Chapter Four

The Household Sector

4.1 INTRODUCTION

The eight stochastic equations that relate to the household sector are explained in this chapter. The eight equations include four consumption equations, three work effort equations, and an equation explaining the value of demand deposits and currency of the household sector. Given the important distinction in the theoretical model between a household's unconstrained and constrained decisions, it will be useful in the following analysis to consider these two types of decisions separately.

In section 4.2 the variables that are assumed to affect the unconstrained decision variables of the household sector are discussed, and then in section 4.3 the treatment of the constraints is discussed. The variables that explain the unconstrained decision variables are those that one expects on microeconomic grounds to affect a household's decisions. The effects of the constraints are handled by adding to the equations determining the unconstrained decision variables certain "constraint" variables (denoted as ZJ_t and ZR_t below).

4.2 THE DETERMINATION OF THE UNCONSTRAINED DECISIONS

In Table 4–1 the decision variables in the theoretical model are matched to the related variables in the empirical model. All the decision variables should be considered for now as being unconstrained. In the theoretical model there is only one type of consumption good, and so there is only one consumption decision variable for each household. In the empirical model, on the other hand, four consumption variables are considered to be decision variables of the household sector. These four variables are expenditures on services, CS_t,

Table 4–1. Matching of Dependent Variables in the Theoretical and Empirical Models for the Household Sector

Decision Variable in the Theoretical Model	*Related Variable(s) in the Empirical Model*
1. XH_{it} (number of goods purchased by household i)	CS_t (expenditures on services) CN_t (expenditures on nondurable goods) CD_t (expenditures on durable goods) KCD_t (stock of consumer durable goods) IH_t (expenditures on housing) KIH_t (stock of houses)
2. HPH_{it} (number of hours that household i is paid for)	$JOBH_t$ (number of jobs in the economy) HPH_t (average number of hours that each job is paid for) $EMPL_t$ (number of people employed in the economy) $MOON_t$ ($=JOBH_t - EMPL_t$, number of moonlighters) TLF_{1t} (labor force of men 25–54) TLF_{2t} (labor force of all persons 16 and over except men 25–54)
3. DDH_{it} (demand deposits of household i)	DDH_t (demand deposits of the household sector)

Note: $JOBH_t = JOBF_t + JOBGC_t + JOBGM_t$

$$HPH_t = \frac{JOBF_tHPF_t + JOBGC_tHPGC_t + JOBGM_tHPGM_t}{JOBH_t}$$

expenditures on nondurable goods, CN_t, the stock of consumer durable goods, KCD_t, and the stock of houses, KIH_t. This separate treatment of the four consumption decision variables can be justified within the context of the theoretical model if it is assumed that the four variables enter the utility function of each household separately. The inclusion of the stocks of consumer durables and houses in the utility function can be justified if it is assumed that the services from durable goods and houses are proportional to the stocks.

The solution of the optimal control problems of the households in Chapter Four in Volume I would proceed in a similar way with four kinds of goods or services rather than one. The main difference that would exist in the four-good case is that the relative prices among the four goods would affect the household's decisions. If services are proportional to stocks and stocks have a life longer than one decision period, then the stocks of durable goods and houses that exist at the beginning of the household's decision period would also, of course, have important effects on the household's decisions. Otherwise, however, the analysis in Chapter Four in Volume I would be little changed. The solution of the control problem would just be slightly more complex.

There is also only one work effort variable for each household in the theoretical model, whereas in the empirical model more than one variable is considered. Six work effort variables are listed in Table 4-1 for the empirical model. The total number of worker hours paid for in the economy is $JOBH_t HPH_t$. If households were never constrained in their work effort, they could be considered as determining this amount. The household sector could also be considered as determining the breakdown of this amount into jobs ($JOBH_t$) and hours per job (HPH_t) and as determining the breakdown of jobs ($JOBH_t$) into the number of different people employed ($EMPL_t$) and the number of moonlighters ($MOON_t$). Finally, the household sector could be considered as determining the total labor force (TLF_{1t} and TLF_{2t}).

In this unconstrained case, "unemployment" (the difference between the number of people in the labor force and the number of people employed) would be completely voluntary. It would be a decision variable of the household sector and would be a function of all the variables that affect the unconstrained decision making processes of the households. (In the theoretical model unemployment was zero in the unconstrained case because search behavior was not considered explicitly.) It will be convenient with respect to the six work effort variables in Table 4–1 to consider in this chapter only the determination of $MOON_t$, TLF_{1t}, and TLF_{2t}. The determination of $JOBH_t$ and HPH_t will be discussed in the next chapter. Once $JOBH_t$ and $MOON_t$ are determined, $EMPL_t$ is simply the difference between the two.

