Journal of Economic Literature 2012, 50:2, 464–476
http:www.aeaweb.org/articles.php?doi=10.1257/jel.50.2.464

Micro and Macro Labor Supply Elasticities: A Reassessment of Conventional Wisdom

Michael Keane and Richard Rogerson*

The response of aggregate labor supply to various changes in the economic environment is central to many economic issues, especially the optimal design of tax policies. Conventional wisdom based on studies in the 1980s and 1990s has long held that the analysis of micro data leads one to conclude that aggregate labor supply elasticities are quite small. In this paper we argue that this conventional wisdom does not hold up to empirically reasonable and relevant extensions of simple life cycle models that served as the basis for these conclusions. In particular, we show that several pieces of conventional wisdom fail in the presence of human capital accumulation or labor supply decisions that allow for adjustment along both the extensive and intensive margin. We conclude that previous estimates of small labor supply elasticities based on micro data are fully consistent with large aggregate labor supply elasticities. (*JEL* D91, E24, J22)

1. *Introduction*

The magnitude of aggregate labor supply responses to various changes in the economic environment is important for a range of economic questions, including, for example the optimal design of tax policy. In addition to being important, the exact magnitude of this response is also well known to be quite controversial. Simply put, researchers who look at micro data typically estimate relatively small labor supply elasticities. But researchers who use representative agent models to study aggregate outcomes typically employ parameterizations that imply relatively large aggregate labor supply elasticities.

In this paper, we argue that this apparent inconsistency is more fiction than fact. Specifically, we argue that a key source of the controversy lies in the fact that many economists have failed to realize that some key pieces of conventional wisdom about labor supply, derived from simple benchmark models used to guide empirical work back in the 1980s and 1990s, do not hold more generally. When one views the situation through the lens of extensions of those simple benchmark models that address some of their key

* Keane: University of New South Wales. Rogerson: Princeton University. We thank Raj Chetty and Christian Haefke for comments. Rogerson thanks both the NSF and the Korea Science Foundation (WCU-R33-10005) for financial support. Keane thanks the Australian Research Council (grant FF0561843).

empirical limitations, many of these pieces of conventional wisdom are no longer valid, and the basis for asserting the inconsistency seemingly vanishes.

A key point we wish to stress from the outset is that, in general, labor supply elasticities are neither a single number nor a primitive feature of preferences. While such an interpretation may be warranted in some contexts under specific assumptions, in general it is problematic. We believe that one important source of confusion in the literature is the idea that one can estimate a labor supply elasticity in one context and import this elasticity into other contexts. We therefore think it is important for economists to adopt a framework where the choice problem of an individual is explicitly formulated, and where the parameters that characterize this choice problem are the key parameters that determine responses of various components of individual labor supply to changes in the economic environment. As a result, we will adopt a structural perspective in this article.

An outline of our paper follows. In the next section, we describe a simple benchmark model that serves to highlight several messages that emerged from research in the 1980s and 1990s, and we discuss why they suggest the existence of a micro versus macro controversy. Section 3 describes several empirically relevant extensions to this benchmark model and shows how they challenge each of these messages, and, as a result, challenge the idea that there is indeed any controversy. Section 4 concludes by describing what we feel are important directions for future research.

2. *Background*

In this section, we present a benchmark model that connects elasticity estimates from panel data with those from aggregate data and which will serve to highlight many ideas about labor supply that persist and that we want to challenge.

2.1 *Benchmark Model*

In each period, a T-period lived household is born with preferences:

$$(1) \quad \sum_{a=0}^{T} \beta^a \left[\frac{1}{1-\frac{1}{\eta}} c_a^{1-\frac{1}{\eta}} - \frac{\alpha}{1+\frac{1}{\gamma}} h_a^{1+\frac{1}{\gamma}} \right],$$

where a denotes age and c_a and h_a are consumption and hours worked at age a respectively. The individual is endowed with one unit of time each period, and faces an exogenous productivity sequence over his life cycle. Specifically, an individual of age a has productivity e_a, so that if he supplies h_a units of time at age a it results in $e_a h_a$ units of labor services, which have unit price w.

To illustrate some key ideas, we consider a tax and transfer system where labor earnings are taxed at the constant rate τ and revenues are used to fund a lump-sum transfer T. In order to abstract from issues of intergenerational redistribution, we assume the lump-sum transfer received by any generation is equal in present value to the tax revenues that they pay.[1] In an infinitely lived agent version of the growth model with a constant returns to scale aggregate production function, neither the steady state wage or interest rate would be affected by this tax policy, and the steady state interest rate would exactly offset the discount factor β. Neither of these properties necessarily hold in an overlapping generations economy. But since our primary interest is in the effects of taxes controlling for changes in any other factors, such as interest rates and wages, for the benefit

[1] This simple tax and transfer system has little connection with the features of tax and transfer systems that we observe in reality. While its analysis is perhaps of limited direct interest in terms of policy analysis, it is very useful as a vehicle to exposit the central issues that we address. The effects of this type of tax/transfer policy correspond to the Hicks elasticity and hence provide a clean connection to the literature on elasticities.

of transparency we will study labor supply assuming these properties do hold.

