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ABSTRACT

This paper discusses the theoretical structure and empirical properties of MX3, a multicountry macroeconometric model with rational expectations. MX3 is a medium-sized quarterly model of the United States, Japan, and West Germany. The primary objective of the model is to analyze the effect of fiscal and monetary rules on national economies in an international context. By incorporating rational expectations into almost all of the model's behavioral equations, MX3 takes a large step toward addressing the "Lucas critique" of model-based policy analysis.

A FORWARD-LOOKING MULTICOUNTRY MODEL: MX3

Joseph E. Gagnon[1]

INTRODUCTION

MX3 is a medium-sized macroeconomic model of the United States, Japan, and West Germany. In MX3, quarterly econometric models of each country are linked by trade and capital flows. To close the system, data from the four next largest industrial economies are aggregated as a proxy for the rest of the world (ROW), and are modeled as a fourth country in MX3.[2] Each country block in MX3 has 11 behavioral equations, 21 identities, 4 government policy rules, and 2 exogenous variables. The scale of MX3 is thus considerably smaller than the Federal Reserve Board's Multicountry Model (MCM). (The MCM has approximately 170 equations per country block.) This paper presents a theoretical description of MX3 and discusses its empirical implementation and estimation.

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1. The author is a staff economist in the Division of International Finance. This paper represents the views of the author and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or other members of its staff.
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2. One avenue for future research is to extend the ROW sector by collecting data from other countries and building separate models for blocs of similar countries. Possible country groupings include the rest of the OECD countries, the OPEC countries, the newly industrialized countries (NICs), the non-oil developing countries, and the socialist countries. It would also be of interest to model each of the seven largest economies separately.

The structure of MX3 is in many ways similar to traditional Keynesian macro models. Economic agents are separated into four groups--households, producers, traders, and governments. Each of the main aggregates in the national income accounts is associated with the decision rule of one or more of these groups. For example, households determine aggregate consumption and producers determine aggregate investment.[3]

MX3 differs from traditional large-scale quantitative macro models in three important dimensions. The first, and most obvious, difference is that expectations are rational and forward-looking rather than backward-looking. MX3 imposes "rational expectations" in the sense that unobserved expectations are set equal to the model's own prediction of the future.[4] Only in the past few years have modelers begun to introduce rational expectations into empirical macro models. Two notable examples are John Taylor's multicountry model and the International Monetary Fund's MULTIMOD.[5] MX3 builds upon the work of these two forerunners.

The second innovation of MX3 lies in its treatment of lags in the structural relations. In MX3, the behavioral equations contain only one lagged dependent variable and no other lagged variables. (The appearance of a lagged dependent variable in the decision rule is a general result of

3. Even though the profits of producers and traders revert to households, the decisions of producers and traders are not directly coordinated with the decisions of households. A general equilibrium in the model is achieved only through the incentives given by market interest rates and prices.

4. Because it is not feasible to compute true expectations in a large stochastic nonlinear model, the expectations variables are solved under the assumption that future disturbances are identically zero, i.e. the model solution enforces certainty equivalence. This procedure introduces an approximation error. Simply put, the model solves nonlinear functions of expectations when the theory calls for expectations of nonlinear functions.

5. See Taylor [1988] and Masson, et. al. [1988] for a description of these models.

optimizing behavior with costly adjustment.) Higher-order dynamics in the behavior of any individual time series are assumed to reflect the transmission and equilibration of shocks throughout the entire system of equations. In other words, a system of several first-order equations typically gives rise to time series behavior of individual variables that is higher than first order. This research takes the view that the apparent significance of lagged variables in much empirical work can be traced to misspecification of the estimation equation and, in particular, to the lack of a good measure of expected future variables.

The third, and perhaps most significant, difference between MX3 and traditional models concerns the long-run properties of the model. MX3 is designed to exhibit the qualities of an optimal stochastic growth model in the long run. The ultimate sources of growth in this economy are exogenous increases in labor force and technology. MX3's parameters are carefully restricted to ensure that changes in government policy and permanent shocks to supply are consistent with steady-state growth paths.

OBJECTIVES

The primary objective of this project is to develop a simulation model for analyzing fiscal and monetary policy. By allowing expectations to react endogenously to changes in policy rules, MX3 takes a large step toward addressing Lucas' [1976] critique of model-based policy analysis.

The essence of the Lucas critique is that the "structural" equations of most macro models really are not capturing stable decision rules of economic agents. Instead, these equations are better characterized as reduced forms that combine the interactions of policymakers and private agents. Lucas demonstrated that one would not expect such a reduced form relationship to hold constant in the face of a change in the policymakers' behavior.

Lucas' prescription for macro modelling is to consider the decision problem for each class of economic agents. Lucas argued that for a wide range of decisionmaking environments, agents base their actions on expectations of future variables as well as the realizations of current and past variables.[6] Only when modellers have correctly identified the optimal decision rules and information sets of each class of agents can they hope to gauge the effects of different policy rules accurately.

Unfortunately, a fully satisfactory analysis of macroeconomic dynamics based on optimizing behavior has yet to be developed, and it is likely to be years away for models of the scale of MX3. The strategy behind MX3 is to build a tractable model now by appealing heuristically to the structural equations that might result from a suitably specified set of agents, tastes, and technologies. There are three guiding assumptions: First, in the absence of shocks, the economy approaches a perfectly competitive, steady-state growth path. Second, in the face of shocks, agents must undertake costly adjustments. Third, the different classes of agents--consumers, producers, traders, and governments--do not coordinate their decisions except through market prices and interest rates.

Many of the structural equations of MX3 are based on the Euler equation decision rules that characterize optimal behavior with quadratic adjustment

6. "Rational expectations" embody a simplifying assumption that ignores any learning process by agents about the nature of the economy or the shocks that have ocurred recently. Under rational expectations, agents know the true stochastic structure of the economy, including the policy rules in effect.

costs.[7] The decision variable is a function of its own past and the expected future discounted sum of the forcing variables. The coefficients on these explanatory variables are typically constrained to ensure an eventual return to an optimal growth path. The speed of adjustment to the steady state can be freely estimated.

A second objective of MX3 is to learn more about the world economy through estimation and testing of the model. Ideally, all the private sector behavioral and government policy equations should be estimated simultaneously using a technique such as full-information maximum likelihood (FIML).[8] Unfortunately, the computational requirements for FIML in all but the smallest rational expectations models are prohibitive.

MX3 was therefore estimated using instrumental variables techniques. One advantage of estimating each equation separately and using instruments for current and future endogenous independent variables is that one need not specify the exact form of the government policy rules before estimating the private sector behavioral equations.[9]

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7. See, for example, Sargent [1978].

8. The advantages of FIML are especially important in the context of rational expectations models because future expectations in the equations being estimated can be solved directly by the model's own structure. Moreover, the implied cross-equation restrictions of rational expectations can be tested, both jointly across all equations and individually in particular equations.

9. The treatment of expectations during the estimation of MX3 thus differs from the treatment of expectations during simulation. In order to simulate the model all equations must be specified, including the policy equations. Because estimation of all the equations simultaneously (FIML) is too expensive, the parameters of MX3 were estimated equation by equation, using instrumental variables for the future expectations.

THEORETICAL STRUCTURE

Overview

MX3's fundamental structure is that of a stochastic growth model with Cobb-Douglas technology, perfectly competitive firms, and long-lived utility-maximizing households. In MX3, households and firms rationally forecast future income and real interest rates when making their consumption and investment plans. Growth in the model is driven exogenously by growth in the labor force and in technology.

With Cobb-Douglas technology and perfect competition, capital's share of total output is given by the exponent on capital in the production function. The capital-output ratio equates the returns to capital with the cost of capital, which is in turn dependent on the real rate of interest. The real interest rate serves to equilibrate consumption and investment at the level of output given by the production function.

While it would be possible to build a model of the economy with only the simple relationships described above, such a model would not be able to explain the short- to medium-run dynamics evident in the data. The transmission of shocks throughout the economy is almost certainly influenced by adjustment costs, gestation lags, and delays in the assimilation of new information. These characteristics of the economic environment may prevent markets from behaving competitively in any given period, and yet market forces may move the economy to a competitive outcome over a longer horizon.

Only recently have economists begun to enrich the dynamics of growth models by solving the decision problems of agents with costs of adjustment or gestation lags. At present, this work has yielded only rudimentary models that require the assumption of continuously competitive market clearing in order to obtain a solution. Extending these models rigorously to allow for monopolistic competition and endogenous entry of new firms is a task beyond the scope of this project.

The structure of MX3 reflects the view that economic theory in its present state yields clearer insights about the long-run behavior of the economy than about short-run dynamics. The approach taken by MX3 is to enforce a competitive steady state in the long run, but to allow (heuristically) for imperfect competition and costly adjustment in the short run. In several instances, the model's dynamics are inspired by optimal decision rules in the face of convex adjustment costs. These decision rules determine the control variable as a function of its previous value and the discounted expected future sum of the forcing variables. However, with the exception of consumption, the structural equations of the model are not derived from the maximization of specific objective functions.

Markets and Agents

Each country is composed of four different types of economic agents. Producers in each country produce a homogeneous good that is differentiated from the goods produced in other countries. Productive capacity is modeled by a Cobb-Douglas function in the capital stock and the labor force. Total production can deviate temporarily from capacity production, but these deviations will be associated with equilibrating price movements.

Traders do not utilize capital and labor; they are modeled as pure arbitragers. Domestic traders purchase goods from domestic producers to sell to foreigners. This trade is characterized by significant costs of transportation and adjustment that prevent the continuous equalization of prices across countries. The preferences of households, producers, and governments for foreign goods relative to domestic goods jointly determine the demand curve faced by foreign traders selling into the domestic market.

Households maximize utility from discounted future consumption subject to their budget constraint. Households own the firms that produce and trade goods, and the net income earned by these firms passes directly to the households. The notional labor supply of each household is constant, but actual labor supplied may fluctuate as output fluctuates around capacity. (The model essentially enforces equal capacity utilization of capital and labor.)

Governments determine the level of the monetary base and real government spending. The government budget constraint determines the level of bonds outstanding. Tax rates are modeled with an ad hoc adjustment mechanism to ensure that the ratio of bonds to taxable income returns to an exogenous target level. The target level of government debt and the speed of adjustment to that target may be considered as additional policy instruments of government.

Financial markets determine the levels of interest rates and exchange rates. These financial markets represent the combined behavior of the four sectors in the model. Production technology and the labor force are modeled as exogenous to the rest of the economy.

Appendix 1 (attached to this paper) presents a simplified overview of a typical country model in MX3 and lists the data mnemonics used in the paper. Appendix 2 (not attached, but available upon request) provides a detailed listing of the equations in MX3; it also documents the model database.

Consumption

In the absence of liquidity constraints, adjustment costs, and information lags, the representative household consumes a constant fraction of its wealth.[10] Wealth is defined as the discounted sum of expected future disposable income.

$$1.\quad C_t = \beta \sum_{i=0}^{\infty} YD_{t+i}\left(1 + \frac{\Delta}{4} + (1-TAU_{t,i})\frac{RL_{t,i}}{4} - \frac{DPA_{t,i}}{4}\right)^{-i}.$$

In equation 1, $RL_{t,i}$ is the nominal interest rate at time t on a risk-free bond maturing after i periods; $TAU_{t,i}$ is the average tax rate on the interest from such a bond; $DPA_{t,i}$ is the average rate of inflation of the domestic absorption deflator between period t and period t+i; and Δ is a risk premium.[11] C is total private consumption and YD is private disposable income. RL, DPA, and Δ are all divided by four to convert annual rates to quarterly rates of discount.

Ceteris paribus, higher levels of current or future income lead to higher current consumption; higher interest rates reduce current

10. This consumption relation can be derived for infinitely-lived households with time-separable, logarithmic utility.

11. The premium Δ has two components. The largest component derives from the fact that private rates of return typically exceed the rate of return on government bonds. This excess return may represent a risk premium, and it has an average value of 6 percentage points in the United States. (See Mehra and Prescott [1985].) The economics profession has made little progress to date in explaining this risk premium or its fluctuations. In MX3 it is assumed to take a constant value of 6 percent.

The second component of Δ is the probability that the representative consumer will not survive until the following year. The probability of death leads all consumers to discount the future at a faster rate than the market rate of interest. (See Blanchard [1985].) In MX3 the probability of death for the representative consumer is assumed to be 2 percent per annum, which implies that the representative consumer expects to live for 50 more years.

consumption. In practice, however, positive shocks to income will tend to raise interest rates via the money demand equation, with ambiguous results for current consumption.

There are two modifications of equation (1) that may or may not be important in modeling consumption. First, a fraction of consumers may be liquidity constrained, so that they simply consume their current disposable income.[12] Second, the non-liquidity-constrained consumers may adjust slowly to shifts in wealth by smoothing consumption from period to period due to an aversion to sharp changes in their spending habits.[13]

$$2.\quad C_t = C_{1t} + C_{2t}.$$

$$3.\quad C_{1t} = aYD_t.$$

$$4.\quad C_{2t} = bC_{2t} + (1-b)(1-a)\beta \sum_{i=0}^{\infty} YD_{t+i}\left(1 + \frac{\Delta}{4} + (1-TAU_{t,i})\frac{RL_{t,i}}{4} - \frac{DPA_{t,i}}{4}\right)^{-i}.$$

12. For a discussion of the empirical magnitude of liquidity constraints, see Hall [1988] and Poterba and Summers [1987]. Given the asymmetry between ability to borrow and ability to save, it may be more descriptive to call these consumers myopic.

13. These households also should be forecasting movements in wealth in order to smooth consumption optimally. It is easy to show that forecastable movements in wealth over short horizons are extremely small under a broad range of environments. Therefore, the current value of wealth is a close approximation to its expected value over the near horizon. For more on habit-formation and slow adjustment in consumption, see Nason [1989].

Even if individual consumers adapt their spending plans rapidly, there will be a lag between the date their plans are made and the date the transactions are recorded. This lag will vary depending on the individual plans: a European vacation may wait until summer, while a new car may be purchased quickly.

According to equation (2) total consumption consists of the sum of consumption by liquidity-constrained consumers, C_1, and consumption by slowly-adjusting, unconstrained consumers, C_2. Liquidity-constrained consumers simply consume their current disposable income, and the parameter, a, represents the share of disposable income earned by liquidity-constrained consumers. The remaining consumers adjust slowly toward the target level of consumption; b is the lagged adjustment parameter. Equations (3) and (4) can be substituted into (2) to yield a simplified expression for total consumption. If liquidity constraints and consumption smoothing are unimportant (a=0 and b=0) equation (5) reduces to equation (1).

$$5.\ C_t = aYD_t + b\left(C_{t-1} - aYD_{t-1}\right)$$

$$+ (1-a)(1-b)\beta \sum_{i=0}^{\infty} YD_{t+i}\left(1 + \frac{\Delta}{4} + (1-TAU_{t,i})\frac{RL_{t,i}}{4} - \frac{DPA_{t,i}}{4}\right)^{-i}.$$

In order to eliminate the infinite sum of future variables in equation (5) consider the following transformation of equation (4) using the term structure relation that is presented in a later section (equation (36)).

$$6.\ C_{2t} = bC_{2t-1}$$

$$+ (1-a)(1-b)\beta \sum_{i=0}^{\infty}\left\{YD_{t+i} * \prod_{j=0}^{i-1}\left(1 + \frac{\Delta}{4} + (1-TAU_{t+j})\frac{RS_{t+j}}{4} - \frac{DPA_{t+j+1}}{4}\right)^{-1}\right\}.$$

The one-period interest rate, $RL_{t,1}$, has been abbreviated to RS_t, as has the one-period inflation rate, DPA_t. This relationship also holds in the subsequent period.

7. $C_{2t+1} = bC_{2t}$

$$+ (1-a)(1-b)\beta \sum_{i=1}^{\infty} \left\{ YD_{t+i} * \prod_{j=1}^{i-1} \left[1 + \frac{\Delta}{4} + (1-TAU_{t+j})\frac{RS_{t+j}}{4} - \frac{DPA_{t+j+1}}{4} \right]^{-1} \right\}.$$

By dividing both sides of equation (7) by $\left[1 + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right]$

and subtracting equation (7) from equation (6), it is easy to show that

8. $$\left[1 + b/\left[1 + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right]\right] C_{2t} = bC_{2t-1}$$

$$+ C_{2t+1}/\left[1 + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right] + (1-a)(1-b)\beta YD_t.$$

Once again, the liquidity-constrained consumers are described by equation (3). Combining equations (2) and (3) with equation (8) yields a description of aggregate consumption that relies on expectations of only one future period.

