3

The Data, Variables, and Equations

3.1 Transition from Theory to Empirical Specifications

The transition from theory to empirical work in macroeconomics is not always straightforward. The quality of the data are never as good as one might like, so compromises have to be made in moving from theory to empirical specifications. Also, extra assumptions usually have to be made, in particular about unobserved variables like expectations and about dynamics. There usually is, in other words, considerable "theorizing" involved in this transition process.[1]

The first step in the transition, which is taken in this chapter, is to choose the data and variables. All the data and variables in the US and ROW models are presented in this chapter. The second step, also taken in this chapter, is to choose which variables are to be treated as exogenous, which are to be determined by stochastic (estimated) equations, and which are to be determined by identities. All the equations in the two models are listed in this chapter. The third step, which is where most of the theory is used, is to choose the explanatory variables in the stochastic equations and the functional forms of the equations. This is the task of Chapters 5 and 6. The discussion in the present chapter relies heavily on the tables in Appendices A and B.

As noted in Section 1.1, the overall MC model consists of estimated structural equations for 33 countries. There are 30 stochastic equations for the United States and up to 15 each for each of the other countries. There are 101 identities for the United States and up to 19 each for each of the others. There are 44 countries in the trade share matrix plus an all other category called "all other" (AO). The trade share matrix is thus 45×45. The countries are listed

[1]This transition is discussed in detail in Fair (1984), Section 2.2.

in Table B.1. The data for the United States begin in 1952:1, and the data for the other countries begin in 1960:1. As will be discussed, some of the country models are annual rather than quarterly.

3.2 The US Model

The data, variables, and equations for the US model are discussed in this section. The relevant tables are Tables A.1–A.9 in Appendix A, and these will be briefly outlined first.

3.2.1 The Tables (Tables A.1–A.9)

Table A.1 presents the six sectors in the US model: household (h), firm (f), financial (b), foreign (r), federal government (g), and state and local government (s). In order to account for the flow of funds among these sectors and for their balance-sheet constraints, the U.S. Flow of Funds Accounts (FFA) and the U.S. National Income and Product Accounts (NIPA) must be linked. Many of the 101 identities in the US model are concerned with this linkage. Table A.1 shows how the six sectors in the US model are related to the sectors in the FFA. The notation on the right side of this table (H1,FA, etc.) is used in Table A.4 in the description of the FFA data.

Table A.2 lists all the variables in the US model in alphabetical order, and Table A.3 lists all the stochastic equations and identities. The functional forms of the stochastic equations are given, but not the coefficient estimates. The coefficient estimates are presented in Tables 5.1–5.30 in Chapter 5. Tables A.2 and A.3 are the main reference tables for the US model. Of the remaining tables, Tables A.4–A.6 show how the variables were constructed from the raw data, Table A.7 lists the first stage regressors that were used for the 2SLS and 3SLS estimates, and Table A.8 shows how the model is solved under various assumptions about monetary policy. Finally, Table A.9 shows which variables appear in which equations. It will be useful to begin with Tables A.4–A.6 before turning to Tables A.2 and A.3.

3.2.2 The Raw Data

The NIPA Data

Table A.4 lists all the raw data variables. The variables from the NIPA are presented first, in the order in which they appear in the *Survey of Current*

Business, August 1993. In early 1992 the NIPA data were revised, with the benchmark year changed from 1982 to 1987. At the same time the Bureau of Economic Analysis began publishing quantity and price indices based on other than fixed weights. The alternatives to the "fixed 1987 weights" are "chain type annual weights" and "benchmark year weights." There are a number of problems with using the fixed 1987 weights over a period as long as that used in this study (1952:1–1993:2),[2] and so the alternative weights have considerable appeal for present purposes. One of the alternative set of weights—the chain type annual weights—was thus used in the construction of the data for the model.

At the time of this writing the alternative weights are not available before 1959 and after 1987. The procedure that was followed to create the real variables from the NIPA data is a follows. First, the regular data from 1988 on were used (based on fixed 1987 weights). Second, the pre-revised data (based on 1982 weights) were used between 1952 and 1958. In the absence of alternative weights for this period, the 1982 weights seemed a better choice than the 1987 weights, since they are closer to the period. The old data for this period that were in units of 1982 dollars were multiplied up to be in units of 1987 dollars, and the old price indices that were 100 in 1982 were multiplied up to be 100 in 1987. Third, the chain type weights were used for the data between 1959 and 1987. Table A.4 shows how this was done. The chain type price indices were taken from NIPA Table 7.1 (variables R84–R93), and the nominal variables were deflated by these indices (see variables R11–R16, R19–R22).

The use of the chain type price indices in this way means that between 1959 and 1987 real GDP is not the sum of its real components. Consequently, a discrepancy variable, denoted $STATP$, was created, which is the difference between real GDP and the sum of its real components. ($STATP$ is constructed using equation 83 in Table A.3.) $STATP$ is, of course, zero before 1959 and after 1987. Between 1959 and 1987 it is a fairly smoothly trending variable, slowly decreasing in absolute value during the period. $STATP$ is taken to be exogenous in the model.

The Other Data

The variables from the FFA are presented next in Table A.4, ordered by their code numbers. Some of these variables are NIPA variables that are not pub-

[2]See Young (1992) and Triplett (1992) for a good discussion of these problems and of the proposed alternative weights.

lished in the *Survey* but that are needed to link the two accounts. Interest rate variables are presented next in the table, followed by employment and population variables. The source for the interest rate data is the *Federal Reserve Bulletin*, denoted FRB in the table. The main source for the employment and population data is *Employment and Earnings*, denoted EE in the table. Some of these data are unpublished data from the Bureau of Labor Statistics (BLS), and these are indicated as such in the table.

Some adjustments that were made to the raw data are presented next in Table A.4. These are explained beginning in the next paragraph. Finally, all the raw data variables are presented at the end of Table A.4 in alphabetical order along with their numbers. This allows one to find a raw data variable quickly. Otherwise, one has to search through the entire table looking for the particular variable. All the raw data variables are numbered with an "R" in front of the number to distinguish them from the variables in the model.

The adjustments that were made to the raw data are as follows. The quarterly social insurance variables R195–R200 were constructed from the annual variables R78–R83 and the quarterly variables R38, R60, and R71. Only annual data are available on the breakdown of social insurance contributions between the federal and the state and local governments with respect to the categories "personal," "government employer," and "other employer." It is thus necessary to construct the quarterly variables using the annual data. It is implicitly assumed in this construction that as employers, state and local governments do not contribute to the federal government and vice versa.

