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LOCAL PRICE VARIATION AND LABOR SUPPLY BEHAVIOR

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Abstract. In standard economic theory, labor supply decisions depend on the complete set of prices: the wage and the prices of relevant consumption goods. Nonetheless, most of theoretical and empirical work ignores prices other than wages when studying labor supply. The question we address in this paper is whether the common practice of ignoring local price variation in labor supply studies is as innocuous as has generally been assumed. We describe a simple model to demonstrate that the effects of wage and non-labor income on labor supply will typically differ by location. We show, in particular, the derivative of the labor supply with respect to non-labor income will be independent of price only when labor supply takes a form based on an implausible separability condition. Empirical evidence demonstrates that the effect of price on labor supply is not a simple "up-or-down shift" that would be required to meet the separability condition in our key proposition.

JEL: J01, J21, R23.

Keywords: labor supply, local labor markets, local prices.

Introduction

In standard economic theory, labor supply decisions depend on the complete set of prices: the wage and the prices of relevant consumption goods. Nonetheless, as Abbott and Ashenfelter (1976) noted some thirty years ago, economists have generally found it a useful abstraction, in both theoretical and empirical work, to ignore prices other than wages when studying labor supply. For example, none of the empirical results on labor supply discussed in the prominent reviews of Pencavel (1986), Killingsworth and Heckman (1986), or Blundell and MaCurdy (1999) are derived using procedures that account for variation in any price variation other than wages.[1]

Most of the empirical work on labor does, however, use national data sets, with individuals who live in different locations and who therefore face different prices for locally-priced goods. These price differences can be quite large, especially for housing. For example, in the 1990 Census, the median housing price in New York is over three times that of the median housing

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[1]Abbott and Ashenfelter (1976)'s evaluation of labor supply in the U.S. over the 1929-67 time period exploits time series changes in relative prices but did not evaluate possible impacts of cross-sectional variation (which, as they say, is "expected to be small"). There is some work that conducts sensitivity analysis, using Bureau of Labor Statistics information on the cost of living to "adjust" wages. See, for instance, DaVanzo et al. (1973) and Masters and Garfinkel (1977).

price in Cleveland.[2] The question we address in this paper is whether the common practice of ignoring local price variation in labor supply studies is as innocuous as has generally been assumed.

The first step we take in examining this issue is to set up a simple theoretical model: an economy in which people live in different locations that have differing levels of a production or consumption amenity. Following logic familiar in urban economics, e.g., in Roback (1982), equilibrium prices will differ across locations. We demonstrate that in such a model, labor supply behavior can vary across location as well.

Our second step is to then demonstrate that when prices vary across location, one can indeed safely ignore local variation in prices only when preferences take a very specific and peculiar form. We also show that the responsiveness of labor supply to *wage* changes will be the same across locations only if the responsiveness of labor supply to *non-labor income* changes is the same across locations.

The third step in our research is to evaluate the potential empirical importance of our theoretical observations. We present results that we obtain using 1990 Public Use Micro-Samples (PUMS) of the 1990 U.S. Census, examining labor supply in the nation's 50 largest cities. We focus on the labor force participation and hours decisions of white married women aged 30 to 50—a group whose labor decisions are quite responsive to changes in wage and non-labor income.

The general idea of our exploration is to look at the basic "building block" empirical relationship that would underlie any empirical analysis of labor supply for this group: the relationship between non-labor income and labor supply. Our innovation is to examine these relationships for each of the 50 cities separately and to demonstrate that there is significant systematic variation among them.

We find that the basic correlation—between labor supply and non-labor income—differs across cities. For example, women who have relatively high non-labor income (primarily husband's income) work relatively fewer hours and have lower participation rates. Importantly, from our perspective, this anticipated negative relationship is substantially more pronounced in cities with inexpensive housing than in cities with expensive housings.

[2]Gabriel and Rosenthal (2004) and Chen and Rosenthal (2006) show that massive housing price differences pertain across cities even after careful adjustment for quality.

1. A Model of Local Labor Markets With Stone-Geary Preferences

We begin by setting out a simple model of local price variation along the lines of Roback (1982) and Haurin (1980). Locations differ along one of two criteria: (i) a location may be inherently more pleasant, i.e, have a higher level of a "consumption amenity" like nice weather, or (ii) a location may be associated with inherently higher productivity, owing, for example, to the presence of a natural resource or to agglomeration economies in production. For simplicity of presentation we restrict attention to cases in which people choose to live in one of two cities.