9. $$C_t = b\left[C_{t-1} - aYD_{t-1}\right]/\left[1 + b/\left[1 + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right]\right]$$

$$+ \left[C_{t+1} - aYD_{t+1}\right]/\left[1 + b + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right] + \left[a + (1-a)(1-b)\beta\right] YD_t.$$

Fixed Investment

The model's investment equation is essentially neoclassical. In the long run, the returns to capital should equal the cost of capital:

$$10. \quad \left[(1-TAU)RS + (1-TAU)\delta - (1-TAU)DPA + \pi\right] * K = \alpha(1-TAU)GDP.$$

The first three terms in the brackets on the left-hand-side of equation (10) represent the cost of holding a unit of capital for one period. The interest charge, RS, is reduced by the tax rate, TAU, because firms are allowed to deduct interest expense from their taxes. Similarly, the depreciation, δ, is also tax deductible. The inflation rate, DPA, represents a capital gain to the firm, so it reduces the cost of holding capital. However, because the ability to deduct future depreciation from the firm's taxes is based on historical nominal cost rather than current value, inflation today increases the firm's future real tax liability. Finally, the model allows for a constant risk premium, π, needed to induce agents to hold capital instead of risk-free government bonds.

The right-hand-side of equation (10) represents the returns to capital. With a Cobb-Douglas production function and competitive markets, capital's share of output is simply the exponent on capital, α, in the production function. These returns are reduced by the average tax rate.

If it is costly to adjust the capital stock, even perfectly competitive markets are not sufficient to enforce equation (10) continuously. Some slowness in the adjustment process will generally be optimal. Equation (12) describes investment as a process that adjusts slowly to deviations between the desired and the actual capital stock. One explanation for slow adjustment of investment is that many capital-spending projects require multi-period commitments of a stream of investment that is costly to change.[14] On the other hand, costly adjustment also provides an incentive

14. See Kydland and Prescott [1982].

for forward-looking behavior. A convenient way to capture both of these effects is to include a lagged dependent variable and expected future values of the target variables in the decision rule. Equation (12) does this without abandoning the long-run relationship in equation (10) and it introduces only two new parameters.

11. $CC_t = \left[(1-TAU_t) * (RS_t + \delta - DPA_{t+1}) + \pi\right].$

12. $IF_t = cIF_{t-1}$
$$+ (1-c)(1-d) \sum_{i=0}^{\infty} d^i \left[\left(\alpha(1-TAU_{t+i})GDP_{t+i}/CC_{t+i}\right) - (1-\delta)K_{t+i-1}\right].$$

13. $K_t = (1 - \delta/4)K_{t-1} + IF_t/4.$

Equation (11) describes the one-period holding cost of capital. The term inside the inner set of brackets in equation (12) can be interpreted as the equilibrium capital stock in the absence of adjustment costs, as given by equations (10) and (11).[15] The second term in the brackets is the capital stock carried over from the previous period. Equation (13) is the perpetual inventory identity which defines the evolution of the capital stock.[16]

15. Equation (12) presents a causal relationship between expected output and desired capital. Future output is not exogenous, however, since it is affected by the amount of capital installed in the current period. Due to decreasing marginal returns to capital in the production function, there will be a unique combination of capital and output that satisfy equation (12) in the steady state.

16. All stock variables refer to quantities at the end of the period. Because all flow variables are expressed at annual rates, they must be divided by four for purposes of stock accumulation. This rule applies to the capital stock, government bonds, and net foreign assets.

As in the case of consumption, it is possible to write equation (12) without the infinite sum of future variables. First, rewrite equation (12) in terms of lag and lead operators (L and F):

$$14.\quad (1-cL)IF_t = (1-dF)^{-1}\left(\alpha(1-TAU_t)GDP_t/CC_t - (1-\delta)K_{t-1}\right).$$

Multiplying both sides of equation (14) by (1-dF) yields the following:

$$15.\quad (1+cd)IF_t = cIF_{t-1} + dIF_{t+1} + (1-c)(1-d)\left(\alpha(1-TAU_t)GDP_t/CC_t - (1-\delta)K_{t-1}\right).$$

Inventory Investment

Producers are assumed to hold inventories to adjust to expected and unexpected changes in demand. Thus, the net change in the stock of inventories responds negatively to current output and positively to expected future output. The cost of holding inventories is the short-term real interest rate.

$$16.\quad II_t = e_0 + e_1GDP_{t+1} - e_2GDP_t - e_3\left(RS_t - DPA_{t+1}\right).$$

Export Prices

Traders are modeled as imperfectly competitive arbitrageurs who buy goods in their home country and sell them in a foreign country. The price of these exports reflects output prices at home and abroad. Export prices are constrained to be homogenous of degree one with respect to output prices. The foreign output price, PGNPW, is a weighted average of foreign prices converted to domestic currency at the exchange rate, E. The weights, w_i, are fixed according to the average share of domestic exports destined for country i over the estimation period. The superscripts index individual countries. The home country is normalized at zero and its superscript is suppressed.

Over time, export prices in all developed economies have fallen relative to aggregate prices. This phenomenon is most likely due to faster technological progress in tradables than nontradables and it is modeled here as a simple function of time.

$$17.\ \log(PEX_t) = g_0 + g_1\log(PEX_{t-1}) + g_2\log(PGNPW_t) + (1-g_1-g_2)\log(PGNP_t) - g_3t.$$

$$18.\ \log(PGNPW_t) = w_1\log(E_t^1*PGNP_t^1) + w_2\log(E_t^2*PGNP_t^2) + (1-w_1-w_2)\log(E_t^3*PGNP_t^3).$$

Export Volumes

Unlike many other econometric models, MX3 allows for different cyclical and secular demand elasticities in trade. The cyclical demand for exports depends on weighted foreign absorption relative to foreign productive capacity, AW/CAPW, and the price of domestic exports relative to the price of foreign exports, PEX/PIM. The secular demand for exports depends on the level of worldwide production capacity, CAPTOT. MX3 thus incorporates the assumption that long-run growth in trade is due as much to supply-side as to demand-side factors. (In equations (20) and (21) the weights, w_i, are the same as those used to compute PGNPW in equation (18).)

19. $\log(EX_t) = h_0 + h_1\log(EX_{t-1}) + h_2\log(AW_t/CAPW_t)$
$+ h_3\log(PEX_t/PIM_t) + h_4\log(CAPTOT_t)$.

20. $\log(AW_t) = w_1\log(A_t^1) + w_2\log(A_t^2) + (1-w_1-w_2)\log(A_t^3)$.

21. $\log(CAPW_t) = w_1\log(CAP_t^1) + w_2\log(CAP_t^2) + (1-w_1-w_2)\log(CAP_t^3)$.

22. $CAPTOT_t = CAP_t + CAP_t^1 + CAP_t^2 + CAP_t^3$.

Import Volumes and Prices

Because each country's exports are the imports of the other countries, it would not be theoretically consistent to model imports and import prices independently of exports and export prices. MX3 thus estimates equations that describe the share of a country's exports that are destined for each other country. These share equations incorporate the global trade balance identity. Country i's total imports are computed in both nominal and real terms by adding up the fraction of each other country's nominal and real exports that are destined for country i. (The aggregate import price for country i is the ratio of nominal to real imports.)

Ideally, there should be two sets of export share equations: one set for nominal exports and one set for real exports. The allocation of nominal and real exports across trading partners need not be identical because the price of exports to different trading partners need not be identical. Unfortunately, on a bilateral quarterly basis only nominal trade shares are available. Both nominal and real imports in MX3 are computed using the same share weights of exports.

As an alternative to modelling the export side, it would be possible to estimate behavioral equations for imports and import prices and use import share equations to compute exports and export prices. The former strategy is adopted by MX3 for two reasons. First, the assumption that nominal and real trade shares move together is more realistic for exports than for imports, as long as export prices are more closely correlated with the exporter's price level than the importer's. Second, it is econometrically easier to model the effect of relative prices on nominal export shares than on nominal import shares. An increase in the price level of one trading partner relative to another will unambiguously increase the share of nominal exports to that country by encouraging both higher prices and quantities. However, an increase in the price level of one trading partner relative to another will have offsetting price and quantity effects on the share of nominal imports from that country.

The allocation of each country's exports among its trading partners is modeled via a system of equations that captures the effects of changing relative prices while forcing the shares to sum to unity for each exporter.[17] SHR1 refers to the share of country 0 exports destined for country 1. $SHR0^1$ refers to the share of country 1 exports destined for country 0.

17. In theory one also might want to capture the effects of relative absorption and relative capacity, but empirically these effects were insignificant.

23. $SHR1_t = \Psi_1 + T_{10}*SHR1_{t-1} + T_{12}*\log\left(E^1_t*PGNP^1_t/E^2_t*PGNP^2_t\right)$

$+ T_{13}*\log\left(E^1_t*PGNP^1_t/E^3_t*PGNP^3_t\right).$

24. $SHR2_t = \Psi_2 + T_{20}*SHR2_{t-1} - T_{12}*\log\left(E^1_t*PGNP^1_t/E^2_t*PGNP^2_t\right)$

$+ T_{23}*\log\left(E^2_t*PGNP^2_t/E^3_t*PGNP^3_t\right).$

25. $SHR3_t = (1-\Psi_1-\Psi_2) - T_{10}*SHR1_{t-1} - T_{20}*SHR2_{t-1}$

$- T_{13}*\log\left(E^1_t*PGNP^1_t/E^3_t*PGNP^3_t\right) - T_{23}*\log\left(E^2_t*PGNP^2_t/E^3_t*PGNP^3_t\right).$

26. $IM_t = SHRO^1_t*EX^1_t + SHRO^2_t*EX^2_t + SHRO^3_t*EX^3_t.$

27. $PIM_t = \left(E^1_t*PEX^1_t*SHRO^1_t*EX^1_t + \ldots + E^3_t*PEX^3_t*SHRO^3_t*EX^3_t\right) / IM_t.$

Finally, net foreign assets are the sum of previous current account surpluses. The currency denomination of all international assets is assumed to be U.S. dollars, and the return on these assets is equal to the return on U.S. government bonds.

28. $NFA_t = \left(1 + RS_t/4\right)NFA_{t-1} + PEX_t*EX_t/4 - PIM_t*IM_t/4.$

Capacity

Capacity output, CAP, is given by a Cobb-Douglas production function. The labor force, L, and production technology, Q, are exogenous. The rate of capacity utilization, CU, is simply the ratio of domestic output to domestic capacity. In this model capacity denotes the sustainable, equilibrium level of output given the values of K, L, and Q, and the preferences of workers and managers. As discussed below, it is possible for the economy to operate above or below "capacity" at any given time.

29. $CAP_t = Q_t*K_{t-1}^{\alpha}*L_{t-1}^{1-\alpha}.$

30. $CU_t = GDP_t/CAP_t.$

Prices

The model abstracts from the labor market in its description of aggregate price behavior; in other words, it treats workers' wages as just additional prices in the system. The model therefore does not rely on movements in the real wage to explain output fluctuations.[18] Instead, MX3

18. The traditional Keynesian explanation of the business cycle relied on countercyclical real wages caused by sticky nominal wages: during periods of high demand, firms would charge higher prices, thus reducing the real wage and encouraging more employment and output. The seminal work of Dunlop [1938] as well as recent studies by Bils [1985] and Roberts [1987] all conclude that the real wage is nearly constant over the business cycle.

posits an expectations-augmented Phillips curve to explain price adjustment. In the model, the rate of inflation accelerates when output is above capacity or when output is expected to be above capacity in the future. Similarly, inflation decelerates when output is below capacity or when output is expected to be below capacity in the future. The model also is characterized by a significant degree of inertia in the inflation rate.

31. $DPGNP_t = p_0 * DPGNP_{t-1} + (1-p_0) * DPGNP_{t+1} + p_1 \log(CU_t)$.

A Phillips curve that is both backward- and forward-looking, like equation (31), can be justified as a rough approximation to a model of staggered price contracts.[19] According to models of staggered contracts, firms and workers set nominal prices for a predetermined period of time and agree to supply whatever quantity is demanded during the contract period. If the contracts last for more than one period, lagged adjustment will be introduced into the inflation process. Because firms and workers try to predict conditions over the life of their contracts, there will also be a forward-looking element to price behavior.

When output equals capacity, CU = 1 and log(CU) = 0. In this state of full employment there is no tendency for inflation to accelerate or decelerate, according to equation (31). The real side of the MX3 model can therefore be in equilibrium at any constant inflation rate of the price level.

The absorption deflator is an average of the GNP deflator and the export and import deflators. It is solved from the nominal GNP identity.

19. See Taylor [1980]. The dynamics induced by staggered contracts are more complex than those of equation (31).

The rate of inflation of output prices and the rate of inflation of absorption prices are defined in annual rates by simple identities.

32. $PA_t*A_t = PGNP_t*GNP_t - PEX_t*EX_t + PIM_t*IM_t - RS_t*NFA_{t-1}$.

33. $DPGNP_t = 4*(PGNP_t-PGNP_{t-1})/PGNP_{t-1}$.

34. $DPA_t = 4*(PA_t-PA_{t-1})/PA_{t-1}$.

Exchange rate

The basic exchange rate equation is motivated by open interest rate parity. The difference in nominal rates of return, RS, across countries is exactly matched by the expected movement of nominal exchange rates, E.[20] There are three exchange rates in the model; U.S. dollars are the numeraire. Equation (35) presents a typical exchange rate equation.

35. $\left(E^1_t - E^1_{t+1}\right) / E^1_t = \left(RS^1_t - RS_t\right) / 4.$

Term Structure

The model incorporates the pure expectations theory of the term structure of interest rates. Long rates are a function of expected future short rates over the term to maturity. Because the other behavioral equations of the model use this term structure relation to simplify their expressions, long-term interest rates are not needed to solve MX3. The implicit equation

20. It is possible to augment the equation to include either a constant risk premium or a variable risk premium that depends on the ratio of foreign to domestic bonds (portfolio balance). See Dooley and Isard [1982] and Frankel [1983].

for the interest rate on a bond maturing in i periods is given below. The one-period interest rate, $RL_{t,1}$, has been abbreviated to RS_t.

36. $(1 + RL_{t,i})^i = (1 + RS_t)(1 + RS_{t+1}) \ldots (1 + RS_{t+i-1})$.

Money Demand - Money Supply

It is possible to model either the short-term interest rate, RS, or the monetary base, MB, as the instrument of monetary policy. One of the main purposes of MX3 is to analyze the effect of different monetary policies on the overall economy. In the simplest case, one may consider a monetary policy that sets a constant growth rate for the monetary base.

The public demands real money balances, MB/PA. The absorption deflator and domestic absorption appear in the money demand equation on the assumption that cash balances are held to support spending. Nominal interest rates adjust to ensure that the public willingly demands the quantity of money supplied.

37. $MB_t = mMB_{t-1}$.

38. $\log(MB_t/PA_t) = r_0 + r_1\log(MB_{t-1}/PA_{t-1}) + r_2\log(A_t) + r_3RS_t$.

Fiscal Policy

Real government spending is denoted by G. Nominal tax revenues, TAX, equal the tax rate, TAU, times taxable income, TI. Taxable income is net national product plus interest on government bonds, B. The stock of government debt is given by the cumulation of past budget deficits minus revenues from money creation.

39. $TAX_t = TAU_t * TI_t$.

40. $TI_t = PGNP_t * GNP_t - \delta K_{t-1} * PA_t + RS_t * B_{t-1}$.

41. $B_t = \left(1 + RS_t/4\right) B_{t-1} + \left(PA_t * G_t - TAX_t\right)/4 - \left(MB_t - MB_{t-1}\right)$.

