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TAXATION AND AGGREGATE FACTOR SUPPLY: PRELIMINARY ESTIMATES

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Abstract

This paper extends the analysis of aggregate factor supply to a model which accounts simultaneously for the consumption/saving and labor/leisure choices. A translog utility maximization model is used to derive the set of consumption and leisure demand equations; these in turn are estimated on U.S. aggregate time series data. The empirical results are striking: we estimate (quite precisely) substantial own and cross price elasticities for current and future consumption and labor supply. The implied interest elasticity of saving is approximately 0.4. The results suggest that previous studies of labor supply and/or consumption which have ignored cross-price effects are misspecified. We also strongly reject the hypothesis that implicit social security had no effect on factor supply.

Taxation and Aggregate Factor Supply:

Preliminary Estimates*

M.J. Boskin** and L.J. Lau**

1. Introduction

The life-cycle supply of the factors of production plays a crucial role in the analysis of many important economic problems. Among these are the optimal tax treatment of capital and labor incomes, the appropriate social rate of discount to be used for public projects, and the construction of indexes of economic welfare. Consider, for example, the simple model

$$U = U(C_w, C_r, L_w) \tag{1}$$

where U is a well-behaved utility function depending upon C_w, the annual flow of consumption during working years, C_r, the annual flow of consumption during retirement, and L_w, the annual flow of leisure during working years.

It then follows from recent analytical results[1] that the efficient (in the sense of minimizing the dead weight loss from raising a given tax revenue) taxation of C_w and C_r (L_w assumed inherently too costly to attempt to tax) requires heavier taxation in the period in which consumption is a weaker substitute for leisure. The tax rates on C_w and C_r

will be equal only if utility is separable between goods and leisure; in general, the tax rates will be given by/2

$$\frac{\hat{t}_w}{\hat{t}_r} = \frac{N_{21} + N_{12} + N_{23}}{N_{21} + N_{12} + N_{13}} \qquad (2)$$

where N_{ij} is the compensated cross elasticity of demand of i with repsect to the price of j ($1 = C_w$, $2 = C_r$, $3 = L_w$). Hence, the optimal tax rate on capital income will be positive ($t_w < t_r$) or negative ($t_w > t_r$) as N_{13} is larger or smaller than N_{23}. Thus, the efficient taxation of capital income depends crucially upon whether or not leisure and consumption during working years are complements, or at least weaker substitutes, than leisure and retirement consumption.

Consider next the appropriate social rate of discount. Recently, Harberger [1968] and Sandmo and Dreze [1971] have derived the result that the appropriate social rate of discount is a weighted average of the gross of tax marginal product of private capital and the net of tax rate of return to saving, the weights depending upon the interest elasticities of investment and saving, respectively. Since business and personal income taxes cause the two rates to diverge sharply, a positive interest elasticity of saving would result in a much lower social rate of discount than the gross private marginal product of capital. In the framework discussed above, the issue is the elasticity of C_w with respect to the forward price of C_r.[3]

Also of interest is the almost total lack of attention given to future consumption in the calculation of indexes of economic welfare. For example, saving is generally ignored in the calculation of constant utility index numbers, i.e., conceptually they often should be calculated as constant life-time utility rather than constant instantaneous utility.

Fortunately, the empirical analysis of factor supply has received renewed attention in recent years. The seminal work of Friedman [1957] and Modigliani [1954; 1963] on life-cycle consumption and of Becker [1964; 1965] on labor supply broadly construed to include human investment and nonmarket work re-kindled interest among empirical economists on these issues. Curiously, however, empirical studies of the role of interest rates or forward prices on consumption are few and far be-tween.[4] Most such studies conclude that interest rates have only a negligible effect on consumption or saving. Boskin [1976] has recently criticized must of this work, es-pecially the structural interpretation of "Denison's-Law," the alleged insensitivity of the saving rate to any economic variables (at full employment). He employed a variety of data sources and advances in econometric techniques to estimate an elasticity of private saving with respect to the real net rate of return of approximately 0.4.

The purpose of the present paper is threefold: First, to see if this sensitivity of saving with respect to the real net rate of return continues to obtain when explicit account is taken of leisure demand and also of the potential influence of social security; second, to estimate the parameters of the demand functions expressly derived from maximizing a utility function of the form of (1); and, third, to begin to expressly account for such life-cycle phenomena as changes in the age distribution of the population. At a subsequent date we hope to be able to use the estimates to draw some provisional conclusions about the issues discussed above.

Toward this end, we present in section 2 our basic model, its properties and estimating equations.