The constructed tax variables R201 and R202 pertain to the breakdown of corporate profit taxes of the financial sector between federal and state and local. Data on this breakdown do not exist. It is implicitly assumed in this construction that the breakdown is the same as it is for the total corporate sector.

The quarterly variable R203, $INTROW$, which is the level of net interest receipts of the rest of the world, is constructed from the annual variable R96 and the quarterly and annual data on the $INTF$ and $INTG$ variables, R45 and R65. Quarterly data on net interest receipts of the rest of the world do not exist. It is implicitly assumed in the construction of the quarterly data that the quarterly pattern of the level of interest receipts of the rest of the world is the same as the quarterly pattern of the level of net interest payments of the firm and federal government sectors. Note that $INTROW$ is the level of net *receipts*, not payments. The other interest variables in the model are net payments.

The tax variables R57 and R62 were adjusted to account for the tax surcharge of 1968:3–1970:3 and the tax rebate of 1975:2. The tax surcharge and the tax rebate were taken out of personal income taxes (TPG) and put into personal transfer payments ($TRGH$). The tax surcharge numbers were taken from Okun (1971), Table 1, p. 171. The tax rebate was 7.8 billion dollars at a quarterly rate.

The multiplication factors in Table A.4 pertain to the population, labor force, and employment variables. Official adjustments to the data on POP, $POP1$, $POP2$, $CL1$, $CL2$, and CE were made a few times, and these must be accounted for. The multiplication factors are designed to make the old data consistent with the new data. For further discussion, see Fair (1984), pp. 414–415.

Table A.5 presents the balance-sheet constraints that the data satisfy. The variables in this table are raw data variables. The equations in the table provide the main checks on the collection of the data. If any of the checks are not met, one or more errors have been made in the collection process. Although the checks in Table A.5 may look easy, considerable work is involved in having them met. All the receipts from sector i to sector j must be determined for all i and j (i and j run from 1 through 6).

3.2.3 Variable Construction

Table A.6 explains the construction of the variables in the model (i.e., the variables in Table A.2) from the raw data variables (i.e., the variables in Table A.4). With a few exceptions, the variables in the model are either constructed in terms of the raw data variables in Table A.4 or are constructed by identities. If the variable is constructed by an identity, the notation "Def., Eq." appears, where the equation number is the identity in Table A.2 that constructs the variable. In a few cases the identity that constructs an endogenous variable is not the equation that determines it in the model. For example, equation 85 constructs LM, whereas stochastic equation 8 determines LM in the model. Equation 85 instead determines E, E being constructed directly from raw data variables. Also, some of the identities construct exogenous variables. For example, the exogenous variables $D2G$ is constructed by equation 49. In the model equation 49 determines TFG, TFG being constructed directly from raw data variables. If a variable in the model is the same as a raw data variable, the same notation is used for both. For example, CD, consumption expenditures on durable goods, is both a variable in the model and a raw data variable.

The financial stock variables in the model that are constructed from flow identities need a base quarter and a base quarter starting value. The base quarter values are indicated in Table A.6. The base quarter was taken to be 1971:4, and the stock values for this quarter were taken from the FFA stock values.

There are also a few internal checks on the data in Table A.6 (aside from the balance-sheet checks in Table A.5). The variables for which there are both raw data and an identity available are GDP, MB, $PIEF$, PUG, and PUS. In addition, the saving variables in Table A.5 (SH, SF, and so on) must match the saving variables of the same name in Table A.6. There is also one redundant equation in the model, equation 80, which the variables must satisfy.

There are a few variables in Table A.6 whose construction needs some explanation.

HFS: Peak to Peak Interpolation of HF

HFS is a peak to peak interpolation of HF, hours per job. The peaks are listed in Table A.6. The deviation of HF from HFS, which is variable HFF in the model, is used in equation 15, which explains overtime hours.

HO: Overtime Hours

Data are not available for HO for the first 16 quarters of the sample period (1952:1–1955:4). The equation that explains HO in the model has log HO on the left hand side and a constant, HFF, and HFF lagged once on the right hand side. The equation is also estimated under the assumption of a first order autoregressive error term. The missing data for HO were constructed by estimating the log HO equation for the 1956:1–1993:2 period and using the predicted values from this regression for the (outside sample) 1952:3–1955:4 period as the actual data. The values for 1952:1 and 1952:2 were taken to be the 1952:3 predicted value.

$TAUS$: Progressivity Tax Parameter—s

$TAUS$ is the progressivity tax parameter in the personal income tax equation for state and local governments (equation 48). It was obtained as follows. The sample period 1952:1–1993:2 was divided into three subperiods, 1952:1–1970:4, 1971:1–1971:4, and 1972:1–1993:2. These were judged from a plot of THS/YT, the ratio of state and local personal income taxes to taxable income, to be periods of no large tax law changes. Two assumptions were then made about the relationship between THS and YT. The first is that within a subperiod THS/POP equals $[D1 + TAUS(YT/POP)](YT/POP)$ plus a random error term, where $D1$ and $TAUS$ are constants. The second is that changes in the tax laws affect $D1$ but not $TAUS$. These two assumptions led to the estimation of an equation with THS/POP on the left hand side and a constant, $DUM1(YT/POP)$, $DUM2(YT/POP)$, $DUM3(YT/POP)$, and $(YT/POP)^2$ on the right hand side, where $DUMi$ is a dummy variable that takes on a value of one in subperiod i and zero otherwise. (The estimation period was 1952:1–1993:2 excluding 1987:2. The observation for 1987:2 was excluded because it corresponded to a large outlier.) The estimate of the coefficient of $DUMi(YT/POP)$ is an estimate of $D1$ for subperiod i. The estimate of the coefficient of $(YT/POP)^2$ is the estimate of $TAUS$. The estimate of $TAUS$ was .00111, with a t-statistic of 11.34. This procedure is, of course, crude, but at least it provides a rough estimate of the progressivity of the state and local personal income tax system.

Given $TAUS$, $D1S$ is defined to be $THS/YT - (TAUS \cdot YT)/POP$ (see Table A.6). In the model $D1S$ is taken to be exogenous, and THS is explained by equation 48 as $[D1S + (TAUS \cdot YT)/POP]YT$. This treatment allows a state and local marginal tax rate to be defined in equation 91: $D1SM = D1S + (2 \cdot TAUS \cdot YT)/POP$.

