Econometric Models and the Study of the Economic Effects of Social Security

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This article provides a relatively nontechnical discussion of previously published research on the use of econometric models in the study of the economic effects of social security. It illustrates the role of econometric model building by focusing on three major applications: forecasting, policy simulation, and hypothesis testing. A series of three macroeconomic examples serves to emphasize that the development and use of such models puts the focus of the analysis on the underlying economic structure. The first example presents a program-specific model of the Social Security system, the second a large-scale model of the U.S. economy, and the third a single-equation analysis of a specific issue.

This article illustrates the role of econometric model building in the economic research program maintained by the U.S. Social Security Administration. It is focused on three major applications of modeling: forecasting, policy simulation, and hypothesis testing—always in the context of models that represent economic structure rather than pure statistical models. The discussion is confined, for the most part, to a macroeconomic perspective and several examples are presented, one of which uses a program-specific model of the U.S. Social Security system, another a large-scale model of the U.S. economy, and a third deals with a single-equation analysis of a specific issue.

Section I provides a brief discussion of the specification and estimation of an aggregate short-term model of the U.S. Social Security program. The model contains a fair amount of program detail and is illustrative of some fundamental issues a model builder must resolve when modeling a complex government program. Both behavioral and "mechanistic" equations are imbedded in the model. Linear and nonlinear estimation techniques are used to estimate the parameters of the model. Several equation specifications are discussed and some estimated equations are presented.

The model described in Section I requires as input exogenous values (values determined outside the model) of aggregate economic variables before it can be solved. Section II illustrates a modeling application in which economic variables, exogenous to a program-specific model, are jointly determined (endogenous) with the program-specific variables from a social security sector model. The example used is a simulation of the macroeconomic effects of alternative financing schemes as estimated by a commercial large-scale model of the U.S. economy. The social security sector included in the commercial model was much simpler than the model described in Section I. In principle, the model in Section I could be integrated into an economy-wide model.

In Section III, a single-equation model is discussed. It deals with the determination of aggregate wage behavior, with particular emphasis on the effect of employer-paid social security contributions. The major interest is in testing a fairly narrowly defined hypothesis about economic behavior.

It is important to note that the material to follow should be viewed as illustrative. The studies cited[1] are

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[1] Material in Section I is based on John C. Hambor, **An Econometric Model of OASDI** (Studies in Income Distribution No. 10), Office of Research and Statistics, Social Security Administration, November 1978. Material in Sections II and III draws heavily on John B. Hagens and John C. Hambor, "The Macroeconomic Effects of a Payroll Tax Rollback," **Eastern Economic Journal**, Vol. VI, No. 1, January 1980.

Editor's Note

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somewhat dated and do not necessarily represent the most current state of analysis. Nevertheless, they represent useful examples of econometric modeling techniques applied to social security issues.

I. A Cyclical Macroeconometric Model of the U.S. Social Security Sector

The model discussed in this section can be used as a forecasting tool or as a policy simulation tool to analyze the impact of short-term fluctuations in economic conditions on social security. Consisting of more than 30 stochastic equations and identities, the model is based on annual data and determines the number of new retirement and disability program beneficiaries, total calendar-year benefit payments by major trust fund category, and calendar-year payroll tax collections from employers, employees, and the self-employed. The model is a recursive, self-contained module that requires, as input, values for contemporaneous economic variables, such as the unemployment rate, wage rate, and inflation rate, for solution—that is, it treats the economic variables as exogenous.

The model consists of two basic types of equations: equations that explain economic behavior and equations that model program mechanics. Behavioral equations designed to measure the quantitative impact of economic factors on the decision to retire or to apply for disabled-worker benefits were developed for separate age groups. The specification of these equations is based on a simple short-run cyclical version of labor-market theory that treats retirement and disability status as alternatives to labor-force participation. Workers are expected to be more likely to retire (if eligible) and to seek disability status (if they think they are eligible) if they are unemployed. Economic theory also predicts that workers will respond to price incentives measured, for example, by the size of potential benefits relative to available earnings. It is generally expected that program participation will increase as benefits rise relative to wages. The equations also contain dummy variables to allow (grossly) for major changes in the program's structure during the estimation period.