Section 3 discusses the data used in this study, i.e., the national income and wealth accounts developed by Jorgenson and Christensen [1972] and estimates of forward prices, etc., developed by the authors.

Section 4 reports our preliminary empirical results. They are indeed striking. While many refinements are still to be made, our preliminary results strongly reject the structural interpretation of "Denison's-Law." Our estimates suggest that the consumption saving choice is strongly influenced by relative prices including the forward price of future consumption. Our estimates, which appear to be measured quite precisely, suggest that leisure and future consumption are much stronger substitutes than leisure and current consumption.

Finally, section 5 concludes with some provisos and a long list of extensions, refinements and improvements we hope to make relative to these preliminary results.

2. The General Model

A. The Direct Utility Function:

We assume that each consumer unit (an individual or a household) has a utility function of the form:

$$U(L_1, C_1, L_2, C_2, B \; ; \; t, A, D, T(A, t) - A, R(t) - A, s)$$

where L_1 = quantity of leisure in period 1.

L_2 = quantity of leisure in period 2.

C_1 = quantity of consumption in period 1.

C_2 = quantity of consumption in period 2.

B = quantity of bequest.

t = calendar time.

A = age.

D = size of the household in equivalent adult consumption units.

$T(A, t)$ = life expectancy of an individual (or head of household) at age A in year t.

$R(t)$ = expected retirement age at time t.

s = sex of individual or head of household.

As a first pass, we make three simplifying assumptions:

(1) $R(t)$ is given exogenously, that is, it is not a choice variable of the consumer unit;

(2) L_2 is assumed to be fixed and equal to $\bar{L}$, that is, the consumer unit supplies no labor in the second

(post-retirement) period.

(3) B and C_2 will be treated as a composite commodity.

B. Utility Maximization:

The consumer unit is assumed to maximize utility with respect to L_1, C_1, and C_2, subject to a wealth constraint:

$$p_1^c C_1 + p_2^c C_2 = (1-\mu) w_1 (\bar{L} - L_1) + W_p + (1-\lambda) W_s$$

where

w_1 = wage rate.

μ = effective tax rate on labor income.

p_1^c = price of consumption in period 1.

p_2^c = forward price of consumption in period 2.

W_p = private wealth.

W_s = social security wealth.

λ = "discount" factor associated with social security wealth.

As usual, one can transform the budget constraint into the canonical form:

$$w_1^* L_1 + p_1^{c*} C_1 + p_2^{c*} C_2 = 1$$

where

$$w_1^* = \frac{(1 - \mu) w_1}{(1-\mu) w_1 \bar{L} + W_p + (1-\lambda) W_s}$$

$$p_1^{c*} = \frac{p_1^c}{(1-\mu) w_1 \bar{L} + W_p + (1-\lambda) W_s}$$

$$p_2^{c*} = \frac{p_2^c}{(1-\mu) w_1 \bar{L} + W_p + (1-\lambda) W_s}$$

C. The Indirect Utility Function

Under mild regularity conditions an indirect utility function of the form:

$$V(w_1^*, p_1^{c*}, p_2^{c*}, t, A, D, T(A,t) - A, R(t) - A, s)$$

exists. If one specifies an indirect utility function, then the demand functions are given through Roy's Identity as:

$$L_1 = \frac{\frac{\partial V}{\partial w_1^*}}{\frac{\partial V}{\partial w_1^*} w_1^* + \frac{\partial V}{\partial p_1^{c*}} p_1^{c*} + \frac{\partial V}{\partial p_2^{c*}} p_2^{c*}} \quad \text{and}$$

$$C_i = \frac{\frac{\partial V}{\partial p_i^{c*}}}{\frac{\partial V}{\partial w_1^*} w_1^* + \frac{\partial V}{\partial p_1^{c*}} p_1^{c*} + \frac{\partial V}{\partial p_2^{c*}} p_2^{c*}}, \qquad i = 1, 2$$

If we assume that the indirect utility function has the homogeneous translog form, we obtain the linear logarithmic expenditure system of Lau and Mitchell [1971], which gives the expenditure shares as:

$$p_i^* x_i = \alpha_i + \sum_{j=1}^{3} \beta_{ij} \ln p_j^* + \beta_{it} t + \beta_{iA} A + \beta_{iT} (T(A, t) - A)$$

$$+ \beta_{iR} (R(t) - A) + \beta_{is} s, \qquad i = 1, \ldots, 3$$

where the subscripts 1 through 3 stand for L_1, C_1, and C_2,

and $\sum_{i=1}^{3} \alpha_i = 1$; $\sum_{i=1}^{3} \beta_{ij} = 0$, $\forall j$; $\sum_{i=1}^{3} \beta_{it} = 0$; $\sum_{i=1}^{3} \beta_{iA} = 0$;

$\sum_{i=1}^{3} \beta_{iT} = 0$; $\sum_{i=1}^{3} \beta_{iR} = 0$; $\sum_{i=1}^{3} \beta_{is} = 0$ and $\beta_{ij} = \beta_{ji}$, $\forall\, i, j$.