Based on equations (39)-(41) it would appear that governments are free to choose values of G and TAU independently and without constraints. However, when private agents form their expectations of future fiscal policy, they recognize that the government must satisfy its budget constraint (equation (41)) at every future date. Thus, an intertemporal budget constraint implicitly restricts the future paths of G and TAU. If the government is not allowed to default on its obligations, the national debt cannot grow so large that interest payments on the debt exceed the government's ability to raise revenues. Assuming a positive interest rate and a fixed rate of money growth, this feasibility condition places an upper bound on the ratio of government debt to taxable income.[21]

21. When there are no liquidity constraints, risk premia, or finite horizons (i.e., a=0 and Δ=0 in the consumption equation) optimizing behavior places the following restrictions on expected future fiscal policy:

42. $$B_t = \sum_{j=1}^{\infty} \left\{ \left(TAX_{t+j}/4 - PA_{t+j} * G_{t+j}/4 + MB_{t+j} - MB_{t+j-1} \right) / \prod_{i=1}^{j} \left(1 + RS_{t+i}/4\right) \right\}.$$

43. $$\lim_{j \to \infty} B_{t+j} / \prod_{i=1}^{j} \left(1 + RS_{t+i}/4\right) = 0.$$

Placing bounds on the ratio of debt to income is sufficient to ensure that (42) and (43) hold, provided that the nominal rate of interest exceeds the growth rate of nominal income.

(Footnote continues on next page)

In order to compute expectations of future fiscal policy in a manner consistent with the government's intertemporal budget constraint, MX3 models the tax rate, TAU, as a reaction function that gradually adjusts to return the ratio of bonds to taxable income to some exogenous target value, BRATIO. The variable TBAR represents the tax rate necessary to return the bond to income ratio to its target, BRATIO, in one period. The actual tax rate, TAU, adjusts part of the way toward TBAR in each period.[22] If desired, automatic stabilizers in the tax system could be added to equation (44). As with the monetary base, government spending and the bond ratio are left unspecified. However, in order to solve the model, some policy rule must be assumed to describe the future behavior of G and BRATIO. In the simplest case, G grows at a constant rate and BRATIO is constant.

44. $TAU_t = wTAU_{t-1} + (1-w)TBAR_t.$

45. $TBAR_t = \left(G_t*PA_t + RS_t*B_{t-1} - 4*(MB_t - MB_{t-1})\right)/TI_t - BRATIO_t + B_{t-1}/TI_t.$

46. $G_t = nG_{t-1}.$

(Footnote continued from previous page)
If the rate of interest is smaller than the growth rate of income, a bounded debt-to-income ratio will still ensure feasibility of future fiscal policy, but it does not guarantee that equations (42) and (43) will hold. However, if households have finite lives or if they are risk averse, then (42) and (43) are no longer necessary for optimality. See Abel, et. al. [1987].

22. The adjustment parameter, w, is always bounded between zero and one. However, depending on the remaining parameters of the model, large values of w may not adjust the tax rate quickly enough to ensure stability.

47. $BRATIO_t = z$.

Accounting Identities

48. $A_t = C_t + IF_t + II_t + G_t$.

49. $GDP_t = A_t + EX_t - IM_t$.

50. $GNP_t = GDP_t + RS_t{*}NFA_{t-1}/PGNP_t$.

51. $YD_t = PGNP_t{*}GNP_t/PA_t - \delta K_{t-1} - TAX_t/PA_t$
$+ RS_t{*}B_{t-1}/PA_t - \left(MB_{t-1} + B_{t-1}\right){*}DPA_t/PA_t$.

ESTIMATION

The equations to be estimated are consumption, fixed investment, inventory investment, export volumes, export prices, export shares, production capacity, price adjustment, and money demand. Since many of the variables in these equations are nonstationary, they must undergo appropriate transformations in order to eliminate heteroscedastic residuals. For most equations, the relationships are estimated in logarithmic form. In other cases, all the nonstationary variables are divided by a smoothly-growing variable with which they are presumed to be cointegrated.[23]

23. The presumed cointegrating relationships are that consumption and investment grow proportionately with output in the long run. These relationships have not been tested with the MX3 data set because of the short sample that is available. However, they are implied by the theory of the previous section.

The data available for estimation are 48 quarterly observations from 1976:1 to 1987:4. The data are expressed at annual rates. All equations are estimated over the maximum possible range after allowing for necessary lags and leads. The consumption, inventory investment, and fixed investment regressions were run in RATS 3.0. The remaining regressions were run in TROLL 13.0.

Wherever practical, MX3 uses common parameter estimates from pooled regressions. In some cases there are theoretical reasons for expecting a common parameter. In other cases a common parameter was imposed only if the unrestricted estimates were not significantly different statistically.

Consumption

The consumption equation (9) is highly nonlinear and it contains expectations of future variables. Hansen and Singleton [1982] develop a generalized method of moments (GMM) procedure for the estimation of nonlinear equations with future expectations. The procedure is based on the orthogonality condition between future disturbances and past information. This orthogonality condition is an implication of rational expectations: agents should use all available information, of which the instruments are a subset, in order to compute the expectations of future variables that concern them. Any deviation between their expectation and the subsequent realization of a variable ought to be orthogonal to all information that was available at the time they formed their expectation.

In order to scale for growth over time, both consumption and disposable income in equation (9) have been divided by production capacity. The equation was estimated for each country individually and in a pooled regression for all countries together. The instruments used were a constant, one lag of consumption, one lag of disposable income, current government spending, a lagged interest rate, a lagged inflation rate, and lagged real money balances.

The liquidity-constraints parameter, a, was not significantly different from zero in any regression. After setting a=0, the equation was reestimated. None of the estimated parameters in any of the single country regressions ever deviated from the pooled estimates by more than two standard deviations. Moreover, the standard errors in the pooled regression were uniformly smaller than the standard errors in the individual country regressions. Therefore, the model takes the coefficients from the pooled regression for every country. These results are shown below:

$$52.\quad \left[1 + b/\left(1 + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right)\right]C_t = bC_{t-1}$$

$$+ C_{t+1}/\left(1 + \frac{\Delta}{4} + (1-TAU_t)\frac{RS_t}{4} - \frac{DPA_{t+1}}{4}\right) + (1-b)\beta YD_t.$$

b = 0.852 (0.059)	β = 0.00985 (0.00101)	Δ = 0.08 n.a.	J = 1.50 (χ^2_5)

The Hansen-Singleton J-statistic, which tests the orthogonality implications of rational expectations, is not significant at conventional levels. Formal tests of parameter constancy were conducted both over time and across countries. These tests are described in Andrews and Fair [1988]. The test for parameter constancy over time splits the sample into two equal subsamples and tests whether the parameters estimated in each subsample are significantly different from each other. This test was not significant at the 10 percent level. There are four tests for parameter constancy across countries. Each test compares the parameters estimated in a single country to the pooled estimates. None of these four tests was significant at the 5 percent level. The ROW estimates were significantly different at the 10 percent level, however.

In addition to tests of parameter constancy, the consumption equation was reestimated after incorporating a constant term and it was also reestimated after incorporating a lag of disposable income. In neither case was the extra term significant at the 5 percent level.

Returning to the estimated equation, one may interpret the economic significance of the coefficients b and β. The estimate of b implies that consumers adjust to new circumstances at the rate of 15 percent per quarter. In other words, after a shock to permanent income, consumption adjusts 47 percent of the way to its new long-run level in the first year. The estimate of β implies that in steady-state, households consume 1 percent of their wealth per quarter.

<u>Inventory Investment</u>

The inventory equation (16) was estimated via GMM. The inventory investment and GDP series were first divided by capacity. The instruments were a constant, a lagged growth rate of GDP, current government spending, a lagged real interest rate, and a lagged growth rate of the monetary base. The equation was estimated on individual countries as well as pooled across countries. In every case the restriction $e_1 = e_2$ could not be rejected. The estimated value of e_1 varies considerably across countries, but in every case the associated standard deviation is quite high. The pooled estimate lies approximately in the middle of the range. Results from the pooled regression are presented here:

53. $II_t = e_0 + e_1\left(GDP_{t+1} - GDP_t\right) - e_3\left(RS_t - DPA_{t+1}\right).$

$e_0 = \underset{(0.0011)}{0.0073}$ $e_1 = \underset{(0.570)}{0.483}$ $e_3 = \underset{(0.035)}{0.078}$ $J = 5.35 \ (\chi^2_2)$

The J-statistic is significant at the 10 percent, but not the 5 percent, level. Parameter constancy tests were conducted across time and across countries as in the case of consumption, and none of the tests was significant at the 10 percent level.

Fixed Investment

The fixed investment equation (15) was also estimated using GMM. Once again, the series IF, GDP, and K were divided by capacity before estimation. The instruments were a constant, two lags of investment, a lagged capital stock, a lagged real interest rate, a lagged growth rate of the monetary base, and a lagged inflation rate.

The discount factor d is fixed at 0.97. This value was calibrated empirically as follows: The rate at which firms discount the future sequence of desired capital stocks ought to be related to the real discount rate and the rate of depreciation of capital. The sum of the average real after-tax interest rate, the Mehra-Prescott risk premium, and the measured rate of depreciation has averaged about 12 percent per annum, or 3 percent per quarter, historically.

The rate of depreciation, δ, and the share of output accruing to capital, α, were estimated independently. The remaining parameters of the fixed investment equation are the lagged adjustment, c, and the risk premium, π. Attempts at estimation were unsuccessful, as the lag coefficient was approximately unity. In the end, the lag coefficient c has been constrained at 0.95, and the risk premium, π, has been estimated independently for each country.

$$54.\quad (1+cd)IF_t = cIF_{t-1} + dIF_{t+1} + (1-c)(1-d)\left(\alpha GDP_t/CC_t - (1-\delta)K_{t-1}\right).$$

$$\text{where } CC_t = (RS_t + \delta - DPA_{t+1}) + \pi \;/\; (1-TAU_t).$$

	Germany	Japan	ROW	USA
π (x100)	4.784 (0.784)	6.707 (0.951)	6.707 (0.888)	6.796 (1.621)
c	0.95 n.a.	0.95 n.a.	0.95 n.a.	0.95 n.a.
d	0.97 n.a.	0.97 n.a.	0.97 n.a.	0.97 n.a.
J (χ^2_6)	7.75	0.01	27.3	35.4

The J-Statistic is significant at the 1 percent level in the ROW and U.S. regressions. The test for parameter constancy is significant at the 1 percent level in every country.

Capital Stock

The depreciation rate of capital was estimated via ordinary least squares (OLS). The regressand is the series defined by K_t-IF_t. The regressor is K_{t-1}. This regression estimates the fraction of capital that survives after one quarter.[24] The quarterly depreciation rate is the

24. Equation (55) is very nearly an identity, and it is treated as such in the model. In practice, statistical agencies estimate the capital stock at a disaggregated level, using different depreciation rates for each type of capital. If the proportion of investment in each type of capital good were

(Footnote continues on next page)

fraction that decays in one quarter, or unity minus the estimated coefficient. The annual depreciation rate is approximately four times the quarterly rate.

$$55.\quad K_t - IF_t = \hat{\delta} * K_{t-1}, \qquad \text{where} \quad \delta = 4 * (1-\hat{\delta}).$$

	Germany	Japan	ROW	USA
$\hat{\delta}$	0.9879 (0.0000)	0.9924 (0.0003)	0.9836 (0.0001)	0.9845 (0.0001)
δ	0.0483	0.0304	0.0658	0.0623
R^2	0.999	0.998	0.996	0.999
D-W	1.34	0.50	0.28	1.13

Production Function

Under perfect competition, the exponent on capital in a Cobb-Douglas production function is equivalent to the fraction of output that accrues to the owners of capital. The value of α used in MX3 differs slightly between the four country blocks. It is estimated by taking the average fraction of after-tax GDP that is composed of capital consumption allowances and operating surplus, according to the OECD's National Accounts over the period 1976-1987. The values of α in Germany, Japan, and the United States are,

(Footnote continued from previous page)
constant over time, then the aggregate depreciation rate would be constant and equation (55) would hold identically.

respectively, 0.35, 0.39, and 0.32. The value of α in ROW has been arbitrarily fixed at the value estimated for Germany.

Technology, Q, is assumed to follow a log-linear time trend. This trend is estimated as the fitted value of the following OLS regression.

56. $\left[\log(GDP_t) - \alpha\log(K_{t-1}) - (1-\alpha)\log(L_{t-1})\right] = \Gamma + \psi t.$

	Germany	Japan	ROW	USA
Γ	2.1990 (0.0051)	0.3792 (0.0024)	1.6272 (0.0035)	2.0944 (0.0080)
ψ	0.00116 (0.00019)	0.00231 (0.00009)	0.00140 (0.00013)	0.00079 (0.00029)
R^2	0.45	0.94	0.72	0.14
D-W	0.41	0.55	0.18	0.15

Output Price

It proved impossible to obtain sensible estimates of the expectations-augmented Phillips curve for the GNP deflator. Consequently, the coefficients on lagged and lead inflation have been arbitrarily set at 0.5 each, and the sensitivity of inflation to capacity utilization has been determined by simulation trials to yield a reasonable responsiveness of prices to aggregate demand.

Since the process of price adjustment is central to understanding the transmission of monetary policy to the rest of the economy, the lack of a well-estimated structural price equation is a serious flaw in the MX3 model as it exists currently. The first step in the next stage of development must be to consider alternative price adjustment mechanisms and estimation

	Germany	Japan	ROW	USA
h_0	-0.612	-0.301	-0.373	-1.645
	(0.192)	(0.172)	(0.187)	(0.318)
h_1	0.775	0.937	0.864	0.476
	(0.069)	(0.033)	(0.067)	(0.101)
h_2	0.688	0.418	0.268	1.929
	(0.223)	(0.223)	(0.112)	(0.297)
h_3	-0.260	-0.107	-0.120	-0.372
	(0.075)	(0.036)	n.a.	(0.092)
h_4	1.000	1.000	1.000	1.000
	n.a.	n.a.	n.a.	n.a.
R^2	0.97	0.99	0.98	0.96
D-W	2.02	2.00	2.05	1.75

59. $\log(PEX_t) = g_0 + g_1\log(PEX_{t-1}) + g_2\log(PGNPW_t)$

$+ (1-g_1-g_2)\log(PGNP_t) + g_3\log(PEX_{t-1}/PEX_{t-2}) - g_4(1-g_1)t.$

	Germany	Japan	ROW	USA
g_0	0.015	0.005	0.008	0.003
	(0.002)	(0.006)	(0.003)	(0.002)
g_1	0.734	0.824	0.985	0.962
	(0.050)	(0.063)	(0.037)	(0.032)
g_2	0.076	0.120	0.000	0.000
	(0.013)	(0.046)	n.a.	n.a.
g_3	0.408	0.136	0.527	0.728
	(0.092)	(0.123)	(0.118)	(0.119)
g_4	-0.0025	-0.0025	-0.0025	-0.0025
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
R^2	1.00	0.93	1.00	1.00
D-W	1.67	1.09	1.27	1.70

A likelihood ratio test for parameter constancy was run by reestimating the entire model over two equal subsamples. The test rejected parameter constancy at the 1 percent level.

Export Shares

The export shares for each country are estimated as systems of equations so that the cross-equation restrictions on the parameters T_{ij} can be imposed. Because the share equations sum to unity, as do the share data, the last equation in the system is omitted from the estimation since its residual is a linear combination of the other residuals. Estimation is by FIML, treating the relative prices across countries as exogenous variables.

60. $$SHR1_t = \Psi_1 + T_{10}*SHR1_{t-1} + T_{12}*\log\left(E_t^1*PGNP_t^1/E_t^2*PGNP_t^2\right) + T_{13}*\log\left(E_t^1*PGNP_t^1/E_t^3*PGNP_t^3\right).$$

61. $$SHR2_t = \Psi_2 + T_{20}*SHR2_{t-1} - T_{12}*\log\left(E_t^1*PGNP_t^1/E_t^2*PGNP_t^2\right) + T_{23}*\log\left(E_t^2*PGNP_t^2/E_t^3*PGNP_t^3\right).$$

62. $$SHR3_t = (1-\Psi_1-\Psi_2) - T_{10}*SHR1_{t-1} - T_{20}*SHR2_{t-1} - T_{13}*\log\left(E_t^1*PGNP_t^1/E_t^3*PGNP_t^3\right) - T_{23}*\log\left(E_t^2*PGNP_t^2/E_t^3*PGNP_t^3\right).$$

	Germany	Japan	ROW	USA
Ψ_1	-0.003 (0.002)	0.007 (0.004)	0.137 0.062)	0.063 (0.014)
Ψ_2	0.014 (0.005)	0.034 (0.003)	0.074 0.031)	0.006 (0.017)
T_{10}	0.900 n.a.	0.876 (0.006)	0.705 (0.090)	0.166 (0.166)
T_{20}	0.850 (0.059)	0.900 n.a.	0.778 (0.079)	0.711 (0.118)
T_{12}	0.000 (0.001)	0.002 (0.003)	0.041 (0.013)	0.005 (0.004)
T_{13}	0.003 (0.001)	0.000 n.a.	0.003 (0.017)	0.018 (0.007)
T_{23}	0.019 (0.007)	0.044 (0.012)	0.000 n.a.	0.009 (0.010)
R_1^2	0.91	0.75	0.90	0.46
R_2^2	0.91	0.97	0.88	0.68

In the case of German export shares, 1 and 2 refer to Japan and the United States, respectively. In the case of Japanese export shares, 1 and 2 refer to Germany and the United States. In the case of ROW, 1 and 2 refer to Germany and the United States. Finally, for the United States, 1 and 2 refer to Germany and Japan, respectively.

