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House Prices and Female Labor Force Participation*

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Abstract: Is there a causal connection between house prices and female labor force participation ? The simple correlation between house prices and female labor force participation across U.S. metro areas is positive. Plausible, informal arguments have been advanced to support causation in either direction: prices raising participation (negative income effects of higher house prices lead more women to work) or participation raising prices (richer two-earner households bid up the price of scarce housing). I construct an equilibrium model of location, labor supply and real estate (land) prices within a metro area which predicts that 1) metro areas with exogenously less buildable land will have higher land prices and more female participation, while 2) metro areas with women exogenously more prone to work will have higher land prices. Using geographic instruments for housing supply, I find little evidence of a positive effect of house prices on female labor force participation, but a somewhat greater possibility that house prices raise female earnings. Likewise, an instrument for female labor supply reveals no consistent significant causal effect of two earner households on housing prices, although the possibility of a positive effect cannot be ruled out.

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Two salient changes over the past four decades have been the rising labor force participation (LFP) of married women and an increase in the real price of housing. This paper examines the possible links between the two phenomena. A plausible argument can be made for causation in either direction. Elizabeth Warren and Amelia Tyagi (2003) have argued that the higher relative cost of housing induces households to supply more labor to the market by sending two earners into the labor market. But an equally plausible case could be made for the causation running in the opposite direction. In Robert Frank and Philip Cook (1995), the rise of two-earner families bids up the price of land thereby raising the relative price of housing. This direction of causation is consistent with the findings of Gyourko, Mayer and Sinai (2006, 2010) who identify increasing national income inequality as a force creating "superstar cities" with markedly higher relative housing costs as the housing demands of an expanding number of high-income households collide with housing supply constraints in certain cities. Although Gyourko, Mayer and Sinai do not explicitly mention the rise of two-income households as a cause of increasing income inequality, other studies have found that assortative mating and a greater tendency for well-educated wives to pursue careers exacerbates income inequality across households. Moretti (2011) shows that high wage, college educated workers are increasingly drawn to cities with high housing costs because they can earn more there but he does not argue that the high housing prices are caused by this sorting.

This paper tries to untangle the direction of causation between house prices and LFP using data on a cross-section of US metropolitan areas. The simple cross-section relation between real house prices and married women's LFP is positive – high-priced housing markets are associated with greater female LFP. This could arise because 1) high house prices induce women to work; 2) more working women bid up housing prices; or 3) a third variable is correlated with both house prices and LFP of women. My empirical results suggest that higher house prices do not raise the LFP rates of married women but there is some likelihood that female LFP increases house prices.

A simple model of labor supply and residential location within a metropolitan area motivates both directions of causation. Assuming a monocentric city in which all employment occurs at the center, households with two earners will have a greater incentive to save on commuting cost by locating close to the city center, bidding up the price of close-in land and raising the overall cost of housing. Other things equal, cities with more two-earner households will have higher land prices. Labor supply choices are made in the standard way, balancing the value of non-market time against the purchased goods foregone by not working, but the household also takes into account the cost of housing and commuting. With reasonable assumptions about preferences and positive assortative mating, the model shows that high wage households will choose to send two earners into the labor market and will reside in high priced housing close to the city center. Lower wage households will have only one earner and will live on the periphery in lower priced housing.

The model can generate differences in labor supply and house prices across metropolitan areas. Cities may differ geographically in the capacity to build housing close to the city center; the model captures that with a parameter which represents the fraction of land that is buildable. These geographic factors will affect the price of land across metropolitan areas and, indirectly, labor supply since the decision to work depends on housing costs and commuting times[1].

Metro areas might also differ in exogenous factors that affect women's labor force participation. If preferences for purchased goods relative to non-market time differ across cities, that would be reflected both in labor supply behavior and, in equilibrium, in land prices. To instrument for female labor force participation, I use a measure of the fraction of the city's males who served in the military during World War II, a variable which has been found to be causally related to female labor force behavior by Acemoglu, Autor and Lyle (2004).

The model generates some empirical implications that are confirmed by the data. House prices are higher and commuting times are longer in metropolitan areas with less close-in buildable land. Married women are less likely to work in cities with longer commuting times.

The hypothesis that house prices cause female labor supply can be probed by instrumenting for endogenous house prices to estimate the extent to which exogenous

[1] The role of commuting time in explaining cross metro area differences in women's labor force participation is highlighted in the work of Black, Kolesnikova and Taylor (2008).

variations in house prices across metropolitan areas affect married women's LFP. The instruments are measures of the topographic characteristics of metropolitan housing markets which may affect both the supply of close-in land, the cost of building on that land, and the desirability of the location. The results show no significant positive effect of house prices on labor supply, though possibly an effect on women's earnings. The reverse direction of causation is examined by instrumenting for female labor supply in an equation explaining house price variation across metro areas using the fraction of the city's males who served in the military during World War II as an instrument. While I cannot reject the null hypothesis of no effect of female labor force participation on house prices, a substantial positive effect also cannot be ruled out.

I. The Empirical Puzzle

The rise in the labor market activity of women, especially married women with children, is well known and has been a central focus of research attention by labor economists. The fraction of married women in the labor market has more than doubled since 1960. Economic explanations for this increase have centered on the rising relative wages of women, availability of effective contraception, and the changing structure of labor demand. Non-economic explanations have relied on what economists term changes in tastes or what sociologists call "norms".

The second time-series observation is the rising relative price of housing in the United States. Although the housing market is cyclic and localized, quality-adjusted house prices nationally have risen on average faster than overall inflation over the past 35 years at least despite the recent sharp decline in house prices. From 1975 to 2010, an index of house prices, based on repeat purchases of the same house, has risen 72.6% relative to the GDP deflator and 40% relative to the CPI.[2]

Cross-section evidence also points to a possible relation between house prices and women working. Housing markets and labor markets in the US are usually identified by metropolitan areas. House prices vary widely by metro area, with the highest prices in California, New York and New England. Less well known is the fact that female LFP

[2] The time period is from the first quarter of 1975 to the first quarter of 2010. See US Housing Finance Agency, http://www.fhfa.gov/webfiles/15762/1q10hpi_reg.txt

varies substantially across metro areas with the highest rates in the upper Midwest.[3] The cross metro area relationship between female LFP and housing prices is significantly positive. In Figure 1, each additional percentage point of female LFP in the 2000 Census data is associated with $2000 extra in median house prices across metropolitan areas. So, the crude cross-section data agree with the time-series evidence.[4]

Empirical associations between house prices and female LFP would not be worth pursuing were there not a plausible theory linking the two. In this case, there are at least *two* theories. First, it is argued that higher housing prices are the *cause* of married Women's LFP. For example, a recent popular book entitled The Two Income Trap Elizabeth Warren and Amelia Tyagi argue that housing has become so expensive that married women must work (in the paid labor force) to maintain the standard of living that households achieved in the 1950's with only one earner. This is essentially an argument based on falling real wages of husbands, a trend which is not evident in the aggregate data, so it would be hard to produce the time series pattern from this theory. To be sure, if house price inflation has been so intense in certain markets that the real earnings of men in those markets had decreased, that might have boosted female LFP in those markets. The reverse would be true in other housing markets, so this theory could be consistent with the cross-section evidence but not with the time series trends.

