A Labor Supply Elasticity Accord?

By Lars Ljungqvist and Thomas J. Sargent*

> "A revision is in order for George Stigler's dictum that all elasticities are 1 in absolute value. A dictum closer to the truth would be that elasticities are closer to 0 than 1 for hours-of-work equations (or weeks-of-work equations) estimated *for those who are working*." James J. Heckman (1993, p. 118)

> "...aggregate observations imply that the aggregate labor supply elasticity is large. Aggregation theory implies that whenever the principal margin of adjustment is the fraction employed and not hours per person employed, the aggregate labor supply elasticity is large." Edward C. Prescott (2005, p. 388)

Strong differences of opinion about the labor supply elasticity prevail. One camp infers that the aggregate labor supply elasticity is large because big fluctuations in aggregate hours of work occur in response to small fluctuations in workers' productivity over the business cycle (Prescott 2005). Another camp points to estimates of low labor supply elasticities from microeconometric studies of primary workers (Heckman 1993). Until recently, an insurmountable gulf between these two camps was fortified by a contentious aggregation theory formerly embraced by real business cycle theorists. The repudiation of that aggregation theory in favor of one more genial to microeconomic observations opens possibilities for an accord about the aggregate labor supply elasticity.

The new aggregation theory drops features to which empirical microeconomists objected and replaces them with life-cycle choices that microeconomists have long emphasized. Whether the new aggregation theory ultimately indicates a small or large macro labor supply elasticity will depend on how shocks and government institutions interact to determine whether workers choose to be at interior solutions for career length.

* Ljungqvist: Stockholm School of Economics, Box 6501, SE-113 83 Stockholm, Sweden, lars.ljungqvist@hhs.se. Sargent: New York University, 19 West 4th Street, New York, NY 10012, thomas.sargent@nyu.edu.

I. Repudiated employment lotteries

Prescott (2005) stressed the importance of Richard Rogerson's (1988) aggregation theory for macroeconomics. Rogerson's theory assumes (i) indivisible labor, and (ii) employment lotteries with complete markets that assign consumption and work to a continuum of people composing a representative family. The technology confronts each family member with a $\{0,1\}$ opportunity either to work or not to work. The family uses employment lotteries to convexify the $\{0,1\}$ choice set by assigning a fraction of family members to work. It attains that fraction by exposing all workers to a chance of being assigned to work. The family insures each member's consumption outcome against employment risk.

We illustrate key implications of Rogerson's aggregation theory in a static economy with a production function that is linear in the single input labor and preferences that are consistent with balanced growth and have a constant intertemporal elasticity of substitution in consumption equal to $1/\gamma$. Such preferences are ordered by a utility function $u(c,1-n)=\frac{c^{1-\gamma}}{1-\gamma}v(1-n)$ for $0<\gamma<1$ and $\gamma>1$, while for $\gamma=1$,

$$u(c,1-n)=\log(c)+v(1-n) \tag{1}$$

where $c\geq 0$ and $n\in\{0,1\}$ are the individual's consumption and indivisible labor supply, respectively, with leisure equal to $1-n$. Rogerson (1988) adopts the additively separable specification in (1) and

shows that in an efficient allocation attainable by employment lotteries supplemented with complete insurance markets, all individuals have the same consumption. The ex ante disutility of work is linear in the probability of working. This implies a utility function for a representative family – i.e., an 'aggregation theory' – that is linear in the fraction of the family N sent to work, to be interpreted as the employment/population ratio. Prescott (2005, p. 385) summarizes this outcome by saying that "the aggregate elasticity of labor supply is infinite up to the point that the fraction employed is one."

Of course, elasticities of *equilibrium* aggregate employment outcomes with respect to anything cannot be infinite, but they can be large. To illustrate how sensitive the aggregate labor supply is under Rogerson's aggregation theory, it is useful to recall the tax experiment of Prescott (2005). Here labor income is taxed at a flat rate τ and all tax revenues are handed back lump sum to individuals. With Rogerson's aggregation theory, at an interior solution $N \in (0,1)$ for the fraction employed, the elasticity of the equilibrium aggregate labor supply N with respect to the net-of-tax rate is

$$\frac{\partial N}{\partial(1-\tau)}\,\frac{1-\tau}{N} = \frac{\gamma}{(1-\tau)(1-\gamma)+\gamma} > 0\,,$$

(see Lars Ljungqvist and Thomas J. Sargent, 2010). Under Rogerson's $\gamma = 1$ specification, the elasticity is unity, a value consistent with Prescott's (2005, p. 387) explanation for European employment being caused by high labor taxes: "Western Europeans work one-third less than North Americans" because "the United States have [tax] rates near 0.40, and France, Germany and Italy near 0.60" (i.e., the net-of-tax rate $(1-\tau)$ is one-third lower for the European countries as compared to the U.S.).

