On Intertemporal Substitution and Aggregate Labor Supply

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In this paper I present an econometric investigation of the implications of the intertemporal substitution hypothesis for aggregate employment in the United States. The tests are based on a version of the hypothesis with time-separable preferences. On the basis of the evidence produced, the hypothesis is quite successful in explaining fluctuations in aggregate employment, although almost totally unsuccessful in accounting for fluctuations in employee hours. These findings suggest that the hypothesis might have an important role to play in macroeconomic modeling, although they contradict attempts to account for aggregate fluctuations solely in terms of continuous competitive equilibrium in labor markets.

I. Introduction

The labor market intertemporal substitution hypothesis (ISH), which states that labor supply responds positively to transitory increases in real wages and increases in the real interest rate, is a central hypothesis of modern, competitive models of the business cycle.[1]

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[1] As with many other important concepts in economics, the concept of intertemporal substitution can be traced back at least to Hicks (1939). Its recent emergence owes a lot to the influential paper by Lucas and Rapping (1969), who also provided the first aggregate test of the hypothesis. For macroeconomic models that implicitly or explicitly rely on ISH, see Lucas (1972), Barro (1976), Brunner, Cukierman, and Meltzer (1980), Grossman and Weiss (1982), Alogoskoufis (1983), and others.

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One of the reasons for the original impact of ISH certainly was the rather favorable evidence in the influential paper of Lucas and Rapping (1969), which introduced the hypothesis to macroeconomics. In recent years, economists have been busy reassessing the evidence at both the microeconomic and the macroeconomic levels. The micro evidence has been based on life cycle considerations (see Heckman 1974). The burgeoning literature that employs panel data includes Heckman and MaCurdy (1980), MaCurdy (1981), Browning, Deaton, and Irish (1985), and other studies. At around the same time, more aggregate time-series evidence has been forthcoming. Hall (1980), Altonji (1982), Andrews and Nickell (1982), Andrews (1983), and Mankiw, Rotemberg, and Summers (1985) have presented new direct evidence for the United States and the United Kingdom.

This recent time-series evidence is mixed. Hall (1980) for the United States and Andrews and Nickell (1982) and Andrews (1983) for the United Kingdom have found that ISH cannot be rejected easily. They have found significant intertemporal labor supply elasticities, although they have been able to reject the overidentifying restrictions implied by their particular models. On the other hand, the evidence of Altonji (1982) and Mankiw et al. (1985) is entirely negative. Altonji generally found wrongly signed and statistically insignificant real wage elasticities, and Mankiw et al. found implausible parameters of the intertemporal utility function.[2]

In this paper I set out to reassess the U.S. time-series evidence. I use a variety of measures of aggregate labor supply. Two of them refer to aggregate employee hours (Altonji, Hall, and Mankiw et al.) and another two are measures of the aggregate number of employees, adjusted by working population. In the regressions for these latter measures I use three alternative wage variables, based on annual, weekly, and hourly earnings, whereas for the hours regressions I use hourly earnings.

A priori there are a number of reasons why the extensive margin of employment decisions is worth investigating. The first is that, for annual (and quarterly) data, most of the fluctuations in employee hours are due to the number of employees and not average weekly hours (see Heckman 1984). Yet the results of Mankiw et al. are based solely on weekly hours. A second reason is that measured average hourly wages might differ substantially from marginal hourly wages since overtime premia are sometimes as high as 50 percent of the

[2] It has to be noted that neither Hall nor Andrews and Nickell have since endorsed ISH. The latter have since focused their research efforts on alternative models of the labor market, highlighting the role of unions, so important in the U.K. context (see Nickell and Andrews 1983; Layard and Nickell 1985).

basic wage. Average annual (or weekly) earnings are much closer to marginal earnings for the relevant period since what the average member of the average household forgoes when he or she decides not to work, in a particular week or year, is average earnings for that period. Since the econometrician has access to average rather than marginal earnings, the aggregate data are perhaps better suited for investigating the extensive margin. A third reason relates to the problem of time aggregation. With annual data, this should be expected to be less serious for average annual or weekly earnings than for hourly earnings. Finally, given the nature of the employment relationship, it would not be too implausible to speculate that, while the participation decision rests largely with employees, the hours decision rests largely with employers. In such a case, one should not expect ISH to explain average weekly hours per employee.[3]

As I recognize that the aforementioned reasons are not overwhelmingly in favor of a sole investigation of fluctuations in the number of employees, I also investigate fluctuations in measures of employee hours.

A brief introduction to my modeling strategy is probably in order. Following a long tradition in macroeconomics, one also honored by the other macroeconomic papers mentioned, I assume that aggregate employment can be modeled as a decision rule of a "representative household." The household is assumed to have an infinite planning horizon (see also Barro and King 1984; Mankiw et al. 1985). This assumption can be justified by appealing to concern of current members of the household for their descendants. If one were to apply the model to individual data, one would have to allow for corner solutions or model the participation decision as a choice among discrete alternatives. For aggregate data, as in most cases, I employ the assumption of a representative household that can allow us to ignore corner solutions and treat the participation decision as a continuous variable. The sawtooth pattern that might characterize the life cycle employment path of individuals is smoothed, it is hoped, both because the timing of nonparticipation within households is not synchronized and, more important, because the timing of nonparticipation decisions is not synchronized *across* households.[4]

Given the considerations above, the representative household is modeled as maximizing an intertemporal constant elasticity of substitution (CES) utility function. The two margins of substitution are

[3] In the light of the results of this paper, some of these points may be quite important.