In contrast to the standard urban location models such as Roback (1982) or Haurin (1980), which fix labor supply to be a constant, we allow labor supply to be a choice variable. Preferences are assumed to be Stone-Geary. This is a particularly transparent form of utility, and, as Ashenfelter and Ham (1979) note, is the simplest functional form of utility used in applied empirical work examining labor supply.[3] We assume, in particular, that individual i has utility u^i as a function of a consumption good x, leisure l (which is scaled so that $0 \leq l \leq 1$), and an amenity level A^j (that is specific to location j), according to a simple Stone-Geary form:

$$u^i = \theta^{ij} A^j (x - c)^{\delta} l^{1-\delta}, \tag{1}$$

where c and δ are parameters that are common across individuals and θ^{ij} is a positive idiosyncratic parameter that equals 1 for a typical individual, but allows for the possibility that person i has a particular attraction, or distaste, for location j (as θ^{ij} is greater than, or less than, 1).

A person living in location j maximizes utility subject to a budget constraint, $p_j x = w_j(1 - l) + N$, where p_j is the price for the local consumption good, w_j is the local wage, and N is non-labor income. Assuming an interior solution pertains, demand for leisure and for the consumption good are, respectively,

$$l(w_j, p_j) = \frac{(1 - \delta)(N + w_j - cp_j)}{w_j}, \tag{2}$$

and

$$x(w_j, p_j) = \frac{\delta(N + w_j - cp_j)}{p_j} + c. \tag{3}$$

[3] See also Blundell and MaCurdy (1999) for a discussion of the Stone-Geary form, as well as other forms used in applied work on labor supply.

Substituting (2) and (3) into (1) gives indirect utility for person i in location j:

$$V^{ij} = \frac{\theta^{ij} A^j \delta^\delta (1-\delta)^{1-\delta} (N + w_j - cp_j)}{p_j^\delta w_j^{1-\delta}}. \tag{4}$$

In equilibrium each individual chooses to live in the location that yields the highest level of utility. There are two locations, $j = 1$ or 2. We work through two cases: first, with differing consumption amenities, and second, with differing levels of productivity in the locations.

Case 1. Differing Levels of the Consumption Amenity. Suppose there is general agreement that location 1 is nicer than location 2, $A^1 > A^2$, and for the moment assume further that there are no idiosyncratic differences in opinion about location, so that $\theta^{ij} = 1$ for all individuals. Since workers are equally productive in the two locations, wages w_1 and w_2 must be the same, say w.[4] In an equilibrium in which people live in both locations, we must have $V^{i1} = V^{i2}$, so using (4), it is clear that p_1 and p_2 must solve

$$\frac{A^1(N + w - cp_1)}{p_1^\delta w^{1-\delta}} = \frac{A^2(N + w - cp_2)}{p_2^\delta w^{1-\delta}}. \tag{5}$$

Inspection of (5) confirms the intuitive result that $p_1 > p_2$; the local consumption good is more expensive in the high-amenity city.

This logic continues to hold if we add back the idiosyncratic taste component to utility. If for the marginal individual $\theta^{i1} = \theta^{i2} = 1$, equation (5) still characterizes equilibrium prices. In this instance, however, some individuals will have a strict preference with regard to location. For example, an individual with $\theta^{i1} > \theta^{i2}$ will have a strict preference for location 1 over location 2.

We turn next to labor supply. Let h be the fraction of time that a person works, $h = 1-l$. From (2), we have

$$h(w, p_j) = \frac{\delta w - (1-\delta)(N - cp_j)}{w}. \tag{6}$$

Although wages are the same in the two locations, labor supply differs. In this example $h(w, p_1) > h(w, p_2)$; individuals supply more labor when they work in the more expensive city.

[4] For simplicity, we are implicitly assuming that labor is the only factor of production, so that firms will be indifferent in hiring if the wage is the same in the two cities. This would not be true, for example, if land were a major factor of production, and had differing prices in the two cities.

Suppose instead we focus on the effect of a wage change in a *local* labor market (examining people who would not move in response to a small change in the wage):[5]

$$\frac{\partial h(w, p_j)}{\partial w} = \frac{(1-\delta)(N - cp_j)}{w^2}. \tag{7}$$

Notice that in this example, the responsiveness of labor supply to a wage change is greater in the inexpensive city than in the inexpensive city, $\frac{\partial h(w,p_2)}{\partial w} > \frac{\partial h(w,p_1)}{\partial w}$.

In contrast, if we are interested in the effect on labor of a change in non-labor income,

$$\frac{\partial h(w, p_j)}{\partial N} = \frac{-(1-\delta)}{w}. \tag{8}$$

this relationship is independent of the local price, i.e., could be written $\frac{\partial h(w)}{\partial N}$.