In Table 4–2 the variables that are important in the theoretical model in influencing a household's decisions are listed and are matched to the relevant variables in the empirical model. As can be seen in the table, there are five price deflators in the empirical model that are of relevance to the household sector, instead of only one in the theoretical model. The variable *YG* in the theoretical model measures the level of transfers payments from the government to each household. The closest variable approximating *YG* in the empirical model is ($YG_t + TPU_t$), which measures transfer payments from the government sector to the household sector. *YG* in the theoretical model has a negative effect on work effort and a positive effect on consumption. The variable that was chosen in the empirical model to represent the effects of *YG* was actually not ($YG_t + TPU_t$), but was instead $YNLH_t$, the measure of nonlabor income of the household sector. $YNLH_t$, which is defined by Equation 71 in Table 2–2, includes ($YG_t + TPU_t$) plus dividend, interest, rental income, and three other items. Two of the three other items are small and not important (transfer payments from the firm sector to the household sector, $FHTRP_t$, and profits of farms, $FHPFA_t$). The other item is employee social security contributions, $HGSI2_t$, which is subtracted from the other variables.

The inclusion of $HGSI2_t$ in the definition of nonlabor income is another example of the imposition of a constraint on the way that taxes affect behavior. Since d_{6t} is the employee social security tax rate, it could have been used directly as an explanatory variable in the stochastic equations of the

Table 4–2. Matching of Explanatory Variables in the Theoretical and Empirical Models for the Household Sector

Explanatory Variable in the Theoretical Model	*Related Variable(s) in the Empirical Model*
1. WH_{it} (wage rate received by household i)	WF_t (average hourly earnings, adjusted for overtime and interindustry employment shifts)
2. PH_{it} (price paid for goods by household i)	PCS_t (price deflator for CS_t) PCN_t (price deflator for CN_t) PCD_t (price deflator for CD_t) PIH_t (price deflator for IH_t) PH_t (price deflator for domestic sales inclusive of indirect business taxes)
3. r_t (bill rate), RH_{it} (loan rate paid by household i)	$RBILL_t$ (bill rate) $RMORT_t$ (mortgage rate)
4. d_3 (personal income tax rate)	d_{3t}^M (marginal personal income tax rate)
5. YG (minimum guaranteed level of income or level of transfer payments to each household)	YG_t (transfer payments from the government sector to the household sector not counting TPU_t) TPU_t (unemployment insurance benefits) $HGSI2_t$ (employee social security taxes) $YNLH_t$ (nonlabor income, $DIVH_t + INTH_t + FHRNT_t + FHTRP_t + FHPFA_t + YG_t + TPU_t - HGSI2_t$)
6. A_{it-1} (value of nondemand deposit assets of the previous period), LH_{it-1} (value of loans taken out of the previous period)	A_{t-1} (value of nondemand deposit securities of the previous period)

Explanatory Variables in the Empirical Model for Which There are no Counterparts in the Theoretical Model

POP_t	(population 16 and over)
POP_{1t}	(population of men 25–54)
POP_{2t}	(population of all persons 16 and over except men 25–54)
KCD_{t-1}	(stock of durable goods of the previous period)
KIH_{t-1}	(stock of houses of the previous period)

household sector. An initial attempt was made to do this, but with little success. It did not appear to be possible to pick up independent effects of d_{6t} in the data, and so $HGSI2_t$ was instead included as a negative item in the definition of nonlabor income. $HGSI2_t$ is, of course, an endogenous variable in the model, but so also are three other variables that are included in the definition of nonlabor income ($DIVH_t$, $INTH_t$, and TPU_t). $YNLH_t$ is thus an endogenous variable in the model.

$HGSI2_t$ is linked to the wage bill of the firm sector, and so it changes when wages change. Therefore, $YNLH_t$ changes as wages change, and so it is not, strictly speaking, a nonlabor income variable. The effect of wages on $YNLH_t$ is, however, fairly small, and for ease of exposition $YNLH_t$ will be referred to simply as nonlabor income.

The lumping together of $YG_t + TPU_t$ and dividend, interest, and rental income in the definition of $YNLH_t$ is yet another example of the imposition of a constraint on the way that the government affects behavior. Transfer payments from the government sector are assumed to be treated by the household sector like any other nonlabor income item. This constraint was again imposed because of the difficulty of estimating separate effects of the two types of income.

In the theoretical model there are both creditor and debtor households. A_{it} in Volume I denotes the value of nondemand deposit assets of creditor households, and LH_{it} denotes the value of loans of debtor households. In the empirical work it is not possible to distinguish between creditor and debtor households, and A_{t-1} in Table 4–2 instead denotes the value of nondemand deposit assets *minus* liabilities of the household sector.

In the estimation of the consumption and work effort equations of the household sector, the explanatory variables for each equation were taken from the variables in Table 4–2. Because of possible multicollinearity problems, only a subset of the variables in the table was tried for any one equation. Some variables that were tried were also dropped if they contributed little to the explanation of the dependent variable. Many of the variables were deflated by population; two of the variables ($YNLH_t$ and A_t) were deflated by the price level; the functional form of all of the equations was taken to be the log form; and some experimentation was done on trying alternative lag structures. The estimated equations are discussed in section 4.4, but before this is done the treatment of the constraints on the household sector must be explained.