Critics of Rogerson's aggregation theory doubt components (ii) of his theory because they don't observe them. Martin Browning, Lars Peter Hansen and Heckman (1999, p. 602) argue that "the employment allocation mechanism strains credibility and is at odds with the micro evidence on individual employment histories." This criticism has often been presumed to pull the rug from under the high labor supply elasticity delivered by Rogerson's aggregation theory. But a new aggregation theory shows that replacing components (ii) of Rogerson's theory with a time-averaging, individual savings life-cycle model while retaining the indivisible labor component (i) of his theory, a high aggregate labor supply elasticity still emerges.

Before turning to that alternative aggregation theory, it is pertinent to describe an important criticism of the logic behind Rogerson's high labor supply elasticity conclusion. Casey B. Mulligan (2001) challenged whether the assumption of indivisible labor is really decisive by adding a distribution of preferences, modeled as (insurable) idiosyncratic preference shocks, across members of a Rogerson household. Mulligan showed how a particular distribution function of such idiosyncratic preference shocks renders the aggregate labor supply isomorphic to that of a representative-agent model with divisible labor. Since the labor supply elasticity can be anything in a model with divisible labor, Mulligan (2001, sec. IIIA) "argue[s] that labor indivisibility *per se* has no implications for aggregate labor market data." Further, Mulligan provides an example of a cumulative distribution function of disutilities of work with a very steep segment that results in nearly constant fractions of working and non-working individuals, regardless of variations in compensation, and thus an aggregate labor supply elasticity that is arbitrarily low. It will be important to confront Mulligan's argument about the irrelevance of indivisible labor again under the new aggregation theory to be described in the next section.

II. New paradigm: lifetime labor supply

Rogerson's representative family chooses a fraction *of its members* to send to work. In the alternative 'time-averaging' aggregation theory, an individual worker is on her own, faces a $\{0,1\}$ employment choice each

instant, chooses what fraction *of her lifetime* to work, and trades a single risk-free asset to smooth consumption across periods of working and not working. Ljungqvist and Sargent (2006) built a continuous-time, life-cycle version of that model. They compared the fraction of lifetime spent working ('career length') with the fraction of the family allocated to work that emerged from a model with an identical period utility function coupled with Rogerson's employment-lotteries aggregation theory. When the subjective discount factor equals the market rate of return in a nonstochastic setting, these two fractions are *identical*. An interior solution for the employment-population ratio in the employment lotteries model translates into an interior solution for career length in the time averaging model, and the same high labor supply elasticity prevails.[1, 2] Prescott, Rogerson and Johanna Wallenius (2009) adopt and extend the framework by adding an intensive margin to the individual's labor supply decision[3] and reaffirm Ljungqvist and Sargent's results about the elasticity of equilibrium employment to a labor tax rate under that extension.[4]

Although this fact is obscured by their emphasis on an equilibrium distribution of reservation wages that depends on individuals' asset holdings as well as their productivity levels, the same time-averaging aggregation theory also emerges from Yongsung Chang and Sun-Bin Kim's (2006) model with infinitely-lived individuals, indivisible labor, incomplete markets, and idiosyncratic productivity shocks. While Ljungqvist and Sargent's finitely lived workers choose lengths of careers and retirements, Chang and Kim's infinitely lived workers make choices about fractions of their infinite lives to devote to leisure as they alternate between spells of working and not working. To appreciate the similar aggregation theories that emerge from these two models, it is instructive to consider a nonstochastic version of Chang and Kim's model. Just such a model is analyzed by Per Krusell, Toshihiko Mukoyama, Rogerson and Ayşegül Şahin (2008, sec. 3). In a steady state, there exists a wide range of asset holdings over which individuals are indifferent between working and not working. Despite the indeterminacy among individuals' time averaging strategies, the market's "invisible hand" assigns the correct aggregate number of individuals to work in each period. This equilibrium outcome thus extends the Ljungqvist and Sargent (2006) result about the equivalence of outcomes between employment lotteries with complete markets and time averaging with incomplete markets to a discrete-time, nonstochastic growth model with infinitely-lived workers.[5]

The equivalence of aggregate employment outcomes notwithstanding, replacing Rogerson's employment lotteries aggregation theory with Ljungqvist-Sargent's time-averaging model substantially realigns microeconomic underpinnings. For example, Mulligan's (2001) result that assuming indivisible labor does not necessarily imply a high aggregate labor supply elasticity becomes tenuous in the life-cycle time-averaging model because of the interpretation that one has to attach to a distribution of preference shocks that would support a low labor supply elasticity. In particular, to get a low elasticity Mulligan's preferences

[1] *Exact* equivalence between the two frameworks breaks down with human capital accumulation. Nevertheless, the important insight survives that, at an *interior* solution for career length, the elasticity of lifetime labor supply is high in a time averaging model (Ljungqvist and Sargent 2006, 2010).