Case 2. Differing Levels of Productivity. Now suppose that locations 1 and 2 are viewed as equally pleasant, $A^1 = A^2$, but productivity is higher in location 1 than in location 2, so that $w_1 > w_2$. The equilibrium condition corresponding to (5), that the marginal individual is indifferent between locations (i.e., $V^{i1} = V^{i2}$), is then

$$\frac{(N + w_1 - cp_1)}{p_1^{\delta} w_1^{1-\delta}} = \frac{(N + w_2 - cp_2)}{p_2^{\delta} w_2^{1-\delta}}. \tag{9}$$

As for labor supply, in city j,

$$h(w_j, p_j) = \frac{\delta w_j - (1-\delta)(N - cp_j)}{w_j}. \tag{10}$$

In general labor supply differs in the two locations, but even with $p_1 > p_2$ and $w_1 > w_2$ we cannot predict which location will have higher labor supply. Similarly, in general $\frac{\partial h(w_1,p_1)}{\partial w} \neq \frac{\partial h(w_2,p_2)}{\partial w}$, and we cannot say in which city labor supply is more responsive to wage changes. On the other hand, in this example the derivative of labor supply with respect to non-labor income,

$$\frac{\partial h(w_j, p_j)}{\partial N} = \frac{-(1-\delta)}{w_j}, \tag{11}$$

turns out to be independent of p_j. In this example the derivative of labor supply with respect to non-labor income does not depend on the local price p, but because in equilibrium the high-productivity city has relatively higher wages, we expect to observe that $\partial h/\partial N$ will be smaller (in absolute value) in the expensive city.

Our examples illustrate two important points. First, cross-sectional variation in wages prices may be associated with variation in labor supply, though that cross-sectional variation

[5] In general, if the wage increases in a labor market, this can attract new individuals to that location. Here we are interested in the effect on the labor supply of individuals who are already in the market, for example people who have an idiosyncratic taste for that location.

is of no value for understanding the behavioral effect of wage changes on labor supply. For instance, in our Case 2, even if in both cities $\frac{\partial h(w_j, p_j)}{\partial w} > 0$, identical individuals may well supply *less* labor in the high-wage city than in the low-city. Second, the responsiveness of labor supply to changes in the wage or non-labor income will typically vary across location.

2. When Does Price Variation Matter for Local Labor Supply?

As we noted in the introduction, there is massive price variation in housing prices across U.S. cities, presumably owing to differences in consumption or production amenities across these locations. The examples given in the last section indicate that labor supply will vary across locations even in the unusually simple and transparent case of Stone-Geary preferences. We next turn to a more systematic investigation of conditions on preferences under which price and income effects on labor supply do not depend on location. As is common in the literature, we restrict attention to the case of quasi-homothetic preferences (of which Stone-Geary is a special case). Having accepted this common simplification, we ask what further restriction are necessary to allow investigators to ignore variation across locations when examining labor supply.[6]

Given quasi-homothetic preferences, indirect utility takes the form

$$V(p, w, N) = \alpha(p, w) + (N + w)\beta(p, w), \tag{12}$$

where, as before, p is a local price, w is a local wage, and N is a non-labor income. Using Roy's identity we derive the demand for leisure,

$$l(p, w, N) - 1 = -\frac{\partial V/\partial w}{\partial V/\partial N} = -\frac{\alpha_w(p, w) + \beta(p, w) + (N + w)\beta_w(p, w)}{\beta(p, w)} = \\ -\frac{\alpha_w(p, w) + (N + w)\beta_w(p, w)}{\beta(p, w)} - 1,$$

$$l(p, w, N) = -\frac{\alpha_w(p, w) + (N + w)\beta_w(p, w)}{\beta(p, w)}. \tag{13}$$

Then hours of labor supply are

$$h(p, w, N) = 1 - l(p, w, N) = 1 + \frac{\alpha_w(p, w) + (N + w)\beta_w(p, w)}{\beta(p, w)} := a(p, w) + (N + w)b(p, w), \tag{14}$$

where $a(p, w) = 1 + \frac{\alpha_w}{\beta}$, $b(p, w) = \frac{\beta_w}{\beta}$.

[6]We could attempt to analyze cases that are more general yet, but as we shall see matters are sufficiently discouraging even for the quasi-homothetic case.

Consider the effect of the change in non-labor income on the labor supply, $\dfrac{\partial h}{\partial N} = b(p,w) = \dfrac{\beta_w(p,w)}{\beta(p,w)}$. Obviously, $\dfrac{\partial h}{\partial N}$ is independent of p (and thus is the same across locations) if and only if $b(p,w) \equiv b(w)$. The next claim provides the condition under which this holds.

Claim. $\dfrac{\beta_w(p,w)}{\beta(p,w)} = b(w) \iff \beta(p,w) = \beta_1(p)\beta_2(w)$.