In steady state, a newly born individual who starts life with zero wealth maximizes (1) subject to:

$$\sum_{a=1}^{T} \beta^a c_a = \sum_{a=1}^{T} (1-\tau)\beta^a e_a h_a w + T.$$

First order conditions for c_a and h_a are:

$$(2) \qquad c_a^{-\frac{1}{\eta}} = \lambda$$

$$(3) \qquad \alpha h_a^{\frac{1}{\gamma}} = (1-\tau)\lambda e_a w,$$

where λ is the multiplier on the budget equation. Equation (2) implies that c_a will be constant over the life cycle.[2] Taking logs of equation (3) gives a simple version of the equation used by MaCurdy (1981) and others in their estimation exercises using micro data:

$$(4) \qquad \log h_a = b + \gamma \log e_a,$$

where $b = \gamma[\log \lambda + \log w + \log(1-\tau) - \log \alpha]$ is a constant from the perspective of following an individual over their life cycle in steady state, and changes in $\log e_a$ are equivalent to changes in log wages for individuals over the life cycle. It follows that this equation (or its equivalent form in first differences: $\Delta \log h_a = \gamma \Delta \log e_a$) provides a strategy for uncovering the preference parameter γ using individual panel data. MaCurdy (1983) shows how one can also use (2) and (3) to uncover η, provided one has data on consumption.

Now consider the steady state effects of a change in the scale of the tax and transfer program, i.e., a change in τ, on hours of work. Equation (4) is not sufficient for this purpose since the value of λ will also differ across the two steady states. To solve for the change in h_a we need to solve for the change in λ. Straightforward manipulations, detailed in Keane and Rogerson (2011), yield:

$$(5) \quad \log h_a = \frac{\gamma}{\eta+\gamma}[(\eta-1)\log w - \eta \log \alpha - \log \bar{c} - \gamma \log e_0] + \frac{\gamma\eta}{\eta+\gamma}\log(1-\tau) + \gamma \log e_a,$$

where $\bar{c}$ is a constant. Note the different coefficients on $\log(1-\tau)$ and $\log e_a$. The coefficient on $\log(1-\tau)$ is always smaller than the coefficient on $\log e_a$, with equality holding in the limit as η goes to infinity, i.e., when utility is linear in consumption and there are no income effects. The effect of life cycle variation in wages represents the Frisch elasticity, whereas the coefficient on taxes represents the Hicks elasticity.

Since hours at all ages change by the same percentage, it follows that aggregate hours H in steady state satisfy:

$$(6) \quad \log H = B + \frac{\gamma\eta}{\eta+\gamma}\log(1-\tau),$$

where B is a constant. The key implication of (5) and (6) is that the aggregate elasticity is the same as the individual elasticity.

2.2 *Micro Evidence on γ Based on the Benchmark Model*

The previous discussion highlights the important role of γ for thinking about labor supply responses to changes in wages and/or taxes. The empirical literature that uses micro data to estimate this structural parameter is vast, so we focus on three influential papers from the early literature: MaCurdy

[2] There are various ways to avoid this counterfactual implication, such as letting the taste parameter α vary with age/demographics—see section 2.2.

(1981), Browning, Deaton, and Irish (1985), and Altonji (1986).[3] Details differ but all three estimate the preference parameter γ, or Frisch elasticity, by regressing hours changes on wage changes. For example, MaCurdy (1981) uses the same basic model described above—extended to allow for heterogeneity and uncertainty—to derive the hours change equation:

$$(7)\quad \Delta \log h_{it} = \gamma \Delta \log w_{it}(1-\tau_{it}) - \gamma \log \beta(1+r_t) + \alpha\gamma\Delta X_{it} + \gamma\xi_{it} + \gamma\Delta\varepsilon_{it},$$

where α, β, and γ are all as above, and we allow for the tax rate (τ_{it}) to vary across time and individuals. The X_{it} are controls for exogenous shifts in tastes for work, the ε_{it} represent unobserved taste shocks, and ξ_{it} represents the surprise part of the change in the marginal utility of wealth (or of consumption) from $t-1$ to t.[4]

Three issues receive considerable attention in this literature: First, ξ_{it} will generally be correlated with wage changes that are not fully anticipated at $t-1$. Second, tastes for work may be correlated with wages (e.g., those with a higher taste for work may also work harder or acquire more skills). Third, the wage is presumably measured with considerable error. To deal with these problems, all three of these influential papers instrument for wage changes, using variables that were presumably known at time $t-1$.

The three papers differ somewhat in their choice of instruments, observed taste shifters and functional forms. Nevertheless, all three obtain very small estimates of γ, the Frisch elasticity, with the preferred estimates being 0.15, 0.09, and 0.31, respectively, for MaCurdy, Browning et al, and Altonji. Since the Frisch elasticity is an upper bound on the Marshall and Hicks elasticities in this benchmark life-cycle labor supply model, it follows that the Marshall and Hicks elasticities (which are relevant for estimating responses to permanent tax changes) are small as well. In fact, MaCurdy shows that his estimates imply that a 10 percent (fully anticipated) increase in wages at all ages would increase labor supply by only 0.8 percent—a very small effect.