[2] Prescott (2006a) endorsed the Ljungqvist and Sargent (2006) life-cycle time-averaging framework. While Prescott's (2005) original Nobel lecture was devoted to the complete-market representative-agent framework, a subsequent version (Prescott, 2006b) contains an added section on "The Life Cycle and Labor Indivisibility."

[3] Compare section 3 of Prescott et al. (2009) with section 3 of Ljungqvist and Sargent (2006).

[4] Compare section 4.1 of Prescott et al. (2009) with section 4.1 of Ljungqvist and Sargent (2006).

[5] The equivalence result of Ljungqvist and Sargent (2006) relies on equality between the subjective discount rate and the market rate of return, an outcome that does indeed hold in a steady state in a growth model. Ljungqvist and Sargent's assumption of continuous time assures that a finitely-lived agent can choose career length as any fraction of his lifetime. A corresponding flexibility evidently prevails in a discrete time setting where agents live forever.

shocks would have to be arranged to imply that observed retirements are predominantly governed by sharp changes in the disutility of work (or alternatively, in the return to work) at dates near observed retirement decisions. It seems to us implausible to impute most retirement decisions to the occurrence of such preference shocks.

III. Common framework, different visions

The displacement of an aggregation theory based on employment lotteries by a time-averaging aggregation theory that focuses on the determinants of lifetime labor supply improves prospects for eventually narrowing the range of opinion about the aggregate labor supply elasticity. But within the lifetime labor supply paradigm, two distinct and active research agendas still embrace very different visions about the size of the aggregate labor supply elasticity.

One research agenda is pursued by adherents of a high aggregate labor supply elasticity, whose goal is served by stressing the fact that a high elasticity continues to prevail despite the shift in aggregation theories used to support it. Michael Keane and Rogerson (2010) express this view when they declare upfront that their "position is that the view that estimates based on micro data rule out large aggregate elasticities is flawed." After surveying various mechanisms, they conclude with the conjecture "that human capital and the extensive margin will be key components of future labor supply models."

A good way to motivate the second research agenda is to note that while Keane and Rogerson embrace the Ljungqvist and Sargent (2006) model with indivisible labor and time averaging, they do not confront Ljungqvist and Sargent's troublesome finding that a model with a high labor supply elasticity fails to explain employment outcomes once labor supply responses to both taxes and nonemployment benefits are included in ways calibrated to the welfare states of Europe. For example, Ljungqvist and Sargent (2006, sec. 2.2) show that extending Prescott's tax analysis to include nonemployment benefits results in predicted employment levels that are very depressed when compared to actual outcomes. With that high labor supply elasticity, the puzzle now becomes not why Europeans work so *little* but rather why they work so *much* compared to Americans.

This situation sets the stage for describing an alternative research agenda that embraces settings where careers end either at an official retirement age affiliated with a government retirement system or with the arrival of large negative and persistent shocks to individual workers' earnings capacities.[6] Those devices throw workers onto a corner that arrests the force for the high labor supply elasticity at an interior solution of the life-cycle time-averaging model, thereby rationalizing the sentiment in favor of a low labor supply elasticity expressed in the epigraph by Heckman. This second research agenda uses the same life-cycle time-averaging model with indivisible labor but focuses on institutions and shocks that disarm the high labor supply elasticity that would prevail without them. Recent examples are Eric French (2005), and Hamish Low, Costas Meghir and Luigi Pistaferri (2010), who study how career length choices are affected by social security and disability insurance in the U.S. In addition, see the studies in Jonathan Gruber and David A. Wise (2004).

IV. A surprising reconciliation?

We believe that the adoption of a common aggregation theory has hastened the day when competing visions about the labor supply elasticity will be reconciled. The structure of the life-cycle time-averaging model dictates that whether the high or low elasticity view will ultimately prevail depends critically on the government institutions that determine the fraction of people who are at a corner with respect to decision to retire. If that fraction is low,

[6] A government-mandated retirement age has been used to justify hard-wiring the retirement decision in overlapping generations models, leading many of them to have low aggregate labor supply elasticities.

the high elasticity view will describe the data, while if it that fraction is high, the low elasticity view must prevail. Thus, the recent shift in the aggregation theory underlying specifications of aggregate labor supply toward the life-cycle time-averaging model has redirected attention toward institutional features affecting career lengths that either disarm or rearm the high labor supply elasticity that reigns off corners.

