(d_2 - a_2)(L_{M2}/L_{W2}) + c_2(c_2 - a_2)(L_{W2}/L_{M2}) \tag{21}$$

For (21) to be true, either $(d_2 - a_2)$ or $(c_2 - a_2)$ must be positive. This requires that either the husband's or the wife's leisure time must contribute more to household utility than does housing. If on the contrary housing contributes more to utility than leisure, then the offer curve will be concave.

Possible shapes for two-worker household offer curves for housing are shown in Figure 1. In curves A and B, $P_H'(u)$ is negative and $P_H''(u)$ is positive and negative respectively. In curves C and D, $P_H'(u)$ is positive and $P_H''(u)$ is positive and negative respectively. Accessibility to the husband's job is more highly valued under curves A and B. But in A, time preference is more important than space preference and in B the opposite holds. Accessibility to the wife's job is more highly valued under curves C and D. But in C, time preference is relatively more important than space preference and in D the opposite holds.[6]

We now wish to compare the single-worker and two-worker households' offer

[5] Beckmann [1] first presented and analyzed a bid rent function of this type where time and space preference are both included.

[6] It is a curiosity of the Cobb-Douglas utility function that a horizontal $P_H(u)$ function is not possible as a special case. This is due to the fact that the marginal utility of extra leisure for either worker must be constant to get a flat $P_H(u)$ function, an impossibility in a Cobb-Douglas form.

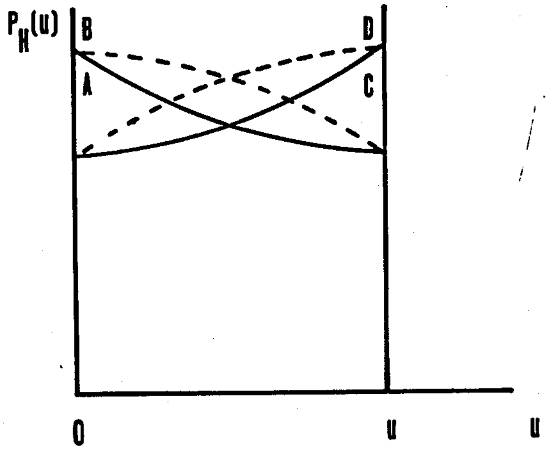

FIGURE 1: Possible Two-Worker Household Offer Curves for Housing.

curves for housing. From Equations (15) to (17) we know the slopes of their offer curves, although not the intercepts. A set of possible shapes is shown in Figure 2. The single-worker households' offer curve, SS, has a continuously decreasing slope. The two-worker households' offer curve (shown in one of four possible shapes as TT) can have a positive or negative slope from $u = 0$ to u', but must have a negative slope past u'. TT must be continuous, since a discontinuity would violate the equal utility property prevailing at all points along the function. We also know that SS has a steeper slope than TT in the region from $u = 0$ to u' and that TT is steeper in the region past u'. I show below that under reasonable conditions, these slope conditions accurately depict the single- and two-worker households' offer curves for housing.

Finally, the intercepts of both SS and TT are unknown. In Figure 2, single-worker households are shown outbidding two-worker households for housing at all locations. This is an unlikely outcome since it implies that two-worker households do not locate at all in the metropolitan area where their jobs are. Two-worker households can bid successfully for housing by buying less leisure and other goods, thus lowering their utility level. Suppose they do so. Since (16) and (17) must still hold, TT rises parallel to itself, changing only its intercept, not its slope. As TT rises, it intersects SS first at u' and then in a region around u'. Thus two-worker households outbid single-worker households for housing sites near the suburban employment center. They maximize utility by locating near their suburban rather than their central area jobs.