These sorts of results have led to a majority view in the profession that labor supply elasticities are quite small. In a recent survey, Saez, Slemrod, and Giertz (2012) write: " . . . optimal progressivity of the tax-transfer system, as well as the optimal size of the public sector, depend (inversely) on the . . . elasticity of labor supply . . . With some exceptions, the profession has settled on a value for this elasticity close to zero . . . In models with only a labor–leisure choice, this implies that the efficiency cost of taxing labor income . . . is bound to be low as well."

2.3 *Messages from the Earlier Literature*

In this subsection, we gather some key implications of the above discussion that we believe have come to be viewed as conventional wisdom.

- (**CW1**) Individual responses of hours to changes in wages are determined solely by preference parameters (i.e., γ and η).
- (**CW2**) Changes in log hours divided by changes in log wages (or taxes) for either anticipated or purely transitory changes are estimates of a structural preference parameter.

[3] For recent reviews of this literature, see Meghir and Phillips (2010) and Keane (2011b).

[4] MaCurdy (1981) did not allow for shocks to the marginal utility of wealth, but MaCurdy (1983) shows how to extend his previous analysis to include them. In terms of implementing the estimation procedure, the only impact is that one needs to lag the instruments, which MaCurdy (1981) actually did, even though he had not incorporated uncertainty formally in his model.

- (**CW3**) If preference parameters do not vary with age, message CW2 holds for individuals of any age.
- (**CW4**) Individual hours respond more to transitory changes in wages (or taxes) than to permanent changes.
- (**CW5**) Aggregate responses in hours are also determined solely by preference parameters, and are the same as individual responses.
- (**CW6**) γ is small.
- (**CW7**) The Frisch elasticity is small, implying that the Hicks and Marshall elasticities are even smaller.

Accepting these messages is tantamount to accepting the view that there is indeed a micro versus macro controversy. In the next section, we show how the recent literature challenges each of these findings in a fundamental way and, at the same time, resolves the controversy.

3. *Recent Challenges to Conventional Wisdom*

In this section, we describe recent work that challenges the conventional wisdom about labor supply outlined above. We will describe two extensions of the benchmark model in detail and then briefly mention a few others. The first extension adds a learning-by-doing human capital production technology, and the second extension specifies that the mapping from work hours to effective labor units involves a nonconvexity. Each of these modifications to technology turns out to have important effects on labor supply responses.

3.1 *Human Capital Accumulation*

The classic analyses of labor supply described in section 2 all assume wages evolve exogenously over the life cycle. Implicitly, these models assume that the approximate doubling of wages that is observed for the average person as they go from their early twenties to their mid-forties would still be realized if these individuals were to stay home and watch television for twenty years and then suddenly decide to look for a job. This seems an untenable position to us. It seems more plausible to think that workers acquire human capital via on-the-job investment in skills, or through learning by doing, implying that the life cycle growth in wages is in fact influenced by work decisions.

A key question is whether this more plausible view of life cycle wage growth alters the basic messages that emerge from analyses that assume exogenous wage growth. Heckman (1976) and Shaw (1989) are early examples of work that incorporated human capital accumulation into life cycle labor supply analysis, but neither considered explicitly the impact of adding human capital on estimates of preference parameters and labor supply responses. Imai and Keane (2004) did address this issue and here we summarize their work.

For ease of exposition, assume that wages are given by the simple equation:[5]

$$(8) \qquad w_{t+1} = \Big(1 + \kappa \sum_{j=0}^{t-1} h_{t-j}\Big) w_1,$$

where $\kappa > 0$ and w_1 represents a person's initial wage (or skill endowment) upon first entering the labor market. Given this simple functional form, a one unit increase in h_t raises the wage by κw_1 in all future periods. This, in turn, raises earnings by $\kappa w_1 h_{t+j}$ for $j = 1 \ldots T - t$.

In a model with human capital, the return to an hour of work, which we will refer to as

[5] In fact, Heckman (1976), Shaw (1989), and Imai and Keane (2004) all assume a much more complex wage process than that given in equation (8). The simple wage equation used here helps to clarify the key points, as it leads to a simple expression in equation (9).

the opportunity cost of time (OCT), consists of the after tax wage *plus* the expected present value of increased (after-tax) earnings in all future periods obtained by working an extra hour at time t. We will refer to the latter as the "human capital term" (HC).

The optimality condition for an interior solution for hours equates the marginal rate of substitution (MRS) between consumption and leisure to the OCT. In particular, using the same utility function as in the previous section we obtain:

$$(9)\qquad \frac{\alpha h_t^{\frac{1}{\gamma}}}{c_t^{-\frac{1}{\eta}}} = w_t(1-\tau_t) + E_t \sum_{j=0}^{T-t} \frac{\kappa w_1 h_{t+1+j}(1-\tau_{t+1+j})}{(1+r)^{1+j}}.$$

In a model without human capital, the MRS is equated to the after-tax wage and the human capital term on the right-hand side of equation (9) vanishes.