The other theoretical story reverses the direction of causation. Here some external cause sends more women into the labor market, raising household money incomes and setting off a bidding war for goods like housing that may be in relatively inelastic supply when location is accounted for. In the extreme form of this argument, with an absolutely fixed supply of housing, the households with the most income will get the best house, and so on down the line. The house a household attains will depend on its income relative to the income of other households. This is the mechanism in the

[3] Black, Kolsnikova, and Taylor (2008) highlight the variation in married women's labor force participation across metro areas and conclude that commuting costs drive some of the variation. They find no correlation between labor force participation with housing cost differences but their analysis uses only 50 large MSAs. The analysis here uses over 200 MSAs. When I restrict my estimates to Black et al's smaller sample of metro areas, I, too, find no correlation between housing cost and labor force participation.

[4] Median house value conflates the price per unit of housing and the quantity of housing. The statistical analyses below use only pure housing price indices. The cross-metro correlation between labor force participation and each of two house price indices is positive. Simple regressions of price indices on LFP show significantly positive coefficients implying that an extra percentage point of female labor force participation raises house prices by roughly .03 standard deviations.

popular book, The Winner-Take-All Society by economists Robert Frank and Philip Cook ((Frank 1995)). So, if other households send wives into the labor market that makes single-earner households worse off because those two-earner households now get the best houses. In other words, two-earner households bid up the price of housing. We would expect that over time, more married women working would lead to higher relative house prices, and that in metro areas with many married women working house prices will be higher.

II. A Model of Housing and Labor Force Participation

In this section, I sketch a simple model in which housing choices and wives' LFP are both endogenous at the individual level and housing markets clear at the level of the metropolitan area. I need a tractable model in which more labor force participation drives up land prices and vice versa, and chose one which is driven by the greater willingness of two-earner couples to pay a premium to live close to the center of the metro area. Alternatively, I could have made special assumptions about preferences such as housing being a complement with other purchased goods but a substitute for leisure to generate the greater demand for housing by two-earner couples.

The model is static, the number of households in a metro area is fixed, and each worker's wage rate is fixed. In other words, the metropolitan area labor market clears, trivially, because labor demand is assumed to be perfectly elastic. One could endogenize wages at some cost of complicating the model, but the main conclusions of the analysis remain. Because the model is intended to explain cross section data, it focuses on causes of long-run differences among metro areas. Interregional trade in goods and services implies that the supply of non-housing consumption and housing structures (excluding land) is perfectly elastic to each metro area in the long run, hence prices do not vary across cities. Variation in quality-adjusted house prices within and across metro areas arises then solely from land prices which can persist in the long run under certain conditions.

Consider a metropolitan area in isolation. The area consists of a central place of employment, a point with no area, surrounded by undifferentiated land on which housing can be built.[5] Every worker who is employed must commute to the center from his house; a worker's commuting costs are proportional to the distance to the center and to the opportunity cost of his time, his wage rate. Every household consists of two adults who each have the same wage rate, but wages vary across households. I assume that every husband works, but wives can choose whether or not to work. The labor supply choice is a binary one. Households with two earners and those with high wages will have a greater incentive to live close to the center to reduce commuting costs, creating a price premium for land close to the center. Households simultaneously choose where to live and whether the wife works, taking into account the equilibrium land prices for different locations.

Within a metro area, households are differentiated only by wages; they have identical preferences over leisure, housing structures , and non-housing consumption. Each household must rent one unit of land for its house, the only decision being where to locate. Allowing density to vary would complicate the model substantially. The land rent, *R* , will depend in equilibrium on location as close-in locations are desirable because they save on commuting costs.

<u>Household Choices</u>

Each household consists of two adults, each of whom can earn *w* if they work, so I am assuming perfect assortative mating. The wage, *w*, differs across households. Denoting *H* as a (0, 1) indicator of whether the wife works and recalling that all husbands work, household income is $w\,(1+H)$. Household income is spent on non-housing consumption, housing (excluding land rent), land rent, and commuting costs. Recall that each housing unit requires one unit of land and that all land is assumed homogeneous except for location. The household takes the land rent function $R(r)$ as given and chooses a location, *r*. The center is $r = 0$.

Commuting costs are assumed to be proportional to the distance from the center, *r*, the wage rate of the household, *w*, and the number of workers in the household $(1+H)$.

[5] This monocentric city model is standard in urban economics although my modifications are not. See Goldstein and Moses (1973)

Specifically, suppose that commuting costs per period are $\alpha w(1+H)r$, where α is a parameter which depends negatively on the speed of commuting.[6] The participation constraint, which is assumed to be satisfied, requires commuting costs to be low enough so that even the lowest wage husband will want to work, living at the boundary of the city.

The two crucial decisions for the household are the labor supply decision and the location decision. Households are assumed to have log-linear preferences over purchased goods (consumption and housing structures excluding land rent) and household non-market time. Household non-market time is taken to be $k+(1-H)$ where k can be thought of as the household's non-market time when both adults work and $k+1$ is the corresponding value when only the husband works. All that matters for household choices is the ratio of k to $k+1$, and that could vary from a value of zero (when $k=0$) to a value approaching one (when k is very large). The bigger is k, the smaller the reduction in household non-market time caused by the second adult working. The household's utility as a function of labor supply (H) and location (r) is the Cobb-Douglas function

(1) $$[k+(1-H)]^{\beta}[w(1+H)-R(r)-\alpha w(1+H)r]^{1-\beta}$$

where purchased consumption equals household earnings, $w(1+H)$ minus land rent, $R(r)$, minus commuting costs, $\alpha wr(1+H)$. Note that location affects utility in two ways: it affects both commuting cost and the land rent.

Besides labor supply, the household must choose location. The first order conditions for optimal r balance the cost of commuting against the higher cost of land closer in:

(2) $$\begin{aligned} R'(r) &= -2\alpha w \quad \text{if } H=1 \\ R'(r) &= -\alpha w \quad \text{if } H=0 \end{aligned}$$

[6] By normalizing units of land area such that one unit is required for each housing unit, distance, r, is measured in the square root of the area unit, and α is the time required to travel a distance equal to the square root of the required lot size.

(2) says that two-earner households will choose a location such that the rent gradient equals twice α times the wage, while one-earner households choose a location where the slope of the land rent gradient equals the wage. Since optimal location depends on *H* and *w*, we can write the household's optimal location as a function, $r(H,w)$. Higher wage and two-earner households will want to live closer to the center to save on commuting costs.

Now consider the labor supply decision. The household opts for two earners when the following condition is met:

$$\Omega > \left(\frac{w[1-\alpha r(0,w)] - R(r(0,w))}{2w[1-\alpha r(1,w)] - R(r(1,w))} \right) \tag{3}$$

where $\Omega \equiv \left(\frac{k}{k+1} \right)^{\beta/1-\beta}$ is a function of the two primitive taste parameters, k and β.