Two of the lag coefficients had to be constrained to avoid estimating unit roots. Two of the relative price coefficients were restricted from taking the wrong sign. Together, these four restrictions could be rejected at the 1 percent level. A test for parameter constancy also rejected constant parameters in favor of a break at midsample at the 1 percent level.

Money Demand

The money demand equations were estimated by two-stage least squares. The instruments are a constant, current government consumption, and one lag each of real money balances, the nominal interest rate, and total absorption.

63. $\log(MB_t/PA_t) = r_0 + r_1\log(MB_{t-1}/PA_{t-1}) + r_2\log(A_t) + r_3RS_t.$

	Germany	Japan	ROW	USA
r_0	-3.286	-1.805	-0.885	-1.395
	(0.814)	(0.746)	(0.272)	(0.190)
r_1	0.678	0.766	0.768	0.776
	(0.081)	(0.094)	(0.063)	(0.038)
r_2	0.477	0.271	0.139	0.193
	(0.116)	(0.110)	(0.039)	(0.026)
r_3	-0.670	-0.840	-0.600	-0.390
	(0.210)	(0.270)	(0.120)	(0.050)
R^2	0.99	0.99	0.96	0.99
D-W	1.82	2.31	2.25	1.74

The German equation was estimated via Cochrane-Orcutt in order to correct for serial correlation. The estimated autocorrelation coefficient was 0.63. In order to check for homogeneity of the effects of the real interest rate and the expected inflation rate on money demand, the lagged rate of inflation was added to the instrument list and the current rate of inflation was added to the list of regressors. The estimated coefficient on the inflation rate was significant at the 5 percent level in the German equation, but not in the other countries' equations. A Chow test for parameter constancy (see Fair [1987]) rejected parameter constancy at the 5 percent level for the ROW equation only. The U.S. equation failed at the 10 percent, but not the 5 percent, level.

Monetary and Fiscal Policy

The coefficients of the monetary base and real government consumption equations are "estimated" by the average rate of growth of these variables over the period 1976-87. The (presumed) constant target ratio of bonds to income, BRATIO, is simply the actual value of the ratio of bonds to taxable income in the fourth quarter of 1987. The coefficient w in the tax adjustment equation has been arbitrarily fixed at 0.95.

Obviously, the simple policy rules described here are not very realistic. One of the most attractive features of MX3 is the ability to consider alternative policy rules, both as descriptions of past behavior and as proposals for future policy. By allowing private expectations to fully incorporate the implications of a particular policy rule, we hope to obtain a more accurate characterization of the economy's behavior under that rule, at least in the long run.

SIMULATION PROPERTIES

This section presents the dynamic response of the model to a simple monetary shock and a simple fiscal shock. The monetary shock consists of a

2 percentage point increase of the U.S. monetary base in the first quarter of 1988. This shock has a permanent effect on the monetary base due to the simple growth rate rule for monetary policy. The second shock increases U.S. government consumption by 1 percent of total U.S. productive capacity in the first quarter of 1988. This shock also has a permanent effect through the simple fiscal spending rule.

In order to highlight the effect of expectations in MX3, each of these shocks is implemented in two different ways. In the "surprise" scenarios, the monetary or fiscal shock is first announced in the quarter of implementation, 1988:1. In the "anticipated" scenarios, the government announces its intention to change monetary or fiscal policy in 1986:1, eight quarters before the planned implementation.

The results of these simulations are presented in terms of percentage deviations from the baseline path, except for real net exports, which are presented as deviations from the baseline path in percentages of baseline capacity output. The baseline path uses actual values through the end of 1987. Beginning in 1988 real variables increase at a constant 3 percent rate, prices increase at a 4 percent rate, nominal variables increase at a 7 percent rate, and interest rates and exchange rates are fixed at their 1987:4 values. Residuals are computed for each equation to keep the model on the baseline path. In other words, when the model is simulated with the residuals it tracks the baseline path. In the shock simulations the model is solved with the baseline residuals in addition to the monetary or fiscal shock. The use of baseline residuals allows us to isolate the effect of the policy shock under consideration.[25]

The first simulation is a surprise increase of the monetary base by 2 percent effective 1988:1. Because MX3 incorporates the long-run neutrality of real activity with respect to money, we know that prices must eventually rise by 2 percent and output must return to its baseline value. Figure 1 demonstrates that the model does perform as expected in the long-run. The domestic price, UPGNP, rises steadily from its baseline level to a maximum value of 2.5 percent over baseline in 1990:4. The price level then drops to a value 1.8 percent above baseline in 1993:3 before gradually approaching its long-run equilibrium of 2 percent above baseline.

Movements in the weighted foreign price level, UPGNPW, primarily reflect movements in exchange rates. Consistent with a long-run equilibrium, we expect that foreign prices will be unaffected by a domestic monetary expansion and that exchange rates will rise proportionally to the increase in the monetary base. The weighted foreign price level in domestic currency should therefore rise by 2 percent in the long-run. Figure 1 shows that UPGNPW jumps almost 2 percentage points in the first quarter before falling sharply by 1 percentage point in the following quarter. UPGNPW remains at about 1 percent above baseline over the next three quarters before climbing back up to--and temporarily overshooting--its long-run value. The dynamic behavior of UPGNPW is primarily explained by lower nominal interest rates in the United States during the first two quarters

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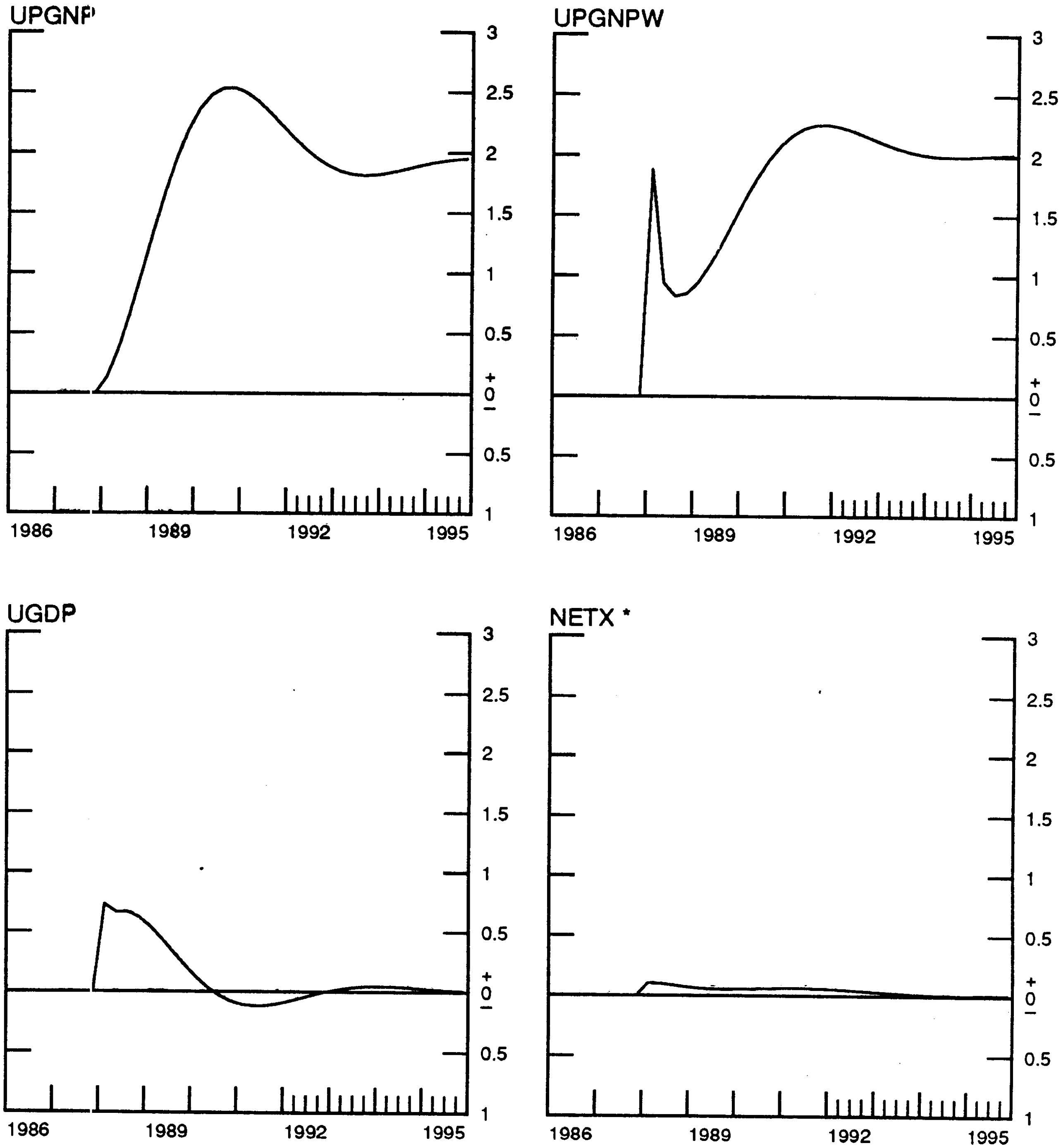
25. An alternative approach is to use the baseline implied by the model with future residuals set at their expected value of zero. This procedure is much more computationally intensive. Moreover, to a first approximation, the effect of the policy shocks relative to baseline is unaffected by which baseline is chosen. If the model were linear, the effect of policy shocks would be completely independent of the baseline.

Figure 1

Surprise Monetary Shock

(Percent Deviation from Baseline)



*In percent deviation from baseline capacity output.

and higher nominal interest rates in the United States over the following 12 quarters. Because of the open interest rate parity equations, movements in exchange rates are completely explained by interest rate differentials after the impact of the shock.

UGDP jumps about 0.7 percent for the first three quarters before returning gradually to its baseline value. There is a very slight, damped oscillation of UGDP about baseline. The minimum value is reached in 1991:2 at -0.12 percent of baseline. Net exports increase by 0.15 percent of potential GDP in the first quarter and decline very slowly thereafter.

Next we consider the behavior of MX3 in the face of an anticipated monetary shock. (See Figure 2.) It is important to remember that traditional macro models cannot consider such an experiment since they do not incorporate future expectations.

The domestic price level responds in almost exactly the same manner as before, except that everything is shifted eight quarters earlier. By the time the monetary base jumps in 1988:1, the price level has already risen by 2.1 percent and it continues to overshoot its equilibrium value, reaching a peak of 2.6 percent above baseline in 1989:1.

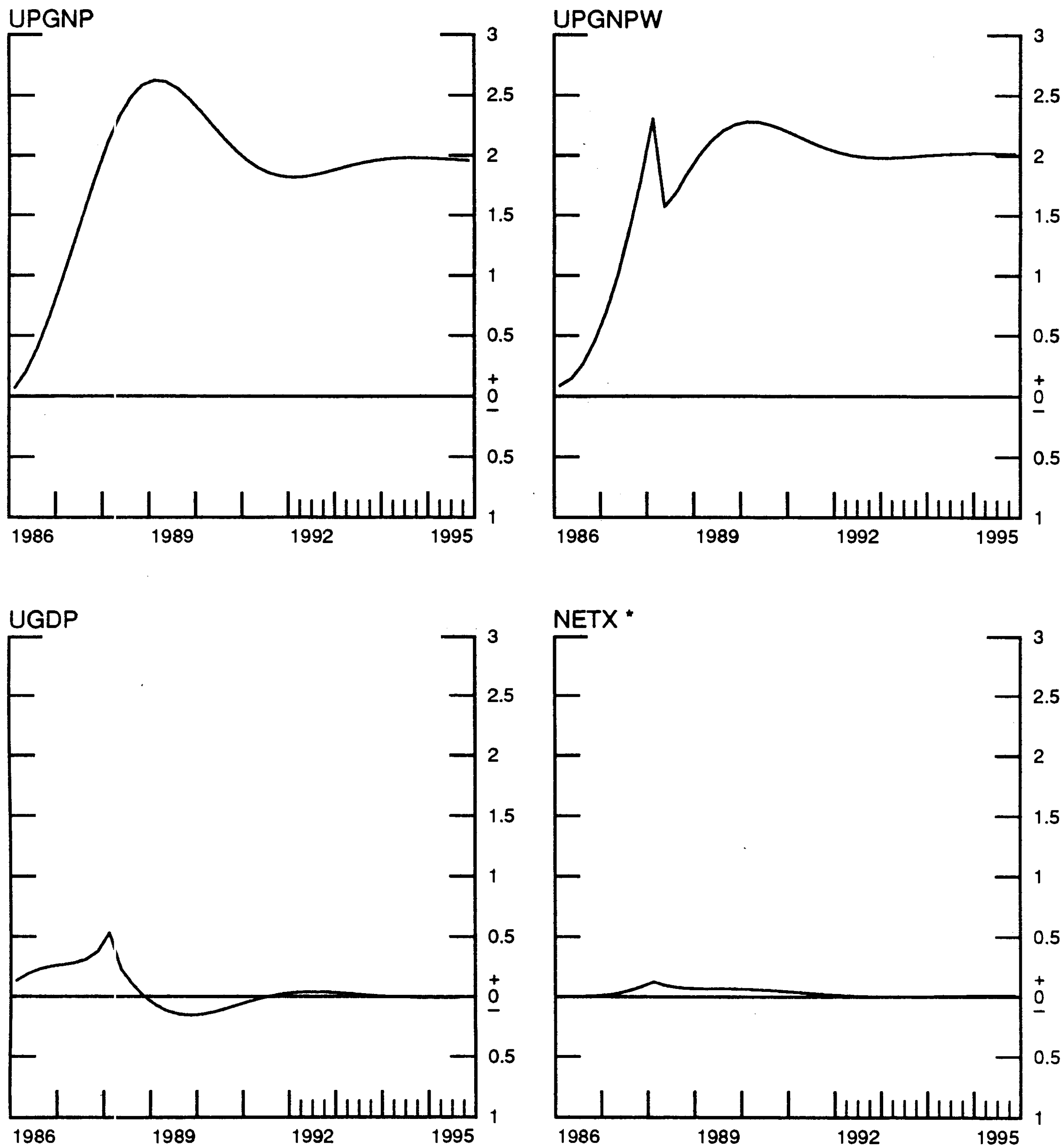
Weighted foreign prices--and the exchange rates--do not jump up on the announcement of future monetary policy. Rather, UPGNPW rises steadily from its baseline value to a first peak of 2.3 percent in 1988:1. The subsequent dynamics are basically a damped version of the behavior of UPGNPW under the surprise monetary shock.

The stimulative effect of the anticipated monetary shock is smaller in magnitude, but more persistent, than the effect of the surprise shock. Despite the presence of rational expectations, there is still a small spike in UGDP in the quarter of impact, 1988:1, when UGDP jumps to 0.5 percent

Figure 2

Anticipated Monetary Shock

(Percent Deviation from Baseline)



*In percent deviation from baseline capacity output.

above baseline. A cyclical trough is reached in 1989:4 at -0.16 percent of baseline output. Net exports rise steadily to a peak of 0.18 percent of baseline capacity output in 1988:1 and fall slowly back to baseline.