The general form of these equations is illustrated in table 1 by the equations used to explain the number of new retirees aged 62–64 (R). The specification allows for a cyclical effect, measured by an age-specific unemployment rate (U) and the effect of benefit payments relative to the wage rate (B/w), with adjustments to model the characteristics of the retirement test. Dummy variables (D) were used to model shifts in parameter values due to major changes in the law. For example, in equation 1.1, the marginal retirement rate of those aged 62–64, given the unemployment rate and the relative benefit rate (coefficient on the eligible population variable (N) in table 1), was reduced when, in 1961, men were allowed to retire at age 62, as had been true for women since 1957.

Equation 1.1 was fitted using annual data from 1957 through 1974. It provides some (weak) evidence for a positive impact of increased unemployment on early retirement decisions and some (weaker) support for a rise in early retirement in response to increases in benefits relative to wages. The equations for older retirees and disability awards are similar in structure and also provide some evidence of cyclical and incentive effects on program participation.

Contributions or payroll taxes, used to finance retirement insurance benefits and disability insurance benefits, are paid in equal amounts by employers and employees from earnings up to a specified annual amount. Currently, maximum taxable earnings are $37,800 per year and the tax rate is 7.00 percent. The significant part of the specification of the tax equations is the modeling of the interrelationship between the taxable maximum and the distribution of covered earnings, which determines total taxable earnings.

The form of the relationship between contributions and the earnings base is

$$T = R_t \, (W_T/W_C) \, W_C, \tag{1}$$

where T is contributions, R_t is the contribution or payroll tax rate, W_T is taxable earnings, and W_C is earnings in employment covered by social security. Because of the nature of the definition of taxable earnings, the ratio (W_T/W_C) requires special treatment.

Since only earnings up to a given annual maximum per person (M) are used to determine Old-Age, Survivors, Disability, and Health Insurance (OASDHI) contributions, the taxable ratio (W_T/W_C) depends on the size of M as well as the position of M in the distribution of covered earnings. Formally, taxable earnings can be represented as

$$W_T = W_B + n \cdot M \tag{2}$$

and thus the taxable ratio (t) as

$$t = \frac{W_T}{W_C} = \frac{W_B + n \cdot M}{W_C}, \tag{3}$$

where W_B is total earnings of workers with earnings below the maximum taxable amount and n is the number of workers with earnings at or above the maximum. For a given M, t depends on the size of W_B relative to total covered earnings above the maximum $(W_C - W_B)$. Likewise, for a given W_C, a change in M changes the size of both W_B and $W_C - W_B$ and thus t. Obviously, the effect of changes in M or W_C on t depends on the shape of the distribution of covered earnings. In particular, the taxable ratio at any point in time can be written as

$$t = \frac{N\int_{y_0}^{M} wf(w)dw + N\left(1-\int_{y_0}^{M} f(w)dw\right)M}{N\int_{y_0}^{y^*} wf(w)dw}, \qquad (4)$$

where f(w) is the density function for earnings, y^o is the lowest earnings in the distribution and y^* is the highest, and N is the total number of workers in covered employment. If the distribution is not constant over time, equation (4) would have to be further modified to account for shifts in f(w).

Since the objective was to maintain a relatively simple expression for contributions in the estimated equations, an explicit modeling of equation (4) would be too complicated for that purpose. The form of the earnings distribution was assumed to be constant through time, and t was represented by

$$t = e^{\gamma(\overline{w}/M)}, \qquad (5)$$

where $\alpha < 0$ is a parameter and $\overline{w}$ is average covered earnings. This functional form is simple, easy to estimate, captures the major impact on contributions from changes in $\overline{w}$, and roughly approximates the earnings distribution for all workers. It also has the desirable properties that as M approaches infinity the taxable ratio approaches 1, and as M approaches zero the taxable ratio approaches zero. Thus, the equation actually estimated was

$$T = AR_t^{C_1} W_C^{C_2} e^{\gamma(\overline{w}/M)}, \qquad (6)$$

where the coefficients are expected to conform to $c_1 = c_2 = 1$ and $\alpha < 0$, and A is a scale factor. The goodness-of-fit criteria measure how well this simplified form approximates the mechanical relationship between payroll taxes, the taxable maximum, and the earnings distribution. Equation 1.2 in table 1 is the estimated version of the equation for private sector payroll taxes.