Imai and Keane (2004) estimate the intertemporal elasticity of substitution using a model that takes into account the HC term in (9). That is, they look at how hours respond to changes in the OCT, rather than the wage. They estimate their model using white males from the NLSY79. The men in their sample are aged 20 to 36 and, as the focus of the paper is solely on labor supply, they are required to have finished school. Imai and Keane (2004) estimate that $\gamma = 3.8$, clearly contradicting message CW6 in the previous section.

To gain intuition for these findings, consider figure 1, which presents a stylized (but fairly accurate) picture of how male wages and hours move over the life cycle. The line labeled "HC" in figure 1 represents the return to human capital investment, the second term on the right-hand side of equation (9). The HC curve decreases with age, both because of diminishing returns to human capital and because the worker approaches the end of the planning horizon T. Because the opportunity cost of time (OCT) equals the wage plus the human capital return, and because the HC term falls with age, the OCT curve is flatter than the wage curve. Indeed, the estimates in Heckman (1976), Shaw (1989), and Imai and Keane (2004) all imply it is much flatter.

Intuitively, the Imai–Keane estimate of γ can be understood as taking the ratio of the slope of the hours curve to the OCT curve in figure 1 while the conventional procedure takes the ratio of the slope of the hours curve to the wage curve. As the OCT curve is much flatter than the wage curve, Imai and Keane find a much larger estimate of the responsiveness of labor supply to the price of time than does the conventional procedure.

Introducing human capital causes some of the other messages of section 2 to fail as well. Consider table 1, which simulates the effects of permanent and transitory tax increases of five percentage points using the Imai–Keane estimates. (We thank Susumu Imai for providing us with these simulations.)[6] In the column labeled "transitory," the tax increase only applies for one year at the indicated age, whereas for the column labeled permanent the tax rate is assumed to be permanently higher. The permanent increase is compensated.[7]

In the transitory case, despite the fact that the value of γ does not vary with age, the hours response varies quite significantly

[6]We hold the pretax wage fixed in these experiments, consistent with the assumptions in section 2.1.

[7]When discussing transitory tax increases, we assume that the revenues are thrown away. This has virtually no effect on the results since the revenue generated from a transitory tax is sufficiently small that the income effects are too small to make much difference for the elasticity calculation (as any extra income is spread over the whole remaining life).

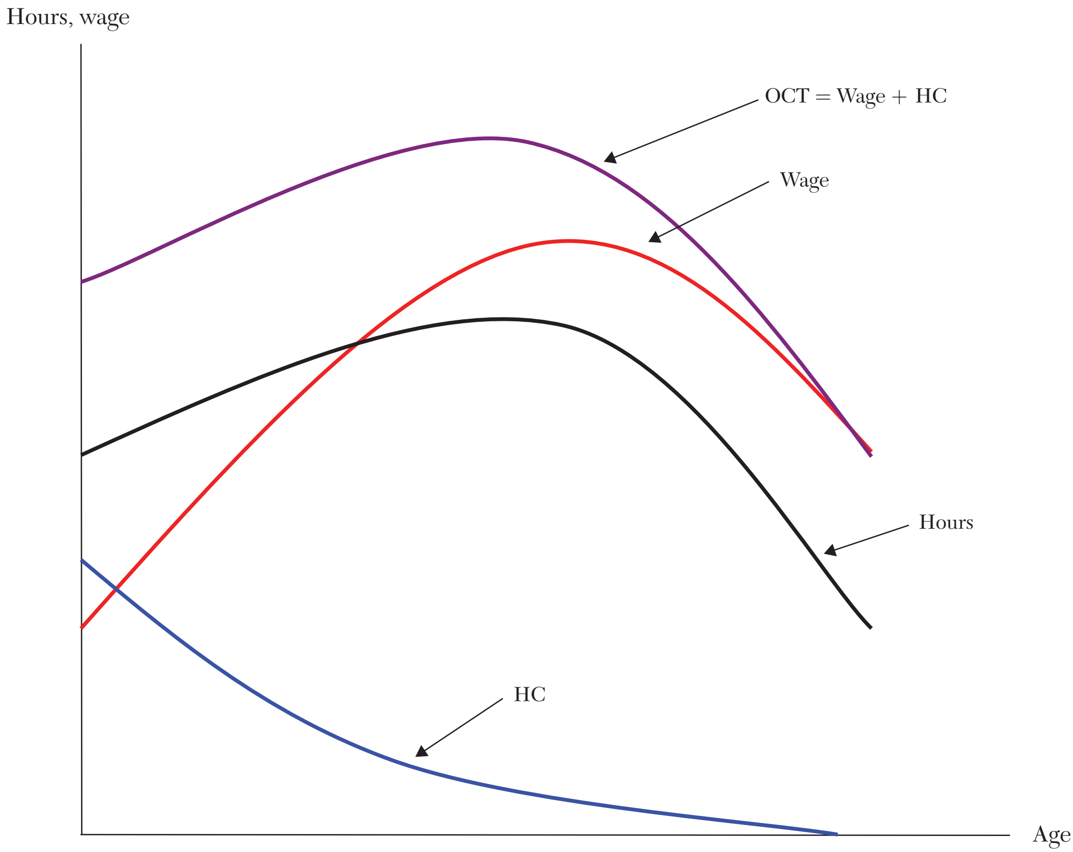

Figure 1. Hours, Wages and Price of Time over the Life Cycle

Note: HC denotes the return to an hour of work experience, in terms of increased present value of future wages. The opportunity cost of time is Wage + HC.