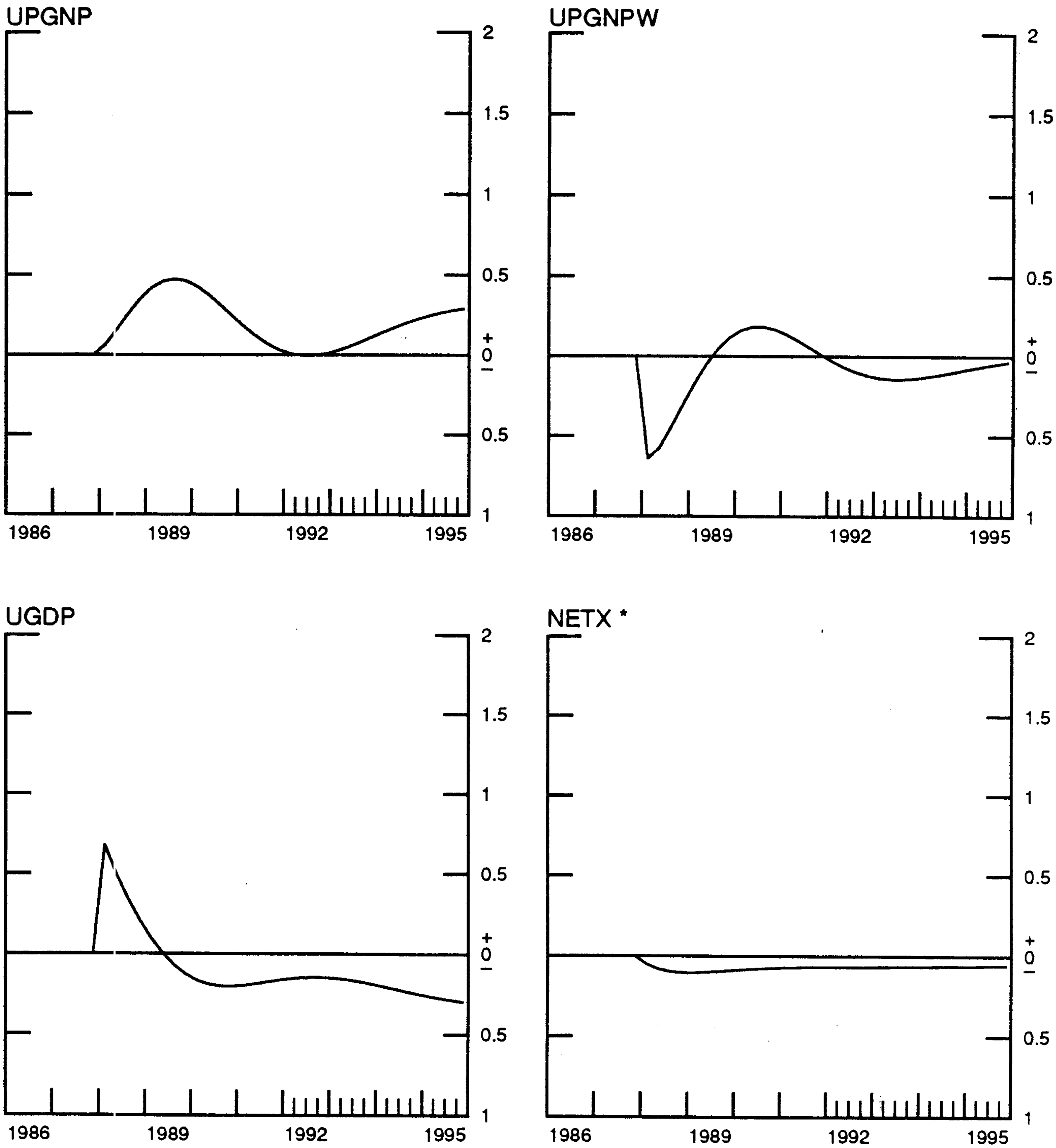
The other shock to be presented is a permanent increase in government consumption by 1 percent of capacity output. Figure 3 shows the behavior of the same four variables in response to a surprise fiscal shock. The domestic price, UPGNP, rises to a peak 0.5 percent above baseline in 1989:3 before falling back to baseline in 1992:1. Beginning in 1993:1 UPGNP gradually rises to a value 0.3 percent above baseline, where it remains permanently. UPGNPW initially drops 0.6 percent below baseline. In subsequent periods it quickly returns to oscillate about the baseline. What is not evident in Figure 3 is that UPGNPW eventually rises to a level about 0.3 percent above baseline after several more years. UGDP jumps 0.7 percent above baseline in the initial period, but it quickly drops below the baseline and it gradually settles at about 0.3 percent below baseline. Finally, net exports drop about 0.1 percent of baseline capacity output by the second period and then begin a gradual return to baseline.

In order to understand the long-run effects of this fiscal shock, we must review the consumption and investment relations in MX3. The increased government consumption necessitates an eventual rise in the tax rate in order to maintain the ratio of bonds to income. The higher tax rate reduces disposable income, and thus consumption, by an amount equal to the rise in government spending. Thus, to a first approximation, government spending fully crowds out private consumption, leaving all other variables unaffected in the long run. This analysis ignores a secondary effect of higher taxes, however. The secondary effect works through the investment equation.

Figure 3

Surprise Fiscal Shock

(Percent Deviation from Baseline)



*In percent deviation from baseline capacity output.

According to equation (10) an increase in the tax rate will reduce the long-run desired capital stock.[26]

It is the secondary effect that explains the permanent drop in UGDP evident in Figure 3. With lower absorption and a fixed monetary base, UPGNP must rise to reduce the level of real money balances. UPGNPW must also rise in the long-run to equilibrate relative prices. When relative prices across countries return to their baseline values and U.S. absorption equals U.S. production capacity, both real and nominal trade flows will reequilibrate. During the transition period the United States runs a real trade deficit, but the favorable terms of trade help to minimize both the nominal trade deficit and the associated decline in net foreign assets.

It is interesting to note that even in the short run, fiscal policy has very little expansionary effect in MX3. Both consumption and investment drop immediately when government spending rises. This crowding out occurs because consumers and investors know that tax rates will rise in the future in order to satisfy the government's intertemporal budget constraint. The strength of this crowding out is somewhat surprising in light of the fact that private agents in MX3 discount the future much faster than the real rate of interest on government bonds. Blanchard [1985] showed that such a wedge between private and government discount rates can reduce crowding out of fiscal policy.

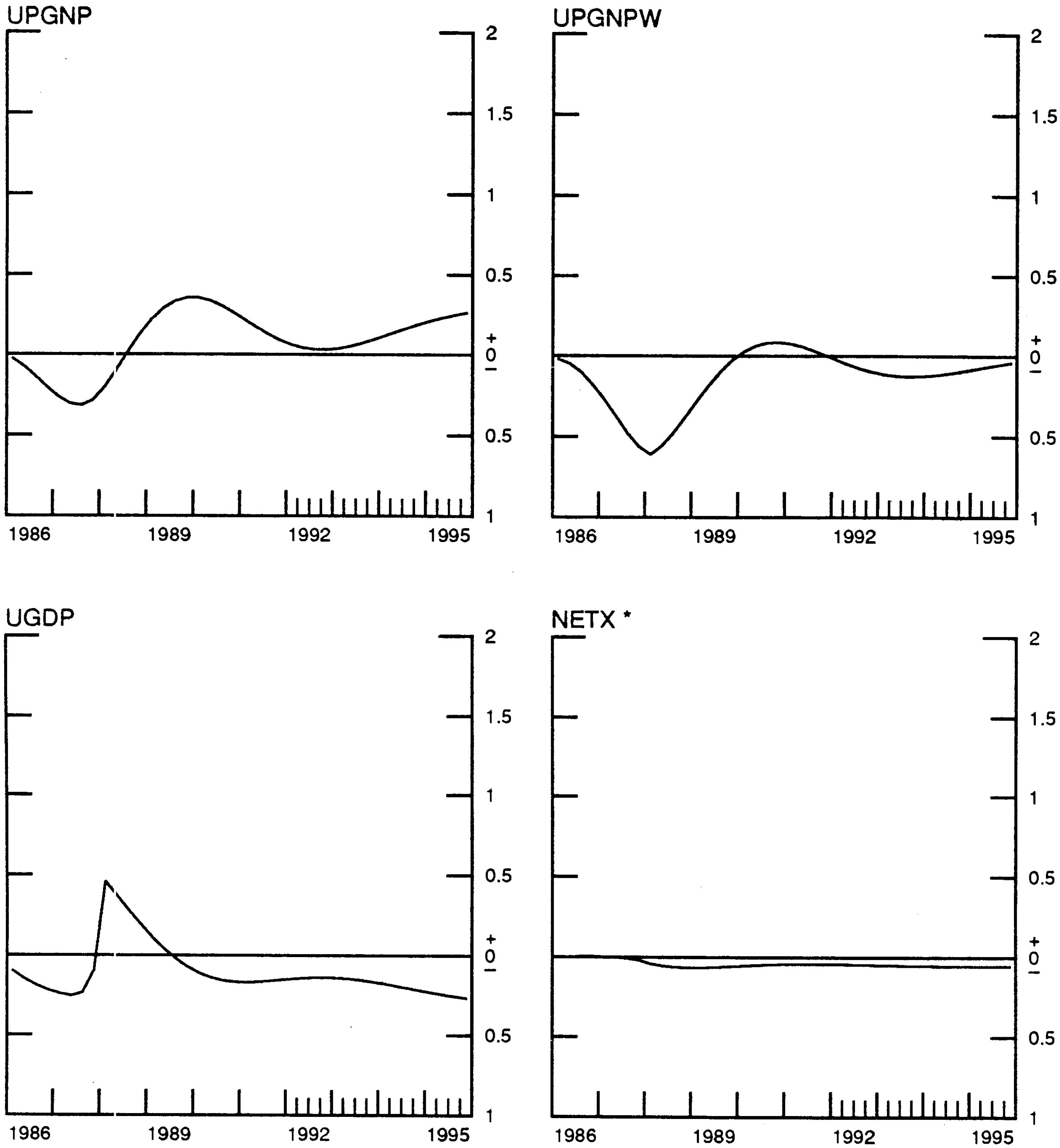
Figure 4 shows that the announcement of a future fiscal expansion is strongly contractionary. Domestic output and domestic prices both drop steadily until 2 quarters before the period of implementation. This

26. This effect hinges on the assumption that the risk premium is constant in after-tax terms. If the risk premium is constant before taxes, then the tax rate does not affect the desired capital stock.

Figure 4

Anticipated Fiscal Shock

(Percent Deviation from Baseline)



*In percent deviation from baseline capacity output.

contraction results from the forward-looking behavior of investors and consumers, who foresee a long-run decline in desired capital and disposable income. After implementation, the expansionary effect of the anticipated policy is only about two-thirds that of the surprise policy. The long-run effects are the same for both surprise and anticipated fiscal expansions.

CONCLUSION

This paper has presented the theoretical structure, empirical implementation, and simulation properties of the MX3 model. The structure of MX3 represents a significant step toward incorporating more economic theory in macroeconometric models. In particular, agents are assumed to have rational expectations; short-run dynamics are constrained to resemble behavior under costly adjustment; and the economy moves toward a competitive steady state in the long run.

The implementation of MX3 has been largely successful, but more work clearly remains to be done. Probably the first areas for further work are the price adjustment and fixed investment equations. Eventually, it would be desirable to expand the geographic coverage of the model so that it captures a more accurate description of global feedbacks to domestic policies.

While the simulations presented in this paper are of some interest for the insights they provide on the properties of MX3, the proposed shocks and the associated policy rules are not wholly satisfactory. It is clearly the case that monetary and fiscal instruments do not evolve exogenously with respect to the rest of the economy. Rather, the monetary and fiscal authorities must be responding in some manner to the shocks that originate in the rest of the economy. They also may respond to evidence on the effect their policies are having on the economy. A realistic policy rule must therefore include some reaction of the policy instruments to information on the economy that the authorities have available at the time the policy instruments are set.

One experiment that is particularly attractive--although it is not explored in this paper--is to consider the dynamic properties of the model under alternative policy rules with stochastic simulations. The objective is to discover the macro policy rules that are best able to stablize output, inflation, or other target variables in the face of shocks similar to those that typically occur. It is particularly important to use a rational expectations model when searching over alternative policy rules if one believes that the private sector will eventually learn about any new rule and alter its behavior accordingly.

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APPENDIX 1: SIMPLIFIED COUNTRY MODEL

I. Data Definitions

A	Absorption
AW	Weighted Foreign Absorption
B	National Debt
BRATIO	Target Ratio of National Debt to Taxable Income
C	Private Consumption
CAP	Capacity Output
CAPTOT	World Capacity Output
CAPW	Weighted Foreign Capacity Output
CC	Cost of Capital
CU	Capacity Utilization Rate
DPA	Inflation Rate (Absorption)
DPGNP	Inflation Rate (GNP)
E	Exchange Rate
EX	Export Volume
G	Government Consumption
GDP	Gross Domestic Product
GNP	Gross National Product
IF	Gross Fixed Investment
II	Inventory Investment
IM	Import Volume
K	Net Capital Stock
L	Labor Force (exogenous)
MB	Monetary Base
NFA	Net Foreign Assets
PA	Absorption Deflator
PEX	Export Deflator
PGNP	GNP Deflator
PGNPW	Weighted Foreign GNP Deflator
PIM	Import Deflator
Q	Production Technology (exogenous, estimated)
RS	Short-term Nominal Interest Rate
SHRx	Share of Total Exports Destined for Country x

TAU	Tax Rate
TAX	Tax Revenues
TBAR	Tax Rate Required to Hit Target Debt Ratio
TI	Taxable Income
YD	Disposable Income

II. Private Sector Demand

Private Consumption	1. $C = C\left(\hat{YD}, \hat{RS}, \hat{DPA}, \hat{TAU}\right)$
Fixed Investment	2. $IF = IF\left(\hat{GDP}, \hat{CC}, \hat{TAU}, K\right)$
Inventory Investment	3. $II = II\left(\Delta \hat{GDP}, RS, \hat{DPA}\right)$
Money Demand	4. $MB = MB\left(A, RS\right) * PA$

III. Aggregate Supply

GNP Deflator (Inflation Rate)	5. $DPGNP = P\left(\hat{DPGNP}, CU\right)$
Capacity Output	6. $CAP = F\left(Q, K, L\right)$

IV. Exchange Rate and Trade

Exchange Rate	7. $\Delta \hat{E}^1 = RS - RS^1$
Export Volume	8. $EX = EX\left(AW/CAPW, PEX/PIM, CAPTOT\right)$
Export Price	9. $PEX = PEX\left(PGNP, PGNPW, t\right)$
Export Shares	10. $SHR1 = SHR1\left(E^1*PGNP^1, \ldots, E^3*PGNP^3\right)$

11. $SHR2 = SHR2\left(E^1*PGNP^1, \ldots, E^3*PGNP^3\right)$

12. $SHR3 = 1 - SHR1 - SHR2$

V. Monetary and Fiscal Policy

Money Supply	13. $\Delta MB = m$
Government Consumption	14. $\Delta G = g$
Target Ratio of National Debt	15. $BRATIO = b$
Tax Rate	16. $TAU = 0.95 * TAU_{-1} + 0.05 * TBAR$

VI. Identities and Definitions

Imports	17. $IM = SHR0^1*EX^1 + SHR0^2*EX^2 + SHR0^3*EX^3$
Import Prices	18. $PIM = \left(SHR0^1*E^1*PEX^1*EX^1 + \ldots + SHR0^3*E^3*PEX^3*EX^3\right) / IM$
Absorption	19. $A = C + IF + II + G$
Gross Domestic Product	20. $GDP = A + EX - IM$
Gross National Product	21. $GNP = GDP + RS*NFA_{-1}/PGNP$
Disposable Income	22. $YD = PGNP*GNP/PA - \delta*K_{-1} - TAX/PA + (RS - DPA)*B_{-1}/PA - RS*MB_{-1}/PA$
Absorption Deflator	23. $PA*A = PGNP*GNP - PEX*EX + PIM*IM - RS*NFA_{-1}$
Inflation Rate (Absorption)	24. $DPA = \Delta PA$
Inflation Rate (GNP)	25. $DPGNP = \Delta PGNP$

Taxable Income	26. $TI = PGNP*GNP - \delta*K_{-1}*PA + RS*B_{-1}$
Tax Revenues	27. $TAX = TAU*TI$
Equilibrium Tax Rate	28. $TBAR = \left(G*PA + RS*\left(B_{-1} - MB_{-1}\right)\right) / TI - BRATIO + B_{-1}/TI_{-1}$
Cost of Capital	29. $CC = (1-TAU) * (RS + \delta - \hat{DPA}) + \pi$
Capacity Utilization	30. $CU = GDP/CAP$
Total World Capacity	31. $CAPTOT = CAP + CAP^1 + CAP^2 + CAP^3$
Weighted Foreign Absorption	32. $AW = \left(A^1\right)^{\omega 1} * \left(A^2\right)^{\omega 2} * \left(A^3\right)^{\omega 3}$
Weighted Foreign Capacity	33. $CAPW_t = \left(CAP_t^1\right)^{\omega 1} * \left(CAP_t^2\right)^{\omega 2} * \left(CAP_t^3\right)^{\omega 3}$
Weighted Foreign Prices	34. $PGNPW_t = \left(PGNP_t^1 * E_t^1\right)^{\omega 1} * \left(PGNP_t^2 * E_t^2\right)^{\omega 2} * \left(PGNP_t^3 * E_t^3\right)^{\omega 3}$
Capital Stock	35. $K = (1 - \delta)*K_{-1} + IF$
Government Bonds	36. $B = (1 + RS)*B_{-1} + PA*G - TAX - RS*MB_{-1}$
Net Foreign Assets	37. $NFA = (1 + RS)NFA_{-1} + PEX*EX - PIM*IM$

Note: Superscripts denote foreign country variables. Variables with hats are future expectations. Δ denotes the percentage rate of change of a variable. δ is the rate of depreciation of fixed capital. π is the risk premium for holding capital instead of government bonds. $\omega 1$-$\omega 3$ are fixed weights that sum to unity.