4.3 THE TREATMENT OF THE CONSTRAINTS

The hours and loan constraints on the households play an important role in the theoretical model. The existence of constraints poses a very serious problem for empirical work because the unconstrained decision values are observed only if the constraints are not binding. Otherwise, only the constrained decision values are observed. All the discussion in the previous section was concerned with the unconstrained decision variables, and so some modification of the equations that result from this discussion must be made to account for the constraints. There is no one obvious way to account for the constraints, and it should be stressed that the approach that will now be described is only one of a number that might be tried. It would clearly be of interest in future work to consider other possible ways of accounting for the constraints.

Let $CSUN_t$ denote the expenditures on services that the household sector would make if it were not constrained, and let CS_t denote the actual expenditures made. Assume that one has specified, from the previous section, an equation determining $CSUN_t$:

$$CSUN_t = f(\cdots). \tag{4.1}$$

Assume also that all the variables on the right-hand side of this equation are observed. If the household sector is not contrained, the ratio $CS_t/CSUN_t$ is one. If the household sector is constrained, then the ratio is less than one, providing that one assumes—as is done here—that binding constraints cause the household sector to consume less than it would have unconstrained. If one can find a variable, say Z_t, such that:

$$\frac{CS_t}{CSUN_t} = Z_t^{\gamma_1},\ \gamma_1 > 0, \tag{4.2}$$

then one has immediately from Equations (4.1) and (4.2) an equation in observed variables, which can then be estimated:

$$CS_t = Z_t^{\gamma_1} f(\cdots). \tag{4.3}$$

Within this framework, the problem of accounting for the constraints reduces itself to finding a variable Z_t for which the specification in (4.2) seems reasonable.

Consider first the hours constraint on the household sector. What one needs is a variable that takes on a value of one when conditions in the labor market are tight and households are not constrained, and a value of less than one otherwise. When the variable is less than one, it should be proportional to the ratio of the constrained to the unconstrained decision values of the household sector. One obvious measure of labor market tightness is $1 - UR_t$, where UR_t is the civilian unemployment rate. Another measure of labor market tightness is J_t^*, which is defined in Equation 76 of Table 2–2 and which is the detrended ratio of total hours paid for in the economy to the total population 16 and over. The number -0.00073513 used in Equation 76 is the estimate of the coefficient of t in the regression of $\log J_t$ on a constant and t for the 1952I–1974II period.

If, say, J_t^* is used as the measure of labor market tightness, one needs to construct a variable Z_t that is a function of J_t^* and that has the

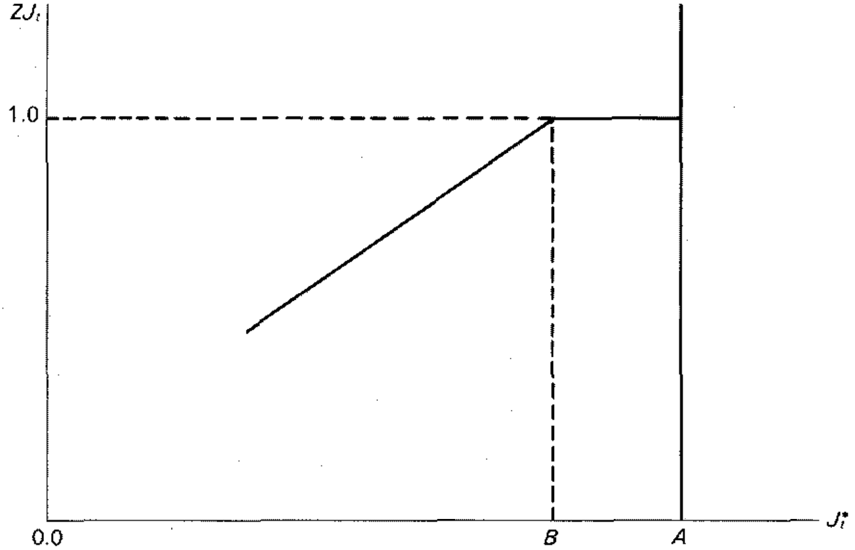

Figure 4-1. Desired Shape of ZJ_t as a Function of J^*

properties just described. The desired shape of Z_t as a function of J_t^* is presented in Figure 4-1. Point A is some value that is larger than the largest value of J_t^* observed in the sample period, and point B is the value of J_t^* above which it seems reasonable to assume that the household sector is not constrained. An approximation to the curve in Figure 4-1 is the left half of the normal density function:

$$Z_t = e^{-\alpha_1 (J_t^* - A)^2}. \tag{4.4}$$

For J_t^* equal to A, Z_t is one, and for J_t^* less than A, Z_t is less than one. How good an approximation the normal density is to the curve in Figure 4-1 depends on how close B is to A and how steep the slope of the line to the left of B is. The goodness of the approximation depends also, of course, on the value chosen for α_1, but it turns out, as will be seen shortly, that a value of α_1 does not have to be specified before estimation of the equation. Another possible choice for the Z_t variable would be to replace J_t^* with $1 - UR_t$ and to take for the value of A some value that is larger than the largest value of $1 - UR_t$ in the sample period. J_t^* turned out to give somewhat better results than did $1 - UR_t$, although both sets of results were fairly close. Only the results using J_t^* are reported below.