Proof. The proof of sufficiency is trivial. To prove necessity we have

$$\begin{aligned}
\frac{\beta_w(p,w)}{\beta(p,w)} &= b(w),\\
\frac{\partial}{\partial w}\ln\beta(p,w) &= b(w),\\
\ln\beta(p,w) &= \int b(w)dw + c(p),\\
\beta(p,w) = e^{\int b(w)dw + c(p)} &= \beta_1(p)\beta_2(w),
\end{aligned}$$

where $\beta_1(p) = e^{c(p)}$, $\beta_2(w) = e^{\int b(w)dw}$. □

The above observations can be summarized in the following proposition:

Proposition 1. *When preferences are quasi-homothetic,* $\dfrac{\partial h}{\partial N}$ *is independent of location if and only if preferences satisfy a separability condition* $\beta(p,w) = \beta_1(p)\beta_2(w)$*.*

Next consider the response of the demand for leisure to wage changes, $\dfrac{\partial h}{\partial w} = a_w(p,w) + b(p,w) + (N+w)b_w(p,w)$. Again, the goal is to derive conditions under which $\dfrac{\partial h}{\partial w}$ does not depend on local prices p. If $b(p,w) = b(w)$, as above, then the only other necessary condition is to have $a_w(p,w)$ independent of p. Now $a_w(p,w)$ is independent of p if and only if it is equal to some function of w only: $a_w(p,w) = f(w)$. Integrating both parts with respect to w, we get $a(p,w) = F(w) + c(p)$. Then the supply of hours of work takes an additively-separable form $h(p,w,N) = c(p) + F(w) + (N+w)b(w)$.

We have established, therefore,

Proposition 2. *When preferences are quasi-homothetic,* $\dfrac{\partial h}{\partial w}$ *and* $\dfrac{\partial h}{\partial N}$ *are independent of location if and only if the demand for leisure has additively-separable form*

$$h(p,w,N) = c(p) + F(w) + (N+w)b(w). \tag{15}$$

Notice that in (15) the effect of local price variation is to simply shift the labor supply function up or down. In this case, it might suffice to merely incorporate location-specific dummies when estimating labor supply functions.[7] Absent this separability, though, local

[7]In fact, in empirical work on labor supply, researchers generally do not even take this simple step.

price variation would have a fundamental impact on the shape of the labor supply function itself.

These two propositions demonstrate that even in the simple case of quasi-homothetic preferences, one needs rather strong conditions in order to have location-independent labor supply responses to income and wage changes.

The Stone-Geary example used in the previous section illustrates the point. Notice that indirect utility can be written in the form $V = \alpha(p, w) + (N + w)\beta(p, w)$, where

$$\alpha(p, w) = -\frac{cp\theta A\delta^{\delta}(1-\delta)^{1-\delta}}{p^{\delta}w^{1-\delta}} = -cp^{1-\delta}\theta A\delta^{\delta}(1-\delta)^{1-\delta} \cdot \frac{1}{w^{1-\delta}}, \tag{16}$$

$$\beta(p, w) = \frac{\theta A\delta^{\delta}(1-\delta)^{1-\delta}}{p^{\delta}w^{1-\delta}} = \frac{\theta A\delta^{\delta}(1-\delta)^{1-\delta}}{p^{\delta}} \cdot \frac{1}{w^{1-\delta}}. \tag{17}$$

Since $\beta(p, w)$ is separable in p and w, the separability condition of Proposition 1 is satisfied. Recall from (6) that $h(p, w, N) = \dfrac{\delta w - (1-\delta)(N - cp)}{w}$. Obviously, this function does not have an additively-separable form from Proposition 2. So we are not surprised to see that indeed the derivative of labor supply with respect to non-labor income N, $\dfrac{\partial h}{\partial N} = -\dfrac{(1-\delta)}{w}$, is independent of p, while the derivative of leisure with respect to wage w, $\dfrac{\partial h}{\partial w} = \dfrac{(1-\delta)(N - cp)}{w^2}$, depends on p.

The primary object of study in labor supply is the responsiveness of labor supply to changes in the wage. We would like to know if observed price variation is important to understanding this issue. Ideally we would like to observe an experiment in which wages are exogenously shifted in each of many different U.S. cities and then trace out changes in labor supplied in each city. Finding data that correspond to such an experiment is a tall order. The work that follows instead focuses exclusively on the sensitivity of labor supply to non-labor income. We can justify this focus with the following result:

Proposition 3. *In general labor supply $h(p, w, F)$ depends on the price of the local good, the wage, and full income $F = w + N$.*[8] *If the key relationship $\dfrac{\partial h}{\partial w}$ is independent of p, then $\dfrac{\partial h}{\partial N}$ is independent of p.*

To prove this proposition we consider first the effect of a change in non-labor income on labor supply, $\dfrac{\partial h(p, w, F)}{\partial N} = \dfrac{\partial h(p, w, F)}{\partial F} \cdot \dfrac{\partial F}{\partial N} = \dfrac{\partial h(p, w, F)}{\partial F}$. This is independent of price p if and only if

$$\frac{\partial h(p, w, F)}{\partial F} = G(w, F). \tag{18}$$

[8] Recall that fulltime work entails $h = 1$, so that the maximum possible labor income is w, making full income $w + N$.