APPENDIX 2: MODEL LISTING AND DATABASE[1]

This appendix is divided into four main parts. The first three parts comprise a complete listing of the current version of the MX3 model: the equation listing, the variable and equation cross-reference table, and the variable definitions. The final part is a detailed description of the MX3 database.

The equation listing is grouped by country and then by sector. In this way, each country model is presented as though it were a separate macroeconometric model using the following format:

1. Private Sector Demand
2. Aggregate Supply
3. Exchange Rate and Trade
4. Monetary and Fiscal Policy
5. Identities and Definitions

The sectors and variables in each country model are preceded by the first letter of the country name. For example, "G.1" is the first sector of the German country model (private sector demand). Likewise, "GGNP" is German gross national product. Although equations are grouped within sectors, equations are numbered consecutively throughout the whole model. Each equation is reported with its coefficient values and labeled with the associated left-hand side variable. (Estimation results and test statistics are reported in the text of the paper).

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1. Special thanks are due to Gwyn Adams for preparing this appendix.

The cross-reference table gives the number of each equation in which each variable in the model appears. It is grouped by endogenous and exogenous variables. The variable listing gives each variable alphabetically with a short definition. The variable listing is also grouped by endogenous and exogenous variables.

The variable naming convention uses the first letter of the variable name to indicate the country. The middle portion of the name describes the variable and the presence of a trailing "V" or "W" indicates a nominal value or fixed weighted value respectively. The existence of a final "_ERR" is used to indicate the error term for the equation describing the indicated endogenous variable. For example, JGDEBTV is current Japanese government debt, and GIF_ERR is the residual term in the German fixed investment equation. Also, the bilateral trade shares are represented in either a "XijS" or "XijS3" format. Both represent the share of country i's exports destined for country j. The trailing 3 indicates the export share with ROW for G-3 countries.

GERMAN MODEL

G1. PRIVATE SECTOR DEMAND

1. GC: Private consumption expenditure - 1980 prices

```
GC/GCAP   =  .852 * GC(-1)/GCAP(-1)/(1  +  .852 /(1
       +  .02 + (1 - GTAU) * GRS/400 - GDPA(1)/400)) + GC(1)/GCAP(1)/(1  +  .852
       +  .02 + (1 - GTAU) * GRS/400 - GDPA(1)/400) + (1  -  .852 )  *  .00985 * GYD/GCAP + GC_ERR
```

2. GIF: Total fixed investment - 1980 prices

```
(1  +  .95  *  .97 ) * GIF/GCAP   =  .95 * GIF(-1)/GCAP(-1)  +  .97 * GIF(1)/GCAP(1) + (1
       -  .95 ) * (1  -  .97 ) *  (  .35 * GCU * 100/(GRS  +  4.83 - GDPA(1)
       +  4.78 /(1 - GTAU)) - (1  -  4.83 /100) * GK(-1)/GCAP) + GIF_ERR
```

3. GII: Inventory investment - 1980 prices

```
GII/GCAP   =  .00733  +  .483 * (GCU(1) - GCU)  -  .000778 * (GRS - GDPA(1)) + GII_ERR
```

4. GMB: Monetary base

```
LOG(GMB/GPA)   =  -3.2863  +  .6776 * LOG(GMB(-1)/GPA(-1))  -  .0067 * GRS
       +  .4771 * LOG(GA) + GMB_ERR
```

G2. AGGREGATE SUPPLY

5. GPGNP: Gross national product deflator - 1980=100.00

```
(GPGNP/GPGNP(-1) - 1) * 400   =  .5 * (GPGNP(-1)/GPGNP(-2) - 1) * 400 + (1
     -  .5 ) * (GPGNP(1)/GPGNP - 1) * 400  +  10 * LOG(GCU) + GPGNP_ERR
```

6. GCAP: Total capacity output

```
GCAP  =  GQ * GK(-1)* *  .35 * GLF(-1)**(1  -  .35 ) + GCAP_ERR
```

G3. EXCHANGE RATE AND TRADE

7. GER: Spot exchange rate - US$/DM

```
(GER(1)/GER - 1) * 400  =  URS - GRS + GER_ERR
```

8. GXGSNI: Exports - NIA basis - 1980 prices

```
LOG(GXGSNI)  =  -.612  +  .775 * LOG(GXGSNI(-1))  +  .688 * LOG(GAW/GCAPW)
     -  .26 * LOG(GPXGSNI/GPMGSNI) + (1  -  .775 )  *  1 * LOG(CAPTOT) + GXGSNI_ERR
```

9. GPXGSNI: Export deflator - NIA basis - 1980 prices

```
LOG(GPXGSNI)  =  .015  +  .734 * LOG(GPXGSNI(-1))  +  .076 * LOG(GPGNPW) + (1  -  .734
     -  .076 ) * LOG(GPGNP)  +  .408 * LOG(GPXGSNI(-1)/GPXGSNI(-2))  -  .0025 * (1
     -  .734 ) * TIME + GPXGSNI_ERR
```

10. XGUS: Share of German exports destined for US

```
XGUS  =  .014  +  .85 * XGUS(-1)  +  0 * LOG(UPGNP/(JER * JPGNP))
     +  .019 * LOG(UPGNP/(RER * RPGNP)) + XGUS_ERR
```

11. XGJS: Share of German exports destined for Japan

```
XGJS  =  -.003  +  .9 * XGJS(-1)  -  0 * LOG(UPGNP/(JER * JPGNP))
     +  .003 * LOG(JER * JPGNP/(RER * RPGNP)) + XGJS_ERR
```

12. XGRS3: Share of German exports destined for ROW

```
XGRS3  =  1  -  .014  -  -.003  -  .85 * XGUS(-1)  -  .9 * XGJS(-1)
     -  .019 * LOG(UPGNP/(RER * RPGNP))  -  .003 * LOG(JER * JPGNP/(RER * RPGNP)) + XGRS3_ERR
```

G4. MONETARY AND FISCAL POLICY

13. GRS: <u>3-month Treasury Bill rate</u>

```
GMB  =  1.0155 * GMB(-1) + GRS_ERR
```

14. GG: <u>Real government purchases - 1980 prices</u>

```
GG  =  1.0049 * GG(-1) + GG_ERR
```

15. GBRATIO: <u>Target ratio of government bonds to taxable income</u>

```
GBRATIO  =  0.262 + GBRATIO_ERR
```

16. GTAU: <u>Actual income tax rate</u>

```
GTAU  =  .95 * GTAU(-1) + (1  -  .95 ) * GTBAR  +  0 * LOG(GCU) + GTAU_ERR
```

G5. IDENTITIES AND DEFINITIONS

17. GMGSNI: Imports - NIA basis - 1980 prices

GMGSNI = (XUGS * UXGSNI * 0.9169 + XJGS * JXGSNI * 4.424 + 1.181 * XRGS3 * RXGSNI * 1.173)/0.5505 + GMGSNI_ERR

18. GPMGSNI: Import deflator - NIA basis - 1980=100.00

GPMGSNI = (XUGS * UPXGSNI * UXGSNI + XJGS * JER * JPXGSNI * JXGSNI + 1.181 * XRGS3 * RER * RPXGSNI * RXGSNI)/(GMGSNI * GER) + GPMGSNI_ERR

19. GA: Absorption

GA = GC + GIF + GG + GII + GA_ERR

20. GGDP: Gross domestic product - 1980 prices

GGDP = GA + GXGSNI - GMGSNI + GGDP_ERR

21. GGNP: Gross national product - 1980 prices

GGNP = GGDP + URS * GNFAV(-1)/(GER * GPGNP) + GGNP_ERR

22. GYD: Disposable income - 1980 prices

GYD = GPGNP * GGNP/GPA
- 4.83 * GK(-1)/100 - GTAXV * 100/GPA + (GRS - GDPA) * GGDEBTV(-1)/GPA - GMB(-1) * GRS/GPA + GYD_ERR

23. GPA: Gross domestic product deflator - 1980=100.00

GPA = (GPGNP * GGNP - GPXGSNI * GXGSNI + GPMGSNI * GMGSNI - URS * GNFAV(-1)/GER)/GA + GPA_ERR

24. GDPA: Rate of inflation of absorption prices

GDPA = (GPA/GPA(-1) - 1) * 400 + GDPA_ERR

25. GDPGNP: Rate of inflation of output prices

GDPGNP = (GPGNP/GPGNP(-1) - 1) * 400 + GDPGNP_ERR

26. GTIV: <u>Nominal taxable income</u>

GTIV = GPGNP * GGNP/100
  - 4.83 * GK(-1) * GPA/10000 + GRS * (GGDEBTV(-1) - GMB(-1))/100 + GTIV_ERR

27. GTAXV: <u>Nominal tax revenues</u>

GTAXV = GTAU * GTIV + GTAXV_ERR

28. GTBAR: <u>Equilibrium tax rate</u>

GTBAR = (GG * GPA + GRS * GGDEBTV(-1))/(GTIV * 100) - GBRATIO + GGDEBTV(-1)/GTIV + GTBAR_ERR

29. GCU: <u>Capacity utilization rate</u>

GCU = GGDP/GCAP + GCU_ERR

30. GAW: <u>Trade weighted foreign absorption</u>

GAW = UA**0.0767 * JA**0.0134 * RA**0.9099 + GAW_ERR

31. GCAPW: <u>Trade weighted foreign total capacity output</u>

GCAPW = UCAP**0.0767 * JCAP**0.0134 * RCAP**0.9099 + GCAPW_ERR

32. GPGNPW: <u>Trade weighted foreign gross national product deflator - 1980=100.00</u>

GPGNPW = (UPGNP/0.8572)**0.0767 * (JPGNP * JER/4.424)**0.0134 * (RPGNP *
  RER/1.173)**0.9099 * 0.5505/GER + GPGNPW_ERR

33. GK: <u>Total net capital stock</u>

GK = (1 - 4.83 /400) * GK(-1) + GIF/4 + GK_ERR

34. GGDEBTV: <u>Current total government debt</u>

GGDEBTV = (1 + GRS/400) * GGDEBTV(-1) + GPA * GG/400 - GTAXV/4 - GMB(-1) *
  GRS/400 + GGDEBTV_ERR

35. GNFAV: <u>Net foreign assets</u>

GNFAV = (1 + URS/400) * GNFAV(-1) + (GPXGSNI * GXGSNI * GER - GPMGSNI *
  GMGSNI * GER)/400 + GNFAV_ERR

JAPANESE MODEL

J1. PRIVATE SECTOR DEMAND

36. JC: Private consumption expenditure - 1980 prices

```
JC/JCAP   =  .852 * JC(-1)/JCAP(-1)/(1  +  .852 /(1
     +  .02 + (1 - JTAU) * JRS/400 - JDPA(1)/400)) + JC(1)/JCAP(1)/(1  +  .852
     +  .02 + (1 - JTAU) * JRS/400 - JDPA(1)/400) + (1  -  .852 )  *  .00985 * JYD/JCAP + JC_ERR
```

37. JIF: Total fixed investment - 1980 prices

```
(1  +  .95  *  .97 ) * JIF/JCAP   =  .95 * JIF(-1)/JCAP(-1)  +  .97 * JIF(1)/JCAP(1) + (1
     -  .95 ) * (1  -  .97 ) *  (  .39 * JCU * 100/(JRS  +  3.04 - JDPA(1)
     +  6.71 /(1 - JTAU)) - (1  -  3.04 /100) * JK(-1)/JCAP) + JIF_ERR
```

38. JII: Inventory investment - 1980 prices

```
JII/JCAP   =  .00733  +  .483 * (JCU(1) - JCU)  -  .000778 * (JRS - JDPA(1)) + JII_ERR
```

39. JMB: Monetary base

```
LOG(JMB/JPA)   =  -1.8045  +  .766 * LOG(JMB(-1)/JPA(-1))  -  .0084 * JRS
     +  .2707 * LOG(JA) + JMB_ERR
```

J2. AGGREGATE SUPPLY

40. JPGNP: Gross national product deflator - 1980=100.00

```
(JPGNP/JPGNP(-1) - 1) * 400   =  .5 * (JPGNP(-1)/JPGNP(-2) - 1) * 400 + (1
     -  .5 ) * (JPGNP(1)/JPGNP - 1) * 400  +  10 * LOG(JCU) + JPGNP_ERR
```

41. JCAP: Total capacity output

```
JCAP  =  JQ * JK(-1)* *  .39 * JLF(-1)**(1  -  .39 ) + JCAP_ERR
```

J3. EXCHANGE RATE AND TRADE

42. JER: Spot exchange rate - US$/DM

(JER(1)/JER - 1) * 400 = URS - JRS + JER_ERR

43. JXGSNI: Exports - NIA basis - 1980 prices

LOG(JXGSNI) = -.301 + .937 * LOG(JXGSNI(-1)) + .418 * LOG(JAW/JCAPW)
- .107 * LOG(JPXGSNI/JPMGSNI) + (1 - .937) * 1 * LOG(CAPTOT) + JXGSNI_ERR

44. JPXGSNI: Export deflator - NIA basis - 1980 prices

LOG(JPXGSNI) = .005 + .824 * LOG(JPXGSNI(-1)) + .12 * LOG(JPGNPW) + (1 - .824
- .12) * LOG(JPGNP) + .136 * LOG(JPXGSNI(-1)/JPXGSNI(-2)) + (1 - .824)
* -.0025 * TIME + JPXGSNI_ERR

45. XJUS: Share of Japanese exports destined for US

XJUS = .034 + .9 * XJUS(-1) + .002 * LOG(UPGNP/(GER * GPGNP))
+ .044 * LOG(UPGNP/(RER * RPGNP)) + XJUS_ERR

46. XJGS: Share of Japanese exports destined for Germany

XJGS = .007 + .876 * XJGS(-1) - .002 * LOG(UPGNP/(GER * GPGNP))
+ 0 * LOG(GER * GPGNP/(RER * RPGNP)) + XJGS_ERR

47. XJRS3: Share of Japanese exports destined for ROW

XJRS3 = 1 - .034 - .007 - .876 * XJGS(-1) - .9 * XJUS(-1)
- .044 * LOG(UPGNP/(RER * RPGNP)) - 0 * LOG(GER * GPGNP/(RER * RPGNP)) + XJRS3_ERR

J4. MONETARY AND FISCAL POLICY

48. JRS: 3-month Treasury Bill rate

JMB = 1.0178 * JMB(-1) + JRS_ERR

49. JG: Real government purchases - 1980 prices

JG = 1.0085 * JG(-1) + JG_ERR

50. JBRATIO: Target ratio of government bonds to taxable income

JBRATIO = 0.283 + JBRATIO_ERR

51. JTAU: Actual income tax rate

JTAU = .95 * JTAU(-1) + (1 - .95) * JTBAR + 0 * LOG(JCU) + JTAU_ERR

J5. IDENTITIES AND DEFINITIONS

52. JMGSNI: Imports - NIA basis - 1980 prices

```
JMGSNI  =  (XUJS * UXGSNI * 0.9169 + XGJS * GXGSNI * 0.5505 + 1.355 * XRJS3
           * RXGSNI * 1.173)/4.424 + JMGSNI_ERR
```