Since households differ only in their value of *w*, the highest wage households will choose two earners and the lowest wage households will choose one earner. To see intuitively why this is so, consider the right hand side of condition (3). If land rent, *R*, doubled when a second earner went to work, then the right hand side of (3) would be independent of *w*. But land rent must less than double when a second earner enters the labor market. Because location, *r*, is chosen solely to minimize the sum of land rent and commuting costs, the worst a household could do when it sends a second earner into the labor force is to keep the same location, *r*, thereby doubling commuting cost but not changing land rent. So land rent increases but by less than a doubling when a second earner goes to work, implying that the ratio on the right hand side of (3) is a decreasing function of the household's wage, *w*.

Equilibrium is characterized by two-earner households choosing to live within a circle closest to the city center while the one earner households live in the ring surrounding this central circle. Among the two-earner households, the highest wage households will live nearest the center and the lowest wage households will live at the boundary of the circle. This pattern will also be observed among the one-earner households.

Market equilibrium

Now consider a metropolitan area composed of N households. The number of households with wage w is given by the function $f(w)$, with support $[\underline{w}, \overline{w}]$. Land can either be used for housing or for some non-housing activity (such as agriculture) with opportunity cost, a. I assume that every household in the city can have positive income net of land rent and commuting costs; this is a participation constraint for the existence of the city's population. The lowest wage households will locate at the edge of the city on the boundary with undeveloped land. Denote the edge of the city by $\overline{r}$. Since each household requires one unit of land for housing, $\overline{r}$ is determined by $N = \pi\overline{r}^2$, or $\overline{r} = \sqrt{N/\pi}$. Figure 2 depicts the circular city.

Land rent at the edge of the city must equal its non-housing value, a, so the total land rent and commuting costs of a one-earner household living on the edge of the city will equal $\underline{w}\alpha\sqrt{N/\pi} + a$. The participation constraint is that the wage income net of housing and commuting costs of that household be positive, or

(4) $$\underline{w}\left(1-\alpha\sqrt{N/\pi}\right) - a > 0$$

The participation constraint puts an upper limit on the population of the city

(5) $$N < \left(\frac{\pi}{\alpha^2}\right)\left(1-\frac{a}{\underline{w}}\right)^2$$

which will be assumed to hold. This in turn puts an upper limit on the geographic size of the city, $\overline{r}$:

(6) $$\overline{r} < \frac{1}{\alpha}\left(1 - \frac{a}{\underline{w}}\right)$$

Depending on the parameters, the city might be composed entirely of one-earner households, entirely of two-earner households, or a mixture of one and two earner households. The last case is the most interesting case, so I focus on that. Since households differ only in wages and since a higher wage makes it more likely that a household will have two earners, if there are both one-earner and two-earner households in the city, there must be a w^*, $\underline{w} < w^* < \overline{w}$, such that all households with $w > w^*$ choose $H = 1$ and all households with $w < w^*$ choose $H = 0$. The labor force participation rate of wives will equal the fraction of households with $w > w^*$, or

(7) $$LFPR = \frac{1}{N} \cdot \int_{w^*}^{\overline{w}} f(w)dw$$

LFPR is a decreasing function of *w**.

We can now derive the equilibrium land rent function R. The lowest wage households live at the urban boundary, where $r = \overline{r}$ and $R(\overline{r}) = a$. The highest wage households live at the center where $r = 0$. Using the results in (2), we can derive the land rent at the center:

(8) $$R(0) = a + \alpha \int_{r^*}^{\overline{r}} \left[F^{-1}(1 - \frac{r^2\pi}{N}) \right] dr + 2\alpha \int_{0}^{r^*} \left[F^{-1}(1 - \frac{r^2\pi}{N}) \right] dr$$

In (8), the function F^{-1} is the inverse of the cumulative function corresponding to the wage density function, $f(w)$. Holding constant the opportunity cost of land, a, and the distribution of wages, $f(w)$, the lower is w^*, the higher will be LFP of wives and also land rents at the center; housing (i.e., land) costs and female LFP are thus simultaneously determined in the model.

As Figure 2 illustrates, the model predicts that two-earner households will live closer to the center of employment than one-earner households. Whether that is true in US cities is an open question, as one would need to interpret the data accounting for complicating factors such as multiple employment centers, children, and local public school quality. All the model requires is that comparing similar one- and two-earner households, the two-earner household is willing to pay more for desirable land, whether desirability is based on proximity to employment or location in a high quality school district.[7] This is consistent with Frank and Cook's emphasis on relative income in allocating goods in inelastic supply.

Comparative Statics across Metropolitan Areas

To this point, the model has focused on one metropolitan area. Now I consider a number of metropolitan areas, each with a fixed and equal population[8]. The model is intended to explain differences in land values and labor supply across metro areas. On the housing supply side, metro areas may differ in the availability of close-in land for building both because of geography or because of legal restrictions on building. The model can reflect unbuildability by adding a parameter θ representing the fraction of land that can be used for building.[9] For simplicity, θ is taken to be constant across all distances from the center.

[7] Rouwendal and van der Straaten (2003) argue that dual earner couples in the Netherlands are willing to pay a premium to live close to major employment centers in order to reduce joint commute times.

[8] At this stage, the model makes the unrealistic assumption that all metro areas must accommodate the same population. Implicitly, the model does not allow migration between metro areas, although I argue below that allowing costly migration would not alter the direction of the comparative statics effects derived here

[9] Rose(1989) finds that both natural geographic restrictions on building and legally imposed restrictions affect urban land prices. Saiz (2008) shows that topographic variables affect housing supply elasticity. Glaeser and Gyourko (2002) argue that legal restrictions are an important cause of differences in house prices across metro areas.

Introducing the new parameter, θ, alters the expression for the edge of the city to $\bar{r} = \sqrt{N/\theta\pi}$. Clearly, for a metro area with some unbuildable land ($\theta < 1$), the city must be built farther out to accommodate the same population, N.

The key endogenous variable in this model is *w**, the boundary wage between two-earner households, who live close to the city center, and one-earner households, who live farther away. Households with a wage of *w** are indifferent between sending one and two earners into the market, which implies that *w** is defined by:

(9) $$\Omega = \frac{(w^*(1-\alpha r(w^*) - R(r(w^*))}{(2w^*(1-\alpha r(w^*) - R(r(w^*))}$$

where *r(w*)* is the optimal location of a *w** household, and *R(r(w*))* is the land rent at *r = r**. The location of the borderline household is given by an expression which equates the demand for land closer than *r**, which is the population with wages greater than *w**, and the supply of land closer than *r**, which is just the buildable fraction θ times the area of a circle with radius *r**.

(10) $$r(w^*) = \sqrt{\frac{N[1-F(w^*)]}{\theta\pi}}$$

The land rent at *r** can be found as was done in deriving (9) by solving the differential equation implied by the rent gradients (2) along with the boundary condition that rent at the edge of the city is *a*.