In addition to the beneficiary and contribution equations, equations explaining the average benefit amount for new beneficiaries, total benefit payments, including payments to beneficiaries already on the rolls, and several identities close the system. The model was designed to be linked with a complete econometric model of the U.S. economy but can also be used as a "stand-alone" device. Given a projection of a set of economic variables, such as the unemployment rate or the average wage rate for the equations just discussed, the model can be used to study the time path of benefit payments and contributions and, therefore, the trust fund balance over various cyclical scenarios. Although in principle it could be used to make official forecasts of trust fund behavior, its use in the official estimation process is restricted because of the simplifications and omissions of program detail required to keep the model manageable and potentially conformable to existing large-scale macro models. These simplifications (from the program perspective), however, do not reduce the model's usefulness for providing insight into the program's short-term cyclical characteristics.

II. Macroeconomic Analysis of Social Security Financing

The previous section described a model that is highly useful for evaluating the effect of economic variables on the Social Security system. To evaluate the impact of Social Security on the economy, however, requires a model of the U.S. economy with an integrated Social Security sector. To illustrate, consider the problem of identifying and measuring the economic effects if the funding of the U.S. system were changed from the current virtually total reliance on the payroll tax to partial reliance on a different funding source.

Table 1.—Examples of regression results from social security model[1]

Equation 1.1

$$R = -.236 + (.214 - .147\,D)\,N + .024\,U + .000182\,(B/w)$$
$$\quad\;(3.8)\quad(6.7)\quad(5.3)\qquad\quad(2.3)\qquad(1.3)$$

$$\overline{R}^2 = .88$$

Equation 1.2

$$T = \text{Exp}\left[\begin{array}{l} -4.57 + 1.02 \ln R_t + 1.01 \ln W_C - .0235\,(\overline{w}/M) \\ (32.6)\quad(24.1)\qquad(32.4)\qquad\qquad(17.3) \end{array}\right]$$

$$\overline{R}^2 = .99$$

[1] Variable symbols are defined in text. Exp is exponential function, ln is natural logarithm, and $\overline{R}^2$ is the coefficient of determination adjusted for degrees of freedom. The absolute value of the t-statistics appears in parenthesis below each coefficient.

One of the most commonly cited reasons for reducing reliance on the payroll tax is the belief that payroll tax increases are inflationary. If true, it follows that a payroll tax rollback would tend to relieve inflationary pressure in the economy. Presumably, the price-reducing effect of a rollback is implied by a model in which prices are determined by costs of production. A reduction in the employer portion of the payroll tax, a component of production costs—other things equal—leads to a drop in prices. But this condition is violated if other cost components are affected by the tax rollback. These other effects depend on the method used to finance the rollback and the shifting pattern of taxes.

A payroll tax cut can be financed by increased debt issue (which may or may not be monetized), by increases in other taxes such as the personal or corporate income tax or a value-added tax (VAT), or by a decrease in government spending. With some financing devices—the VAT being one example—other components of production costs are directly increased, offsetting the cost-reducing effect of the payroll tax cut. Since production costs and thus prices are likely to be sensitive to changes in aggregate demand, the demand effects of the package must also be considered. Additionally, the shifting pattern of taxes should be included in any analysis of the effect of a payroll tax rollback on costs and prices. If the rollback is shifted back to employees in the form of higher nominal earnings or fringe benefits, then the cost-reducing effect is offset. Of course, the shifting pattern of the alternative financing instruments may lead to other indirect cost changes.