The homogeneous translog indirect utility function is a homothetic utility function which implies that as total full wealth increases, holding prices constant, all expenditures will increase proportionally. Whether this is realistic is, of course, an empirical proposition. However, this assumption may be relaxed through the introduction of nonhomogeneity parameters such as $\bar{L}$ and $\bar{C}_1$ which may be estimated by iterative or search methods. On the first pass we maintain the homogeneity assumption; however, we will relax it in subsequent work.

In order to implement econometrically the model as described in Section 2, we need to be able to relate the current consumption of each age cohort, which is directly observable, to the annualized consumption flow during their working life. One can then aggregate across age cohorts to obtain the aggregate current consumption which is again directly observable. Aggregate current saving then consists of two parts: planned consumption during the remainder of the working life and planned consumption (plus bequest) during the retirement period, both aggregated across age cohorts. Aggregate current consumption will then depend on the same variables which affect the consumption choices of each age cohort and in addition will depend on the age distribution of the population in the economy. As a first pass we make the simplifying assumption that the form of the aggregate current consumption function is the same as the individual age-cohort specific consumption functions in Section 2. In a subsequent paper we shall attempt to derive the aggregate current consumption functions as the sum of individual age-cohort specific consumption functions rigorously.[5]

3. Data and Estimation Methods

The data used in this study come from a variety of sources reporting on aggregate U.S. time series from 1929 to 1969. Most of the data are derived from the complete-and-consistent-accounting system for the private sector of the U.S. economy developed by Christensen and Jorgenson [1972]. These data include information on private income, consumer expenditure, labor compensation, property compensation, rates of return on capital, etc. We exclude expenditure on durables, and include the rental flow on durables, in consumption. We also have developed series on average household size, average retirement age, life expectancy, human investment, the age composition of the population, the sex composition of the labor force, etc. We are using these data both to attempt to generate more reasonable life-cycle variables than are usually used in estimation of consumption functions; the results reported below, as a first step, are intended only to compare our estimation methods with the usual analysis. We will report our estimates with the "life-cycle" adjusted variables in a subsequent paper. We shall also report results which deal explicitly with human capital accumulation. The results reported here, like all consumption or saving function estimates which are used to analyze aggregate capital accumulation, implicitly assume arbitrage between human and nonhuman capital formation.

The definitions of the key variables used in the analysis are as follows:

<u>Current Consumption</u>: As mentioned above, we exclude durables expenditure and include their rental flow; in real per capita terms, as are all other aggregate values.

<u>Wealth</u>: Ando-Modigliani market value of private non-human capital stock.

<u>Social Security Wealth</u>: Feldstein's social security wealth series, as used by Barro [1977].

<u>Wage rates</u>: After-tax wage rates, adjusted for changes in labor force composition; see Jorgenson and Christensen [1972].

<u>Forward Price of Future Consumption</u>: The forward price of future consumption is defined as

$$P_2 = P_1 e^{-rT}$$

where r is the real after-tax rate of return on capital P_1 is the current price index and T is the length of time between saving and dissaving. Boskin [1976] discusses alternative estimates of the expected long-run real after tax rate of return on capital. Alternative estimates yield results similar to those reported below. In the results reported below T is taken to be twenty years. The results are quite robust with respect to variations in T in the range ten to thirty years.

Leisure Consumption: Annual hours available minus average hours of work. In the estimates reported below, available hours are set at 4000; we also allowed this parameter to vary in increments of 500 hours; the results were similar to those reported below. Ideally, the hours available represent total hours in a year less time necessary to maintain human capital (e.g. sleeping and eating). Further, we are unable with these data to separate nonmarket work from true leisure and this should be kept in mind in interpreting the results below.

Further recall that these are preliminary estimates. Our goal, ultimately, is to develop and implement more theoretically sound measures of the life-cycle variables under study, including human investment, permanent income or wealth, etc. In the present paper our goal is the much more modest one of analyzing labor supply and consumption decisions jointly. Since many consumption and labor supply functions have been reported which ignore cross price effects, we hope to begin to examine the full set of own and cross-price effects. After all, one reason for working is to earn income in order to save for future, especially retirement, consumption.