[4] This paper does not address aggregation problems at all. This is almost standard in macroeconomics and is potentially dangerous (see Geweke 1985), but the problems that it raises are beyond the scope of this investigation.

between consumption and leisure and the single-period utilities of pairs of consumption and leisure. I allow for a different substitution elasticity for each of the two margins. The specification of the utility function is similar to that of Mankiw et al., and, like them, I am not concerned with deriving closed-form solutions but utilize the Euler equations.[5]

In this paper I am not mainly concerned with retrieving the parameters of the utility function. This requires heroic extra assumptions anyway and is not attempted. My main concern is to obtain consistent estimates of the intertemporal real wage and interest rate elasticities of aggregate labor supply. The usefulness of ISH in explaining aggregate fluctuations in employment ultimately rests on the magnitude of these elasticities. Nevertheless, the estimates allow some inferences about the *relative* magnitude of the consumption/leisure and intertemporal substitution elasticities.

My estimates suggest that, for measures of the total number of employees, the real wage and interest rate elasticities are high and relatively well determined. The overidentifying restrictions implied by the structural model are not generally rejected at conventional significance levels. This is surprising given that the model is rather parsimoniously specified and there is no state dependence. It cannot be explained only by the low power of general single-equation tests for overidentifying restrictions, such as the Basmann (1960) test utilized. For some of the specifications I also experimented with tests of the exclusion restrictions implied for particular subsets of the instruments. It turns out that, in some of the specifications, one could reject the exclusion restriction on the lagged dependent variable. This could be sufficient evidence against time-separable preferences. However, further work would be needed to consistently derive and test a generalized model augmented to allow for state dependence. It has to be emphasized that the estimates for the two measures of the total number of employees are otherwise very favorable to ISH, and other overidentifying restrictions cannot be rejected.

For one of the measures of aggregate employee hours, the one divided by the working population with fixed age and sex composition, the estimated parameters are correctly signed, but the intertemporal real wage elasticity is somewhat lower than the estimated elasticity with measures of the number of employees. Furthermore, none of the parameters of interest is statistically significant at conventional significance levels. The results, however, are nowhere as negative as

[5] In many respects, the theoretical framework in this paper is similar to that of Barro and King (1984) and Mankiw et al. (1985). It relies on time-separable preferences and in this sense is a special, albeit important, case of ISH.

those of Altonji, who utilized a similar dependent variable. The ISH fares a lot worse for the measure of aggregate weekly hours in which working population is not adjusted for age and sex composition. Such was the measure utilized by Mankiw et al., who also found extremely negative results.[6]

All in all, my results suggest that the intertemporal substitution hypothesis is not necessarily incompatible with the evidence on fluctuations in the number of employees and the unemployment rate in the United States, although it is not satisfactory in accounting for fluctuations in employee hours. These new features of the evidence presented in this paper would be consistent with macroeconomic models of nominal contracting, where labor supply considerations are important ex ante, but ex post firms determine employment. They would also be consistent with a generalization of ISH to allow for expected rationing. This is a major generalization, not attempted in this paper.

The paper addresses the question of differences with other studies, namely, Hall (1980), Altonji (1982), and Mankiw et al. (1985). The differences with Hall and Mankiw et al. are not major. For their measures of employment and real wages, the results more or less coincide. Altonji relies on specifications different from the one used here, or in the other two studies for that matter. In an attempt to explain the quite significant differences, I investigate his specifications in the Appendix and suggest that maybe a reason for the different results is his approximation of normal employment. Altonji used a time trend as the only additional proxy for normal employment. It is argued in the Appendix that if there are additional variables that would account for changes in normal employment, this could affect the estimates. If one substitutes a forward moving average for normal employment, the resulting estimates of the intertemporal real wage and interest rate elasticities turn out not too different from my specifications with time-separable preferences.

The rest of the paper is organized as follows: In Section II, I discuss the theoretical underpinnings of the estimated short-run employment equation. This, as suggested above, is based on the Euler equations resulting from maximization of an intertemporal, time-separable utility function. Econometric issues and the main body of estimates and tests are presented in Section III, where I also discuss the differences with previous aggregate time-series studies. The final section sums up the findings.

[6] No attempt is made to address the questions raised by many indirect tests of ISH, such as Barro (1977, 1981), Altonji and Ashenfelter (1980), Ashenfelter and Card (1982), and others. Reconciliation of microeconomic and macroeconomic evidence also lies outside the scope of this paper. See Ashenfelter (1984) and Heckman (1984) for an exchange that illustrates the numerous difficulties.

II. Theoretical Considerations

In this section I briefly present a theoretical model consistent with the intertemporal substitution hypothesis. This serves as the basis for specifying and interpreting the employment equations estimated in the next section.

The unit of analysis is a representative household that derives pleasure from consumption and leisure, and whose utility function is stationary and separable over time. The household is assumed to be a "dynasty" in that it has an infinite horizon.