The analysis of such a complex set of interrelated economic effects is most easily undertaken by using a large scale macroeconometric model of the economy. A set of equations models the specifics of the economic linkages between the various taxes and other financing methods and their ultimate output and price effects. Without such a device, it would be nearly impossible to organize coherently the information needed to estimate such effects quantitatively. To illustrate, a simulation using the Data Resources, Inc. (DRI) econometric model[2] that analyzed the financing of about a third of Social Security costs from a new source, is reported. The comparative effects of this simulated financing change on real output growth and inflation over a 5-year period were calculated for several different financing mechanisms.

One issue that had to be resolved before proceeding to the calculations was how to characterize the burden of the employer share of the payroll tax in the simulations. Although most economists would agree that labor eventually pays the employer tax through lower real wages, considerable disagreement exists about the short-term impact of the employer tax. The simulations were run imposing the assumption that reductions in the employer tax are reflected fairly quickly in lower product prices, rather than being passed along in larger employee wage increases or higher profits. Thus, the results provide a best case (from an inflation perspective) scenario. In Section III, some (contradictory) evidence on this issue is presented in the context of a single-equation econometric analysis.

The output and price effects of the alternative financing schemes are reported in table 2 as 5-year cumulative percentage changes. All calculations were done with the DRI model and covered the period 1979-83. The results indicate that the offsets to the payroll tax rollback essentially cancelled any output effects from the rollback, except for the debt financing case. The effects on inflation varied. Aside from the debt financing case, the VAT offset produced the only increased inflationary effect, while the other alternatives resulted in a lowering of inflation, although by differing amounts. Since the VAT is directly inflationary and the other methods do not generally result in substantial upward price pressure, the result is not surprising. The output growth and large amount of additional inflation in the debt financing case reflect the fact that in this simulation, by holding interest rates approximately fixed, the expansionary effect of the payroll tax rollback was monetized.

The impact on variables other than output and prices could be discussed, since the simulations produce a measure of the economic impact of the rollback on all endogenous variables in the model. The discussion is not pursued further, however, since the main point here is that to provide such estimates for evaluation, a detailed model is needed.

III. Incidence of the Payroll Tax: A Single-Equation Analysis

The simulations reported in the preceding section depended on the incidence assumption imposed in the model. This section describes some empirical work in which time-series data were used to estimate directly the shifting pattern of the payroll tax. The focus is the effect of payroll tax changes on the time path of worker

Table 2.—Five-year cumulative output and price effects of five alternative financing schemes to offset a one-third reduction in payroll taxes

Financing method	Percent	
	Output	Prices
Increase in Federal debt (holding interest rates unchanged)	1.4	1.6
Increase in the personal income tax	.4	-1.1
Reduction in Federal Government expenditures	-.1	-2.3
Increase in a hypothetical value-added tax	0	.9
Increase in the corporate income tax	.1	-.7

[2] Data Resources, Inc. (DRI) simulations were based on the model solution for May 1978 and used the 1978A version of the macro model.

compensation—that is, whether the tax is shifted backward to workers, and, if so, the time pattern of this shift. The question of whether the tax results in higher prices or lower profit, if it is not fully backward shifted, is ignored.

The estimated equation follows the traditional theory of aggregate wage determination. Disregarding taxes for the moment, the rate of change in nominal compensation, $\dot{w}$, is typically modeled as depending on excess labor-market demand, ED, and expected price inflation, $\dot{p}^e$. The linear form of this expectations-augmented Phillips Curve is

$$\dot{w} = \alpha_0 + \alpha_1 \, ED + \alpha_2 \dot{P}^e. \tag{7}$$

Coefficient α_0 measures real compensation growth, approximately equal to average labor productivity growth, and α_1 measures the sensitivity of compensation to excess demand in the labor market. As α_1 increases, the Phillips Curve steepens and labor markets move to equilibrium more rapidly. Coefficient α_2 is a measure of the degree of money illusion displayed in the labor market. If there is no money illusion (workers are only concerned with expected real compensation and its time path), then $\alpha_2 = 1$. If there is complete money illusion, $\alpha_2 = 0$.