The estimation of the system of consumer demand equations discussed in section 2 imposes several restrictions on the coefficients. In particular, adding up

$$\sum_i \beta_{ij} = 0$$

and symmetry

$$\beta_{ij} = \beta_{ji}$$

are implications of utility maximization. The latter restriction constrains the same parameters in separate equations to the same values. We employ an iterative search procedure to estimate these parameters by least squares. Of course, the prices and income are potentially endogeneous. Indeed, Boskin's [1976] estimates of the interest elasticity of saving double when he allows for such endogeneity. We shall report the results of two stage least squares estimates of our translog demand system in a subsequent paper.

With these provisos concerning the data and estimation methods in mind, we turn to a discussion of our empirical results.

4. Empirical Results

With the provisos mentioned above in mind, we present in tables 1 and 2 our preliminary empirical results, estimates of the parameters of consumer demand equations based on aggregate U.S. time series data. Table 1 reports our results excluding any wealth effect of social security. The equations perform quite well by conventional measures. The estimated standard errors of each regression are a small fraction of the mean values of the dependent variables. The parameter estimates do not violate any restrictions of consumer theory. The estimated standard errors for almost all of the coefficients are less than one - tenth of their respective point estimates, i.e., virtually all of the own-and cross-price effects and expenditure shares are estimated quite precisely.

Table 2 reports our results including full social security wealth in the budget constraint, i.e., $\lambda = 0$. Again, the estimated standard errors of the regression are a minute fraction of the mean values of the dependent variables. Almost all of the coefficients are estimated quite precisely. Comparing the coefficients in tables 1 and 2, we see that the introduction of social security wealth does not change the estimated own and cross price effects very much.

It is instructive to test formally the hypothesis of no social security effect on consumption or labor supply during the period under study. This may be done via the usual likelihood ratio test. As reported in table 2, the test of $\lambda = 1$, no effect of social security, versus $\lambda = 0$, is rejected with a χ^2 statistic twice the critical value. We also allowed λ to vary from 0 to 1 in increments of 0.1. The maximum value of the likelihood function occurred at $\lambda = 0$. While these data suggest that social security did indeed influence aggregate factor supply in the period between the 1930's and 1960's, two cautionary notes are in order. First, our analysis suggests that social security affected aggregate factor supply. Feldstein [1974a] suggests that social security reduced private saving. Boskin [1977] suggests it accelerated earlier retirement. Our results do not distinguish between effects on labor supply and consumption, and hence cannot be viewed as support of either of these propositions.

Second, and conceptually much more important, these data refer to the period when social security was first starting up and during which an enormous intergenerational transfer of resources was made to the first few cohorts of retirees under social security. It may well be that there was a corresponding reduction in private transfers, as discussed, for example, by Barro [1975]. A large percentage of such transfers might well have occurred outside normal market processes and hence escape the usual types of national income accounting. More importantly, once the social security system matures, it may well be that each cohort will get back in benefits approximately its contribution plus interest and that social security will have no effect whatsoever on private savings decisions. Extrapolating from the transition phase therefore may be quite misleading. The statement that social security appears to have had an impact on aggregate factor supply in this period is not the same as saying that it changed the steady-state form of the saving function and is consistent either with the view that it continues to affect private factor supply or with the view that in the steady state it is neutral.

Since the coefficients of the translog consumer demand system are not easily directly interpretable, we present in table 3 some of the more interesting own and cross price elasticities.[6] Note first that these are functions of the parameters and we may thus compute their point estimates and estimated asymptotic standard errors. Their estimated t-ratios range from five to forty, so all are measured quite precisely.

Note first that the forward price of future consumption, which is developed from estimates of the long run expected real net of tax rate of return on capital, has a substantial effect on current consumption. When translated into the more usually discussed net real rate-of-return elasticity of private saving, our estimate is 0.4. This is quite similar to the estimates obtained by Boskin [1976], who estimated consumption functions only. While hardly enormous, it substantially exceeds the commonly accepted conjecture in the "Denison's Law" tradition of a zero elasticity of the private saving rate with respect to any economic variable at full employment.

Even this modest interest elasticity of saving has drastic implications for such issues as the relative efficiency and incidence of income and consumption taxes, the appropriate social rate of discount, etc. These are discussed in some detail in Boskin [1976].

Note also the fact that future consumption is much more price elastic than present consumption and that the cross elasticities, while much smaller than the own elasticities, are hardly negligible. While much more work remains to be done, as discussed below, these results hint not only that heavy taxation of capital is inefficient, but that the optimal tax rates (see Stiglitz and Boskin [1977]) may even call for heavier taxes on current than on future consumption (i.e., a consumption tax combined with an interest income subsidy).