Leaving aside pretensions of too much generality right from the start, I assume certainty equivalence and the following functional form for the intertemporal utility function:

$$V_t = \sum_{i=0}^{\infty} \left(\frac{1}{1+\delta}\right)^i [c_{t+i}^{1-\alpha} + d(l_0 - l_{t+i})^{1-\alpha}]^{(1-\epsilon)/(1-\alpha)}, \qquad (1)$$

where δ is the assumed constant utility rate of time preference, c_{t+i} and l_{t+i} are planned consumption demand and labor supply, respectively, l_0 is the full labor endowment of the household each period, assumed to be a parameter, and d, ϵ, and α are the other parameters of the utility function. The term $1/\alpha$ is the elasticity of substitution of consumption for leisure, and $1/\epsilon$ is the intertemporal elasticity of substitution of the single-period utilities given by

$$[c_{t+i}^{1-\alpha} + d(l_0 - l_{t+i})^{1-\alpha}]^{1/(1-\alpha)}.$$

The household is assumed to be a price taker in competitive product, labor, and asset markets. It chooses paths of consumption and leisure to maximize (1) subject to a wealth constraint:

$$\sum_{i=0}^{\infty} \rho_{ti}(p_{t+i}c_{t+i} - w_{t+i}l_{t+i}) = A_t, \qquad (2)$$

$$\rho_{ti} = \frac{1}{(1+r_t)(1+r_{t+1})\ldots(1+r_{t+i-1})}, \quad \text{for } i > 0;\ \rho_{t0} = 1,$$

where ρ_{ti} is the discount factor, r_{t+i} is the (rationally expected) nominal interest rate, p_{t+i} and w_{t+i} are, respectively, the (rationally expected) price level and nominal wage at $t + i$, and A_t is the predetermined stock of assets at t.

A similar setup has been utilized in the recent papers by Barro and King (1984) and Mankiw et al. (1985). Using the first-order conditions for a maximum of (1) subject to (2), one can derive what Mankiw et al. called the static first-order condition, which implies that, at the optimum, the household cannot be made better off by trading consumption for leisure within periods at the expected real wage for the period. One can also derive Euler equations for consumption and leisure that imply that at the optimum the household cannot be made better off by trading consumption or leisure across periods at the relevant real interest rate. Taking the Euler equations for $i = 0$ and using the static condition to eliminate c_t and c_{t+1}, after some rearrangement we end up with

$$\left(\frac{l_0 - l_t}{l_0 - l_{t+1}}\right)^{-\epsilon} = \frac{1}{1+\delta}\frac{w_t/p_t}{w_{t+1}/p_{t+1}} \times \left[\frac{1 + d^{-\alpha}(w_{t+1}/p_{t+1})^{(1-\alpha)/\alpha}}{1 + d^{-\alpha}(w_t/p_t)^{(1-\alpha)/\alpha}}\right]^{(\alpha-\epsilon)/(1-\alpha)} \frac{p_t(1+r_t)}{p_{t+1}}. \tag{3}$$

Equation (3) is stated only in terms of planned current and future leisure, the expected current and future real wages, and the (exponential of the) ex ante real interest rate.

Taking the logarithm of (3) and using the Taylor approximations

$$\log l_0 \simeq \phi_0 + \phi \log(l_0 - l_{t+i}) + (1 - \phi)\log l_{t+i}, \quad 0 \leq \phi \leq 1,$$

$$\log\left[1 + d^{-\alpha}\left(\frac{w}{p}\right)_{t+i}^{(1-\alpha)/\alpha}\right] \simeq \pi_0 + \pi \log\left[d^{-\alpha}\left(\frac{w}{p}\right)_{t+i}^{(1-\alpha)/\alpha}\right], \quad 0 \leq \pi \leq 1,$$

we end up with the following log-linear equation for labor supply:

$$\log l_t = \log l_{t+1} + \gamma_1\left[\log\left(\frac{w_t}{p_t}\right) - \log\left(\frac{w_{t+1}}{p_{t+1}}\right)\right] + \gamma_2 R_t + \gamma_0, \tag{4}$$

where $R_t \simeq \log(1 + r_t) - \log(p_{t+1}/p_t)$ is the ex ante real interest rate,

$$\gamma_1 = \frac{(1-\phi)[\alpha(1-\pi) + \epsilon\pi]}{\phi\alpha\epsilon},$$

$$\gamma_2 = \frac{1-\phi}{\phi}\frac{1}{\epsilon},$$

and γ_0 is a function of various parameters such as the log of the utility rate of time preference and the π's and ϕ's in the approximations. In estimation it will be captured by a constant and a trend. Although the two elasticities of substitution cannot be identified from γ_1 and γ_2, we can use their estimates to make inferences about their relative magnitudes. If $\gamma_1 > \gamma_2$ then $\epsilon > \alpha$, and the intertemporal substitution elasticity $1/\epsilon$ is smaller than the static substitution elasticity $1/\alpha$. Accordingly, if $\gamma_1 < \gamma_2$ then $\epsilon < \alpha$, and if $\gamma_1 = \gamma_2$ then $\epsilon = \alpha$.

Equation (4) is very similar to the Lucas-Rapping (1969) supply function. There are two main differences: First, where Lucas and Rapping have "permanent" variables, time-separable preferences imply anticipations of next period's variables. Second, assets do not appear in (4) because initial wealth affects l_t and l_{t+1} in the same way.

We can now turn to estimation and testing.

III. Estimation and Testing

A number of decisions have to be made in moving from theory to estimation and testing. The first concerns the relation of the theoretical concepts to the aggregate measures of employment and wages that are available. For the reasons stated in the Introduction, I do not wish to confine myself to any particular measure of employment but rather follow Lucas and Rapping and Altonji in using alternative measures. In fact, I am more agnostic than they were and use four alternative measures of employment: (1) the number of employees in nonagricultural employment adjusted by an index of the working population with constant age and sex composition, (2) an employment rate defined as one minus the civilian unemployment rate, (3) an index of total employee hours (nonagricultural) divided by the adjusted population index, and finally (4) an index of total employee hours divided by an unadjusted working population index. The second and third of these measures have been used by Altonji and the fourth by Mankiw et al., whereas Hall used detrended total employee hours. As for earnings, I use average hourly earnings (nonagricultural) in all equations involving employee hours, but for the reasons stated in the Introduction, I use three alternative measures—annual, weekly, and hourly earnings—in the equations involving the two measures of the number of employees. With apologies, I stick to the implicit personal consumption deflator for p and Moody's Aaa corporate bond rate for r throughout.[7]