with age, contradicting message CW3 in the previous section. Specifically, at age 20, a temporary 5 percent tax increase reduces hours by 1.5 percent. This implies a labor supply elasticity with respect to transitory tax changes of approximately 0.3. In contrast, at age 60, a temporary 5 percent tax increase reduces hours by 8.6 percent, implying an elasticity of roughly 1.7, more than five times larger than the value for younger workers. However, since both figures are far smaller than the value of $\gamma = 3.8$, neither of these elasticities provide accurate estimates of the underlying preference parameter. Thus, we conclude that messages CW1, CW2, CW3, and CW6 all fail to hold in this model.

Why does the labor supply elasticity increase with age in this model? And why is the effect of transitory tax increases so small despite the high value of γ? Two observations help to explain this. First, a temporary tax increase alters the current after-tax wage in equation (9) but has no effect on the human capital component of the OCT. Second, at

TABLE 1
Effects of an Unexpected 5 percent Tax Increase on Hours Worked (in percent) in Imai–Keane

Age	Transitory	Permanent
20	−1.5	−3.2
25	−1.8	−2.7
30	−2.2	−2.4
35	−2.6	−2.3
40	−3.2	−2.3
45	−3.8	−2.8
50	−4.7	−4.2
60	−8.6	−10.5

young ages, the wage is a relatively small part of the opportunity cost of time (i.e., a large part of the return to work comes in the form of increased future wages).[8] Thus, the response to a transitory tax change is much less than the response to a change in the OCT. However, as workers age, the wage becomes a larger fraction of the OCT (see figure 1), and the hours response increases.

Next we contrast the responses to permanent and transitory changes. A striking result in table 1 is that, for younger workers, permanent tax increases have larger effects on current labor supply than do transitory tax increases. For instance, a 5 percent tax increase that takes place at age 25 reduces current hours by 1.8 percent for a transitory change but by 2.7 percent for a permanent change. So at age 25, the permanent tax effect is about 50 percent greater. This is in direct contradiction to message CW4. By the mid-30s, the effects of permanent and transitory tax cuts are roughly equal. Only in the 40s do effects of transitory tax cuts become somewhat larger.

Why can permanent tax changes have larger short run effects than transitory tax changes once human capital is introduced? As noted earlier, in equation (9), a transitory tax increase only directly reduces the current after-tax wage, which is just one component of the OCT. In contrast, a permanent tax increase also reduces the expected present value of future after-tax earnings, thereby reducing the human capital term in the OCT. Although a permanent tax change has a larger effect on the OCT, it also has a larger income effect. Thus, which has a greater effect depends on the size of experience returns relative to that of the income effect (see Keane 2011a for a detailed derivation). Experience returns are greater at younger ages, which explains why permanent tax changes have larger effects than transitory changes only at younger ages.

Finally, we consider the effects of a permanent tax increase on aggregate labor supply in a model with human capital. This is arguably more relevant in the context of optimal tax policy. Keane (2011a) uses the Imai–Keane model to simulate the impact of an unexpected permanent 5 percent tax rate increase (starting at age 20 and lasting through age 65) on labor supply over the entire working life. If the revenue is redistributed as a lump sum

[8] According to Imai and Keane's (2004) estimates, at age 20 the wage is less than half of the opportunity cost of time, but by age 40 the wage is 84 percent of the opportunity cost of time.

transfer, labor supply drops by 6.6 percent, implying a compensated (or Hicks) elasticity with respect to permanent tax changes of roughly 1.3. We conclude that message CW7 fails in this model. Interestingly, the initial impact on labor supply (at young ages) is very modest, but the effect becomes very large in the 50s and 60s. This is because the tax increase slows the rate of human capital investment, leading to substantial reductions in the pretax wage at older ages (see Keane 2011a for more details on these simulations).

3.2 *Models with Intensive and Extensive Margins*

In this section, we present a second extension of the benchmark model that emphasizes two distinct components of lifetime labor supply: the fraction of life spent in employment and the time devoted to work when employed. Our discussion is based on Rogerson and Wallenius (2009).[9]

The individual maximization problem is formulated in continuous time to make the fraction of life spent in employment a continuous variable. An individual has length of life normalized to one and preferences:

$$\int_0^1 \left[\log(c(a)) - \alpha \frac{h(a)^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right] da,$$

where $c(a)$ and $h(a)$ are consumption and time devoted to market work at age a, respectively. As in section 2, individual productivity varies over the life cycle and is denoted by $e(a)$ and there are complete markets for borrowing and lending, so the individual faces a present value budget equation.[10] Following Prescott, Rogerson, and Wallenius (2009), the key innovation relative to section 2 is a nonconvexity in the mapping from time devoted to work to the resulting labor services. In particular, if a worker of age a devotes h units of time to market work, it yields labor services of $g(h)e(a)$, where for ease of exposition $g(h)$ is assumed to take the form:

$$g(h) = \max\{h - \bar{h}, 0\}.$$

The key implication is that the relation between total labor earnings and hours devoted to market work is convex.[11] The present value budget equation is:

$$(10 \quad \int_0^1 c(a)da = w\int_0^1 \max\{h(a) - \bar{h}, 0\}e(a)da,$$

where w is the wage rate per unit of labor services, assumed to be constant.[12]