We note also that the coefficients imply a slightly backward-bending labor supply function. The total wage elasticity is about -0.08. This estimate is somewhat less backward-bending than the estimates of many others (see, e.g., Ashenfelter and Heckman [1973] and Harberger [1964]). Of course, the pure substitution elasticity is modestly positive even in these aggregate data. This may be due to the corrections for labor force composition; in view of the substantial evidence of large labor supply elasticities estimated from household data for wives and the elderly (see, e.g., Boskin [1977], Rosen [1976], Heckman [1974], etc.), we shall not push this point too far. Also note the non-trivial cross-interest rate elasticity for labor supply. While it is unusual to include interest rates (or forward prices of future consumption) in labor supply functions, it is not unreasonable to believe that many workers are earning a substantial share of their _marginal_ earnings in order to save for future consumption. These results suggest that previous estimates of _both_ labor supply functions and consumption functions have been misspecified since they exclude the cross-price terms.

5. Conclusions and Caveats

Our preliminary results prove quite interesting and promising. We cannot emphasize too strongly that these results are preliminary. Our ultimate goal is to develop what might best be called life cycle national accounts (as opposed to current accounts), to incorporate human capital explicitly into the analysis and to improve our analytic and econometric procedures. We feel that we have made some progress in the results reported here and that these are not without interest in and of themselves. We are also in the process of dealing with all of the following issues: better measurement of permanent income, consumption and saving in the face of changes in the (age and household) structure of the population and (sex) composition of the labor force which render current measures of these variables suspect; the econometric problems of consistent aggregation, treatment of serial correlation in simultaneous equation systems, endogeneity of the prices (for a first step in this direction, see Boskin [1976]); explicit human investment functions; general nonhomogeneity; more general models of expectations concerning future incomes; and, hopefully, the endogeneity of retirement, and separating bequests from future consumption.

Footnotes

[1] See, for example, Atkinson and Stiglitz [1976].

[2] See Harberger [1964]. If the two periods are of different lengths (e.g., a work life of forty years and a retirement life of twenty years), the formula would be weighted to reflect this difference.

[3] In the alternative approach which shadow prices public investment funds and discounts at the consumption rate of interest (e.g. Feldstein [1974b]), the shadow price depends upon these elasticities.

[4] Thus, Break [1974] notes "Unfortunately, empirical evidence on the interest elasticity of the saving rate is rare."

[5] See Lau [1977] for a discussion of aggregation across consumers with different attributes.

[6] Evaluated at 1955 values of the variable. The elasticities are quite similar if evaluated at, say, 1969 values.

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Table 1

Preliminary Estimates of

Aggregate Factor Supply Equations

(Social Security Wealth Excluded; $\lambda=1$)

Parameter	Estimated Coefficient (estimated standard errors in parentheses)
α_L	0.2138
	(0.0196)
β_{LL}	0.0875
	(0.0062)
$\beta_{L1} = \beta_{1L}$	-0.1697
	(0.0126)
α_1	0.6138
	(0.0467)
β_{11}	0.0270
	(0.0338)
log of likelihood function	105.08

N.B. $\beta_{L2} = \beta_{2L} = -(\beta_{LL} + \beta_{21})$

$\beta_{12} = \beta_{21} = -(\beta_{L1} + \beta_{11})$

Table 2

Preliminary Estimates of Aggregate Factor Supply Equations (Social Security Wealth Included; $\lambda=0$)

Parameter	Estimated Coefficient (estimated standard errors in parentheses)
α_L	0.1762
	(0.0138)
β_{LL}	0.0812
	(0.0041)
$\beta_{L1} = \beta_{1L}$	-0.1332
	(0.0106)
α_1	0.5271
	(0.0529)
β_{11}	0.0353
	(0.0399)
log of likelihood function	108.85

test of no effect of social security:

$$-2 \ln \lambda = 7.54 > \chi^2_{.05} = 3.84$$

Table 3

Estimated Elasticities*

With Respect to:	C_1	C_2	Labor
W	0.28	1.11	-0.08
	(3.07)	(39.46)	(-15.64)
P_1	-0.89	0.28	0.18
	(-6.75)	(3.79)	(10.88)
P_2	0.52	-1.49	-0.08
	(2.87)	(-15.71)	(-3.93)
R**	-0.54	1.54	0.08
	(-2.87)	(15.71)	(3.93)

* t-statistics in parentheses.

** Allowing income to vary with R. The elasticities with respect to R holding full permanent income constant are similar, but slightly larger in absolute value.