Consider next the loan constraint. One needs to find a variable that takes on a value of one when conditions in the financial markets are

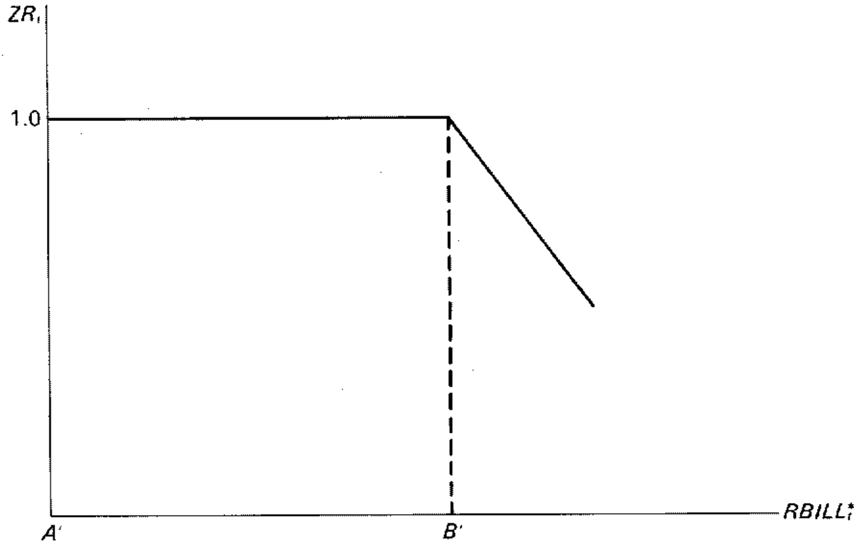

Figure 4-2. Desired Shape of ZR_t as a Function of $RBILL_t^*$

loose and households are not constrained, and a value of less than one otherwise. When the variable is less than one, it should again be proportional to the ratio of the constrained to the unconstrained values of the household sector. One possible measure of the tightness of the financial markets is the bill rate, $RBILL_t$. $RBILL_t$ does, however, have a positive trend during much of the postwar period, and a possibly better measure of the tightness of the financial markets is a partly detrended version of the bill rate. The version used in this study is $RBILL_t^*$, defined by Equation 79 in Table 2-2. $RBILL_t^*$ is $RBILL_t$ detrended up to the 1970IV. The number 0.019757 used in Equation 79 is the estimate of the coefficient of t in the regression of log $RBILL_t$ on a constant and t for the 1952I–1970IV period.

If $RBILL_t^*$ is used as the measure of tightness in the financial markets, one needs to construct a variable, Z_t, that is a function of $RBILL_t^*$ and that has the properties just described. The desired shape of Z_t as a function of $RBILL_t^*$ is presented in Figure 4-2. Point A' is some value that is smaller than the smallest value of $RBILL_t$ observed in the sample period, and point B' is the value of $RBILL_t^*$ below which it seems reasonable to assume that the household sector is not constrained. An approximation to the curve in Figure 4-2 is the right half of the normal density function:

$$Z_t = e^{-\alpha_2(RBILL_t^* - A')^2}. \tag{4.5}$$

For $RBILL_t^*$ equal to A', Z_t is one, and for $RBILL_t^*$ greater than A', Z_t is less than one. It also turns out in this case that a value of α_2 does not have to be specified before estimation.

To distinguish the Z_t for the hours constraint in Equation (4.4) from the Z_t for the loan constraint in Equation (4.5), the former will be denoted as ZJ_t and the latter as ZR_t. This is the notation used in Table 2–2. Both constraints may, of course, be binding at the same time. If both constraints are binding, they are assumed to interact multiplicatively:

$$\frac{CS_t}{CSUN_t} = ZJ_t^{\gamma_1} ZR_t^{\gamma_2}, \; \gamma_1 > 0, \; \gamma_2 > 0. \tag{4.6}$$

This equation says that if neither constraint is binding ($ZJ_t = 1$ and $ZR_t = 1$), then CS_t equals $CSUN_t$. Otherwise, CS_t is less than $CSUN_t$.