This framework can easily be modified to test for the amount of shifting of the payroll tax. First, split compensation into nonpayroll tax compensation, w^n, and employer payroll taxes, T,

$$w = w^n + T. \tag{8}$$

Letting r be the effective employer payroll tax rate with base w^n ($r = T/w^n$), we have

$$w = w^n (1 + r). \tag{9}$$

In percentage changes, this becomes approximately,

$$\dot{w} = \dot{w}^n + (1 \dot{+} r). \tag{10}$$

By substituting equation (10) into the expectations-augmented Phillips Curve and allowing $(1 \dot{+} r)$ to have a free coefficient,

$$\dot{w}^n = \alpha_0 + \alpha_1 \, ED + \alpha_2 \dot{P}^e + \beta (1 \dot{+} r). \tag{11}$$

If $\beta = 0$, then a payroll tax change, $(1 \dot{+} r) > 0$, for example, has no effect on nonpayroll tax compensation, w^n. In other words, there is no backward shifting resulting in a lower wage increase, and compensation, w, rises by the full amount of the tax increase. If $\beta = -1$, then $\dot{w}^n$ drops by the full amount of the tax increase and w does not change, indicating complete backward shifting. In general, the absolute value of β measures the fraction of an employer payroll tax increase that is borne by labor in the form of lower nonpayroll tax compensation.

With the addition of lagged values of the inflation rate as proxies for $\dot{p}^e$, and lagged values of $(1 \dot{+} r)$, equation (11) was estimated with annual data for the period 1954–76. Modifications to allow for episodic wage-price control programs during the 1960's and 1970's, plus an adjustment of the measured unemployment rate for changes in the "natural" unemployment rate, were also added to the specification before estimation.

The results indicated that about 80 percent of the employer tax is shifted backward to workers after 3 years. The lag structure or shifting pattern, however, was counterintuitive. The estimated shifting pattern indicated that more than 100 percent of the tax was backward shifted after 2 years (statistically significant negative values for β on $(1 \dot{+} r)$ and $(1 \dot{+} r)$ lagged 1 year), but the process reversed in the third year (statistically significant positive value for β on $(1 \dot{+} r)$ lagged 2 years) and was (statistically) zero thereafter. The sum of the β's added to about -0.8. Thus, although this analysis seemed to provide evidence of substantial backward shifting of the payroll tax, the estimated lag pattern is difficult to explain. The lag pattern result substantially weakens any conclusions concerning the potential size of the inflationary impact of the payroll tax based on this analysis. Although one might be tempted to say that the estimation provides strong evidence that the employer tax has little inflationary impact (at most 20 percent of any increase eventually could be passed on in higher prices), the results should only be interpreted as a caution to those who would assume full and rapid forward shifting of the tax.

Commentary

In Section III, econometric techniques applied to the analysis of wage behavior did not provide a definitive answer about payroll tax incidence. Because the analysis was concentrated on the structure, or the determinants of economic behavior, however, a framework based on theory was available, and thus allowed a rigorous evaluation of the statistical results. Because the analysis took place in the context of this framework, it was possible to make the judgment that the statistical results were weak. Further analysis within that framework may lead to better structural parameter estimates, or even to a revised and improved framework. The point is, econometric modeling deals with economic structure in order to better understand economic behavior. For example, updating and refining of the social security sector model in Section I should result in a better representation of how the economy affects the U.S. retirement system. A linking of that model with a model like the DRI macroeconometric model would provide a mechanism to evaluate more fully the interrelationships between the economy and the social security sector.

Econometric modeling is a tool that can be employed to develop structural estimates to be used for the analysis of economic behavior. Such a tool, if properly applied, can produce defensible economic forecasts and policy simulations. Its major advantage over other more mechanical techniques (trend analysis or other more sophisticated time-series methods, for example) is that when it goes wrong, the difficulty is usually easier to identify. Knowledge about the underlying structure of a process is more useful in understanding the outcomes of the process than methods relying solely on outcomes.