$TAUG$: **Progressivity Tax Parameter—g**

$TAUG$ is the progressivity tax parameter in the personal income tax equation for the federal government (equation 47). A similar estimation procedure was followed for $TAUG$ as was followed above for $TAUS$, where 27 subperiods where chosen. The 27 subperiods are: 1952:1–1953:4, 1954:1–1963:4, 1964:1–1964:4, 1965:1–1965:4, 1966:1–1967:4, 1968:1–1970:4, 1971:1–1971:4, 1972:1–1972:4, 1973:1–1973:4, 1974:1–1975:1, 1975:2–1976:4, 1977:1–1977:1, 1977:2–1978:2, 1978:3–1981:3, 1981:4–1982:2, 1982:3–1983:2, 1983:3–1984:4, 1985:1–1985:1, 1985:2–1985:2, 1985:3–1987:1, 1987:2–1987:2, 1987:3–1987:4, 1988:1–1988:4, 1989:1–1989:4, 1990:1–1990:4, 1991:1–1991:4, and 1992:1–1993:2. The estimate of $TAUG$ was .00270, with a t-statistic of 1.84. Again, this procedure is crude, but it provides a rough estimate of the progressivity of the federal personal income tax system.

Given $TAUG$, $D1G$ is defined to be $THG/YT - (TAUG \cdot YT)/POP$ (see Table A.6). In the model $D1G$ is taken to be exogenous, and THG is explained by equation 47 as $[D1G + (TAUG \cdot YT)/POP]YT$. This treatment allows a federal marginal tax rate to be defined in equation 90: $D1GM = D1G + (2 \cdot TAUG \cdot YT)/POP$.

KD: Stock of Durable Goods

KD is an estimate of the stock of durable goods. It is defined by equation 58:

$$KD = (1 - DELD)KD_{-1} + CD \tag{58}$$

Given quarterly observations for CD, which are available from the NIPA, quarterly observations for KD can be constructed once a base quarter value and a value for the depreciation rate $DELD$ are chosen. End of year estimates of the stock of durable goods are available from 1925 through 1990 from the *Survey of Current Business*, January 1992, Table 4, p. 137. Given the value of KD at, say, the end of 1952 and given a value of $DELD$, a quarterly series for KD can be constructed using the above equation and the quarterly series for CD. This was done for different values of $DELD$ to see how close the constructed end of year (i.e., fourth quarter) values of KD could be matched to the values published in the *Survey*. The value of $DELD$ that was chosen as achieving a good match is .049511. A quarterly series for KD was then constructed using this value and a base quarter value of 313.7 in 1952:4, which is the value published in the *Survey* for 1952.

KH: Stock of Housing

KH is an estimate of the stock of housing of the household sector. It is defined by equation 59:

$$KH = (1 - DELH)KH_{-1} + IHH \tag{59}$$

A similar procedure was followed for estimating $DELH$ as was followed for estimating $DELD$. The value of $DELH$ that was chosen as achieving a good match of the created stock data to the published stock data is .006716. (The housing stock data are also in Table 4 in the January 1992 issue of the *Survey*.) The residential stock data that is published in the *Survey* is for total residential investment, which in the model is $IHH + IHK + IHB$, whereas equation 59 pertains only to the residential investment of the household sector. The procedure that was used for dealing with this difference is as follows. First, the value for $DELH$ was chosen using total residential investment as the investment series, since this series matched the published stock data. Second, once $DELH$ was chosen, KH was constructed using IHH (not total residential investment). A base quarter value of 1270.276 in 1952:4 was used, which is .98 times the value published in the *Survey* for 1952. The value .98 is the average of $IHH/(IHH + IHK + IHB)$ over the sample period.

KK: Stock of Capital

KK is an estimate of the stock of capital of the firm sector. It is determined by equation 92:

$$KK = (1 - DELK)KK_{-1} + IKF \tag{92}$$

A similar procedure was followed for estimating $DELK$ as was followed for estimating $DELD$ and $DELH$. (Again, the stock data are in Table 4 in the January 1992 issue of the *Survey*.) It turned out in this case that three values of $DELK$ were needed to achieve a good match, one (.014574) for the 1952:1–1970:4 period, one (.018428) for the 1971:1–1980:4 period, and one (.023068) for the 1981:1–1993:2 period. The nonresidential stock data that is published in the *Survey* is for total fixed nonresidential investment, which in the model is $IKF + IKH + IKB + IKG$, whereas equation 92 pertains only to the fixed nonresidential investment of the firm sector. A similar procedure was followed here as was followed for residential investment above. First, the values for $DELK$ were chosen using total fixed nonresidential investment as the investment series, since this series matched the published stock data. Second, once the values for $DELK$ were chosen, KK was constructed using IKF (not total fixed nonresidential investment). A base quarter value of 887.571 in 1952:4 was used, which is .71 times the value published in the *Survey* for 1952. The value .71 is the average of $IKF/(IKF + IKH + IKB + IKG)$ over the sample period.

V: Stock of Inventories

V is the stock of inventories of the firm sector (i.e., the nonfarm stock). By definition, inventory investment (IVF) is equal to the change in the stock, which is equation 117:

$$IVF = V - V_{-1} \tag{117}$$

Both data on V and IVF are published in the *Survey*, the data on V in Table 5.13. For present purposes V was constructed from the formula $V = V_{-1} + IVF$ using the IVF series and base quarter value of 870.0 in 1988:4. The base quarter value was taken from Table 5.13 in the July 1992 issue of the *Survey*.

Excess Labor and Excess Capital

In the theoretical model the amounts of excess labor and excess capital on hand affect the decisions of firms. In order to test for this in the empirical work, one needs to estimate the amounts of excess labor and capital on hand in each period. This in turn requires an estimate of the technology of the firm sector.

The measurement of the capital stock KK is discussed above. The production function of the firm sector for empirical purposes is postulated to be

$$Y = \min[\lambda(JF \cdot HF^a), \mu(KK \cdot HK^a)] \tag{3.1}$$

where Y is production, JF is the number of workers employed, HF^a is the number of hours worked per worker, KK is the capital stock discussed above, HK^a is the number of hours each unit of KK is utilized, and λ and μ are coefficients that may change over time due to technical progress. The variables Y, JF, and KK are observed; the others are not. For example, data on the number of hours paid for per worker exist (HF in the model), but not on the number of hours actually worked per worker (HF^a).

Equation 92 for KK and the production function 3.1 are not consistent with the putty-clay technology of the theoretical model. To be precise with this technology one has to keep track of the purchase date of each machine and its technological coefficients. This kind of detail is not possible with aggregate data, and one must resort to simpler specifications.

Given the production function 3.1, excess labor was measured as follows.[3] Output per paid for worker hour, $Y/(JF \cdot HF)$, was plotted for the 1952:1–1993:2 period. The peaks of this series were assumed to correspond to cases in which the number of hours worked equals the number of hours paid for, which implies that the values of λ in equation 3.1 are observed at the peaks. The values of λ other than those at the peaks were assumed to lie on straight lines between the peaks. This gives an estimate of λ for each quarter.