Consider now the estimation of the equation explaining CS_t. Assume for sake of argument that the equation explaining $CSUN_t$, i.e., $f(\cdots)$ in (4.1), is simply:

$$CSUN_t = e^{\beta_0} Q_t^{\beta_1} e^{\varepsilon_t}, \tag{4.7}$$

where Q_t is the one explanatory variable in the equation and ε_t is an error term. Substituting (4.7) into (4.6) and taking logs yields:

$$\log CS_t = \beta_0 + \beta_1 \log Q_t + \gamma_1 \log ZJ_t + \gamma_2 \log ZR_t + \varepsilon_t. \tag{4.8}$$

Substituting the expressions for ZJ_t and ZR_t in (4.4) and (4.5) into (4.8) then yields:

$$\log CS_t = \beta_0 + \beta_1 \log Q_t - \gamma_1\alpha_1(J_t^* - A)^2 - \gamma_2\alpha_2(RBILL_t^* - A')^2 + \varepsilon_t. \tag{4.9}$$

Given values for A and A', Equation (4.9) can be directly estimated. There are no longer any unobserved variables to be concerned about. The coefficients γ_1 and α_1 cannot be separately estimated, nor can the coefficients γ_2 and α_2, but it is not really important to be able to do so. What is important is that the variables $(J_t^* - A)^2$ and $(RBILL_t^* - A')^2$ pick up the effects of the constraints, not that one be able to separate their coefficient estimates into estimates of the γ_i parameters in Equation (4.6) and estimates of the α_i parameters in the approximating equations (4.4) and (4.5).

Since the choice of either γ_1 or α_1 is arbitrary, α_1 has been chosen for scale purposes to be 1/10000 (see Equation 77 in Table 2–2). Similarly, α_2 has been chosen for scale purposes to be 1/1000 (see Equation 80 in Table 2–2). The value of A was taken to be 335.9, which is slightly larger than the largest value of J_t^* in the sample period, and the value of A' was taken to be 0.608, which is slightly smaller than the smallest value of $RBILL_t^*$ in the sample period.

To summarize, the constraints on the household sector were handled in this study by adding to the equations explaining the decision variables of the household sector the variables $(J_t^* - A)^2$ and $(RBILL_t^* - A')^2$. This converts each equation from one with an unobserved variable on the left-hand side (the unconstrained decision value) to one with an observed variable on the left-hand side (the constrained decision value). It is clear that this treatment of the constraints requires a number of restrictive assumptions. It does have the advantage, however, of allowing one not to have to estimate separately the α_i coefficients in Equations (4.4) and (4.5) and the γ_i coefficients in Equation (4.6). The data are effectively allowed to estimate both sets of coefficients at the same time, thus allowing there to be fewer a priori constraints imposed on the data than might be the case with other specifications. No a priori constraints of a zero-one type, for example, are imposed on the data.

Regarding the loan constraint, considerable thought was given in this study to possible ways of using the flow-of-funds data to help measure the constraint. The problem with the flow-of-funds data, however, is that they all measure the effects of the constrained decisions, and there seemed no obvious way to use the data to get a direct indication of when the loan constraint was binding. In terms of the notation in Volume I, there seemed no obvious way to measure $LBMAX_t$, the maximum value of loans that the bank sector chooses in the period. All that one observes is the net result of what happens after the firm and household sectors have taken $LBMAX_t$ into account in their decision making processes.

The two constraint variables, ZJ_t and ZR_t, are endogenous and are treated as such in the estimation work. ZJ_t is a function of J_t^*, which is a function of J_t, which in turn is a function of $JOBF_t$ and HPF_t. The latter two variables, as will be seen in the next chapter, are two endogenous variables in the model. ZR_t is a function of $RBILL_t^*$, which in turn is a function of $RBILL_t$, $RBILL_t$ being another endogenous variable in the model.

Although ZJ_t and ZR_t can be treated like any other endogenous variables for purposes of estimation, a slight modification of the variables has to be made for purposes of solving the model. Consider Equation 77 in Table 2–2 explaining ZJ_t:

$$77.\ ZJ_t = e^{-1/10000(J_t^* - 335.9)^2}.$$

In the data, J_t^* is always less than 335.9 by construction (see above). In the solution of the model, however, there is nothing that guarantees that the predicted value of J_t^* will always be less than 335.9. If the predicted value of

J_t^* is greater than or equal to 335.9, this indicates a very tight labor market (tighter than ever existed in the data). In tight labor markets, ZJ_t is supposed to take on a value of one (or close to one). Consequently, in the solution program for the model, the predicted value of ZJ_t was set equal to one whenever the predicted value of J_t^* was greater than 335.9. Otherwise, Equation 77 was used to determine the predicted value of ZJ_t. A similar procedure was followed for ZR_t. The predicted value of ZR_t was set equal to one whenever the predicted value of $RBILL_t^*$ was less than 0.608, but otherwise Equation 80 in Table 2–2 was used to determine the predicted value of ZR_t.