Thus far we have described a single agent decision problem. At the risk of trivializing general equilibrium considerations, but with a gain of transparency, assume a small open economy in which the real interest rate is exogenously fixed at zero, and an aggregate production function that is linear in labor services.[13]

Rogerson and Wallenius use this model to assess the quantitative consequences of a simple tax and transfer scheme in which a proportional tax on labor earnings is used

[9] Heckman (1984, 1993) had previously argued that explicit modeling of the extensive margin was a key step in building better empirical models of labor supply.

[10] See Wallenius (2010) for a version of this model that generates life cycle wage growth through human capital investment as an Imai and Keane (2004). In related work, Wallenius (2011) shows how distinguishing between intensive and extensive margins influences the estimation of γ.

[11] French (2005) assumes that labor earnings are given by $w(h-\bar{h})^{1+\theta}$, where $\theta > 0$. For the issues that we discuss here, the choice of formulation does not matter.

[12] Note that there is no discounting and the interest rate is set to zero, so that these two factors offset.

[13] The small open economy assumption is not essential since one can always specify a government debt policy that will support a steady state equilibrium with a zero interest rate.

TABLE 2
Estimated Micro Elasticities

$\gamma = 2.0$	$\gamma = 1.0$	$\gamma = 0.5$	$\gamma = 0.1$
1.29	0.59	0.28	0.05

to finance a uniform lump-sum transfer to all individuals. Specifically, they investigate how γ matters for the aggregate labor supply response. For each of several values of γ they choose values for the model's other parameters to match three targets: fraction of life spent in employment, peak hours worked over the life cycle, and wage changes over the life cycle. Because of the nonconvexities in the $g(h)$ function, wages per unit of time, denoted by w^h, are not the same as wages per unit of labor services.[14] The calibration assumes $e(a)$ is piecewise linear and the labor tax rate is 0.3.

Given a value of γ and the calibration procedure just described, the model will generate a life cycle profile for hours worked, $h(a)$, and hourly wages, $w^h(a)$. Using the portion of the life cycle with positive hours, Rogerson and Wallenius run the regression:

$$(11)\quad \log(h(a)) \;=\; b_0 + \tilde{\gamma}\log(w^h(a)) + \varepsilon(a).$$

The resulting parameter estimate $\tilde{\gamma}$ is the micro labor supply elasticity for individuals in the model, viewed through the lens of the standard model described in section 2. Table 2 shows the estimated values of $\tilde{\gamma}$ for the calibrated model for four different values of γ: 0.1, 0.5, 1.0, and 2.0.

[14] If the fixed time cost $\bar{h}$ were interpreted as a commuting cost, then this effect would not be present. This interpretation is not relevant for the main results reported below, but does have interesting implications for the connection between standard labor supply regressions and the underlying preference parameter γ.

Lower values of γ are associated with lower estimated elasticities, but interestingly, the estimated value of $\tilde{\gamma}$ is only about half as large as the true value of γ. It follows that message CW2 fails in this extension. The reason for this discrepancy is the nonlinearity of the earnings function in hours. In particular, the nonlinearity of g implies that higher hours worked imply higher hourly wage rates, so that $w^h(a)$ moves more over the life cycle than the underlying exogenous productivity profile $e(a)$.

Rogerson and Wallenius then examine what happens to aggregate hours if the tax rate is increased to 0.5, which corresponds to the average effective tax on labor income in several economies in continental Europe in recent years. Table 3 reports values for aggregate hours (H), fraction of life spent in employment (f), and peak hours worked over the life cycle (h^p) in the $\tau = 0.5$ economy relative to the $\tau = 0.3$ economy for each of the the four values of γ.

The key finding is that the implied change in aggregate hours worked is large in all four cases—more than 20 percent—despite the dramatic differences (a factor of 25) in estimated micro labor supply elasticities as shown in table 2. This finding contradicts message CW5, that individual labor supply elasticities are a sufficient statistic for computing aggregate labor supply elasticities. Additionally, since the key feature of the model that severs the link between individual and aggregate labor supply elasticities is the technology that maps time at work into labor

TABLE 3
Relative Outcomes for $\tau = 0.5$

γ	H	f	h^p
2.0	.777	.857	.856
1.0	.784	.825	.918
0.5	.788	.808	.956
0.1	.790	.794	.991

services, this economy also has the property that individual and aggregate labor supply responses depend on both technology and preferences. So message CW1 also fails. We note that although γ has virtually no effect on the change in aggregate hours worked, it has very significant effects on how the change in aggregate hours is broken down into changes in working life versus changes in hours worked while employed (the smaller is γ the more important is the former).