Integrating both sides of (18) we then notice that labor supply must have following additively separable form:

$$h(p,w,F) = g(w,F) + c(p,w) = g(w,w+N) + c(p,w). \tag{19}$$

Similarly, the effect of the change in wages on labor supply does not depend on p if and only if

$$\frac{\partial h(p,w,F)}{\partial w} = Q(w,F), \tag{20}$$

or, integrating both sides,

$$h(p,w,F) = q(w,F) + k(p) = q(w,w+N) + k(p). \tag{21}$$

Compare the additive separability requirements (19) and (21). The latter takes the same basic form, but is more restrictive. It follows that when $\frac{\partial h}{\partial w}$ is independent of local price p, $\frac{\partial h}{\partial N}$ is independent of the local price p.

3. Empirical Results

Theoretical considerations outlined in the preceding section suggest that unless one is willing to place strong restrictions on preferences, labor supply responsiveness to non-labor income and to the wage will vary across locations. It is possible, of course, that in reality the differences are insignificant and do not pose a problem for empirical work. We examine this possibility using a data set of married white women—a group that is likely to have substantial variation in labor supply (e.g., in response to differences in wage, non-labor income, and possibly local prices). Data used in the analysis are from 1990 Public Use Micro Sample (PUMS);[9] data include married non-Hispanic white women, aged 30 to 50, who live in the 50 largest Metropolitan Statistical Areas (MSAs) in the United States.

The goal of this exploration is to see if there are systematic differences in labor supply related to differences in local prices. We look at the relationship between labor supply and non-labor income, using as our definition family income minus the woman's own income. Given previous research on married women's labor supply, one would generally expect to find an inverse relationship between non-labor income and labor supply, i.e., leisure is likely a "normal good." The question examined here is whether that relationship differs in a systematic way across cities.

[9] Data were provided by Minnesota Population Center, Ruggles et al. (2004).

We understand that examining the relationship between non-labor income and married women's labor labor supply in cross-section is far from the "state of the art" in estimating labor supply. Still, it seems to us to be a reasonable first pass at the issue, especially given that our focus is not so much on any estimated relationship *per se*, but on differences in the relationships in expensive and inexpensive urban areas.

In our investigation of the differences in the response of labor supply to the change in non-labor income, we do not want to specify any parametric form because of concerns that results might be sensitive to the functional form.[10] Instead we use a non-parametric matching estimator. Two measures of labor supply are used: *annual hours* of work and an *employment participation* dummy variable.[11] The data do not allow us to perform this analysis for each city because it does not provide enough support. Instead we divide the sample roughly into thirds and examine differences between the most "expensive" cities (the 17 MSAs within top one third of housing prices) and "inexpensive" cities (the 17 MSAs with the lowest housing prices).

Our comparison of married women's labor supply in inexpensive and expensive cities then follows three additional steps. The first step is to place households into deciles according to "non-labor income" (which is predominately the husband's income). Then within each decile we compare the labor supply of women who live in the expensive cities relative to the labor supply of women who live in inexpensive cities. The goal is to compare the labor supply of otherwise similar women, so we use an estimator the matches women with exactly the same age and level of education. Separate analyses are also conducted for women with high school education and college education. Thus, the second step is to match each woman living in an expensive city with the corresponding women living in inexpensive cities, i.e., match each woman in each non-labor income decile d_i $(i = 1, \dots, 10)$, with age and education vector $x = X$, to women with these same characteristics living in inexpensive cities. In the analysis that centers on annual work hours this is

$$\Delta(X, d_i) = E(h_1|x = X, d_i) - E(h_0|x = X, d_i), \tag{22}$$

where h_1, h_0 are annual hours of work in expensive and inexpensive city respectively. In the absence of selection, this might be taken to be the causal effect on labor supply (measured in hours per year) of living in an expensive city relative to an inexpensive city. The third

[10] See, for example, DaVanzo et al. (1973).

[11] We also repeated the analysis with several other measures of labor force participation such as indicator of full-time position, for instance. The results remain essentially the same.

step is to average across all women in each decile d_i:

$$\Delta_n(d_i) = \int \Delta(x|d_i) dF_n(x|i),$$

where $dF_n(x|d_i)$ is the national distribution of x in the decile d_i.

Our analysis is repeated using a second measure of labor supply—a labor force participation dummy variable. When these empirical exercises are carried out separately for women with high school degree and with college degree, X is simply an age vector.

Results are reported in Table 1. The difference in annual hours of work between women living in expensive and inexpensive cities is substantial (and statistically significant) for many of the non-labor income deciles. For example, in ninth decile women in expensive cities work considerably longer hours than corresponding women in inexpensive cities. College educated women in this decile work on average 129 hours more, while women with high school education work on average 89 hours more.

There is an apparent and striking pattern depicted in Table 1 and illustrated in Figure 1. First, we notice, that as we might have expected, among these married women leisure appears to be a normal good; women with higher levels of outside income generally work fewer hours per year and have lower participation rates. More importantly, for our purposes, the relationship between non-labor income and labor supply is quite different for expensive and inexpensive cities. At the very lowest levels of non-labor income (e.g., deciles 1 and 2), women living in expensive cities have lower labor supply than women living in inexpensive cities. For the most part, the opposite is true for women in the high non-labor income deciles; among women with high non-labor income, labor force participation and average hours worked are higher in expensive cities than in inexpensive cities.