One final point about the treatment of the constraints should be made, which has to do with the assumption that all the variables in $f(\cdots)$ in Equation (4.1) are observed. It will be seen in the next section, from examining the results in Table 2-3, that the lagged dependent variable in each equation is an important explanatory variable in the equation. Since only constrained decision values are assumed always to be observed, a lagged dependent variable in the present context is a lagged constrained decision value, not a lagged unconstrained value. Therefore, the assumption here is that lagged constrained values enter functions like $f(\cdots)$ in Equation (4.1). For example, CS_{t-1} is assumed to enter $f(\cdots)$ in (4.1), not $CSUN_{t-1}$. Since lagged dependent variables are used to try to capture expectational effects, there is no compelling reason for making one assumption or the other regarding whether lagged unconstrained or lagged constrained decision values enter functions like $f(\cdots)$. The assumption that lagged constrained decision values enter the functions was made primarily on grounds of convenience.

It is also the case, as will be seen in the next section, that some left-hand side variables have been deflated by population. This, however, poses no added difficulties in interpreting the effects of the constraints. If, for example, $CSUN_t$ in Equation (4.1) is divided by POP_t, the equation can be multiplied through by POP_t, leaving $CSUN_t$ on the left-hand side. Then after adjusting the equation by use of the constraint variables to have CS_t be the left-hand side variable, the equation can be divided back through by POP_t.

4.4 THE ESTIMATES OF THE EQUATIONS FOR THE HOUSEHOLD SECTOR

There are eight stochastic equations for the household sector. The functional forms chosen for these equations, the explanatory variables used in each equation, and the TSLS and FIML coefficient estimates of the equations are presented in Table 2–3 in Chapter Two. These equations will not be repeated here, but instead reference will be made throughout this section to Table 2–3.

The first four equations are consumption equations, explaining

$$\log \frac{CS_t}{POP_t}, \log \frac{CN_t}{POP_t}, \log \frac{KCD_t}{POP_t}, \quad \text{and} \quad \log \frac{KIH_t}{POP_t},$$

where POP_t is the population of all persons 16 and over. The next three equations are work effort equations, explaining

$$\log \frac{TLF_{1t}}{POP_{1t}}, \log \frac{TLF_{2t}}{POP_{2t}}, \quad \text{and} \quad \log \frac{MOON_t}{POP_t}.$$

TLF_{1t}/POP_{1t} is the labor force participation rate of men 25–54, and TLF_{2t}/POP_{2t} is the participation rate of all persons 16 and over except men 25–54. $MOON_t/POP_t$ is the percent of the population holding two jobs. The eighth equation explains log DDH_t/POP_t, where DDH_t/POP_t is the value of demand deposits and currency of the household sector deflated by population.

Each of the first seven equations in Table 2–3 includes as explanatory variables a subset of the variables listed in Table 4–2. These are again the variables that are important in the theoretical model in influencing a household's decisions. It will be useful to consider all seven equations together regarding the estimated effects of the various explanatory variables. First, the price deflators have a negative effect in all seven equations, and the wage rate has a positive effect in all seven equations. In the consumption equations the price deflator and the wage rate were not constrained to have equal coefficients in absolute value, but in the work effort equations they were.[a] The price deflator used in the work effort equations is PH_t, the price deflator for domestic sales inclusive of indirect business taxes.

One or more interest rate variables are included in three of the consumption equations (Equations 1, 3, and 4), all with negative coefficient estimates; and one interest rate variable is included in one of the work effort equations (Equation 6), with a positive coefficient estimate. The two interest rate variables considered in the estimation work for the household sector are the bill rate and the mortgage rate, the former being taken as a proxy for the short term rates affecting the household sector and the latter being taken as a proxy for the long term rates.

The nonlabor income variable is included in three of the consumption equations (Equations 1, 2, and 3), with positive coefficient estimates; and in one of the work effort equations (Equation 5), with a negative coefficient estimate. The value of assets of the previous period is included in two of the consumption equations (Equations 1 and 2), with positive coefficient estimates; and in one of the work effort equations (Equation 6), with a negative coefficient estimate. The marginal personal income tax rate is included in one of the consumption equations (Equation 2), with a negative estimated effect; and in two of the work effort equations (Equations 5 and 7), with negative estimated effects.

All the results just cited are consistent with the results in the theoretical model. In the theoretical model the price level has a negative effect and the wage rate has a positive effect on consumption and work effort; the interest rate has a negative effect on consumption and a positive effect on work effort; nonlabor income (i.e., *YG*, the minimum guaranteed level of income) has a positive effect on consumption and a negative effect on work effort; the value of assets of the previous period has a positive effect on consumption and a negative effect on work effort; and the personal income tax rate has a negative effect on consumption and work effort.