3.3 *Other Findings*

Here we briefly note some additional findings of interest in the recent literature (see Keane and Rogerson 2011 for a much more detailed discussion). The two extensions of the benchmark model described above both show that aspects of technology (not just preferences) are critical in influencing individual and aggregate labor supply responses to a given wage or tax change. Domeij and Floden (2006) argues that market structure is also relevant. The idea is that if young (relatively low-wage) individuals are credit constrained, they may work more than they otherwise would have (given perfect access to credit markets). As a result, labor supply elasticities for these workers do not map directly into preference parameters. Related but distinct, Low (2005) argues that in a model with uncertainty and precautionary savings, young individuals will work more than predicted by a complete markets model because of a desire to accumulate assets that can be used to self-insure against future shocks. Again, the mapping from labor supply elasticities to preference parameters is broken.

A third line of work, represented by Chang and Kim (2006, 2007), shows that, in a model with an active extensive margin, the extent of heterogeneity in the economy is an important influence on the aggregate labor supply elasticity. It follows that any estimate of the response along the extensive margin is influenced by the extent and nature of heterogeneity in the population being studied.

Lastly, restrictions on the constraint set of individuals matter. Rogerson (2011) argues that, if there are coordination issues among workers that require a common workweek, idiosyncratic variation in wages may not be useful in uncovering preference parameters.

4. *Conclusion*

Based on recent major surveys of the micro labor supply literature (e.g., Blundell and MaCurdy 1999, Meghir and Phillips 2010, Saez, Slemrod, and Giertz 2012), it is fair to say the consensus view among labor economists is that labor supply elasticities are small. In contrast, macroeconomists generally work with equilibrium models in which Hicks (or compensated) and Frisch (or intertemporal) labor supply elasticities are quite large (i.e., in the range of 1 to 2). In this survey, we have described recent work that seeks to reconcile this apparent conflict.

This literature can be viewed as consisting of two branches. The first focuses on the micro perspective. In the basic life cycle labor supply model (i.e., MaCurdy 1981), the only source of dynamics is borrowing/saving. A number of authors have considered extensions of this model to include other potentially important sources of dynamics, such as human capital accumulation. This work has shown that, if the true model contains other sources of dynamics, but the data is viewed through the lens of the basic model, then estimates of labor supply elasticities will tend to seriously understate their true values.

The second branch focuses on the macro perspective. This literature emphasizes issues associated with aggregation in the presence of the extensive margin. This literature has shown that small (intensive margin) elasticities at the individual level can be consistent with large elasticities at the aggregate level. In some cases, the value of the preference parameter γ, which was the focus of much of the early literature, is virtually irrelevant for the response of aggregate hours to specific changes in the economic environment.

Both of these literatures share one key point in common, however. In the basic life cycle model of MaCurdy (1981), there is a direct link between parameters of individual level preferences and the Hicks and Frisch elasticities at the *aggregate* level. All the extensions to the basic model that we have described break that direct link. This is not to say that individual preference parameters no longer matter. But, in general, labor supply elasticities are not only a function of preference parameters but also of all other aspects of the economic environment as well: This includes the wage process (e.g., how human capital is accumulated), the production technology (e.g., how productivity varies with hours), and so on.

In these more complicated environments, estimation of individual preferences alone is not adequate to model labor supply. Predicting the effects of changes in wages and/or taxes will, in general, require structural modeling of the complete economic environment. As we have shown, even in simple models, changes in after-tax wages can have effects on labor supply that differ greatly depending on the nature of the change, how long it has been in effect, and the age group affected. Thus, it is very difficult to generalize from historical episodes to predict how people would respond to a new policy change (as is implicit in a simple reduced form or natural experiment approach). An even more basic point is that, even if we could predict labor supply responses to hypothetical changes in public policy simply by extrapolation from historical episodes, we cannot evaluate the welfare consequences of policies without a model of the economic structure.

In our view, the literature we have described can credibly support a view that compensated and intertemporal elasticities at the macro level fall in the range of 1 to 2 that is typically assumed in macro general equilibrium models. Indeed, the problem that confronts us now is that the reconciliation is, in a sense, too easy. That is, we have described in detail two mechanisms that can achieve the desired reconciliation (and mentioned a few others). Of these, which are actually the most relevant? In our view, answering this question will require building models with multiple mechanisms, and seeing how well they explain multiple aspects of behavior—not just labor supply, but also schooling, occupational choice, savings, etc. (The work by Keane and Wolpin 2001, 2010 is an example of this type of strategy). Obviously this is a large (and daunting) program for future research. But it is important to realize that simply being able to reconcile aggregate labor supply responses with observations from micro data is not in itself sufficient. The specific mechanism(s) used to achieve the reconciliation will potentially lead to different implications regarding welfare effects of policies, even if those policies generate similar labor supply responses.

References

Altonji, Joseph G. 1986. "Intertemporal Substitution in Labor Supply: Evidence from Micro Data." *Journal of Political Economy* 94 (3): S176–215.

Blundell, Richard, and Thomas E. MaCurdy. 1999. "Labor Supply: A Review of Alternative Approaches." In *Handbook of Labor Economics, Volume 3A*, edited by Orley Ashenfelter and David Card, 1559–1695. Amsterdam; New York and Oxford: Elsevier Science, North-Holland.