In short, the labor/leisure choice appears not to conform to the additively separable form described in Proposition 2; local prices do not merely shift labor supply up or down. We see that the derivative $\partial h/\partial N$ is observed to be generally negative (at least beyond the lowest decile levels of N), and is be smaller (in absolute value) in the expensive city. This generalization holds true for both high school and college educated women.

Also, as we have noted, results are similar when we use "average hours" or "labor force participation rates" as our measure of labor supply. It is worth noting that in these cities 66% of high-school educated women and 70% of college educated women are employed on average. Thus percentage point differences of 5 to 7, between expensive and inexpensive cities, represent differentials of 8 to 10 percent, which seem to us to be quite substantial.

The non-parametric approach we have taken does have one disadvantage: The non-labor income distribution within each decile might be somewhat different for women in the expensive cities than in the inexpensive cities. An alternative flexible parametric approach to estimation, described in the Appendix, provides nearly identical inferences.

Our empirical findings are roughly consistent with Case 2 examined in Section 1 above. In that equilibrium example, with Stone-Geary preferences, we notice that the responsiveness of labor supply to non-labor income must be greater in inexpensive (low-productivity) cities than expensive (high-productivity) cities.

4. Concluding Remarks

We have described a simple model to demonstrate that the effects of wage and non-labor income on labor supply will typically differ by location. We show, in particular, the derivative of the labor supply with respect to non-labor income will be independent of price only when labor supply takes a form based on an implausible separability condition.

Empirical evidence demonstrates that the effect of price on labor supply is not a simple "up-or-down shift" that would be required to meet the separability condition in our key proposition. For example, among women with low non-labor income, living in an inexpensive city is associated with *higher* labor force participation and *longer* work hours, while among women with high non-labor income, living in an inexpensive city is associated with *lower* labor force participation and *shorter* work hours.

This work has a number of implications for empirical strategies in estimating labor supply and also for other policy research. First, our research makes clear it that empirical work should never use cross-sectional variation in wages to estimate parameters in labor supply models. We document big differences in quantity of labor supplied across cities (for married women) that may have little to do with behavioral responses to cross-sectional variation in the wage.

Second, because labor supply elasticities will vary by location, researchers must be careful in interpreting results based on instrumental variables (IV) strategies. For example, suppose an IV approach is used in which the IV is the price of coal. Variation in the price of coal arguably serve as an excellent source of wage variation in the coal industry, but the resulting estimates of the effect on labor supply would apply only for the regions where the coal industry is a major employer. If local prices differ in those regions from other parts of the country, the estimated relationships will not be generalizable for the country as a whole.

Third, using a back-of-the-envelope example, we show that the evidence we present in Table 1 is consistent with the possibility that wage elasticities or labor supply (for married women) are quite different across cities. Notice that the Slutsky equation, in elasticity form, gives the relationship

$$\varepsilon_w = \varepsilon_w^H + \left[\frac{wh}{N}\right]\varepsilon_N, \tag{23}$$

where ε_w is the observed wage elasticity of supply, ε_w^H is the corresponding Hicksian elasticity (reflecting the pure substitution effect), and ε_N is the elasticity of labor supply with respect to non-labor income. Now consider college-educated married women at the median level of non-labor income. Notice that if we take as causal the relationship drawn in Figure 1, going from the 4th to 6th deciles in income we would estimate a non-labor income elasticity $\varepsilon_N = -0.46$ in the expensive cities and -0.29 in the inexpensive cities. Suppose that the Hicksian elasticity is $\varepsilon_w^H = 0.50$ (and is the same in both cities). We estimate that for the average woman at the 4th decile wh/N is 0.57 in inexpensive cities and 0.61 in expensive cities.[12] Thus the the uncompensated labor supply elasticity is more than a third higher in expensive cities than inexpensive cities, 0.33 vs. 0.24.

Fourth, as an example of an application to policy-related research, we notice that there may be locational differences in the response of female labor supply to changes in taxes. Changes in income taxes, for instance, would have different effects in different cities. A closely related implication centers on the analysis of social welfare policy. (Recall, for example, that it is wives of husbands with low earnings who work less in more expensive cities.) We believe that further analysis of policy implications is warranted.

[12]In fact, the ratio of women's earnings to non-labor household income (primarily men's earnings) is larger in expensive cities than in inexpensive cities at every decile.

Appendix

The empirical inferences drawn in Table 1 are based on an entirely non-parametric approach. We divided our sample into ten non-labor income deciles, and compared labor supply across women within each of these cells. Our central finding is that for women in low non-income deciles labor supply is *lower* in expensive cities than in inexpensive cites, while for women in high non-income deciles labor supply is *higher* in expensive cities than in inexpensive cities.