(11) $$R(r^*) = a + \alpha\int_{r^*}^{\bar{r}} F^{-1}(1-\frac{\theta\pi r^2}{N})dr$$

Variations across metro areas in labor supply preferences, Ω, and in buildable land , θ , result in variation in both land rents and female LFP. Comparative statics of the system (9), (10) and (11) with respect to the parameters Ω and θ can be illustrated with figures representing specific numerical solutions to the land rent function. Figure 3 shows the how rent gradients and female LFP vary with Ω. High values of Ω arise when the parameter k is large, signifying little loss of household non-market time when a second adult works, and when β , the utility weight on leisure, is small. High values of Ω yield equilibria with more female LFP and with higher land rents. Higher Ω pushes out r^* , the boundary between the two-earner and one-earner households. By (8), the land rent for all land within the r^* circle rises because the steeper part of the rent gradient, where $R'(r) = -2\alpha w$ begins farther out.

The effects of variation across metro areas in the parameter θ, the buildable land parameter, are illustrated by Figure 4. A decrease in θ pushes the city boundary outward to gain enough buildable land to accommodate the fixed population. This raises commuting costs because the typical household must live farther away from the center. Because close-in land is now scarcer, the rent on land at any distance from the center also rises. The net result of these two effects is to raise female LFP. The income effect of higher land prices outweighs the effect of greater commuting times in raising the cost of working.

This model suggests the following results. First, higher values of Ω , the labor supply preference parameter, raises the LFP of wives and pushes out the boundary between the two income and one income households, thereby increasing land rents for all close-in land. An increase in buildable land, represented by a higher value of θ, reduces both land rents and the LFP of wives. Note that variations in either Ω or θ generate a positive correlation between land values and LFP.

Effects of Migration, Agglomeration Economies, and Amenities

The model above assumes that there is no migration between cities. What would equilibrium look like if movement were possible? Recall that in the basic model there is no amenity difference between cities, nor is there any labor market difference. In that model, a household can earn the same wage no matter where it locates. The only difference between cities relevant to individuals is the price of land as a function of distance from the center. Cross-metro area variations in the land rent function would be caused either by differences across cities in land availability (θ) or the preferences of households in the metro area (Ω). Perfectly costless mobility leads households to move between cities seeking the cheapest land (adjusting for distance) until in equilibrium every city has the same housing prices as a function of distance from the center. Moreover, in equilibrium each city would have the same LFP rates. Cities with less buildable land (lower θ) would be smaller in population (but identical in maximum distance from the center, $\overline{r}$). To sustain differences in LFP across cities in this model, any migration must be less than costless.

If labor markets differ across cities, the model resembles the models of Rosen (1974) and Roback (1982) in which equilibrium establishes compensating differentials in wages and land rents. For example, suppose agglomeration economies raise the level of wages in cities with large populations compared to smaller cities. In equilibrium, higher wages in large cities will be offset by higher land rents. With the additional assumptions of the model developed above, larger cities would have higher female LFP rates and also would attract migrating high wage couples from smaller cities. This agglomeration effect would produce a positive correlation between land rents and female LFP across cities of varying sizes, but not across cities of the same size. Although agglomeration economies are a plausible mechanism connecting land rents and labor supply, including population size as a proxy for agglomeration economies that does not materially change the empirical results reported below.

Amenity differences across cities could also conceivably generate a positive cross-section relation between LFP and house prices but it would require special (and untestable) restrictions on preferences. The most obvious mechanism would be a positive relation between the taste for amenities and the taste for goods relative to leisure. Besides being untestable, this assumption is somewhat counterintuitive since a priori one might expect leisure and amenities to be stronger complements than goods and amenities. If amenities were luxury goods, then there would be migratory sorting of households with high wage households migrating toward high amenity cities bidding up the price of land there. However, Gyourko, Mayer and Sinai (2010) show that their "superstar" cities with high house prices actually experience lower population growth than other cities.

III. Empirical Tests

Consider some empirical implications of the model at hand. One implication is that across cities, more buildable land reduces commuting times. In column 1 of Table 2, I explain average commuting times across metro areas in the US with variables representing the fraction of land <u>not</u> covered by water or by land outside the United States and land with more than a 20% slope within a 25 mile radius of the city center. [10] These variables are intended to be empirical counterparts of the parameter θ in the model above. The results in column 1 show that metro areas with less buildable land and more steep slopes have longer commuting times, although the slope variable is not significant.

A second implication of the model is that house prices are higher in metro areas with less buildable land. I use two quality-adjusted house price indices constructed by Yong Chen and Stuart Rosenthal (2008) and by Edgar Olsen as described in Olsen, Davis and Carillo (2005). While each house price index uses a different methodology, they both attempt to control for housing quality differences across metro areas and are quite highly correlated. I standardize these indices so that a unit represents one standard deviation in house price variation across metro areas.

Saiz (2010) studies the effect of topography and land use regulations on the elasticity of housing supply and finds that the fraction of land covered with water or

[10] This statistic was calculated using mapping technology that neglects small bodies of water, so the variation is driven by large bodies of water like oceans and large lakes and by proximity to international borders, where the assumption is that the land in another country is not a perfect substitute for land within the borders of the U.S.

steeply sloped makes the supply of housing less elastic, which implies higher prices in the face of demand shocks. In columns 2 and 3 of Table 2, I regress the two house price indices on the geographic variables. These variables might also be picking up amenities, as much of the non-buildable land is water and proximity to water is a valued amenity. Moreover, steeply sloped land allows for views which may also be an amenity. The prediction is that a low fraction of buildable land and more sloped land increases house prices. Columns 2 and 3 shows that this prediction is confirmed with both geographic variables strongly significant in the predicted direction . Increasing the fraction of land not under water by ten percentage points reduces house prices by .2 standard deviations, while reducing the fraction of sloped land by ten percentage points reduces prices by about .3 standard deviations. The results in Table 2 can be viewed as the first stage estimates for the instrumental variable estimates of labor supply in Tables 3 and 4.

<u>Household Labor Supply Decisions and House Prices</u>

Does house price variation across metro areas affect married women's labor supply? Using the 2000 Census Public Use Micro Sample (PUMS) sample of households, I select a one percent sample of married women, aged 21 to 65, with spouse present in the household, living in metro areas. . This yields a sample size of roughly 200,000 women, which is described in the right panel of Table 1. Table 3A examines labor supply behavior with linear probability estimates of LFP and Table 3B estimates probits on LFP. Column (1) in both Tables 3A and 3B sets a baseline regression showing the importance of education, young children, the metro area unemployment rate, and other family income, including husband's earnings. Columns (2) and (4) in Tables 3A and 3B add house prices as well as mean commuting times within the metro area.

Adding the metro area variables shows that even when we consider individual data and control for household and other metro area determinants of labor supply, house prices exert a positive effect on labor force participation although neither coefficient is significant. Black, Kolesnikova and Taylor (2008) emphasize the role of commute times in generating cross metro area differences in married women's labor supply. That finding is echoed here where the estimated coefficient implies that 3-4 minutes more in commute time reduces LFP by a percentage point.