In this vein, Ljungqvist and Sargent (2010) offer the following narrative about the last half century of employment outcomes in North America and Europe. Both continents had initially instituted social security programs with implicit tax wedges that implied corner solutions to career lengths for primary workers at the official retirement ages. On both sides of the Atlantic, those institutions induced primary workers to plan to work until the official retirement age (the binding official retirement age having disarmed any adverse response of career length to the higher taxes and more generous benefits in Europe). But starting in the 1980s, the global economic environment changed in ways that put permanent negative shocks into a subset of individual workers' continuation earnings profiles. That threw those workers off the official retirement age corner via a wealth effect that under balanced-growth preferences causes workers with positive pension capital to shorten their career lengths. Its more generous benefits made that effect larger in Europe, pushing up unemployment and disability rates in Europe relative to America.

This historical narrative pushes workers on and off corner solutions associated with official retirement ages. But what will happen if the social retirement arrangements are reformed to disarm the corner solution associated with an officially mandated retirement age? Models of indivisible labor and time averaging predict that a high aggregate labor supply elasticity will prevail. Then the low hours-elasticity observation for primary workers, as noted in our introductory epigraph from Heckman, will become irrelevant for describing how individuals plan to adjust their career lengths in response to tax changes. In this way, appropriate institutional changes could ultimately prove Prescott correct about a high aggregate labor supply elasticity.

Beyond the positive question of whether the aggregate labor supply elasticity is small or large lie important normative questions about how to reform taxation and social institutions compensating people for retirement and disability in ways designed to reduce deadweight losses affiliated with individuals' decisions about working longer.[7]

REFERENCES

Browning, Martin, Lars Peter Hansen, and James J. Heckman. 1999. "Micro Data and General Equilibrium Models." In *Handbook of Macroeconomics, Vol. 1A*, ed. John Taylor and Michael Woodford. Amsterdam: North Holland.

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*, 47:1–27.

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

Gruber, Jonathan, and David A. Wise. 2004. *Social Security Programs and Retirement around the World.* Chicago: University of Chicago Press.

Heckman, James J. 1993. "What Has Been Learned About Labor Supply in the Past Twenty Years?" *American Economic Review*, 83:116–121.

Keane, Michael, and Richard Rogerson. 2010. "Reconciling Micro and Macro Labor Supply Elasticities." Unpublished.

Krusell, Per, Toshihiko Mukoyama, Richard Rogerson, and Ayşegül Şahin. 2008. "Aggregate Implications

[7] In the frictionless and deterministic model of Ljungqvist and Sargent (2006), preferential tax treatment of older workers would result only in individuals' changing the timing of their lifetime labor supply. Such tax arbitrage over the life cycle would be limited in a richer model with uncertainties about health, job opportunities and the accumulation of human capital.

of Indivisible Labor, Incomplete Markets, and Labor Market Frictions." *Journal of Monetary Economics*, 55:961–979.

Ljungqvist, Lars, and Thomas J. Sargent. 2006. "Do Taxes Explain European Employment? Indivisible Labor, Human Capital, Lotteries, and Savings." In *NBER Macroeconomics Annual*, ed. Daron Acemoglu, Kenneth Rogoff and Michael Woodford. Cambridge, Mass.: MIT Press.

Ljungqvist, Lars, and Thomas J. Sargent. 2010. "Career Length: Effects of Curvature of Earnings Profiles, Earnings Shocks, Taxes, and Social Security." Unpublished.

Low, Hamish, Costas Meghir, and Luigi Pistaferri. 2010. "Wage Risk and Employment Risk over the Life Cycle." *American Economic Review*, 100(4):1432–1467.

Mulligan, Casey B. 2001. "Aggregate Implications of Indivisible Labor." *Advances in Macroeconomics*, 1(1): article 4.

Prescott, Edward C. 2005. "The Transformation of Macroeconomic Policy and Research." In *Les Prix Nobel 2004*, 370–395. Stockholm: Almqvist & Wiksell International. [http://nobelprize.org/economics/laureates/2004/prescott-lecture.pdf]

Prescott, Edward C. 2006a. "Comment." In *NBER Macroeconomics Annual*, ed. Daron Acemoglu, Kenneth Rogoff and Michael Woodford. Cambridge, Mass.: MIT Press.

Prescott, Edward C. 2006b. "Nobel Lecture: The Transformation of Macroeconomic Policy and Research." *Journal of Political Economy*, 114(2):203–235.

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

Rogerson, Richard. 1988. "Indivisible Labor, Lotteries, and Equilibrium." *Journal of Monetary Economics*, 21:3–16.