Here we present a flexible parametric approach that, as it turns out, leads to this same inference. The idea we implement here is to estimate labor supply regressions using as independent variables *age*, entered as 21 dummy variables for each age, 30 to 50 inclusive, and *non-labor income,* entered as a fourth-order polynomial. We estimate these labor supply regressions—separately for high-school women and college women and separately for each of our labor supply variables (*employment* and *hours worked*)—using the sample of women from the expensive cities. We similarly estimate corresponding regressions using the sample of women from the inexpensive cities. Then for each woman i who lives in the expensive cities we estimate the outcome of interest $\hat{y}_{1i}$ (e.g., "predicted" employment, or "predicted" hours worked) using the regression parameter from the *expensive* city, and similarly estimate $\hat{y}_{0i}$ using regression parameters from the *inexpensive* city. Finally we form the estimated gap,

$$\hat{\Delta}_i = \hat{y}_{1i} - \hat{y}_{0i}$$

for each individual. Notice that this last quantity is the "impact of the treatment on the treated" where the "treatment" is being located in an expensive city rather than in an inexpensive city.

To summarize findings in a way that will be comparable to Table 1, we aggregate estimates into deciles of non-labor income. We report 95 percent confidence intervals in brackets based on a bootstrap procedure with 999 replications in Table 3.

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FIGURE 1. Variation Between Expensive and Inexpensive Locations in Annual Hours and Participation Rates, by Non-Labor Income Decile

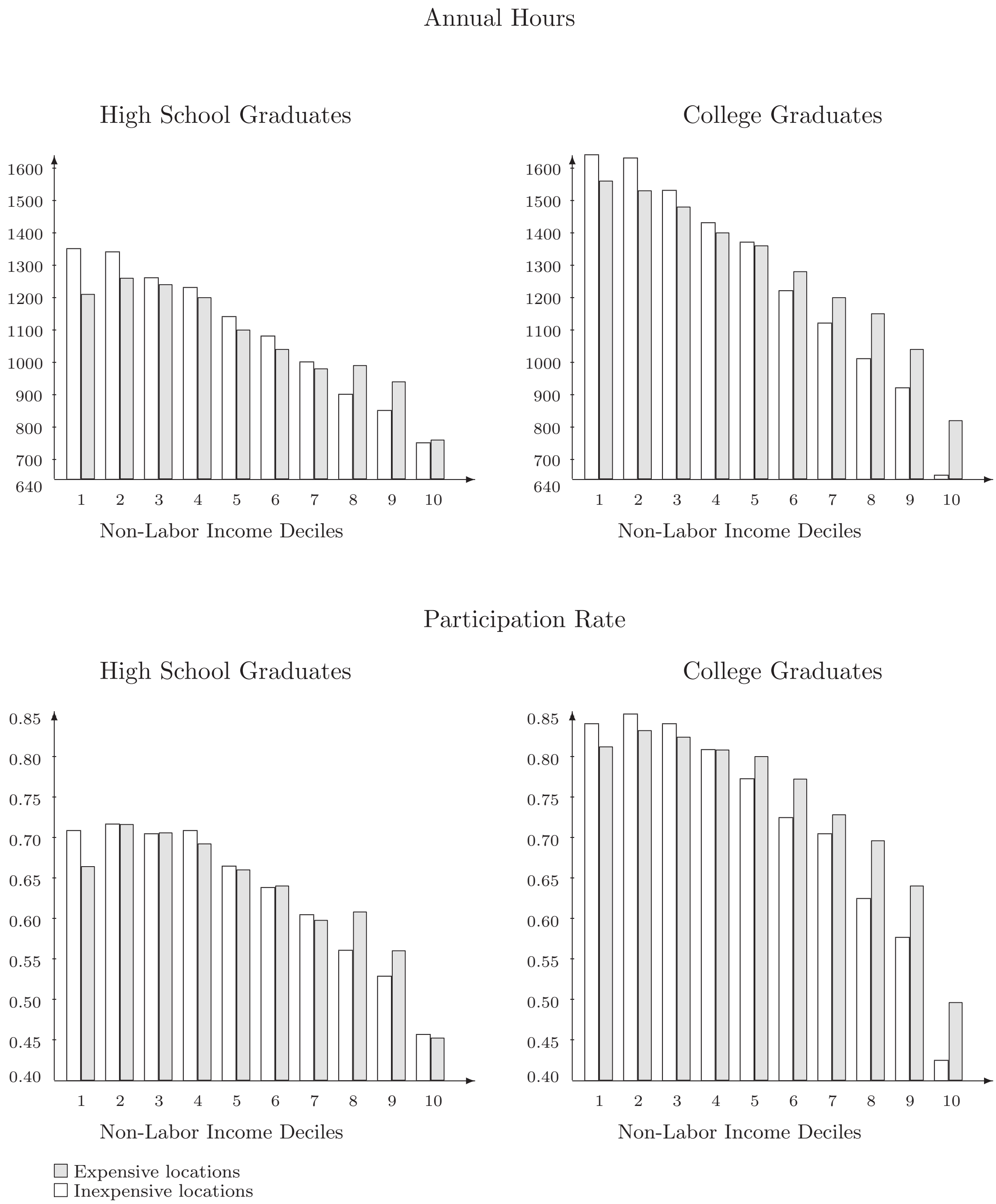

TABLE 1. Differences in Annual Hours and Participation Rates Between Expensive and Inexpensive Locations by Non-Labor Income Deciles