Instrumenting for House Prices

Since house prices and mean travel times are endogenous to labor supply behavior in the metro area, we need to uncover whether the positive relation between house prices and labor supply reflects causality from house prices to labor supply. To do this, I repeat the labor supply estimates of columns (2) and (4) in both Tables 3A and 3B, except that I instrument for both house prices and mean travel times with the geographical determinants of housing prices used in Table 2. These estimates, in columns (3) and (5) of each table, show that when instrumented, neither variations in the Rosenthal-Chen house price index nor in the Olsen index appear to increase women's labor supply. Indeed, the estimated coefficients switch from positive to negative in all cases. For the IV probit estimates in Table 3B we can soundly reject the hypothesis of a positive effect of house prices on female labor supply, while for the linear probability estimates in Table 3A, the standard errors are large enough that we cannot rule out a positive response of labor supply to higher house prices. Looking at 95% confidence bounds, the most positive effect of house prices on LFP is given by the estimate in column (5) of Table 3A. That upper bound estimate implies that a standard deviation increase in house prices would raise the probability of working by .005, which is a quite small effect. It is very unlikely that house prices exert a substantial positive effect on LFP.

For the IV estimates in Tables 3A and 4A, standard F-tests show that the excluded geographic instruments are not weak, at least in the first stage regression explaining the main endogenous variable of interest, house prices. Hansen's J-statistic fails to reject the null hypothesis that the overidentifying exclusion restrictions are valid.

Tables 4A and 4B offer another view of the effect of house prices on female labor market behavior. Here the dependent variable is earnings rather than LFP, including women with no earnings; Table 4A presents linear estimates while Table 4B shows Tobit estimates. Earnings capture two additional behaviors that might be affected by house prices. Most obviously, earnings incorporate the effect of variation in hours, but in addition may capture individual investments in earning capacity not picked up by years of education. The hypothesis would be that higher house prices induce women to earn more both by working more and by earning more per hour, which is borne out by the positive estimates in columns (2) and (4) of both Tables 4A and 4B. However, instrumenting for house prices in columns (3) and (5) reveals insignificantly positive effects of house prices on female earnings in the linear estimates in Table 4A and insignificantly negative effects in the Tobit estimates of Table 4B. At 95% confidence, the upper bounds of the estimates in Table 4A imply that a standard deviation in house prices raises female earnings by about $1000, while the Tobit estimates imply a much smaller effect of about $300. So while it is very unlikely that house prices have an appreciable positive effect on labor force participation, the effect on female earnings may well be positive.[11]

From these IV estimates, one can conclude that house prices have at most a very small positive effect on female labor force participation with a possibly somewhat greater effect on female earnings. To check the robustness of the results in Tables 3 and 4 to alternative instruments, I reestimated the models in Tables 3 and 4 using the geographical and regulatory instruments used by Saiz (2010). The results were not dramatically different.

Instrumenting for Labor Supply

Do exogenous determinants of labor supply (analogous to variation in Ω in the model) affect a metro area's house prices ? Here the search for valid instruments is more difficult. Metro area differences in the determinants of labor supply at the individual level are valid instruments only if one supposes that they do not affect house prices directly, except for their influence on female LFP or earnings. For example, other family

[11] The Rosen-Roback model predicts a positive correlation between earnings and land prices if productivity varies across metro areas. Both female earnings and land rents will be higher in more productive metro areas. The empirical results in Tables 4A and 4B are presumably not the result of this mechanism since house price variation is induced by the geographic instruments which should be independent of productivity. Also, the results are unaffected when I control for population size as a proxy for agglomeration-based productivity differences.

income and number of children under five affect spousal labor supply but also likely exert a direct effect on housing demand. For an instrument, I follow Acemoglu, Autor and Lyle (2004) and use the fraction of males in the metro area who were in the military during World War II. As Acemoglu et al show, this disruption to civilian labor markets had long-lasting effects on the labor supply of women.

Table 5 shows the IV estimates explaining house prices across metro areas instrumenting for female LFP and earnings with male mobilization rates during World War II.[12] The F-statistic on the mobilization rate is 11.8 in the first stage regressions (shown in Table 6) explaining labor force participation and 14.1 in those explaining female earnings so the instrument is not a weak one by the Stock-Yogo criteria. The estimates in Table 5 show no statistically significant effect of female labor force participation or earnings on house prices. However, looking at the 95% confidence bounds we cannot rule out a positive effect size as large as 0.17 (for labor force participation) or .36 (for female earnings). These would imply substantial effects on house prices; a 6 percentage point increase in LFP or $2800 more in earnings would raise house prices by a standard deviation. So we cannot rule out the possibility of substantial positive effects of female labor market activity on house prices from the cross section data. However, the data do not allow us to detect even the direction of an effect with any confidence.

Can we detect an effect of labor force participation on changes in house prices using changes over time within metro areas instead of cross-metro area data ? To pursue this, I regress the percent change in house prices over a decade on the female LFP rate at the beginning of the decade, using metro area data and a fixed effects estimator. The two decades of data are the 1980's and the 1990's, since quality-adjusted house price data by metro area is not available before the 1970's . The result is:

$$\%\Delta Houseprice_{i,t} = 2.04 FemaleLFP_{i,t-1} - .408 Decade90s - .471$$

The standard error on lagged female LFP is 2.83 so we cannot reject the hypothesis of no relationship, but the mean effect is positive and not trivial in size.

[12] Data from U.S. Selective Service System (1948). Data is provided only at the state level. For metro areas entirely within one state, I assume that state's mobilization rate applies to the metro area. For metro areas crossing state boundaries, I construct a weighted average of the relevant states' mobilization rates, the weights being the shares of the metro areas population in each state.

Conclusion

We began with the observations that female LFP and house prices are positively related across US metro areas and that both have risen in the past three decades. The paper seeks to discover whether any causal direction can be teased out of the data. A model of the joint determination of labor supply and housing demand in a metro area generates the prediction that land values will be sensitive to labor supply determinants such as preferences for purchased goods relative to non-market time. It can also generate labor supply affected by determinants of land values such as the availability of buildable land in the metro area.

Instrumenting house prices with geographic variables, it appears to be quite unlikely that house prices raise female labor force participation, though there may be effects on earnings. Instrumenting for female LFP with World War II male mobilization rates, the effect size or direction cannot be pinned down with any precision so we cannot rule out a positive effect of female labor supply and earnings on house prices.