The second decision concerns estimation methods. There are at least two ways of obtaining estimates of equation (4). One is to postulate stochastic processes driving real wages and the real interest rate and then to derive the rational expectations solution (see Wallis 1980). However, this would presumably require either specifying a complete model for the rest of the economy (at least a vector autoregression) or confining oneself to univariate autoregressive moving average processes. The former method is too expensive, especially in terms of degrees of freedom, while the latter is too limited to be satisfactory. Both would also involve all the problems associated with obtaining

[7] It has to be admitted that, strictly speaking, the theoretical model in Sec. II does not apply to modeling the extensive margin. To interpret the estimates in terms of such a framework, one has to assume that the employment rate is a continuous variable chosen by the representative household.

rational expectations solutions (see Blanchard 1979). A second method is to use the actual future variables in place of their rational expectations and rely on instrumental variables estimation to obtain consistent estimates (see McCallum 1976; Wallis 1980; Wickens 1982; and others). This procedure is very useful if one is interested in a single equation (or a subsystem) since it does not require the complete specification and estimation of a system of simultaneous equations. In our case, where we have expectations of variables only one period ahead, it is especially appropriate since we have to give up only the last observation in estimating the equation.[8]

Estimates of the aggregate labor supply equation (4) appear in tables 1 and 2 for the two alternative measures of the total number of employees and in table 3 for the two alternative measures of employee hours.

In each case I first present estimates of an unrestricted equation of the form

$$\log l_t = \omega_0 + \omega_1 \log l_{t+1} + \omega_2 \log\left(\frac{w}{p}\right)_t + \omega_3 \log\left(\frac{w}{p}\right)_{t+1} + \omega_4 R_t + \omega_5 t + v_t, \quad (5)$$

where t is a time trend included to capture factors that might shift the constant. The constants in the Taylor approximations are what we especially expect to shift through time, but so could other scale factors (l_0, e.g.) or the utility rate of time preference. The term v_t is assumed to be a white-noise process reflecting random measurement and aggregation errors but also possible optimization errors or transitory taste shifts on the part of the representative household.

For each combination of measures of employment and real wages, I also present estimates of another two equations: (4), which involves the restrictions $\omega_1 = 1$ and $\omega_2 = -\omega_3 = \gamma_1$, and an additional equation with the extra restriction $\omega_2 = -\omega_3 = \omega_4$ (or $\gamma_1 = \gamma_2$), which I shall refer to as the Hall restriction. This restriction is a direct consequence of the assumption that $\alpha = \epsilon$ in the intertemporal CES utility function.[9]

[8] Another advantage of this method is that the tests are conditional on only the instrument list and not on other simplifying assumptions about the structure of the rest of the economy. Testing hypotheses in conjunction with a number of extraneous simplifying assumptions is a more general problem in methodology, the Duhem-Quine thesis, and it often arises in macroeconomics (see Cross 1982).

[9] In fact, as suggested by Barro (1980), the intertemporal substitution variable $s_t = r_t - \log(p_{t+1}/w_t)$, which Hall (1980) used, is slightly different from the measure that results from the restriction $\alpha = \epsilon$. This latter measure is given by $\hat{s}_t = r_t - \log(w_{t+1}/w_t)$ and is the one used in this paper to test the Hall restriction.

TABLE 1

INSTRUMENTAL VARIABLES ESTIMATION OF EQUATION (4) (Annual Data, 1948–82)

Equation	Right-Hand-Side Variables: $\log l_{t+1}$	$\log(w/p)_t$	$\log(w/p)_{t+1}$	R_t	$\bar{R}^2$	Standard Error of Estimate	Durbin-Watson	F
				A. w = Average Annual Earnings				
1	.79	1.91	−1.97	.65	.46	.017	2.03	.92
	(.33)	(.86)	(.86)	(.25)				(8,21)
2	1.00	1.50	−1.50	.74	.46	.017	2.08	.84
		(.60)	(.60)	(.22)				(2,29)
3	1.00	.79	−.79	.79	.35	.018	2.01	7.89
		(.31)	(.31)	(.31)				(1,31)
				B. w = Average Weekly Earnings				
4	1.04	1.16	−1.17	.76	.55	.015	1.70	.86
	(.21)	(.40)	(.40)	(.23)				(8,21)
5	1.00	1.19	−1.19	.74	.59	.015	1.68	.01
		(.36)	(.36)	(.18)				(2,29)
6	1.00	.51	−.51	.51	.33	.019	1.80	20.98
		(.23)	(.23)	(.23)				(1,31)
				C. w = Average Hourly Earnings				
7	1.09	.89	−.87	.68	.19	.020	1.92	1.58
	(.27)	(.99)	(.96)	(.36)				(8,21)
8	1.00	.92	−.92	.59	.29	.019	1.90	.07
		(.85)	(.85)	(.28)				(2,29)
9	1.00	.44	−.44	.44	.17	.021	1.91	6.41
		(.30)	(.30)	(.30)				(1,31)

NOTE.—l_t is the number of wage and salary workers in nonagricultural establishments, adjusted by population with fixed age and sex composition. The dependent variable is $\log l_t$. All equations were estimated with a constant and trend, which are not reported. Asymptotic standard errors of individual coefficients are in parentheses, as well as the degrees of freedom for the F-statistics.