The same outcome would hold if the situation in Figure 2 were reversed and two-worker households outbid single-worker households for housing everywhere in the city. In this case two-worker households would have higher incomes and utility levels. However they need only just outbid single-worker households to obtain housing. This requires a bid of $SS + \epsilon$ at some u, a lower amount than TT. The difference between TT and $SS + \epsilon$ represents a consumer surplus gain for

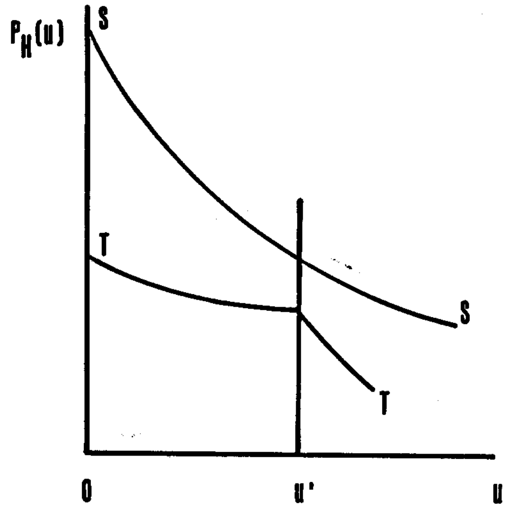

FIGURE 2: Single- and Two-Worker Household Offer Curves for Housing.

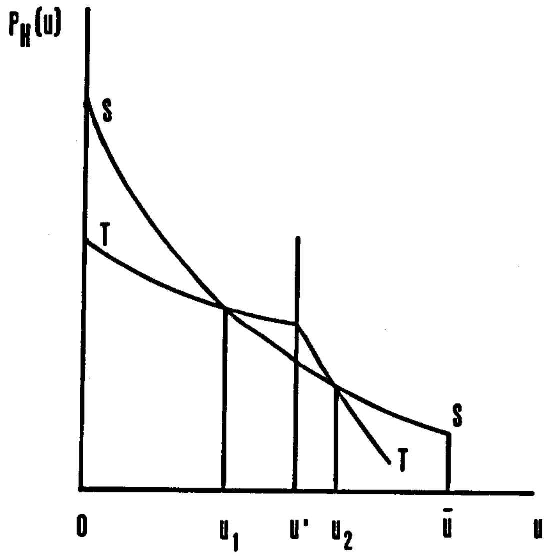

FIGURE 3: Housing Market Equilibrium.

two-worker households; a sum they are willing to pay for housing but do not actually have to pay. Clearly this difference is greatest at u'. Therefore two-worker households bid for land around u' by raising their offer level just sufficiently to bid away a sector around u' large enough to house all two-worker households.

Thus regardless of the initial positions of the offer curves, the same locational outcome prevails. At equilibrium, two-worker households outbid single-worker households in a region around u'. This is shown in Figure 3, where single-worker households occupy the central area from $u = 0$ to u_1, two-worker households occupy a ring around u' from u_1 to u_2 and single-worker households occupy the outer suburbs from u_2 to the edge of the city. Here, since all men are assumed to work at the center and all women at u', women workers on average must have shorter commuting trips than men.

We have thus constructed a model in which purely economically rational behavior by households leads to an outcome in which women workers commute shorter distances than men workers. It remains, however, to show that the slope conditions depicted in Figure 2 are valid. From Equations (15) through (17), the condition under which SS is steeper than TT in the $u = 0$ to u' region is

$$\frac{r_{M2} - r_{W2}}{r_{M1} + sf} < \frac{H_2(u)}{H_1(u)} \tag{22}$$

The condition under which TT is steeper than SS in the region past u' is

$$\frac{r_{M2} + r_{W2} + 2sf}{r_{M1} + sf} > \frac{H_2(u)}{H_1(u)} \tag{23}$$

where sf is the monetary outlay on commuting per hour.