The hours constraint variable enters all four consumption equations and two of the three work effort equations, with positive coefficient estimates. From Equation (4.8) it can be seen that the coefficient estimates are expected to be positive, since γ_1 is postulated to be positive. The estimates are not, of course, estimates of γ_1, because α_1 has been arbitrarily set equal to 1/10000. As discussed above, it is not possible to obtain separate estimates of γ_1 and α_1. The loan constraint variable enters only the housing equation (Equation 4), with the expected positive coefficient estimate. Otherwise, the variable did not appear to be important in explaining any of the other decision variables of the household sector.

Some experimentation was done with estimating alternative lag structures, and in the end the following constraints were imposed on the data. First, a four quarter average of the marginal tax rate variable lagged one quarter ($\bar{d}^M_{3t-1}$) was used as the tax rate variable. This seemed like a reasonable procedure in the sense that it may take people a few quarters to perceive a change in their marginal tax rate. Since the equations are in log form, the explanatory variable relating to $\bar{d}^M_{3t-1}$ was taken to be $\log(1 - \bar{d}^M_{3t-1})$. If $\bar{d}^M_{3t-1}$ were zero, then this form says that $\bar{d}^M_{3t-1}$ would have no effect on the decision variables. If instead the variable $\log \bar{d}^M_{3t-1}$ were used, this would imply an effect of plus infinity (assuming the coefficient estimate of $\log \bar{d}^M_{3t-1}$ to be negative) if $\bar{d}^M_{3t-1}$ were zero, which does not seem reasonable.

In one of the two labor force participation equations (Equation 5), a four quarter average of the log of $YNLH_t/(PH_t\, POP_t)$ lagged one quarter was used as the nonlabor income variable. This procedure is equivalent to constraining the coefficients of $\log(YNLH_{t-i}/(PH_{t-i}\, POP_{t-i}))$, $i = 1, 2, 3, 4$, to be the same.

All the explanatory variables in the housing equation are lagged at least one quarter. Since it generally takes longer than a quarter to build a house, the longer lags that seemed to pertain to the housing equation are consistent with what one would expect. The mortgage rate is included twice in the housing equation, with lags of one and two quarters. The data seemed capable of picking up separate effects of the two lagged values. The other equation where it seemed possible to pick up separate effects of the lagged values of the same variable was Equation 2 for nondurable consumption, where the nonlabor income variable was included contemporaneously and with a lag of one quarter.

Lagged dependent variables are included in all seven equations. As mentioned in Chapter One, each of the equations was initially estimated under the assumption of first order serial correlation to make sure that the lagged dependent variables are not erroneously picking up serial correlation effects. Serial correlation turned out to be important in only two equations, Equations 3 and 4, explaining the stocks of durable goods and houses. The serial correlation assumption was retained for these two equations, and the estimates of the serial correlation coefficients for these two equations are presented in Table 2–3 along with the other coefficient estimates. For each of the other equations, the serial correlation coefficient was constrained to be zero.

The final equation estimated for the household sector is Equation 8, explaining the household sector's holdings of demand deposits and currency (DDH_t). In the theoretical model, DDH_t is a function of the household sector's expenditures on goods, but here the best results were obtained by taking DDH_t to be a function of taxable income (YH_t) and the bill rate. A time trend was also included in the equation to pick up any possible trend in the relationship between DDH_t/POP_t and the other explanatory variables in the equation.

Four dummy variables were added to Equation 3 explaining KCD_t to account for the effects of the automobile strikes in 1964 and 1970. Otherwise, the strikes did not appear to have a strong enough effect on any of the other variables in the household sector to warrant the further use of dummy variables.

Regarding the four consumption categories, some experimentation was done in this study to see if it were possible to pick up substitution or complementary effects among the categories. In theory, all the variables listed in Table 4–2 should be included in each consumption equation. The price of services, for example, should have an effect on all four consumption categories, not just on the consumption of services. It did not appear to be possible, however, to pick up these effects in the data, and so no substitution or complementary effects of this kind are included in the model.

Equations 1, 2, 3, 4, and 8 are the equations in the household sector for which FIML estimates were obtained. As can be seen in Table 2–3, the TSLS and FIML estimates of these five equations are quite close. The largest differences occur for the serial correlation coefficient in Equation 3 and for the coefficients of the two constraint variables in Equation 4.

This completes the discussion of the stochastic equations for the household sector in Table 2–3. The explanatory variables that have been used in the equations, other than the constraint variables and the lagged dependent variables, are variables that one would expect on microeconomic grounds to affect households' unconstrained decisions. After adjusting for the effects of the constraints and for expectational and lag effects, the results do seem to indicate that these variables have important effects on the decision variables of the household sector. The question of how the household sector interacts with the other sectors in the model is taken up in Chapter Nine. To conclude this chapter, four further comments about the household sector will be made.