Given an estimate of λ for a particular quarter and given equation 3.1, the estimate of the number of worker hours required to produce the output of the quarter, denoted $JHMIN$ in the model, is simply Y/λ. In the model, λ is

[3] The estimation of excess labor in the following way was first done in Fair (1969) using three digit industry data.

denoted LAM, and the equation determining $JHMIN$ is equation 94 in Table A.3. The actual number of workers hours paid for $(JF \cdot HF)$ can be compared to $JHMIN$ to measure the amount of excess labor on hand. The peaks that were used for the interpolations are listed in Table A.6 in the description of LAM.[4]

For the measurement of excess capital there are no data on hours paid for or worked per unit of KK, and thus one must be content with plotting Y/KK. This is, from the production function 3.1, a plot of $\mu \cdot HK^a$, where HK^a is the average number of hours that each machine is utilized. If it is assumed that at each peak of this series HK^a is equal to the same constant, say $\bar{H}$, then one observes at the peaks $\mu \cdot \bar{H}$. Interpolation between peaks can then produce a complete series on $\mu \cdot \bar{H}$. If, finally, $\bar{H}$ is assumed to be the maximum number of hours per quarter that each unit of KK can be utilized, then $Y/(\mu \cdot \bar{H})$ is the minimum amount of capital required to produce Y (denoted $KKMIN$). In the model, $\mu \cdot \bar{H}$ is denoted MUH, and the equation determining $KKMIN$ is equation 93 in Table A.3. The actual capital stock (KK) can be compared to $KKMIN$ to measure the amount of excess capital on hand. The peaks that were used for the interpolations are listed in Table A.6 in the description of MUH.

The estimated percentages of excess labor and capital by quarter are presented in Table 3.1. For labor each figure in the table is 100 times $[(JF \cdot HF)/JHMIN - 1.0]$, and for capital each figure is 100 times $(KK/KKMIN - 1.0)$. The table shows that in the most recent recession both excess labor and capital peaked at 3.6 percent in 1991:1. The largest value for excess labor during the entire 1952:1–1993:2 period was 4.9 percent in 1960:4. The largest value for excess capital was 10.5 percent in 1982:4.[5]

[4]The values of LAM before the first peak were assumed to lie on the backward extension of the line connecting the first and second peaks. Similarly, the values of LAM after the last peak were assumed to lie on the forward extension of the line connecting the second to last and last peak. Contrary to the case for LAM, for some of the peak to peak interpolations in this study the values before the first peak were taken to be the value at the first peak. This is denoted “flat beginning” in Table A.6. Also, for some of the interpolations the values after the last peak were taken to be the value at the last peak. This is denoted “flat end” in Table A.6.

[5]A few values in Table 3.1 are negative. A negative value occurs when the actual value of output per paid for worker hour or output per capital is above the interpolation line. The peak to peak interpolation lines were not always drawn so that every point between the peaks lay on or below the line.

Table 3.1
Estimated Percentages of Excess Labor and Capital

Quar.	ExL	ExK	Quar.	ExL	ExK	Quar.	ExL	ExK	Quar.	ExL	ExK
1952:1	1.0	1.9	1962:3	.1	.0	1973:1	-.8	-1.1	1983:3	1.7	4.7
1952:2	1.1	3.3	1962:4	.4	1.2	1973:2	.0	-.7	1983:4	1.5	3.1
1952:3	1.2	2.8	1963:1	.7	.7	1973:3	1.1	.3	1984:1	1.2	1.1
1952:4	1.4	1.2	1963:2	.7	.5	1973:4	.9	.2	1984:2	1.0	.0
1953:1	.6	.2	1963:3	-.4	-.3	1974:1	2.3	2.2	1984:3	.8	.1
1953:2	-.1	.0	1963:4	.1	.2	1974:2	2.5	3.2	1984:4	1.0	.6
1953:3	.5	1.3	1964:1	-1.5	-1.1	1974:3	3.3	4.9	1985:1	1.4	1.0
1953:4	.0	2.9	1964:2	-.7	-.8	1974:4	2.9	6.4	1985:2	1.2	1.6
1954:1	1.4	4.9	1964:3	-.4	-.4	1975:1	3.2	9.8	1985:3	.5	1.1
1954:2	1.2	5.8	1964:4	.8	.7	1975:2	1.1	8.6	1985:4	.8	1.5
1954:3	.2	4.9	1965:1	.5	.0	1975:3	.4	6.9	1986:1	-.3	1.1
1954:4	.0	3.6	1965:2	1.5	.6	1975:4	.6	6.0	1986:2	.0	2.1
1955:1	-.3	1.4	1965:3	.1	.3	1976:1	.0	4.2	1986:3	.2	2.0
1955:2	.2	.7	1965:4	.0	.0	1976:2	.3	4.3	1986:4	.7	2.4
1955:3	1.2	.0	1966:1	-.7	-1.3	1976:3	.4	4.7	1987:1	1.0	2.0
1955:4	2.3	-.2	1966:2	.2	-.2	1976:4	.0	4.0	1987:2	.9	1.4
1956:1	2.6	.7	1966:3	.6	.2	1977:1	-.1	3.2	1987:3	1.1	1.1
1956:2	3.0	1.1	1966:4	.5	.8	1977:2	.5	2.1	1987:4	.7	.2
1956:3	3.5	1.9	1967:1	1.0	1.2	1977:3	.0	1.2	1988:1	.5	.0
1956:4	2.3	1.3	1967:2	.1	1.5	1977:4	1.4	2.3	1988:2	1.2	-.1
1957:1	1.9	1.2	1967:3	.3	1.2	1978:1	1.7	2.6	1988:3	1.1	.1
1957:2	2.1	2.0	1967:4	.9	1.5	1978:2	1.0	.0	1988:4	1.4	-.2
1957:3	2.1	2.2	1968:1	.0	1.0	1978:3	1.0	.1	1989:1	2.1	-.2
1957:4	2.5	4.5	1968:2	.1	.3	1978:4	1.0	-.1	1989:2	2.0	.0
1958:1	2.2	7.0	1968:3	.3	.3	1979:1	2.1	1.0	1989:3	2.5	.3
1958:2	1.5	6.6	1968:4	1.1	1.0	1979:2	2.4	1.8	1989:4	2.4	.3
1958:3	.1	3.9	1969:1	1.6	.0	1979:3	2.4	2.0	1990:1	2.6	.0
1958:4	-.5	1.4	1969:2	2.3	1.3	1979:4	2.6	2.7	1990:2	2.4	.2
1959:1	1.0	1.6	1969:3	2.4	2.0	1980:1	2.2	3.4	1990:3	2.5	.9
1959:2	2.2	.0	1969:4	3.1	3.7	1980:2	3.4	6.9	1990:4	3.5	2.2
1959:3	3.0	1.9	1970:1	3.5	5.2	1980:3	3.1	7.4	1991:1	3.6	3.6
1959:4	2.8	2.1	1970:2	3.8	6.6	1980:4	2.2	5.8	1991:2	3.1	3.5
1960:1	1.8	1.3	1970:3	2.0	6.3	1981:1	1.8	4.9	1991:3	2.9	3.3
1960:2	3.9	2.9	1970:4	2.8	8.3	1981:2	1.7	5.4	1991:4	2.7	3.3
1960:3	4.2	3.3	1971:1	1.0	5.7	1981:3	1.4	5.3	1992:1	2.0	2.8
1960:4	4.9	5.2	1971:2	1.6	6.0	1981:4	2.6	7.2	1992:2	1.5	2.0
1961:1	4.0	5.1	1971:3	1.0	5.8	1982:1	3.3	9.1	1992:3	.0	.5
1961:2	1.3	3.9	1971:4	1.8	5.4	1982:2	2.6	9.1	1992:4	.0	.0
1961:3	.6	2.9	1972:1	1.5	3.9	1982:3	3.3	10.4	1993:1	.6	.6
1961:4	.0	1.4	1972:2	.9	2.6	1982:4	3.0	10.5	1993:2	1.2	.8
1962:1	.6	.7	1972:3	.3	1.8	1983:1	2.6	9.5			
1962:2	.7	.4	1972:4	.1	1.0	1983:2	1.2	6.4			