Browning, Martin, Angus Deaton, and Margaret Irish. 1985. "A Profitable Approach to Labor Supply and Commodity Demands over the Life-Cycle." *Econometrica* 53 (3): 503–43.

Chang, Yongsung, and Sun-Bin Kim. 2006. "From Individual to Aggregate Labor Supply: A Quantitative Analysis Based on a Heterogeneous Agent Macroeconomy." *International Economic Review* 47 (1): 1–27.

Chang, Yongsung, and Sun-Bin Kim. 2007. "Heterogeneity and Aggregation: Implications for Labor-Market Fluctuations." *American Economic Review* 97 (5): 1939–56.

Chang, Yongsung, Sun-Bin Kim, Kyooho Kwon, and Richard Rogerson. 2011. "Interpreting Labor Supply Regressions in a Model of Full- and Part-Time Work." *American Economic Review* 101 (3): 476–81.

Domeij, David, and Martin Floden. 2006. "The Labor-Supply Elasticity and Borrowing Constraints: Why Estimates Are Biased." *Review of Economic Dynamics* 9 (2): 242–62.

French, Eric. 2005. "The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour." *Review of Economic Studies* 72 (2): 395–427.

Heckman, James J. 1976. "Estimates of a Human Capital Production Function Embedded in a Life-Cycle Model of Labor Supply." In *Household Production and Consumption*, edited by Nestor E. Terleckyj, 227–59. New York: National Bureau of Economic Research.

Heckman, James J. 1984. "Comments on the Ashenfelter and Kydland Papers." *Carnegie–Rochester Conference Series on Public Policy* 21: 209–24.

Heckman, James J. 1993. "What Has Been Learned about Labor Supply in the Past Twenty Years?" *American Economic Review* 83 (2): 116–21.

Imai, Susumu, and Michael P. Keane. 2004. "Intertemporal Labor Supply and Human Capital Accumulation." *International Economic Review* 45 (2): 601–41.

Keane, Michael P. 2011a. "Income Taxation in a Life Cycle Model with Human Capital." Australian Research Council Centre of Excellence in Population Ageing Research Working Paper 2011/17.

Keane, Michael P. 2011b. "Labor Supply and Taxes: A Survey." *Journal of Economic Literature* 49 (4): 961–1075.

Keane, Michael P., and Richard Rogerson. 2011. "Reconciling Micro and Macro Labor Supply Elasticities: A Structural Perspective." National Bureau of Economic Research Working Paper 17430.

Keane, Michael P., and Kenneth I. Wolpin. 2001. "The Effect of Parental Transfers and Borrowing Constraints on Educational Attainment." *International Economic Review* 42 (4): 1051–1103.

Keane, Michael P., and Kenneth I. Wolpin. 2010. "The Role of Labor and Marriage Markets, Preference Heterogeneity, and the Welfare System in the Life Cycle Decisions of Black, Hispanic, and White Women." *International Economic Review* 51 (3): 851–92.

Low, Hamish W. 2005. "Self-Insurance in a Life-Cycle Model of Labour Supply and Savings." *Review of Economic Dynamics* 8 (4): 945–75.

MaCurdy, Thomas E. 1981. "An Empirical Model of Labor Supply in a Life-Cycle Setting." *Journal of Political Economy* 89 (6): 1059–85.

MaCurdy, Thomas E. 1983. "A Simple Scheme for Estimating an Intertemporal Model of Labor Supply and Consumption in the Presence of Taxes and Uncertainty." *International Economic Review* 24 (2): 265–89.

Meghir, Costas, and David Phillips. 2010. "Labour Supply and Taxes." In *Dimensions of Tax Design: The Mirrlees Review*, edited by Stuart Adam et al., 202–74. Ocford and New York: Oxford University Press.

Prescott, Edward C., Richard Rogerson, and Johanna Wallenius. 2009. "Lifetime Aggregate Labor Supply with Endogenous Workweek Length." *Review of Economic Dynamics* 12 (1): 23–36.

Rogerson, Richard. 2011. "Individual and Aggregate Labor Supply with Coordinated Working Times." *Journal of Money, Credit, and Banking* 43: 7–37.

Rogerson, Richard, and Johanna Wallenius. 2009. "Micro and Macro Elasticities in a Life Cycle Model with Taxes." *Journal of Economic Theory* 144 (6): 2277–92.

Saez, Emmanuel, Joel Slemrod, and Seth H. Giertz. 2012. "The Elasticity of Taxable Income with Respect to Marginal Tax Rates: A Critical Review." *Journal of Economic Literature* 50 (1): 3–50.

Shaw, Kathryn L. 1989. "Life-Cycle Labor Supply with Human Capital Accumulation." *International Economic Review* 30 (2): 431–56.

Wallenius, Johanna. 2010. "Life Cycle Labor Supply and Retirement in a Model with Endogenous Human Capital Accumulation." Unpublished.

Wallenius, Johanna. 2011. "Human Capital Accumulation and the Intertemporal Elasticity of Substitution of Labor: How Large Is the Bias?" *Review of Economic Dynamics* 14 (4): 577–91.