TABLE 2

INSTRUMENTAL VARIABLES ESTIMATION OF EQUATION (4) (Annual Data, 1948–82)

Equation	Right-Hand-Side Variables: $\log l_{t+1}$	$\log(w/p)_t$	$\log(w/p)_{t+1}$	R_t	$\bar{R}^2$	Standard Error of Estimate	Durbin-Watson	F
	A. w = Average Annual Earnings							
1	1.01	.90	−.85	.34	.34	.010	2.21	1.51
	(.35)	(.28)	(.29)	(.19)				(8,21)
2	1.00	.91	−.91	.35	.38	.010	2.19	.04
		(.27)	(.27)	(.11)				(2,29)
3	1.00	.57	−.57	.57	.36	.010	2.30	1.75
		(.18)	(.18)	(.18)				(1,31)
	B. w = Average Weekly Earnings							
4	.90	.88	−.85	.36	.51	.009	1.54	1.08
	(.24)	(.19)	(.19)	(.14)				(8,21)
5	1.00	.87	−.87	.39	.53	.009	1.61	.11
		(.18)	(.18)	(.10)				(2,29)
6	1.00	.47	−.47	.47	.42	.010	1.95	8.12
		(.13)	(.13)	(.13)				(1,31)
	C. w = Average Hourly Earnings							
7	.80	.63	−.59	.20	.20	.011	1.78	2.60
	(.26)	(.39)	(.39)	(.17)				(8,21)
8	1.00	.68	−.68	.26	.18	.012	1.86	.30
		(.37)	(.37)	(.13)				(2,29)
9	1.00	.36	−.36	.36	.18	.012	2.10	.98
		(.18)	(.18)	(.18)				(1,31)

NOTE.—l_t is one minus the civilian unemployment rate. The dependent variable is $\log l_t$. All equations were estimated with a constant and trend, which are not reported. Asymptotic standard errors of individual coefficients are in parentheses, as well as the degrees of freedom for the F-statistics.

TABLE 3

INSTRUMENTAL VARIABLES ESTIMATION OF EQUATION (4) (Annual Data, 1948–82)

Equation	Right-Hand-Side Variables: $\log l_{t+1}$	$\log(w/p)_t$	$\log(w/p)_{t+1}$	R_t	$\bar{R}^2$	Standard Error of Estimate	Durbin-Watson	F
A.*								
1	.86	.68	−.60	.42	.15	.026	2.02	1.76
	(.30)	(1.25)	(1.22)	(.43)				(8,21)
2	1.00	.48	−.48	.45	.11	.026	2.06	.14
		(1.23)	(1.23)	(.37)				(2,29)
3	1.00	.41	−.41	.41	.11	.026	2.08	.00
		(.42)	(.42)	(.42)				(1,31)
B.*								
4	.81	.26	−.16	.19	.13	.012	1.85	2.85
	(.19)	(.34)	(.33)	(.16)				(8,21)
5	1.00	.20	−.20	.19	.06	.013	1.87	2.37
		(.32)	(.32)	(.14)				(2,29)
6	1.00	.12	−.12	.12	.03	.013	1.94	1.79
		(.18)	(.18)	(.18)				(1,31)

NOTE.—w is average hourly earnings. The dependent variable is $\log l_t$. All equations were estimated with a constant and trend, which are not reported. Asymptotic standard errors of individual coefficients are in parentheses, as well as the degrees of freedom for the F-statistics.

* In pt. A, l is total employee hours adjusted by working population with fixed age and sex composition. In pt. B, l is total employee hours adjusted by working population.

In the tables, $\bar{R}^2$ refers to the coefficient of determination for the differenced variable $\log l_t - \log l_{t+1}$, and F refers to F-statistics that test the restrictions that each equation implies for the immediately more general one preceding it. For the estimates of (5), F is a Basmann test for overidentifying restrictions. The instruments used are two lags of employment, real wages, the nominal interest rate, inflation, the rate of growth of M1, and real government purchases.[10]

The results in tables 1, 2, and 3 can be summarized as follows: For the two measures of the number of employees (tables 1 and 2) the evidence appears consistent with (4). The elasticity of labor supply to transitory changes in real wages is around unity and is statistically significant at conventional significance levels, with one exception. This is when hourly earnings are being used as w. Even in this case, however, the order of magnitude of the point estimates is the same as for the other measures of earnings. The real interest rate always has a significant independent influence. The interest rate semi-elasticity is around .70 for the equations in table 1 and around .35 for table 2. To my knowledge this is the first time that a statistically significant real interest rate semi-elasticity has been identified independently in aggregate time-series labor supply equations based on ISH. In neither case can the restrictions implied by (4) be rejected against (5), nor can the overidentifying restrictions implied by the latter. With reference to this last point, one might have reasons to believe that a general test like the Basmann test is not very powerful. This is a point to which I return below. As for the Hall restriction, with one exception, it is always rejected. On the basis of the estimates, it appears that the intertemporal substitution elasticity is lower than the static substitution elasticity between consumption and leisure. It should be noted that the Durbin-Watson statistics do not indicate rejection of the hypothesis of the lack of first-order residual autocorrelation, although in some cases they are near the bounds of the indeterminate region.

The results are not as consistent with ISH for measures of employee hours (see table 3). Neither real wages nor the real interest rate seems to have a statistically significant influence at conventional significance levels. For adjusted employee hours, the point estimates are correctly signed and are around one-half of the estimates for the number of employees, but the standard errors are more than double the unrestricted estimates. The Hall restriction cannot be rejected in this case, but given the size of the standard errors this is hardly surprising. For unadjusted employee hours, the results are even less

[10] See App. B for data definitions and sources. The data used in this investigation are available from the author on request.

consistent with ISH. The point estimates are extremely low, and it is not even worth commenting on other features of these estimates.