Comparisons to the Fay-Medoff Estimates[6]

It is of interest to compare the estimates of excess labor in Table 3.1 with the survey results of Fay and Medoff (1985). Fay and Medoff surveyed 168 U.S. manufacturing plants to examine the magnitude of labor hoarding during economic contractions. They found that during its most recent trough quarter, the typical plant paid for about 8 percent more blue collar hours than were needed for regular production work. Some of these hours were used for other worthwhile work, usually maintenance work, and after taking account of this, 4 percent of the blue collar hours were estimated to be hoarded for the typical plant.

The estimates of excess labor in Table 3.1 probably correspond more to the concept behind the 8 percent number of Fay and Medoff than to the concept

[6]The following discussion is updated from Fair (1985).

behind the 4 percent number. If, for example, maintenance work is shifted from high to low output periods, then $JHMIN$ is a misleading estimate of worker hour requirements. In a long run sense, $JHMIN$ is too low because it has been based on the incorrect assumption that the peak productivity values could be sustained over the entire business cycle. This error is not a serious one from the point of estimating the labor demand equations in Chapter 5. If the same percentage error has been made at each peak, which is likely to be approximately the case, the error will merely be absorbed in the estimates of the constant terms in the equations. The error is also not serious for the Fay-Medoff comparisons as long as the Fay-Medoff concept behind the 8 percent number is used. This concept, like the concept behind the peak to peak interpolation work, does not account for maintenance that is shifted from high to low output periods.

There are two possible troughs that are relevant for the Fay-Medoff study, the one in mid 1980 and the one in early 1982. The first survey upon which the Fay-Medoff results are based was done in August 1981, and the second (larger) survey was done in April 1982. A follow up occurred in October 1982. The plant managers were asked to answer the questionnaire for the plant's most recent trough. For the last responses the trough might be in 1982, whereas for the earlier ones the trough is likely to be in 1980. Table 3.1 shows that the percentage of excess labor reached 3.4 percent in 1980:2 and 3.3 percent in 1982:1.[7]

The Fay-Medoff estimate of 8 percent is thus compared to the 3.4 and 3.3 percent values in Table 3.1. These two sets of results seem consistent in that there are at least two reasons for expecting the Fay-Medoff estimate to be somewhat higher. First, the trough in output for a given plant is on average likely to be deeper than the trough in aggregate output, since not all troughs are likely to occur in the same quarter across plants. Second, the manufacturing sector may on average face deeper troughs than do other sectors, and the aggregate estimates in Table 3.1 are for the total private sector, not just manufacturing. One would thus expect the Fay-Medoff estimate to be somewhat higher than the aggregate estimates, and 8 percent versus a number around 3 to 3.5 percent seems consistent with this.

The Fay-Medoff results appear to provide strong support for the excess labor hypothesis. At a micro level Fay and Medoff found labor hoarding and

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[7]The estimates in Fair (1985) using earlier data were 4.5 percent in 1980:4 and 5.5 percent in 1982:1. The use of more recent data has thus lowered the excess labor estimates by a little over a percentage point. Also, the Fay-Medoff estimate of 4 percent hoarded labor cited above was 5 percent in an earlier version of the paper cited in Fair (1985).

of a magnitude that seems in line with aggregate estimates. This is one of the few examples in macroeconomics where a hypothesis has been so strongly confirmed using detailed micro data.

Labor Market Tightness: The Z Variable

An important feature of the theoretical model is the possibility that households may at times be constrained in how much they can work. In the empirical work one needs some way of measuring this constraint. The approach taken here is the following. The variable JJ in the model is the ratio of the total number of worker hours paid for in the economy to the total population 16 and over (equation 95). JJ was first plotted for the 1952:1–1993:2 period, and a peak to peak interpolation was made. The interpolation series is denoted JJP, and the peaks that were used for this interpolation are presented in Table A.6 in the description of JJP. A variable Z was then defined as $\min(0, 1 - JJP/JJ)$, where Z is called the "labor constraint variable." In the data Z is always nonpositive because JJP is constructed from the peak to peak interpolations and is always greater than or equal to JJ. In the solution of the model, however, the predicted value of JJ may be greater than JJP, in which case Z is taken to be zero. Z is a labor constraint variable in the sense that it is zero or close to zero when the worker hours-population ratio is at or near its peak and gets progressively larger in absolute value as the ratio moves below its peak. The exact use of Z is explained in Chapter 5.

YS: Potential Output of the Firm Sector

A measure of the potential output of the firm sector, YS, is used in the price equation (equation 10). YS is defined by equation 98:

$$YS = LAM(JJP \cdot POP - JG \cdot HG - JM \cdot HM - JS \cdot HS) \qquad (98)$$

JJP is the peak or potential ratio of worker hours to population (as constructed from the peak to peak interpolation of JJ), and so $JJP \cdot POP$ is the potential number of worker hours. The terms that are subtracted from $JJP \cdot POP$ in equation 98 are, in order, the number of federal civilian worker hours, the number of federal military worker hours, and the number of state and local government worker hours. The entire number in parentheses is thus the potential number of worker hours in the firm sector. LAM is the coefficient λ in the production function 3.1. Since YS in equation 98 is LAM times the potential number of workers in the firm sector, it can be interpreted as the potential output of the firm sector unless the capital input is insufficient to produce YS. This construction of YS is thus based on the assumption that there is always sufficient capital on hand to produce YS.