53. JPMGSNI: Import deflator - NIA basis - 1980=100.00

```
JPMGSNI  =  (XUJS * UPXGSNI * UXGSNI + XGJS * GER * GPXGSNI * GXGSNI + 1.355
            * XRJS3 * RER * RPXGSNI * RXGSNI)/(JMGSNI * JER) + JPMGSNI_ERR
```

54. JA: Absorption

```
JA  =  JC + JIF + JG + JII + JA_ERR
```

55. JGDP: Gross domestic product - 1980 prices

```
JGDP  =  JA + JXGSNI - JMGSNI + JGDP_ERR
```

56. JGNP: Gross national product - 1980 prices

```
JGNP  =  JGDP + URS * JNFAV(-1)/(JER * JPGNP) + JGNP_ERR
```

57. JYD: Disposable income - 1980 prices

```
JYD  =  JPGNP * JGNP/JPA
     -  3.04 * JK(-1)/100 - JTAXV * 100/JPA + (JRS - JDPA) * JGDEBTV(-1)/JPA - JMB(-1) *
          JRS/JPA + JYD_ERR
```

58. JPA: Gross domestic product deflator - 1980=100.00

```
JPA  =  (JPGNP * JGNP - JPXGSNI * JXGSNI + JPMGSNI * JMGSNI - URS * JNFAV(-1)/JER)/JA + JPA_ERR
```

59. JDPA: Rate of inflation of absorption prices

```
JDPA  =  (JPA/JPA(-1) - 1) * 400 + JDPA_ERR
```

60. JDPGNP: Rate of inflation of output prices

```
JDPGNP  =  (JPGNP/JPGNP(-1) - 1) * 400 + JDPGNP_ERR
```

61. JTIV: Nominal taxable income

```
JTIV  =  JPGNP * JGNP/100
     -  3.04 * JK(-1) * JPA/10000 + JRS * (JGDEBTV(-1) - JMB(-1))/100 + JTIV_ERR
```

62. JTAXV: Nominal tax revenues

```
JTAXV  =  JTAU * JTIV + JTAXV_ERR
```

63. JTBAR: Equilibrium tax rate

```
JTBAR  =  (JG * JPA + JRS * JGDEBTV(-1))/(JTIV * 100) - JBRATIO + JGDEBTV( -1)/JTIV + JTBAR_ERR
```

64. JCU: Capacity utilization rate

```
JCU  =  JGDP/JCAP + JCU_ERR
```

65. JAW: Trade weighted foreign absorption

```
JAW  =  UA**0.2954 * RA**0.6637 * GA**0.0409 + JAW_ERR
```

66. JCAPW: Trade weighted foreign total capacity output

```
JCAPW  =  UCAP**0.2954 * RCAP**0.6637 * GCAP**0.0409 + JCAPW_ERR
```

67. JPGNPW: Trade weighted foreign gross national product deflator - 1980=100.00

```
JPGNPW  =  (UPGNP/0.8572)**0.2954 * (RPGNP * RER/1.173)**0.6637 * (GPGNP *
              GER/0.5505)**0.0409 * 4.424/JER + JPGNPW_ERR
```

68. JK: Total net capital stock

```
JK  =  (1  -  3.04 /400) * JK(-1) + JIF/4 + JK_ERR
```

69. JGDEBTV: Current total government debt

```
JGDEBTV  =  (1 + JRS/400) * JGDEBTV(-1) + JPA * JG/400 - JTAXV/4 - JMB(-1) *
              JRS/400 + JGDEBTV_ERR
```

70. JNFAV: Net foreign assets

```
JNFAV  =  (1 + URS/400) * JNFAV(-1) + (JPXGSNI * JXGSNI * JER - JPMGSNI *
              JMGSNI * JER)/400 + JNFAV_ERR
```

ROW MODEL

R1. PRIVATE SECTOR DEMAND

71. RC: Private consumption expenditure - 1980 prices

```
RC/RCAP    =  .852 * RC(-1)/RCAP(-1)/(1  +  .852 /(1
      +  .02 + (1 - RTAU) * RRS/400 - RDPA(1)/400)) + RC(1)/RCAP(1)/(1  +  .852
      +  .02 + (1 - RTAU) * RRS/400 - RDPA(1)/400) + (1  -  .852 )  *  .00985 * RYD/RCAP + RC_ERR
```

72. RIF: Total fixed investment - 1980 prices

```
(1  +  .95  *  .97 ) * RIF/RCAP   =  .95 * RIF(-1)/RCAP(-1)  +  .97 * RIF(1)/RCAP(1) + (1
      -  .95 ) * (1  -  .97 ) *  (  .35 * RCU * 100/(RRS  +  6.58 - RDPA(1)
      +  6.71 /(1 - RTAU)) - (1  -  6.58 /100) * RK(-1)/RCAP) + RIF_ERR
```

73. RII: Inventory investment - 1980 prices

```
RII/RCAP   =  .00733  +  .483 * (RCU(1) - RCU)  -  .000778 * (RRS - RDPA(1)) + RII_ERR
```

74. RMB: Monetary base

```
LOG(RMB/RPA)   =  -.8852  +  .7683 * LOG(RMB(-1)/RPA(-1))  -  .006 * RRS
      +  .139 * LOG(RA) + RMB_ERR
```

R2. AGGREGATE SUPPLY

75. RPGNP: Gross national product deflator - 1980=100.00

```
(RPGNP/RPGNP(-1) - 1) * 400   =  .5 * (RPGNP(-1)/RPGNP(-2) - 1) * 400 + (1
     -  .5 ) * (RPGNP(1)/RPGNP - 1) * 400  +  10 * LOG(RCU) + RPGNP_ERR
```

76. RCAP: Total capacity output

```
RCAP  =  RQ * RK(-1)* *  .35 * RLF(-1)**(1  -  .35 ) + RCAP_ERR
```

R3. EXCHANGE RATE AND TRADE

77. RER: Spot exchange rate - US$/DM

```
(RER(1)/RER - 1) * 400  =  URS - RRS + RER_ERR
```

78. RXGSNI: Exports - NIA basis - 1980 prices

```
LOG(RXGSNI)  =  -.373  +  .864 * LOG(RXGSNI(-1))  +  .268 * LOG(RAW/RCAPW)
     -  .12 * LOG(RPXGSNI/RPMGSNI) + (1  -  .864 )  *  1 * LOG(CAPTOT) + RXGSNI_ERR
```

79. RPXGSNI: Export deflator - NIA basis - 1980 prices

```
LOG(RPXGSNI)  =  .008  +  .985 * LOG(RPXGSNI(-1))  +  0 * LOG(RPGNPW) + (1  -  .985
     -  0 ) * LOG(RPGNP)  +  .527 * LOG(RPXGSNI(-1)/RPXGSNI(-2)) + (1  -  .985 )
     *  -.0025 * TIME + RPXGSNI_ERR
```

80. XRUS3: Share of ROW exports destined for US

```
XRUS3  =  .074  +  .778 * XRUS3(-1)  +  .041 * LOG(UPGNP/(GER * GPGNP))
     +  0 * LOG(UPGNP/(JER * JPGNP)) + XRUS3_ERR
```

81. XRGS3: Share of ROW exports destined for Germany

```
XRGS3  =  .137  +  .705 * XRGS3(-1)  -  .041 * LOG(UPGNP/(GER * GPGNP))
     +  .003 * LOG(GER * GPGNP/(JER * JPGNP)) + XRGS3_ERR
```

82. XRJS3: Share of ROW exports destined for Japan

```
XRJS3  =  1  -  .074  -  .137  -  .778 * XRUS3(-1)  -  .705 * XRGS3(-1)
     -  0 * LOG(UPGNP/(JER * JPGNP))  -  .003 * LOG(GER * GPGNP/(JER * JPGNP)) + XRJS3_ERR
```

R4. MONETARY AND FISCAL POLICY

83. RRS: 3-month Treasury Bill rate

RMB = 1.0297 * RMB(-1) + RRS_ERR

84. RG: Real government purchases - 1980 prices

RG = 1.005 * RG(-1) + RG_ERR

85. RBRATIO: Target ratio of government bonds to taxable income

RBRATIO = 0.569 + RBRATIO_ERR

86. RTAU: Actual income tax rate

RTAU = .95 * RTAU(-1) + (1 - .95) * RTBAR + 0 * LOG(RCU) + RTAU_ERR

R5. IDENTITIES AND DEFINITIONS

87. RMGSNI: Imports - NIA basis - 1980 prices

```
RMGSNI  =  (XURS3 * UXGSNI * 0.9169/1.3 + XGRS3 * GXGSNI * 0.5505/1.183 +
            XJRS3 * JXGSNI * 4.424/1.243)/1.173 + RMGSNI_ERR
```

88. RPMGSNI: Import deflator - NIA basis - 1980=100.00

```
RPMGSNI  =  (XURS3 * UPXGSNI * UXGSNI/1.3 + XGRS3 * GER * GPXGSNI * GXGSNI
             /1.183 + XJRS3 * JER * JPXGSNI * JXGSNI/1.243)/(RMGSNI * RER) + RPMGSNI_ERR
```

89. RA: Absorption

```
RA  =  RC + RIF + RG + RII + RA_ERR
```

90. RGDP: Gross domestic product - 1980 prices

```
RGDP  =  RA + RXGSNI - RMGSNI + RGDP_ERR
```

91. RGNP: Gross national product - 1980 prices

```
RGNP  =  RGDP + URS * RNFAV(-1)/(RER * RPGNP) + RGNP_ERR
```

92. RYD: Disposable income - 1980 prices

```
RYD  =  RPGNP * RGNP/RPA
     -  6.58 * RK(-1)/100 - RTAXV * 100/RPA + (RRS - RDPA) * RGDEBTV(-1)/RPA - RMB(-1) *
          RRS/RPA + RYD_ERR
```

93. RPA: Gross domsetic product deflator - 1980=100.00

```
RPA  =  (RPGNP * RGNP - RPXGSNI * RXGSNI + RPMGSNI * RMGSNI - URS * RNFAV(-1)/RER)/RA + RPA_ERR
```

94. RDPA: Rate of inflation of absorption prices

```
RDPA  =  (RPA/RPA(-1) - 1) * 400 + RDPA_ERR
```

95. RDPGNP: Rate of inflation of output prices

```
RDPGNP  =  (RPGNP/RPGNP(-1) - 1) * 400 + RDPGNP_ERR
```

96. RTIV: Nominal taxable income

```
RTIV  =  RPGNP * RGNP/100
     -  6.58 * RK(-1) * RPA/10000 + RRS * (RGDEBTV(-1) - RMB(-1))/100 + RTIV_ERR
```

97. RTAXV: Nominal tax revenues

```
RTAXV  =  RTAU * RTIV + RTAXV_ERR
```

98. RTBAR: Equilibrium tax rate

```
RTBAR  =  (RG * RPA + RRS * RGDEBTV(-1))/(RTIV * 100) - RBRATIO + RGDEBTV( -1)/RTIV + RTBAR_ERR
```

99. RCU: Capacity utilization rate

```
RCU  =  RGDP/RCAP + RCU_ERR
```

100. RAW: Trade weighted foreign absorption

```
RAW  =  UA**0.4593 * JA**0.1956 * GA**0.3451 + RAW_ERR
```

101. RCAPW: Trade weighted foreign total capacity output

```
RCAPW  =  UCAP**0.4593 * JCAP**0.1956 * GCAP**0.3451 + RCAPW_ERR
```

102. RPGNPW: Trade weighted foreign gross national product deflator - 1980=100.00

```
RPGNPW  =  (UPGNP/0.8572)**0.4593 * (JPGNP * JER/4.424)**0.1956 * (GPGNP *
              GER/0.5505)**0.3451 * 1.173/RER + RPGNPW_ERR
```

103. RK: Total net capital stock

```
RK  =  (1  -  6.58 /400) * RK(-1) + RIF(-1)/4 + RK_ERR
```

104. RGDEBTV: Current total government debt

```
RGDEBTV  =  (1 + RRS/400) * RGDEBTV(-1) + RPA * RG/400 - RTAXV/4 - RMB(-1) *
              RRS/400 + RGDEBTV_ERR
```

105. RNFAV: Net foreign assets

```
RNFAV  =  (1 + URS/400) * RNFAV(-1) + (RPXGSNI * RXGSNI * RER - RPMGSNI *
              RMGSNI * RER)/400 + RNFAV_ERR
```

U.S. MODEL

U1. PRIVATE SECTOR DEMAND

106. UC: Private consumption expenditure - 1982 prices

UC/UCAP = .852 * UC(-1)/UCAP(-1)/(1 + .852 /(1
+ .02 + (1 - UTAU) * URS/400 - UDPA(1)/400)) + UC(1)/UCAP(1)/(1 + .852
+ .02 + (1 - UTAU) * URS/400 - UDPA(1)/400) + (1 - .852) * .00985 * UYD/UCAP + UC_ERR

107. UIF: Total fixed investment - 1982 prices

(1 + .95 * .97) * UIF/UCAP = .95 * UIF(-1)/UCAP(-1) + .97 * UIF(1)/UCAP(1) + (1
- .95) * (1 - .97) * (.32 * UCU * 100/(URS + 6.23 - UDPA(1)
+ 6.8 /(1 - UTAU)) - (1 - 6.23 /100) * UK(-1)/UCAP) + UIF_ERR

108. UII: Inventory investment - 1982 prices

UII/UCAP = .00733 + .483 * (UCU(1) - UCU) - .000778 * (URS - UDPA(1)) + UII_ERR

109. UMB: Monetary base

LOG(UMB/UPA) = -1.395 + .776 * LOG(UMB(-1)/UPA(-1)) - .0039 * URS
+ .1926 * LOG(UA) + UMB_ERR

U2. AGGREGATE SUPPLY

110. UPGNP: Gross national product deflator - 1982=100.00

```
(UPGNP/UPGNP(-1) - 1) * 400   =  .5 * (UPGNP(-1)/UPGNP(-2) - 1) * 400 + (1
     -  .5 ) * (UPGNP(1)/UPGNP - 1) * 400  +  10 * LOG(UCU) + UPGNP_ERR
```

111. UCAP: Total capacity output

```
UCAP  =  UQ * UK(-1)* *  .32 * ULF(-1)**(1  -  .32 ) + UCAP_ERR
```

U3. TRADE

112. UXGSNI: Exports - NIA basis - 1982 prices

```
LOG(UXGSNI)  =  -1.645  +  .476 * LOG(UXGSNI(-1))  +  1.929 * LOG(UAW/UCAPW)
     -  .372 * LOG(UPXGSNI/UPMGSNI) + (1  -  .476 )  *  1 * LOG(CAPTOT) + UXGSNI_ERR
```

113. UPXGSNI: Export deflator - NIA basis - 1980 prices

```
LOG(UPXGSNI)  =  .003  +  .962 * LOG(UPXGSNI(-1))  +  0 * LOG(UPGNPW) + (1  -  .962
     -  0  ) * LOG(UPGNP)  +  .728 * LOG(UPXGSNI(-1)/UPXGSNI(-2)) + (1  -  .962 )
     *  -.0025 * TIME + UPXGSNI_ERR
```

114. XUGS: Share of US exports destined for Germany

```
XUGS  =  .063  +  .166 * XUGS(-1)  +  .005 * LOG(GER * GPGNP/(JER * JPGNP))
     +  .018 * LOG(GER * GPGNP/(RER * RPGNP)) + XUGS_ERR
```

115. XUJS: Share of US exports destined for Japan

```
XUJS  =  .006  +  .711 * XUJS(-1)  -  .005 * LOG(GER * GPGNP/(JER * JPGNP))
     +  .009 * LOG(JER * JPGNP/(RER * RPGNP)) + XUJS_ERR
```

116. XURS3: Share of US exports destined for ROW

```
XURS3  =  1  -  .063  -  .006  -  .166 * XUGS(-1)  -  .711 * XUJS(-1)
     -  .009 * LOG(JER * JPGNP/(RER * RPGNP))  -  .018 * LOG(GER * GPGNP/(RER * RPGNP)) + XURS3_ERR
```