How do these results compare with previous studies? Let us start with points of agreement: My results do not contradict the findings of Mankiw et al. (1985) since their measure of employment (leisure) was "per capita total hours worked by the civilian labor force" (p. 235). For this measure my results are similar to theirs. It has to be concluded that ISH is not an appropriate hypothesis for explaining average hours worked. I will return to this point in the conclusions below. The results are also consistent with Hall's estimates. His measures are total employee hours and hourly earnings, and his method of estimation (detrending plus an autoregressive transformation of the data) roughly corresponds to mine. His specification is comparable with equation 3 in table 3. The estimated point elasticity (.41) is quite close to Hall's, and this is one of the few equations for which the Hall restriction is accepted. It has to be noted that, in general, the Hall restriction results in lower intertemporal real wage elasticities.

The study with which I seem to be less in agreement is Altonji's (1982) paper. Because Altonji in general tested versions of ISH different from the ones tested here (e.g., he did not in general rely on time-separable preferences), in order to compare his results with mine I had to go beyond the basic specifications employed in this study. This is shown in Appendix A. I show that the differences may be due to the fact that Altonji's test of the Lucas-Rapping model was a test of ISH and a particular theory about the natural rate of employment, namely, that the latter depends only on normal real wages, assets, the real interest rate, and a time trend. It is shown in Appendix A that if one estimates a version of the Lucas-Rapping model proxying normal employment in the same way as normal real wages, the resulting estimates are not wrongly signed as Altonji found in the majority of cases, but in fact are very close to mine.

In the remainder of this section I examine the robustness and further statistical features of my estimates. I concentrate on the equations for the number of employees adjusted by working population with fixed age and sex composition. Three particular specifications are further investigated: parts A and B of table 1 and also part A of table 3, which involves employee hours.

In table 4 I present estimates of (4) for both gross and net-of-tax wages and interest rates. The tax rate is Seater's (1985) measure of the average marginal tax rate on household income. As this was available only up to 1980, the equations are estimated for 1948–79. Parts A and B prove quite robust to netting out taxes. If anything, we get even higher intertemporal real wage and interest rate elasticities. Part C is again inconsistent with ISH. In fact we get a sign reversal. Given that

TABLE 4

INSTRUMENTAL VARIABLES ESTIMATION OF EQUATION (4) FOR GROSS AND NET-OF-TAX WAGES AND INTEREST RATES (Annual Data, 1948–79)

Wages and Interest Rates	Right-Hand-Side Variables: $\log l_{t+1}$	$\log(w/p)_t$	$\log(w/p)_{t+1}$	R_t	Standard Error of Estimate	Durbin-Watson
	A. l = age/sex-adjusted number of employees, w = annual earnings					
Gross	1.00	1.38	−1.38	.70	.017	2.10
		(.50)	(.50)	(.25)		
Net	1.00	2.09	−2.09	1.21	.023	2.23
		(.92)	(.92)	(.53)		
	B. l = age/sex-adjusted number of employees, w = weekly earnings					
Gross	1.00	1.15	−1.15	.96	.014	1.66
		(.29)	(.29)	(.23)		
Net	1.00	1.20	−1.20	1.13	.019	1.70
		(.45)	(.45)	(.39)		
	C. l = age/sex-adjusted employee hours, w = hourly earnings					
Gross	1.00	1.25	−1.25	1.02	.025	2.01
		(.84)	(.84)	(.47)		
Net	1.00	−.13	.13	.27	.029	1.93
		(.94)	(.94)	(.38)		

NOTE.—See note to table 1. Net refers to $w(1 - \tau)$ and $r(1 - \tau)$, where τ is Seater's (1985) average marginal tax rate on household income. The dependent variable is $\log l_t$.

Mankiw et al. used net-of-tax variables throughout, this latter result makes the findings for employee hours even more consistent with theirs. Note that in all cases the standard errors of estimate increase.

In table 5, I present a number of tests on the overidentifying (exclusion) restrictions implied by (5) for various subsets of the instruments. The general Basmann test presented in tables 1–3 is not very powerful against specific alternatives. The statistics in table 5 test those alternatives directly. For annual earnings, it is very hard to reject any of the overidentifying restrictions. Even the exclusion restriction on the lagged dependent variable cannot be rejected at the 5 percent level. This latter restriction is in fact the only one rejected at 5 percent, for weekly earnings. For employee hours and average hourly earnings, the picture is different. The most significant rejection concerns the exclusion restrictions on aggregate demand variables, especially lagged monetary growth (cols. 2–5). This was also found by Hall (1980) and suggests that aggregate demand policies do not affect employee hours through only anticipated changes in real wages and the real interest rate, as suggested by ISH, but through other channels as well. These results reinforce the conclusions about the failure of ISH to provide a satisfactory theory for fluctuations in employee hours.

As a final check on the robustness of the estimates, I report in table 6 "moving window" estimates of γ_1 and γ_2 for a fixed sample size of 20 observations from 1948–67 to 1963–82. Although the point estimates vary, there is no clear pattern in their variation, nor dramatic and sustained breakdowns. One may look at them and draw one's own conclusions. Chow tests, with a split in 1965, yield F-statistics of 0.91 for annual earnings, 3.48 for weekly earnings, and 3.42 for hourly earnings. The critical values are 2.7 (5 percent) and 4.1 (1 percent).

On the basis of these additional tests, one can only conclude that it is very hard to reject ISH as a theory of fluctuations in the total number of employees, and it is rather easy to reject it for employee hours.