First, it should be noted, as mentioned in section 1.1, that when the hours constraint is binding on the household sector, the specification of the consumption equations is similar to a specification that would include labor income directly as an explanatory variable in the equations. When the hours constraint variable, ZJ_t, is not close to one, it is a function of the number of hours paid for in the economy. ZJ_t is not close to one when the hours constraint is binding on the household sector, so that when the hours constraint is binding, there is a variable on the right-hand side of the consumption equations that is a function of the number of hours paid for. Since the wage rate is also included in the consumption equations, there is something like a labor income variable on the right-hand side of the equations when the constraint is binding. When the constraint is not binding (ZJ_t close to one), then only the wage rate part of labor income is included as an explanatory variable.

The second comment concerns the inclusion of the hours constraint variable in the work effort equations. ZJ_t is an important explanatory variable in the equation explaining the labor force participation of all persons 16 and over except men 25–54 (Equation 6). This result is interpreted within the context of the model as indicating that when the hours constraint is binding on the household sector, the participation rate that results from the solutions of the households' constrained optimal control problems is less than the rate that would result if the households were not constrained. As mentioned in section 1.1, effects of this sort are sometimes referred to in the literature as "discouraged worker" effects. The hours constraint variable in Equation 6 can thus be thought of as picking up discouraged worker effects if one wants to use this terminology. The hours constraint variable also has, of course, important effects in the consumption equations, where the "discouraged" terminology is generally not used.

The third comment concerns the question of real versus nominal interest rates. All of the interest rates considered in this study are nominal interest rates. The concept of a real interest rate is not needed. In the theoretical model a household solves its multiperiod optimal control problem after having formed expectations of future prices, wages rates, and interest rates. Any "real" interest rate effects are captured through these expectations and the other factors that affect the solution of the household's problem. In the empirical model, prices, wage rates, and interest rates are included together in the equations, along with lagged endogenous variables to capture expectational effects, and so any "real" interest rate effects should be picked up, at least in some approximate way, through these variables.

It should be noted in passing that interest rates have an effect on the decision variables of the household sector through the A_{t-1} variable, as well as directly. A_{t-1} is the value of the securities of the household sector at the end of period $t-1$. It has a positive effect on service and nondurable consumption in Table 2–3 and a negative effect on the labor force participation of persons 16 and over except men 25–54. A_{t-1} includes capital gains or losses on corporate stocks. The value of capital gains or losses during period $t-1$ (CG_{t-1}) is, as will be seen in Chapter Six, a negative function of the bond rate in period $t-1$. The bond rate in period $t-1$ is in turn a positive function of the bill rate in period $t-1$. Consequently, the bill rate in period $t-1$ has an effect on consumption and work effort in period t through its effect on A_{t-1}.

The fourth and final comment concerns the treatment of financial disequlibrium effects in the housing market. These effects are assumed to be captured in the model through the inclusion of the loan constraint variable in the equation explaining the stock of houses (Equation 4). This approach differs from the approach that I took in specifying the monthly housing starts sector in my forecasting model [14]. For the forecasting model separate equations explaining the supply of and demand for housing starts were specified and estimated, and the two equations were estimated under the assumption that the housing market is not always in equilibrium. The equations were estimated by one of the techniques described in Fair and Jaffee [24]. One of the key assumptions of this approach is the assumption that the observed quantity of a variable is equal to the minimum of the quantity demanded and the quantity supplied. In the case of housing, the assumption is that one observes the minimum of the demand for housing starts from the household sector and the equivalent supply of housing starts from the financial sector. In periods of disequilibrium, either the household sector is constrained by the financial sector from borrowing the amount of money that it wants to at the current prices and interest rates or the financial sector is prevented from making as many loans to finance housing investment as it wants to at the current interest rates.

Although the approach taken in the present study differs in important ways from my earlier approach, the two approaches are not inconsistent with each other. In the present specification, the loan constraint is at times binding on the household sector and at times not. When it is binding, it causes the household sector to spend less on housing than otherwise. This case corresponds in the earlier approach to the case in which the observed quantity of housing starts is equal to the equivalent supply from the financial sector. When the loan constraint is not binding, it has no effect on the housing expenditures of the household sector. This case corresponds in the earlier approach to the case in which the observed quantity of housing starts is equal to the demand from the household sector. (Both approaches assume that the supply of housing from the construction sector is never a constraint in the market. The questions of how the construction sector may at times be a constraint in the housing market and how one might handle this are discussed in Fair [14], Chapter 8, and Fair [16].) This comparison of the two approaches provides a good example of there being more than one way to specify disequilibrium effects. As mentioned in the previous section, it is clearly of interest in future work to consider alternative approaches.

NOTE

[a]The results in Fair [18] for sixteen age-sex groups indicate that labor force participation rates are responsive to the real wage, which is one of the reasons for imposing in this study the constraint in the work effort equations that the coefficients of the wage rate and price deflator be equal in absolute value.