The Bond Variables BF and BG

BF is an estimate of the value of long term bonds issued by the firm sector in the current period. Similarly, BG is an estimate of the value of long term bonds issued by the federal government sector in the current period. These variables are determined by equations 55 and 56 respectively. They are used in the interest payments equations, 19 and 29. The construction of BF and BG is somewhat involved, and this discussion is presented in Chapter 5 in the context of the discussion of equations 19 and 29.

3.2.4 The Identities

The identities in Table A.3 are of two types. One type simply defines one variable in terms of others. These identities are equations 31, 33, 34, 43, 55, 56, 58–87, and 89–131. The other type defines one variable as a rate or ratio times another variable or set of variables, where the rate or ratio has been constructed to have the identity hold. These identities are equations 32, 35-42, 44-54, 57, and 88. Consider, for example, equation 50:

$$TFS = D2S \cdot PIEF \tag{50}$$

where TFS is the amount of corporate profit taxes paid from firms (sector f) to the state and local government sector (sector s), $PIEF$ is the level of corporate profits of the firm sector, and $D2S$ is the "tax rate." Data exist for TFS and $PIEF$, and $D2S$ was constructed as $TFS/PIEF$. The variable $D2S$ is then interpreted as a tax rate and is taken to be exogenous. This rate, of course, varies over time as tax laws and other things that affect the relationship between TFS and $PIEF$ change, but no attempt has been made to explain these changes. This general procedure was followed for the other identities involving tax rates.

A similar procedure was followed to handle relative price changes. Consider equation 38:

$$PIH = PSI5 \cdot PD \tag{38}$$

where PIH is the price deflator for housing investment, PD is the price deflator for total domestic sales, and $PSI5$ is a ratio. Data exist for PIH and PD, and $PSI5$ was constructed as PIH/PD. $PSI5$, which varies over time as the relationship between PIH and PD changes, is taken to be exogenous. This procedure was followed for the other identities involving prices and wages. This treatment means that relative prices and relative wages are exogenous in the model. (Prices relative to wages are not exogenous, however.) It is beyond the scope of the model to explain relative prices and wages, and the foregoing treatment is a simple way of handling these changes.

Another identity of the second type is equation 57:

$$BR = -G1 \cdot MB \tag{57}$$

where BR is the level of bank reserves, MB is the net value of demand deposits of the financial sector, and $G1$ is a "reserve requirement ratio." Data on BR and MB exist, and $G1$ was constructed as $-BR/MB$. (MB is negative, since the financial sector is a net debtor with respect to demand deposits, and so the minus sign makes $G1$ positive.) $G1$ is taken to be exogenous. It varies over time as actual reserve requirements and other features that affect the relationship between BR and MB change.

Many of the identities of the first type are concerned with linking the FFA data to the NIPA data. An identity like equation 66

$$0 = SH - \Delta AH - \Delta MH + CG - DISH \tag{66}$$

is concerned with this linkage. SH is from the NIPA, and the other variables are from the FFA. The discrepancy variable, $DISH$, which is from the FFA, reconciles the two data sets. Equation 66 states that any nonzero value of saving of the household sector must result in a change in AH or MH. There are equations like 66 for each of the other five sectors: equation 70 for the firm sector, 73 for the financial sector, 75 for the foreign sector, 77 for the federal government sector, and 79 for the state and local government sector. Equation 77, for example, is the budget constraint of the federal government sector. Note also from Table A.3 that the saving of each sector (SH, SF, etc.) is determined by an identity. The sum of the saving variables across the six sectors is zero, which is the reason that equation 80 is redundant.

3.2.5 The Stochastic Equations

A brief listing of the stochastic equations is presented in Table A.3. The left hand side and right hand side variables are listed for each equation. Chapter 5 discusses the specification, estimation, and testing of these equations. Of the thirty equations, the first nine pertain to the household sector, the next twelve to the firm sector, the next five to the financial sector, the next to the foreign sector, the next to the state and local government sector, and the final two to the federal government sector.

3.3 The ROW Model

The data, variables, and equations for the ROW model are discussed in this section. Remember that the ROW model includes structural models for 32 countries. The relevant tables for the model are Tables B.1–B.7 in Appendix B, and these will be outlined first.

3.3.1 The Tables (Tables B.1–B.7)

Table B.1 lists the countries in the model and provides a brief listing of the variables per country. The 32 countries for which structural equations are estimated are Canada (CA) through Thailand (TH), which are countries 2 through 33. Countries 34 through 45 are countries for which only trade share equations are estimated. A detailed description of the variables per country is presented in Table B.2, where the variables are listed in alphabetical order. Data permitting, each of the 32 countries has the same set of variables. Quarterly data were collected for countries 2 through 14, and annual data were collected for the others. Countries 2 through 14 will be referred to as "quarterly" countries, and the others will be referred to as "annual" countries. The way in which each variable was constructed is explained in brackets in Table B.2. All of the data with potential seasonal fluctuations have been seasonally adjusted. In some cases, quarterly data for a particular variable, such as a population variable, did not exist. When quarterly data were needed but only annual data were available, quarterly observations were interpolated from annual data using the procedure described in Table B.6.

Table B.3 lists the stochastic equations and the identities. The functional forms of the stochastic equations are given, but not the coefficient estimates. The coefficient estimates for all the countries are presented in Chapter 6. Table B.4 lists the equations that pertain to the trade and price links among the countries, and it explains the construction of the trade share variables—the α_{ij} variables. It also explains how the quarterly and annual data were linked for the trade share calculations. Table B.5 lists the links between the US and ROW models. Finally, Table B.7 explains the construction of the balance of payments data—data for variables S and TT.

It will be useful to begin with a discussion of the construction of some of the variables in Table B.2.

3.3.2 The Raw Data

The data sets for the countries other than the United States (i.e., the countries in the ROW model) begin in 1960. The sources of the data are the IMF and OECD. Data from the IMF are international financial statistics (IFS) data and direction of trade (DOT) data. Data from the OECD are quarterly national accounts data, annual national accounts data, quarterly labor force data, and annual labor force data. These are the "raw" data. As noted above, the way in which each variable was constructed is explained in brackets in Table B.2. When "IFS" precedes a number or letter in the table, this refers to the IFS variable number or letter. Some variables were constructed directly from IFS and OECD data (i.e., directly from the raw data), and some were constructed from other (already constructed) variables.