IV. Conclusions

On the basis of the results reported in the present paper one cannot easily assert that the evidence favors a theory of the business cycle based entirely on continuously clearing, competitive labor markets. On the other hand, the evidence is very favorable to ISH as a theory of fluctuations of aggregate employment in the United States. The estimated intertemporal real wage and interest rate elasticities are substantially higher than previous estimates. It can also be claimed that, conditional on ISH, the static substitution elasticity between con-

TABLE 5

TESTS OF OVERIDENTIFYING RESTRICTIONS (Annual Data, 1948–82; Instrumental Variables Estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\log l_{t-1}$	+						+	+		+		+
$\log l_{t-2}$							+	+		+		
$\log(w/p)_{t-1}$	+						+	+	+		+	
$\log(w/p)_{t-2}$							+	+	+			
$\log r_{t-1}$	+						+					
$\log r_{t-2}$							+					
$\Delta \log p_{t-1}$	+						+					
$\Delta \log p_{t-2}$							+					
$\Delta \log m_{t-1}$	+	+	+		+							
$\Delta \log m_{t-2}$		+	+									
$\log g_{t-1}$	+	+		+		+						
$\log g_{t-2}$		+		+								
	F-Statistics for Additional Right-Hand-Side Variables											
Annual	1.08	1.94	1.40	1.15	1.73	.48	.92	1.00	2.07	1.82	3.84	3.58
Weekly	1.17	1.27	1.83	1.17	2.14	.58	.86	1.55	2.35	2.70	3.55	5.10
Hourly	2.40	3.17	5.95	.96	11.6	.30	1.76	1.88	1.45	2.85	.59	5.13
Degrees of freedom	6,23	4,25	2,27	2,27	1,28	1,28	8,21	4,25	2,27	2,27	1,28	1,28

NOTE.—The estimated specifications were based on (5), and the additional right-hand-side variables for each test are marked vertically with crosses. The dependent variable is $\log l_t$. See table 4.

TABLE 6

Moving Window Estimates

Sample	Annual γ_1	Annual γ_2	Weekly γ_1	Weekly γ_2	Hourly γ_1	Hourly γ_2
1948–67	1.52	.92	1.42	1.32	.61	1.56
	(.55)	(.30)	(.33)	(.23)	(.92)	(.49)
1949–68	1.92	.43	1.44	.93	1.46	.95
	(.53)	(.29)	(.31)	(.23)	(.91)	(.47)
1950–69	2.04	.31	1.35	.98	1.19	1.00
	(.62)	(.32)	(.29)	(.22)	(.87)	(.45)
1951–70	1.41	.73	1.10	1.05	.98	.63
	(.53)	(.46)	(.31)	(.41)	(.86)	(.79)
1952–71	1.70	.59	.88	1.06	.85	.51
	(.54)	(.49)	(.29)	(.44)	(.74)	(.77)
1953–72	1.84	.81	.90	1.00	.97	.44
	(.60)	(.47)	(.30)	(.42)	(.87)	(.75)
1954–73	1.78	.92	.84	.69	.60	−.25
	(.77)	(.56)	(.35)	(.42)	(.74)	(.67)
1955–74	1.24	.34	.71	.35	.52	−.44
	(1.20)	(.89)	(.49)	(.60)	(.76)	(.72)
1956–75	.53	−.15	.50	.11	.28	−.51
	(1.23)	(.94)	(.62)	(.73)	(.96)	(.88)
1957–76	1.39	.53	.85	.51	.91	.16
	(.87)	(.65)	(.51)	(.61)	(.92)	(.84)
1958–77	.67	.25	.73	.57	1.49	.82
	(.86)	(.62)	(.44)	(.51)	(.68)	(.63)
1959–78	.61	.33	1.23	1.17	1.64	1.03
	(.91)	(.66)	(.35)	(.42)	(.65)	(.59)
1960–79	1.19	.61	1.35	1.23	1.59	1.00
	(1.06)	(.77)	(.35)	(.43)	(.65)	(.60)
1961–80	.69	.41	1.27	1.15	1.43	.84
	(1.17)	(.81)	(.35)	(.39)	(.69)	(.56)
1962–81	.95	.56	.81	.52	1.19	.51
	(.70)	(.37)	(.27)	(.21)	(.47)	(.27)
1963–82	.56	.32	.77	.41	1.17	.34
	(.64)	(.31)	(.27)	(.18)	(.48)	(.23)

Note.—See table 4 and the text for estimation details.

sumption and leisure is higher than the intertemporal elasticity of substitution.

One reason for the differences from other recent studies, although not the only one, is that they have concentrated almost exclusively on fluctuations in aggregate employee hours. I partly confirm their findings, especially those of Mankiw et al. (1985) for average hours.

The findings of this paper suggest new directions for future research. We are in need of a theory that would be able to explain the apparent success of ISH in accounting for fluctuations in the number of employees, in terms of anticipated changes in the interest rate, and transitory changes in real wages, and its failure in accounting for fluctuations in hours worked. Whether this will take the form of the nominal contracting approach of Gray (1976), Fischer (1977), and Taylor (1979), some extension of ISH to allow for the possibility of rationing, or some totally different explanation is something that remains to be seen.