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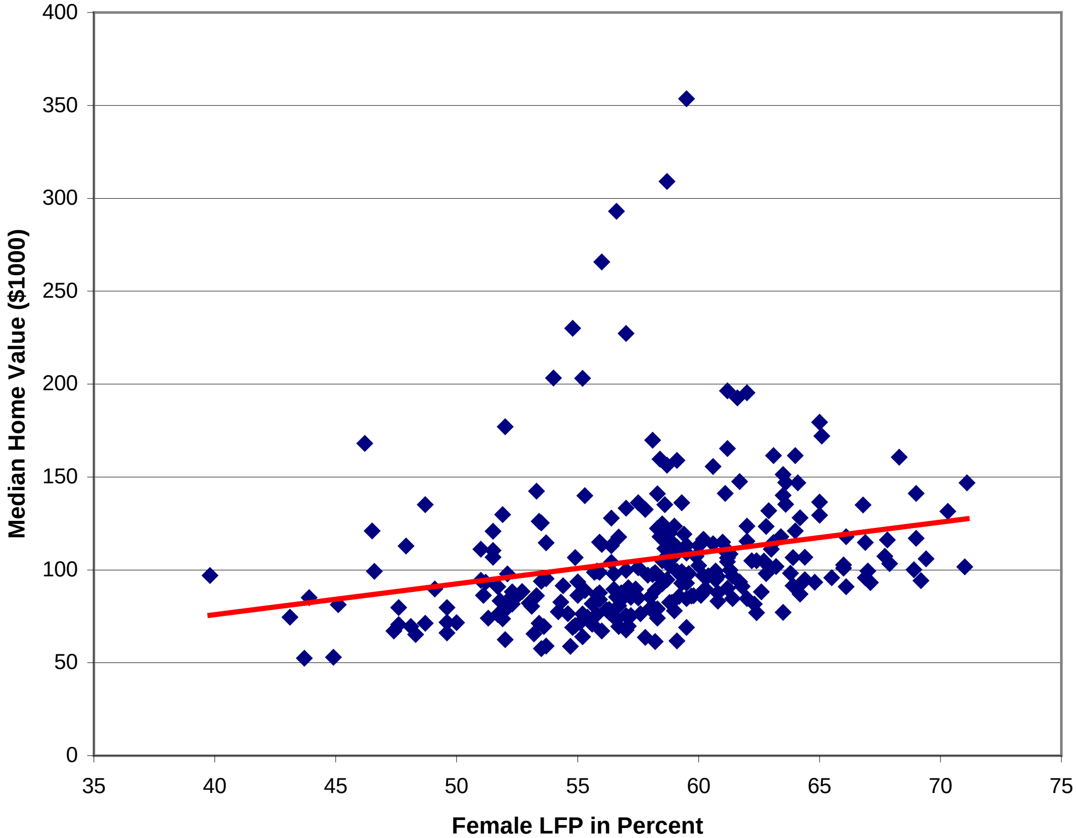


Figure 1: Median Home Value and Female Labor Force Participation
Across US Metro Areas: 2000 Census

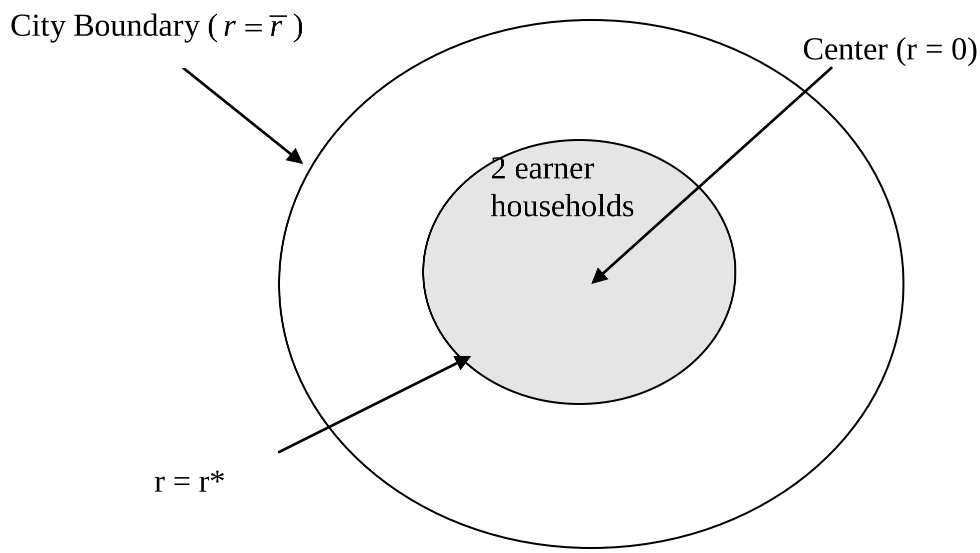
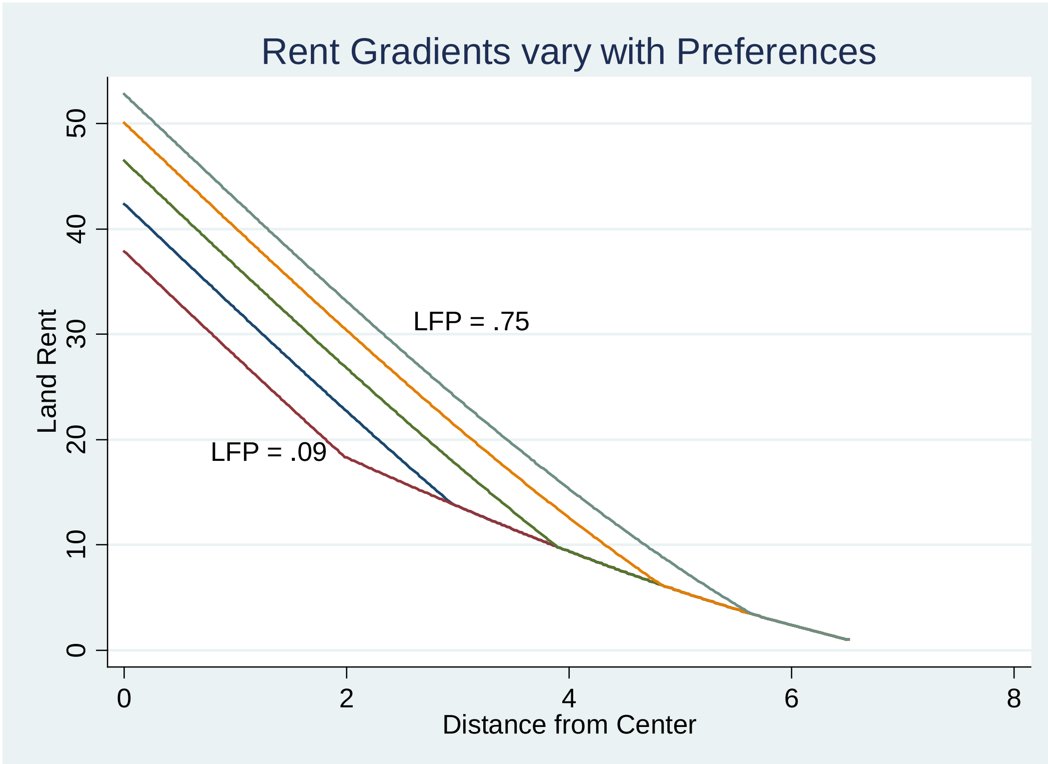