3.3.3 Variable Construction

S, TT, and A: Balance of Payments Variables

One important feature of the data collection is the linking of the balance of payments data to the other export and import data. The two key variables involved in this process are S, the balance of payments on current account, and TT, the value of net transfers. The construction of these variables and the linking of the two types of data are explained in Table B.7. Quarterly balance of payments data do not generally begin as early as the other data, and the procedure in Table B.7 allows quarterly data on S to be constructed as far back as the beginning of the quarterly data for merchandise imports and exports ($M\$$ and $X\$$).

The variable A is the net stock of foreign security and reserve holdings. It was constructed by summing past values of S from a base period value of zero. The summation begins in the first quarter for which data on S exist. This means that the A series is off by a constant amount each period (the difference between the true value of A in the base period and zero). In the estimation work the functional forms were chosen in such a way that this error was always absorbed in the estimate of the constant term. It is important to note that A measures only the net asset position of the country vis-à-vis the rest of the world. Domestic wealth, such as the domestically owned housing stock and plant and equipment stock, is not included.

K: The Capital Stock

If depreciation is proportional to the capital stock K, then $K = (1-\delta)K_{-1}+I$, where δ is the depreciation rate and I is gross investment. (See, for example, equation 92 for the US model.) Given 1) a value for δ, 2) a base value for K, and 3) data on I, K can be constructed from this formula. Although, as discussed in Section 3.2.3, data on both the capital stock and investment exist for the United States, only data on investment exist for most other countries. Therefore, some way must be found for constructing K for the other countries that does not require direct data on K. This was done as follows.

First, the U.S. data were used to compute an implicit depreciation rate. This rate is about .015 (1.5 percent) per quarter for fixed nonresidential and residential capital combined. (The data on I for the other countries includes both fixed nonresidential and residential investment, and so the appropriate depreciation rate is for the sum of the two.) This rate is the value that was used for δ in the construction of K for each of the other countries. (For countries with annual data, the value used for δ was .06.)

Second, a base value of K was constructed. A preliminary base value was chosen, and K was constructed for each period using this base value and the depreciation rate of .015 (.06 for the annual countries). The capital-output ratio (K/Y) was then computed for the first and last periods. If the ratios in the two periods were similar, the base value was used. Otherwise, the preliminary base value was changed, and the process was repeated. The process was stopped when the ratios in the first and last periods were similar. In other words, the base value was chosen so as to make the capital-output ratio have no long run trend.

This procedure for constructing data on K is obviously crude, but it is about the best that can be done given the available data. It provides at least a rough estimate of the capital stock of each country.

V: Stock of Inventories

Data on inventory investment, denoted $V1$ in the ROW model, are available for each country, but not data on the stock of inventories, denoted V. By definition $V = V_{-1} + V1$. (See, for example, equation 117 for the US model.) Given this equation and data for $V1$, V can be constructed once a base period and base period value are chosen. The base period was chosen for each country to be the quarter or year prior to the beginning of the data on $V1$, and the base period value was taken to be zero. This means that the constructed data for

V are off by a constant amount throughout the sample period (the difference between the true value in the base period and zero). This error is absorbed in the estimate of the constant term in the equation in which V appears as an explanatory variable, which is the production equation 4.

Excess Labor and Excess Capital

As was the case for the United States, the short run production function for each country is assumed to be one of fixed proportions:

$$Y = \min[\lambda(J \cdot HJ^a), \mu(K \cdot HK^a)] \tag{3.2}$$

where Y is production, J is the number of workers employed, HJ^a is the number of hours worked per worker, K is the capital stock discussed above, HK^a is the number of hours each unit of K is utilized, and λ and μ are coefficients that may change over time due to technical progress. The notation in equation (3.2) is changed slightly from that in (3.1) for the United States. J is used in place of JF because there is no disaggregation in the ROW model between the firm sector and other sectors. Similarly, HJ^a is used in place of HF^a. Finally, K is used in place of KK because there is no disaggregation in the ROW model between types of capital. Note also that Y refers here to the total output of the country (real GDP), not just the output of the firm sector. Data on Y, J, and K are observed (or, in the case of K, constructed); the others are not. Also, contrary to the case for the United States, data on the number of hours paid for per worker (denoted HF in the US model) are not available.

Given the production function 3.2, excess labor was measured as follows for each country. Y/J was plotted over the sample period, and peaks of this series were chosen. This is from 3.2 a plot of $\lambda \cdot HJ^a$. If it is assumed that at each peak HJ^a is equal to the same constant, say $\overline{HJ}$, then one observes at the peaks $\lambda \cdot \overline{HJ}$. Straight lines were drawn between the peaks (peak to peak interpolation), and $\lambda \cdot \overline{HJ}$ was assumed to lie on the lines. If, finally, $\overline{HJ}$ is assumed to be the maximum number of hours that each worker can work, then $Y/(\lambda \cdot \overline{HJ})$ is the minimum number of workers required to produce Y, which is denoted $JMIN$ in the ROW model. $\lambda \cdot \overline{HJ}$ is denoted LAM, and the equation determining $JMIN$ is equation I-13 in Table B.3. The actual number of workers on hand (J) can be compared to $JMIN$ to measure the amount of excess labor on hand.

A similar procedure was followed to measure excess capital. Y/K was plotted over the sample period, and peaks of this series were chosen. This is from 3.2 a plot of $\mu \cdot HK^a$. If it is assumed that at each peak HK^a is equal to the same constant, say $\overline{HK}$, then one observes at the peaks $\mu \cdot \overline{HK}$. Straight lines were drawn between the peaks, and $\mu \cdot \overline{HK}$ was assumed to lie on the lines. If, finally, $\overline{HK}$ is assumed to be the maximum number of hours that each machine can be utilized, then $Y/(\mu \cdot \overline{HK})$ is the minimum amount of capital required to produce Y, which is denoted $KMIN$ in the ROW model. $\mu \cdot \overline{HK}$ is denoted MUH, and the equation determining $KMIN$ is equation I-11 in Table B.3. The actual capital stock (K) can be compared to $KMIN$ to measure the amount of excess capital on hand.

Labor Market Tightness: The Z variable

A labor market tightness variable (the Z variable) was constructed for each country in the same manner as was done for the United States. For each country a peak to peak interpolation of JJ $(= J/POP)$ was made, and JJP (the peak to peak interpolation series) was constructed. Z is then equal to the minimum of 0 and $1 - JJP/JJ$, which is equation I-16 in Table B.3. See the discussion in Section 3.2.3 about the Z variable.