Appendix A

Comparisons with Altonji's Estimates

Altonji (1982) relied on a different version of ISH, directly related to the specifications of Lucas and Rapping (1969). In my notation, this specification can be written as

$$\log l_t = \beta_0 + \beta_1\left[\log\left(\frac{w}{p}\right)_t - \log\left(\frac{w}{p}\right)_t^*\right] - (\beta_2 - \beta_1)\log\left(\frac{w}{p}\right)_t^* + \beta_3 R_t - \beta_4 \Omega_t + \epsilon_t + \epsilon_t^*, \quad \text{(A1)}$$

where stars denote normal future variables, Ω real wealth, ϵ_t a transitory error component, and ϵ_t^* a component that affects normal labor supply. Equation (A1) can be used to derive an equation for normal labor supply by assuming that current wages and the interest rate are equal to normal:

$$\log l_t^* = \beta_0 - (\beta_2 - \beta_1)\log\left(\frac{w}{p}\right)_t^* + \beta_3 R_t^* - \beta_4 \Omega_t + \epsilon_t^*. \quad \text{(A2)}$$

Subtracting (A2) from (A1), we get

$$\log l_t = \log l_t^* + \beta_1\left[\log\left(\frac{w}{p}\right)_t - \log\left(\frac{w}{p}\right)_t^*\right] + \beta_3(R_t - R_t^*) + \epsilon_t. \quad \text{(A3)}$$

Estimating (A1) would give estimates identical to (A3) if one could adequately control for ϵ_t^* or if the instruments used were predetermined with respect to both ϵ_t and ϵ_t^*. However, if ϵ_t^* is correlated with these instruments, estimates of (A1) that did not adequately control for ϵ_t^* would be biased according to standard statistical arguments. This problem does not arise in (A3) if one could construct an adequate proxy of $\log l_t^*$.

In table A1, I present unrestricted estimates of both my specification (5) and (A1) and (A3). Normal employment and real wages were approximated by a geometric distributed lead on actual employment and real wages, and for simplicity I assumed a constant normal real interest rate. Note that, as a referee has pointed out, this procedure results in (A3) being close to a weighted average of the Euler equations for labor supply. I used the same decay parameter as Altonji, 0.80, and I terminated the distributed lead after 6 years so that the sample coincides with his. I used the McCallum (1976) instrumental variables method, with the same instruments as for all other estimates. As can be seen from table A1, the estimates of (A3) are very similar to the estimates of (5), irrespective of whether one also uses a lagged dependent variable. For employee hours, which are reported in table A1, the estimates are no worse than for my specification. If one uses the unemployment rate as the dependent variable, the results are very similar to those reported in table 2. If one uses a time trend as the only proxy for normal employment,

TABLE A1

COMPARISONS WITH ALTONJI (1982) (Annual Data, 1948–76; Instrumental Variables Estimation)

A.

EQUATION	Right-Hand-Side Variables: $\log l_{t+1}$	$\log(w/p)_t$	$\log(w/p)_{t+1}$	R_t	$\log l_{t-1}$	STANDARD ERROR OF ESTIMATE	DURBIN-WATSON
1	1.08	1.49	−1.68	1.22	...	.027	2.04
	(.46)	(1.08)	(1.53)	(.97)			
2	.85	.97	−1.15	.61	.39	.024	2.73
	(.42)	(.99)	(1.38)	(.91)	(.19)		

B.

EQUATION	Right-Hand-Side Variables: $\log l_t^*$	$\log(w/p)_t$	$\log(w/p)_t^*$	R_t	$\log l_{t-1}$	STANDARD ERROR OF ESTIMATE	DURBIN-WATSON
3	...	−.39	1.25	−.77	...	.027	1.55
		(.63)	(.76)	(.50)			
4	...	−.48	1.06	−.99	.48	.024	2.40
		(.55)	(.66)	(.45)	(.18)		
5	1.11	1.37	−1.38	1.12	...	.027	1.93
	(.55)	(1.08)	(1.51)	(1.06)			
6	.89	.94	−1.01	.56	.41	.024	2.63
	(.49)	(.97)	(1.33)	(.97)	(.19)		

NOTE.—See the text and the previous tables. The instruments used are the same for all estimates. The dependent variable is $\log l_t$.

then one gets the same type of estimates as Altonji, with "wrong" signs for both real wages and the real interest rate. These features seem to suggest that the discrepancies between my own estimates and Altonji's may be due to the time trend being insufficient as a control for ϵ_t^*. This interpretation is supported by the results of Andrews and Nickell (1982) for the United Kingdom, who obtained estimates consistent with (A1) by introducing additional controls for the normal employment component ϵ_t^*.

Appendix B

Data Definitions and Sources

The four employment variables used are defined as follows:

$$l(1) = L/\mathrm{POP},\ l(2) = 1 - U,\ l(3) = l(1) \times H,\ l(4) = L \times \frac{H}{LF},$$

where L is wage and salary workers in nonagricultural employment (ERP),[11] POP is an index of population with constant age and sex composition, defined as in Lucas and Rapping (1969) and Altonji (1982), U is the civilian unemployment rate (ERP), H is average weekly hours, total private nonagricultural (ERP), and LF is civilian labor force.

The three real wage variables used are defined as

$$\frac{w(1)}{p} = \frac{A}{p},\ \frac{w(2)}{p} = \frac{W}{p},\ \frac{w(3)}{p} = \frac{W/H}{p},$$

where A is average gross yearly compensation of employees, excluding agriculture (SCB), W is average gross weekly earnings, total private nonagricultural (ERP), and p is the implicit personal consumption deflator (ERP).

Other variables used include r, Moody's Aaa corporate bond rate (ERP), m, the yearly average of M1 (FRB), and g, total federal purchases of goods and services (ERP).

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[11] The sources of the variables (in parentheses) are *Economic Report of the President* (ERP), *Survey of Current Business* (SCB), and the *Federal Reserve Bulletin* (FRB).

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