	All women		Women with HS degree		Women with college degree	
Non-labor income decile	Δ in annual hours	Δ in participation rates	Δ in annual hours	Δ in participation rates	Δ in annual hours	Δ in participation rates
d1	-117.34	-0.04	-136.10	-0.04	-78.08	-0.02
	(14.23)	(0.0065)	(24.57)	(0.012)	(34.88)	(0.016)
d2	-75.46	-0.01	-75.72	0.00	-99.43	-0.02
	(14.32)	(0.0063)	(24.36)	(0.011)	(36.47)	(0.016)
d3	-54.14	-0.01	-19.42	0.00	-46.71	-0.01
	(13.74)	(0.0060)	(23.39)	(0.012)	(33.98)	(0.015)
d4	-15.14	0.00	-28.97	-0.01	-20.59	0.00
	(13.88)	(0.0062)	(23.63)	(0.012)	(37.16)	(0.016)
d5	-20.68	0.01	-51.79	0.00	-13.31	0.03
	(13.31)	(0.0063)	(24.14)	(0.012)	(34.57)	(0.015)
d6	2.59	0.02	-39.52	0.00	59.98	0.05
	(13.66)	(0.0068)	(24.14)	(0.013)	(31.66)	(0.015)
d7	12.47	0.01	-16.11	0.00	85.60	0.03
	(14.38)	(0.0072)	(24.79)	(0.013)	(30.99)	(0.015)
d8	83.55	0.05	81.95	0.05	139.38	0.08
	(14.62)	(0.0076)	(26.78)	(0.014)	(30.24)	(0.015)
d9	83.61	0.04	88.98	0.03	128.59	0.06
	(15.80)	(0.0083)	(33.44)	(0.017)	(30.84)	(0.016)
d10	82.59	0.04	15.74	0.00	172.35	0.07
	(18.45)	(0.0098)	(41.52)	(0.023)	(28.04)	(0.015)

Notes: Authors' calculations, Five-Percent 1990 PUMS. Sample consists of white, non-Hispanic married women, aged 30 to 50. Bootstrapped standard errors using 999 replications reported in parentheses.

TABLE 2. Differences in Annual Hours and Participation Rates Between Expensive and Inexpensive Locations by Non-Labor Income Deciles, Parametric Approach

	Women with HS degree		Women with college degree	
Non-labor income decile	Δ in annual hours	Δ in participation rates	Δ in annual hours	Δ in participation rates
d1	-128.7 (22.04)	-0.034 (0.0110)	-118.1 (34.23)	-0.027 (0.0143)
d2	-93.4 (12.42)	-0.021 (0.0066)	-72.5 (17.76)	-0.016 (0.0079)
d3	-68.6 (11.10)	-0.013 (0.0059)	-36.6 (16.07)	-0.002 (0.0074)
d4	-47.1 (10.82)	-0.005 (0.0056)	-9.5 (15.23)	0.009 (0.0071)
d5	-28.1 (10.26)	0.001 (0.0056)	19.1 (14.59)	0.021 (0.0066)
d6	-2.1 (11.15)	0.01 (0.0056)	46.5 (14.18)	0.032 (0.0066)
d7	23.8 (12.73)	0.019 (0.0061)	76.5 (14.59)	0.045 (0.0071)
d8	55.3 (15.28)	0.030 (0.0077)	108.6 (17.27)	0.058 (0.0082)
d9	87.5 (20.48)	0.042 (0.0102)	143.5 (20.89)	0.075 (0.0099)
d10	81.6 (38.06)	0.036 (0.0207)	123.1 (30.26)	0.066 (0.0151)

Notes: Authors' calculations, 1990 PUMS. Sample is all married, white, non-Hispanic women between the ages of 30 and 50 inclusive. The covariates are nonlabor income and age. Using fourth-order polynomial, we use the sample of women from expensive cities to estimate the outcome of interest, which we denote $\hat{y}_{1i}$ for the ith women. Using the sample of women from inexpensive cities, we estimate parameters for a fourth-order polynomial and then evaluate the function using the covariates of women from the expensive city sample, which we denote $\hat{y}_{0i}$ for the ith women. We then form the parameter for the "impact of treatment on the treated" as $\hat{\Delta}_i = \hat{y}_{1i} - \hat{y}_{0i}$. We then aggregate estimates into deciles of nonlabor income. We report standard errors based on bootstrap with 999 replications.