Equation (22) holds under a variety of circumstances. Assuming that housing consumption by two-worker households is at least as great as that of one-worker households, (22) is true whenever the wage rate of workers in single-worker households is as great as the differential between married men's and women's wages. Alternatively, (22) holds if wives' wage rates are equal to or exceed husbands' in two-worker households ($r_{W2} \geqq r_{M2}$) or if r_{M1} and r_{M2} are near equality. In general, two-worker households' offer curves should be flatter than those for single-worker households, since for the former, the incentive to pay high amounts for a central location should be offset by existence of the suburban job. Thus, commuting costs are reduced little if at all by a central location and two-worker households should be outbid for these locations by single-worker households. The only exception to this would occur if the wage of male workers in the two-worker households were extremely high relative to the wage of female workers *and* to the wage of workers in single-worker households. In this case only, two-worker households would be willing to pay a premium for a central location to reduce commuting time for their male workers, even though this caused increased commuting time for their female workers.

Equation (23) holds if the ratio of housing consumption levels of two- versus one-worker households is less than or equal to the ratio of their household wage rates. This is true whenever the elasticity of housing demand with respect to changes in the total household hourly wage rate is not more than unity. Since increases in the wage rate should cause households to work less, this is consistent with an income elasticity of demand for housing which exceeds unity. In more intuitive terms, two-worker households should be less willing to live beyond u' than are single-worker households, since for each mile they locate further out, two-worker households incur twice as high marginal commuting costs. This effect would only be offset if two-worker households had much higher total incomes than single-worker households, since higher income households tend to prefer suburban locations.

Thus, under a fairly wide variety of circumstances, the model shows that single- and two-worker households can choose for purely rational reasons to locate in cities so that women workers commute shorter distances than men. Economically irrational assumptions, such as that women are casual or secondary workers without a strong attachment to the labor force, are not necessary conditions for this result to occur.

APPENDIX

The Appendix presents data supporting the two assumptions in the model that married women are more likely than other workers to take suburban jobs and that

TABLE 1: Percentage of Married Women and Other Workers With Suburban Jobs[a]

	Married Women Workers	Men Workers	Men and Single Women Workers
New York	31.9	24.9	23.5
Philadelphia	56.4	51.4	49.4
Washington, D.C.	59.2	55.0	52.5
Los Angeles	57.0	56.1	54.5
San Francisco	68.7	64.0	62.0
Chicago	51.6	46.3	44.8

[a] Source: *1970 Census of Population, Journey to Work*, PC (2)—6C.

TABLE 2: Percentage of Men and Women Workers Having Short Commuting Journeys[a]

	All Women Workers	All Men Workers
Boston SMSA		
Boston City	84.3	73.7
Suburban Towns	49.5	40.0
Los Angeles SMSA		
Los Angeles City	77.4	67.9
Long Beach City	64.2	59.3
Suburban Towns	44.7	29.0
Chicago SMSA		
Chicago City	87.8	81.2
Suburban Towns	49.2	32.1
San Francisco SMSA		
San Francisco City	94.2	88.9
Oakland City	66.4	55.9
Suburban Towns	42.1	37.2
New York SMSA		
Manhattan	89.8	84.4
Brooklyn	50.0	48.9
Suburban Towns	52.3	35.2

[a] Source: See Table 1.

women workers have shorter commuting journeys. Table 1 shows that for six large U.S. cities, 54 percent of married women workers have suburban jobs, while only 49 percent of men workers and 48 percent of men and single women workers have suburban jobs.

Information on the length of men's versus women's commuting journeys can be inferred indirectly from the 1970 *Census of Population*. The Census gives the number of workers who live in SMSA subdivisions and the number who work in the same subdivisions. For several SMSA's, the subdivisions include a sample of small suburban towns.

Assume that any worker who lives and works in a suburban town has a shorter commuting journey than a worker who lives in the same town but works outside. The same argument can be made for workers who live and work in the central city of an SMSA, although the argument becomes weaker as the size of the central city relative to that of the SMSA increases. Table 2 presents data showing the percentage of workers having short commuting journeys for central cities and an average of suburban towns in five SMSA's. The data show that women workers consistently choose shorter commuting journeys than men workers.

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