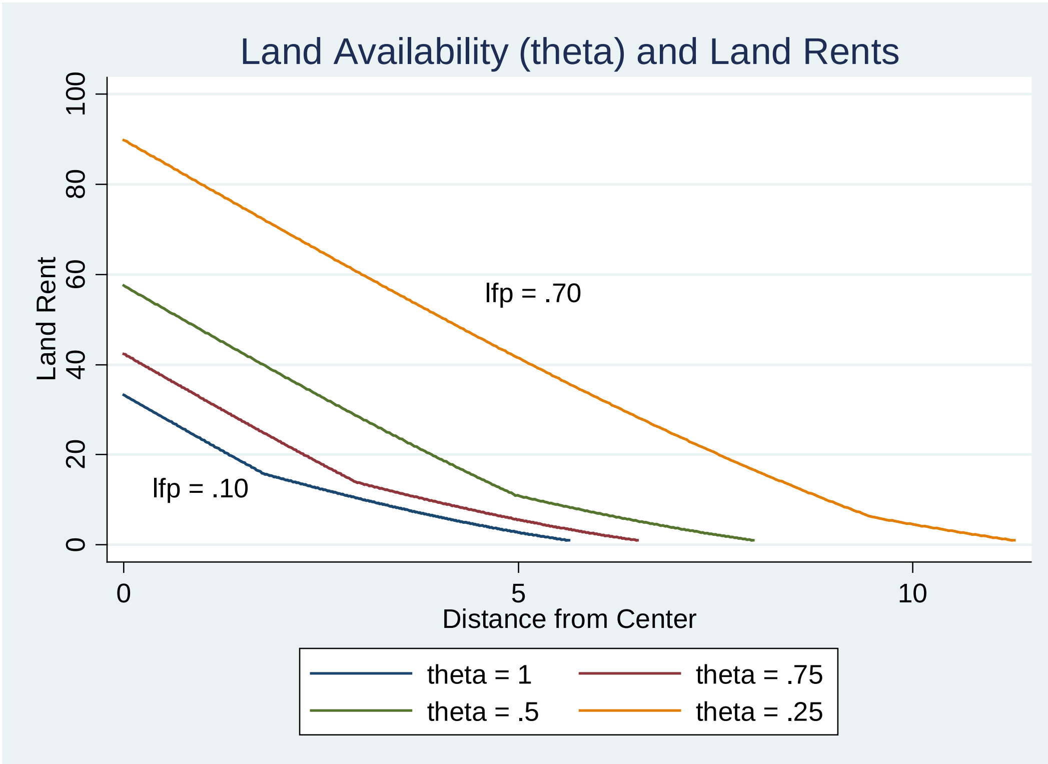
Figure 2: The Circular City



Rent Gradients for Five Values of the Taste Parameter Ω

Figure 3

(notes: a numerical example in which a = 1, α= .05, θ= .75, N = 100, and the wage distribution is uniform over (50, 100). The five rent gradients correspond to five values of the taste parameter, Ω (.44, .45, .46, .47, 48) The lowest value of Ω yields a female labor force participation rate of .09 and the lowest rent gradient. The highest value of Ω yields a female labor force participation rate of .70 and the highest rent gradient. The kinks in gradients occur at r*, the boundary between the one-earner households and the two-earner households. The city boundary occurs at 6.514)



Rent Gradients for Four Values of the Land Availability Parameter, θ

Figure 4

(notes: a numerical example in which a = 1, α= .05, Ω = .45, N = 100, and the wage distribution is uniform over (50, 100). The four rent gradients correspond to four values of the land availability parameter, θ (.25, .5, .75, 1) The lowest value of θ yields a female labor force participation rate of .70 and the highest rent gradient. The highest value of θ yields a female labor force participation rate of .10 and the lowest rent gradient. The kinks in gradients occur at r*, the boundary between the one-earner households and the two-earner households. The city boundary occurs further out the lower the value of θ)

Table 1: Descriptive Statistics

Metro Area Variables	Mean (Std. Dev)	Individual Level Variables for Married Women (N= 203974)	Mean (Std. Dev.)
Rosenthal-Chen house price index standardized (N= 297)	0 (1)	High School	.257 (.44)
Olsen house price index standardized (N= 329)	0 (1)	Some College	.301 (.46)
Fraction of Buildable Land (N= 283)	.925 (.158)	College	.306 (.46)
Fraction of land with slope greater than 20% (N=93)	.087 (.111)	Labor Force Participation	.679 (.46)
Mean Travel to Work Time (minutes) (N = 295)	22.5 (3.7)	Number of Children under five	.30 (.60)
Female labor force participation (%) (N = 277)	58.0 (5.4)	Other Family Income (thousands of dollars)	63.76 (66.57)
Median full-time male earnings (1000$) (N= 275)	36.4 (4.7)	Wage Income (wives) (thousands of dollars)	20.97 (29.19)
Median full-time female earnings (1000$) (N=275)	25.7 (3.4)	Metro area unemployment rate, April 2000	3.62 (1.64)

Notes: Rosenthal index from Y.Chen and S. Rosenthal (2008). Index is $(Q_H + Q_B)/2$. Olsen index from unpublished estimates by Edgar Olsen as described in Olsen et al (2005). . Fraction of buildable land and 20% slope variables are author's calculations using Census maps. Climate variables from NOAA. Other variables from US Census 2000 and Census 2000 PUMS

Table 2: Effects of Geography on Cross-Metro Area Differences in Commute Times and House Prices

	(1)	(2)	(3)
	Mean Commute Time	Rosenthal-Chen House Price Index	Olsen House Price Index
Fraction of Buildable Land	-4.61*** (1.20)	-1.93*** (.45)	-1.96*** (.39)
Fraction of sloped land	2.21 (2.46)	3.51*** (.86)	2.97*** (.93)
F-Statistic	F(3,254)= 36.8	F(7,250)=21.2	F(3,279)=20.5
Number of Observations	258	254	283

Notes: dummy for missing slope data is also included. Robust standard errors in parentheses. *** = 1% significance, ** = 5% significance, * = 10% significance.

Table 3A: Labor Force Participation of Married Women: Linear Probability Models

	(1) OLS	(2) OLS	(3) IV	(4) OLS	(5)IV
High School	17.6*** (.7)	17.5*** (.74)	17.4*** (.78)	17.5*** (.73)	17.5*** (.76)
Some College	26.4*** (.66)	26.1*** (.66)	26.1*** (.68)	26.2*** (.65)	26.1*** (.70)
College	32.8*** (.69)	32.8*** (.72)	32.8*** (.68)	32.8*** (.71)	32.9*** (.71)
Kids under 5	-13.9*** (.32)	-13.9*** (.34)	-13.9*** (.33)	-13.9*** (.33)	-13.9*** (.33)
Other Family Income	-.10*** (.005)	-.09*** (.006)	-.09*** (.005)	-.09*** (.006)	-09*** (.005)
Metro Area Unemployment Rate	-.98*** (.23)	-.86*** (.22)	-.89*** (.23)	-.82*** (.21)	-.93*** (.26)
Rosenthal-Chen House Price Index		.097 (.44)	-1.05* (.62)		
Olsen House Price Index				.51 (.38)	-1.33 (.91)
Mean Travel Time		-.26** (.11)	-.047 (.24)	-.36*** (.12)	.076 (.31)
F-test of excluded instruments (house price)			F= 11.11 p = .000		F = 4.74 p = .004
F-test of excluded instruments (travel time)			F= 2.56 p= .06		F=2.56 p = .06
test of overidentifying restrictions: p value of Hansen's J			.85		.97
Number of Observations	202829	196831	192295	196831	192295

Notes: 2000 Census data. IV estimates are GMM. Standard errors in parentheses, clustered on metro areas. Coefficients and Standard errors multiplied by 100 for clarity. Other included covariates are age, age squared, and race. House prices and mean travel times are instrumented with topographical variables.