YS: Potential Output

A measure of potential output (YS) was constructed for each country in the same manner as was done for the United States. The only difference is that here output refers to the total output of the country rather than just the output of the firm sector. The equation for YS is $YS = LAM \cdot JJP \cdot POP$, which is equation I-17 in Table B.3. Given YS, a gap variable can be constructed as $(YS - Y)/YS$, which is denoted ZZ in the ROW model. ZZ is determined by equation I-18 in Table B.3.

3.3.4 The Identities

The identities for each country are listed in Table B.3. There are up to 19 identities per country. Equation I-1 links the non NIPA data on imports (i.e., data on M and MS) to the NIPA data (i.e., data on IM). The variable $IMDS$ in the equation picks up the discrepancy between the two data sets. It is exogenous in the model. Equation I-2 is a similar equation for exports. Equation I-3 is the income identity; equation I-4 defines inventory investment as the difference between production and sales; and equation I-5 defines the stock of inventories as the previous stock plus inventory investment. The income identity I-3 is the empirical version of equation 2.4 in Section 2.2.3 except that the level of imports (IM) has to be subtracted in I-3 because C, I, and G include imports.

Equation I-6 defines S, the balance of payments on current account, the saving of the country. This is the empirical version of equation ii in Section 2.2.3. Equation I-7 defines A, the net stock of foreign security and reserve holdings, as equal to last period's value plus S. (Remember that A is constructed by summing past values of S.) This is the empirical version of equation i′ in Section 2.2.8.

Equation I-8 links M, total merchandise imports in 85 lc, to $M85\$A$, merchandise imports from the countries in the trade share matrix in 85 \$. The variable $M85\$B$ is the difference between total merchandise imports (in 85\$) and merchandise imports (in 85\$) from the countries in the trade share matrix. It is exogenous in the model.

Equation I-9 links E, the average exchange rate for the period, to EE, the end of period exchange rate. If the exchange rate changes fairly smoothly within the period, then E is approximately equal to $(EE + EE_{-1})/2$. A variable $PSI1$ was defined to make the equation $E = PSI1[(EE+EE_{-1})/2]$ exact, which is equation I-9. One would expect $PSI1$ to be approximately one and not to fluctuate much over time, which is generally the case in the data.

Equation I-10 defines the capital stock, and equation I-11 defines the minimum capital stock needed to produce the output. These two equations were discussed above. Equation I-12 defines the civilian unemployment rate, UR. $L1$ is the labor force of men, and $L2$ is the labor force of women. J is total employment, including the armed forces, and AF is the level of the armed forces. UR is equal to the number of people unemployed divided by the civilian labor force.

Equations I-13 through I-18 pertain to the measurement of excess labor, the labor constraint variable, and potential output. These have all been discussed above.

Finally, equation I-19 links PM, the import price index obtained from the IFS data, to PMP, the import price index computed from the trade share calculations. The variable that links the two, $PSI2$, is taken to be exogenous.

3.3.5 The Stochastic Equations

The stochastic equations for a given country are listed in Table B.3. There are up to 15 estimated equations per country. It will be useful to relate some of the equations in the table to those in the theoretical model in Chapter 2, Section 2.2.3. Chapter 6 discusses the specification, estimation, and testing of these equations. As will be discussed in Chapter 6, many of these equations are similar to the corresponding equations in the US model.

Equation 1 in Table B.3 explains the demand for imports. It is matched to equation 2.2 of the theoretical model. Equation 2 explains consumption. It is matched to equation 2.1 except that consumption for equation 2 includes consumption of imported goods. In the theoretical model X_h is only the value of domestically produced goods consumed. Equation 3 explains fixed investment, and equation 4 explains production with sales as an explanatory variable, which is in effect an inventory investment equation. Neither of these equations was included in the theoretical model. The price equation 5 is matched to equation 2.3.

Equation 6 explains the demand for money, and it is matched to equation 2.6. Equation 7 is an interest rate reaction function, explaining the short term interest rate RS. RS is equivalent to R in the theoretical model. (Interest rate reaction functions are discussed in Section 2.2.7.) Equation 8 is a term structure of interest rates equation, explaining the long term interest rate RB. The theoretical model does not contain a long term rate. Equation 9 is an exchange rate reaction function, explaining the exchange rate E. E is equivalent to e in the theoretical model. (Exchange rate reaction functions are also discussed in Section 2.2.7.) Equation 10 is an estimated arbitrage condition and explains the forward exchange rate. In the theoretical model this equation would be $F = e\frac{1+R}{1+r}$, where F is the forward rate.

Equation 11 explains the price of exports. In the theoretical model the price of exports is simply the price of domestic output, but this is not true in practice and an additional equation has to be introduced, which is equation 11. Equation 12 explains the wage rate; equation 13 explains the demand for employment; and equations 14 and 15 explain the labor force participation rates of men and women, respectively. These equations are not part of the theoretical model because it has no labor sector.

3.3.6 The Linking Equations

The equations that pertain to the trade and price links among countries are presented in Table B.4. (All imports and exports in what follows are merchandise imports and exports only.) The equations L-1 define the export price index for each country in U.S. dollars, $PX\$_i$. i runs from 1 through 44, and so there are 44 such equations. $PX\$_i$ depends on the country's exchange rate and on its export price index in local currency.

The equations L-2 are the trade link equations. The level of exports of country i in 85 \$, $X85\$_i$, is the sum of the amount that each of the other 44 countries imports from country i. For example, the amount that country j imports from country i is $\alpha_{ij} M85\$A_j$, where α_{ij} is the fraction of country i's exports imported by j and $M85\$A_j$ is the total imports of country j from the countries in the trade share matrix. There are 33 of these trade link equations. The α_{ij} values are determined from the trade share equations. These equations are discussed in Section 6.16, and the use of these equations in the solution of the model is discussed in Section 9.2.

The equations L-3 link export prices to import prices, and there are 33 such equations. The price of imports of country i, PMP_i, is a weighted average of the export prices of other countries (except for country 45, the "all other" category, where no data on export prices were collected). The weight for country j in calculating the price index for country i is the share of country j's exports imported by i.

The equations L-4 define a world price index for each country, which is a weighted average of the 33 countries' export prices except the prices of Saudi Arabia and Venezuela, the oil exporting countries. (As discussed in Section 6.12, the aim is to have the world price index not include oil prices.) The world price index differs slightly by country because the own country's price is not included in the calculations. The weight for each country is its share of total exports of the relevant countries.

Table B.5 explains how the US and ROW models are linked. When the two models are combined (into the MC model), the price of imports PIM in the US model is endogenous and the level of exports EX is endogenous.