Table 3B: Labor Force Participation of Married Women: Probit Models

	(1)Probit	(2) Probit	(3) IV Probit	(4)Probit	(5)IV Probit
High School	.465*** (..019)	.461*** (.020)	.457*** (.009)	.462*** (.019)	.460*** (.010)
Some College	.725*** (.017)	.717*** (.017)	.716*** (.008)	.720*** (.017)	.717*** (.012)
College	.937*** (.017)	.936*** (.017)	.936*** (.010)	.936*** (.017)	.938*** (.011)
Kids under 5	-.403*** (.01)	-.405*** (.011)	-.405*** (.005)	-.404*** (.011)	-.405*** (.006)
Other Family Income (x 10^{-6})	-2.74*** (.16)	-2.70*** (.17)	-2.68*** (.05)	-2.71*** (.17)	-2.68*** (.05)
Metro Area Unemployment Rate	-.029*** (.007)	-.025*** (.006)	-.026*** (.002)	-.024*** (.006)	-.027*** (.002)
Rosenthal-Chen House Price Index		.002 (.013)	-.032*** (.004)		
Olsen House Price Index				.015 (.012)	-.041*** (.006)
Mean Travel Time		-.008** (.003)	-.002 (.002)	-.011*** (.004)	-.002 (.004)
Number of Observations	202829	196831	192295	196831	192295

Notes: 2000 Census data. IV estimates use Newey's two step procedure. Standard errors in parentheses. Standard errors are clustered on metro areas for columns (1), (2) and (4). Bootstrapped standard errors for columns (3) and (5). Other included covariates are age, age squared, and race. House prices and mean travel times are instrumented with topographical variables.

Table 4A: Labor Earnings of Married Women: Linear Models

	(1) OLS	(2) OLS	(3) IV	(4) OLS	(5)IV
High School	5.92*** (.24)	6.35*** (.27)	6.2*** (.27)	6.27*** (.26)	6.19*** (.25)
Some College	11.30*** (.33)	11.7*** (.36)	11.6*** (.35)	11.6*** (.34)	11.6*** (.33)
College	24.10*** (.82)	24.2*** (.81)	24.4*** (.76)	24.1*** (.78)	24.4*** (.75)
Kids under 5	-4.0*** (.16)	-4.07*** (.17)	-4.1*** (.16)	-4.08*** (.17)	-4.05*** (.16)
Other Family Income	-.0046 (.00457	-.0074 (.0046)	-.007* (.0039)	-.0075 (.0046)	-.0069* (.0040)
Metro area unemployment rate	-.25 (.25)	-.35*** (.11)	-.37*** (.11)	-.33*** (.09)	-.35*** (.10)
Rosenthal-Chen House Price Index		1.13*** (.26)	.48 (.35)		
Olsen House Price Index				1.31*** (.20)	.58 (.39)
Mean Travel Time		.24*** (.07)	.28* (.15)	.15** (.70)	.23 (.16)
F-test of excluded instruments (house price first stage)			F= 11.11 p = .000		F = 4.74 p = .004
F-test of excluded instruments (travel time first stage)			F= 2.56 p= .06		F=2.56 p = .06
test of overidentifying restrictions: p value of Hansen’s J			.28		.19
Number of Observations	202829	192277	192295	196831	192295

Notes: 2000 Census Data. IV estimates are GMM estimates. Robust standard errors in parentheses, clustered on metro areas. Other included covariates are age, age squared, and race. House prices and mean travel times are instrumented with topographical variables.

Table 4B: Labor Earnings of Married Women: Tobit Models

	(1) Tobit	(2)Tobit	(3) IV Tobit	(4) Tobit	(5)IV Tobit
High School	12.85*** (.62)	13.3*** (.67)	13.3*** (.25)	13.2*** (.66)	13.3*** (.26)
Some College	20.9*** (.89)	21.2*** (.94)	21.4*** (.29)	21.19*** (.92)	21.44*** (.27)
College	35.9*** (1.49)	35.9*** (1.51)	36.4*** (.37)	35.85*** (1.5)	36.45*** (.30)
Kids under 5	-8.05*** (.28)	-8.13*** (.30)	-8.15*** (.17)	-8.14*** (.30)	-8.15*** (.14)
Other Family Income (x 10^{-3})	-.028*** (.006)	-.031*** (.006)	-.031*** (.002)	-.031*** (.0058)	-.031*** (.003)
Metro area unemployment rate	-.603*** (.272)	-.702*** (.168)	-.737*** (.06)	-.662*** (.16)	-.741*** (.06)
Rosenthal-Chen House Price Index		1.10*** (.39)	-.02 (.14)		
Olsen House Price Index				1.44*** (.271)	-.043 (.17)
Mean Travel Time		.023** (.009)	.377*** (.08)	.097 (.09)	.39*** (.09)
Number of Observations	202829	196831	192295	196831	192295

Notes: 2000 Census Data. IV estimates use Newey's two step method. Standard errors in parentheses. Standard errors are clustered on metro areas for columns (1), (2) and (4). Bootstrap standard errors for columns (3) and (5). Other included covariates are age, age squared, and race. House prices and mean travel times are instrumented with topographical variables. Coefficients are in thousands of dollars.

Table 5: IV Estimates of Cross-Metro Area Differences in House Prices

	(1)	(2)	(3)	(4)
	Rosenthal-Chen Index		Olsen Index	
Female Labor Force Participation Rate	.024 (.077)	———	-.077 (.067)	———
Median Female Earnings	———	.051 (.157)	———	-.173 (.186)
Median Male Earnings	.086** (.037)	.073 (.074)	.124*** (.032)	.169** (.08)
Fraction of Buildable Land	-1.98** (.87)	-1.82*** (.40)	-1.11* (.66)	-1.64*** (.38)
Slopes Above 20%	2.75*** (.63)	2.52*** (.49)	1.76*** (.63)	2.48*** (.64)
Number of Observations	231	231	257	257

Note: Estimates are GMM estimates with robust standard errors. Instruments for female labor supply and female earnings are World War II male mobilization rates. *** = 1% significance, ** = 5% significance, * = 10% significance.

Table 6: First Stage Estimates for IV Estimates in Table 5

	(1)	(2)
	Female Labor Force Participation Rate	Median Female Earnings
Mobilization Rate	-20.18*** (4.37)	-9.36*** (1.19)
Median Male Earnings	.455** (.065)	.46*** (.024)
Fraction of Buildable Land	8.81*** (1.81)	.974 (.54)
Slopes Above 20%	-2.44 (3.59)	2.98** (1.17)
Number of Observations	231	257

Note: Estimates are GMM estimates with robust standard errors. Instruments for female labor supply and female earnings are World War II male mobilization rates. *** = 1% significance, ** = 5% significance, * = 10% significance.