U4. MONETARY AND FISCAL POLICY

117. URS: 3-month Treasury Bill rate

UMB = 1.0195 * UMB(-1) + URS_ERR

118. UG: Real government purchases - 1982 prices

UG = 1.0067 * UG(-1) + UG_ERR

119. UBRATIO: Target ratio of government bonds to taxable income

UBRATIO = 0.317 + UBRATIO_ERR

120. UTAU: Actual income tax rate

UTAU = .95 * UTAU(-1) + (1 - .95) * UTBAR + 0 * LOG(UCU) + UTAU_ERR

U5. IDENTITIES AND DEFINITIONS

121. UMGSNI: Imports - NIA basis - 1982 prices

UMGSNI = (XGUS * GXGSNI * 0.5505 + XJUS * JXGSNI * 4.424 + 1.294 * XRUS3 * RXGSNI * 1.173)/0.9169 + UMGSNI_ERR

122. UPMGSNI: Import deflator - NIA basis - 1982=100.00

UPMGSNI = (XGUS * GPXGSNI * GXGSNI * GER + XJUS * JPXGSNI * JXGSNI * JER + 1.294 * XRUS3 * RPXGSNI * RXGSNI * RER)/UMGSNI + UPMGSNI_ERR

123. UA: Absorption

UA = UC + UIF + UG + UII + UA_ERR

124. UGDP: Gross domestic product - 1982 prices

UGDP = UA + UXGSNI - UMGSNI + UGDP_ERR

125. UGNP: Gross national product - 1982 prices

UGNP = UGDP + URS * UNFAV(-1)/UPGNP + UGNP_ERR

126. UYD: Disposable income

UYD = UPGNP * UGNP/UPA
- 6.23 * UK(-1)/100 - UTAXV * 100/UPA + (URS - UDPA) * UGDEBTV(-1)/UPA - UMB(-1) * URS/UPA + UYD_ERR

127. UPA: Gross domestic product deflator - 1982=100.00

UPA = (UPGNP * UGNP - UPXGSNI * UXGSNI + UPMGSNI * UMGSNI - URS * UNFAV(-1))/UA + UPA_ERR

128. UDPA: Rate of inflation of absorption prices

UDPA = (UPA/UPA(-1) - 1) * 400 + UDPA_ERR

129. UDPGNP: Rate of inflation of output prices

UDPGNP = (UPGNP/UPGNP(-1) - 1) * 400 + UDPGNP_ERR

130. UTIV: Nominal taxable income

UTIV = UPGNP * UGNP/100
- 6.23 * UK(-1) * UPA/10000 + URS * (UGDEBTV(-1) - UMB(-1))/100 + UTIV_ERR

131. UTAXV: Nominal tax revenues

UTAXV = UTAU * UTIV + UTAXV_ERR

132. UTBAR: Equilibrium tax rate

UTBAR = (UG * UPA + URS * UGDEBTV(-1))/(UTIV * 100) - UBRATIO + UGDEBTV(-1)/UTIV + UTBAR_ERR

133. UCU: Capacity utilization rate

UCU = UGDP/UCAP + UCU_ERR

134. CAPTOT: Total world capacity

CAPTOT = UCAP * 0.8572 + GCAP * 0.5505 + JCAP * 4.424 + RCAP * 1.173 + CAPTOT_ERR

135. UAW: Trade weighted foreign absorption

UAW = GA**0.0463 * RA**0.8532 * JA**0.1005 + UAW_ERR

136. UCAPW: Trade weighted foreign total capacity output

UCAPW = GCAP**0.0463 * RCAP**0.8532 * JCAP**0.1005 + UCAPW_ERR

137. UPGNPW: Trade weighted foreign gross national product deflator - 1980=100.00

UPGNPW = (GPGNP * GER/0.5505)**0.0463 * (RPGNP * RER/1.173)**0.8532 *
(JPGNP * JER/4.424)**0.1005 * 0.8572 + UPGNPW_ERR

138. UK: Total net capital stock

UK = (1 - 6.23 /400) * UK(-1) + UIF/4 + UK_ERR

139. UGDEBTV: Current total government debt

UGDEBTV = (1 + URS/400) * UGDEBTV(-1) + UPA * UG/400 - UTAXV/4 - UMB(-1) *
URS/400 + UGDEBTV_ERR

140. UNFAV: <u>Net foreign assets</u>

```
UNFAV  =  (1 + URS/400) * UNFAV(-1) + (UPXGSNI * UXGSNI - UPMGSNI * UMGSNI )/400 + UNFAV_ERR
```

CROSS REFERENCE LIST OF ENDOGENOUS VARIABLES AND EQUATIONS

VARIABLE	EQUATION NUMBER
CAPTOT	8 43 78 112 134
GA	4 19 20 23 65 100 135
GAW	8 30
GBRATIO	15 28
GC	1 19
GCAP	1 2 3 6 29 66 101 134 136
GCAPW	8 31
GCU	2 3 5 16 29
GDPA	1 2 3 22 24
GDPGNP	25
GER	7 18 21 23 32 35 45 46 47 53 67 80 81 82 88 102 114 115 116 116 122 137
GG	14 19 28 34
GGDEBTV	22 26 28 34
GGDP	20 21 29
GGNP	21 22 23 26
GIF	2 19 33
GII	3 19
GK	2 6 22 26 33
GMB	4 13 22 26 34
GMGSNI	17 18 20 23 35
GNFAV	21 23 35
GPA	4 22 23 24 26 28 34
GPGNP	5 9 21 22 23 25 26 45 46 47 67 80 81 82 102 114 115 116 137 137
GPGNPW	9 32
GPMGSNI	8 18 23 35
GPXGSNI	8 9 23 35 53 88 122
GRS	1 2 3 4 7 22 26 28 34
GTAU	1 2 16 27
GTAXV	22 27 34
GTBAR	16 28
GTIV	26 27 28
GXGSNI	8 20 23 35 52 53 87 88 121 122
GYD	1 22
JA	30 39 54 55 58 100 135
JAW	43 65
JBRATIO	50 63
JC	36 54
JCAP	31 36 37 38 41 64 101 134 136
JCAPW	43 66
JCU	37 38 40 51 64
JDPA	36 37 38 57 59
JDPGNP	60
JER	10 11 12 18 32 42 53 56 58 67 70 80 81 82 88 102 114 115 116 116 122 137
JG	49 54 63 69
JGDEBTV	57 61 63 69
JGDP	55 56 64
JGNP	56 57 58 61
JIF	37 54 68
JII	38 54
JK	37 41 57 61 68
JMB	39 48 57 61 69
JMGSNI	52 53 55 58 70
JNFAV	56 58 70
JPA	39 57 58 59 61 63 69
JPGNP	10 11 12 32 40 44 56 57 58 60 61 80 81 82 102 114 115 116 137 137
JPGNPW	44 67
JPMGSNI	43 53 58 70
JPXGSNI	18 43 44 58 70 88 122
JRS	36 37 38 39 42 57 61 63 69
JTAU	36 37 51 62
JTAXV	57 62 69
JTBAR	51 63
JTIV	61 62 63
JXGSNI	17 18 43 55 58 70 87 88 121 122
JYD	36 57
RA	30 65 74 89 90 93 135
RAW	78 100
RBRATIO	85 98
RC	71 89
RCAP	31 66 71 72 73 76 99 134 136
RCAPW	78 101
RCU	72 73 75 86 99
RDPA	71 72 73 92 94
RDPGNP	95
RER	10 11 12 18 32 45 46 47 53 67 77 88 91 93 102 105 114 115 116 116 122 137
RG	84 89 98 104
RGDEBTV	92 96 98 104
RGDP	90 91 99
RGNP	91 92 93 96
RIF	72 89 103
RII	73 89

VARIABLE	EQUATION NUMBER																	
RK	72	76	92	96	103													
RMB	74	83	92	96	104													
RMGSNI	87	88	90	93	105													
RNFAV	91	93	105															
RPA	74	92	93	94	96	98	104											
RPGNP	10	11	12	32	45	46	47	67	75	79	91	92	93	95	96	114	115	116
	137	137																
RPGNPW	79	102																
RPMGSNI	78	88	93	105														
RPXGSNI	18	53	78	79	93	105	122											
RRS	71	72	73	74	77	92	96	98	104									
RTAU	71	72	86	97														
RTAXV	92	97	104															
RTBAR	86	98																
RTIV	96	97	98															
RXGSNI	17	18	52	53	78	90	93	105	121	122								
RYD	71	92																
UA	30	65	100	109	123	124	127											
UAW	112	135																
UBRATIO	119	132																
UC	106	123																
UCAP	31	66	101	106	107	108	111	133	134									
UCAPW	112	136																
UCU	107	108	110	120	133													
UDPA	106	107	108	126	128													
UDPGNP	129																	
UG	118	123	132	139														
UGDEBTV	126	130	132	139														
UGDP	124	125	133															
UGNP	125	126	127	130														
UIF	107	123	138															
UII	108	123																
UK	107	111	126	130	138													
UMB	109	117	126	130	139													
UMGSNI	121	122	124	127	140													
UNFAV	125	127	140															
UPA	109	126	127	128	130	132	139											
UPGNP	10	11	12	32	45	46	47	67	80	81	82	102	110	113	125	126	127	129
	130	130																
UPGNPW	113	137																
UPMGSNI	112	122	127	140														
UPXGSNI	18	53	88	112	113	127	140											
URS	7	21	23	35	42	56	58	70	77	91	93	105	106	107	108	109	125	126
	127	127	130	132	139	140												
UTAU	106	107	120	131														
UTAXV	126	131	139															
UTBAR	120	132																
UTIV	130	131	132															
UXGSNI	17	18	52	53	87	88	112	124	127	140								
UYD	106	126																
XGJS	11	12	52	53														
XGRS3	12	87	88															
XGUS	10	12	121	122														
XJGS	17	18	46	47														
XJRS3	47	87	88															
XJUS	45	47	121	122														
XRGS3	17	18	81	82														
XRJS3	52	53	82															
XRUS3	80	82	121	122														
XUGS	17	18	114	116														
XUJS	52	53	115	116														
XURS3	87	88	116															

CROSS REFERENCE LIST OF EXOGENOUS VARIABLES AND EQUATIONS

VARIABLE	EQUATION NUMBER
CAPTOT_ERR	134
GA_ERR	19
GAW_ERR	30
GBRATIO_ERR	15
GC_ERR	1
GCAP_ERR	6
GCAPW_ERR	31
GCU_ERR	29
GDPA_ERR	24
GDPGNP_ERR	25
GER_ERR	7
GG_ERR	14
GGDEBTV_ERR	34
GGDP_ERR	20
GGNP_ERR	21
GIF_ERR	2
GII_ERR	3
GK_ERR	33
GLF	6
GMB_ERR	4
GMGSNI_ERR	17
GNFAV_ERR	35
GPA_ERR	23
GPGNP_ERR	5
GPGNPW_ERR	32
GPMGSNI_ERR	18
GPXGSNI_ERR	9
GQ	6
GRS_ERR	13
GTAU_ERR	16
GTAXV_ERR	27
GTBAR_ERR	28
GTIV_ERR	26
GXGSNI_ERR	8
GYD_ERR	22
JA_ERR	54
JAW_ERR	65
JBRATIO_ERR	50
JC_ERR	36
JCAP_ERR	41
JCAPW_ERR	66
JCU_ERR	64
JDPA_ERR	59
JDPGNP_ERR	60
JER_ERR	42
JG_ERR	49
JGDEBTV_ERR	69
JGDP_ERR	55
JGNP_ERR	56
JIF_ERR	37
JII_ERR	38
JK_ERR	68
JLF	41
JMB_ERR	39
JMGSNI_ERR	52
JNFAV_ERR	70
JPA_ERR	58
JPGNP_ERR	40
JPGNPW_ERR	67
JPMGSNI_ERR	53
JPXGSNI_ERR	44
JQ	41
JRS_ERR	48
JTAU_ERR	51
JTAXV_ERR	62
JTBAR_ERR	63
JTIV_ERR	61
JXGSNI_ERR	43
JYD_ERR	57
RA_ERR	89
RAW_ERR	100
RBRATIO_ERR	85
RC_ERR	71
RCAP_ERR	76
RCAPW_ERR	101
RCU_ERR	99
RDPA_ERR	94
RDPGNP_ERR	95
RER_ERR	77
RG_ERR	84
RGDEBTV_ERR	104
RGDP_ERR	90
RGNP_ERR	91
RIF_ERR	72
RII_ERR	73
RK_ERR	103

VARIABLE	EQUATION NUMBER			
RLF	76			
RMB_ERR	74			
RMGSNI_ERR	87			
RNFAV_ERR	105			
RPA_ERR	93			
RPGNP_ERR	75			
RPGNPW_ERR	102			
RPMGSNI_ERR	88			
RPXGSNI_ERR	79			
RQ	76			
RRS_ERR	83			
RTAU_ERR	86			
RTAXV_ERR	97			
RTBAR_ERR	98			
RTIV_ERR	96			
RXGSNI_ERR	78			
RYD_ERR	92			
TIME	9	44	79	113
UA_ERR	123			
UAW_ERR	135			
UBRATIO_ERR	119			
UC_ERR	106			
UCAP_ERR	111			
UCAPW_ERR	136			
UCU_ERR	133			
UDPA_ERR	128			
UDPGNP_ERR	129			
UG_ERR	118			
UGDEBTV_ERR	139			
UGDP_ERR	124			
UGNP_ERR	125			
UIF_ERR	107			
UII_ERR	108			
UK_ERR	138			
ULF	111			
UMB_ERR	109			
UMGSNI_ERR	121			
UNFAV_ERR	140			
UPA_ERR	127			
UPGNP_ERR	110			
UPGNPW_ERR	137			
UPMGSNI_ERR	122			
UPXGSNI_ERR	113			
UQ	111			
URS_ERR	117			
UTAU_ERR	120			
UTAXV_ERR	131			
UTBAR_ERR	132			
UTIV_ERR	130			
UXGSNI_ERR	112			
UYD_ERR	126			
XGJS_ERR	11			
XGRS3_ERR	12			
XGUS_ERR	10			
XJGS_ERR	46			
XJRS3_ERR	47			
XJUS_ERR	45			
XRGS3_ERR	81			
XRJS3_ERR	82			
XRUS3_ERR	80			
XUGS_ERR	114			
XUJS_ERR	115			
XURS3_ERR	116			

ALPHABETICAL LIST OF ENDOGENOUS VARIABLES FOR MODEL

MNEMONIC	EQUATION	DEFINITION
CAPTOT	134	Total World Capacity
GA	19	Absorption
GAW	30	Trade weighted foreign absorption
GBRATIO	15	Target ratio of government bonds to taxable income
GC	1	Private consumption expenditure - 1980 prices
GCAP	6	Total capacity output
GCAPW	31	Trade weighted foreign total capacity output
GCU	29	Capacity utilization rate
GDPA	24	Rate of inflation of absorption prices
GDPGNP	25	Rate of inflation of output prices
GER	7	Spot exchange rate - US$/DM
GG	14	Real government purchases - 1980 prices
GGDEBTV	34	Current total government debt
GGDP	20	Gross domestic product - 1980 prices
GGNP	21	Gross national product - 1980 prices
GIF	2	Total fixed investment - 1980 prices
GII	3	Inventory investment - 1980 prices
GK	33	Total net capital stock
GMB	4	Monetary base
GMGSNI	17	Imports - NIA basis - 1980 prices
GNFAV	35	Net foreign assets
GPA	23	Gross domestic product deflator - 1980=100.00
GPGNP	5	Gross national product deflator - 1980=100.00
GPGNPW	32	Trade weighted foreign gross national product deflator - 1980=100.00
GPMGSNI	18	Import deflator - NIA basis - 1980=100.00
GPXGSNI	9	Export deflator - NIA basis - 1980 prices
GRS	13	3-month Treasury bill rate
GTAU	16	Actual income tax rate
GTAXV	27	Nominal tax revenues
GTBAR	28	Equilibrium tax rate
GTIV	26	Nominal taxable income
GXGSNI	8	Exports - NIA basis - 1980 prices
GYD	22	Disposable income - 1980 prices
JA	54	Absorption
JAW	65	Trade weighted foreign absorption
JBRATIO	50	Target ratio of government bonds to taxable income
JC	36	Private consumption expenditure - 1980 prices
JCAP	41	Total capacity output
JCAPW	66	Trade weighted foreign total capacity output
JCU	64	Capacity utilization rate
JDPA	59	Rate of inflation of absorption prices
JDPGNP	60	Rate of inflation of output prices
JER	42	Spot exchange rate - US$/DM
JG	49	Real government purchases - 1980 prices
JGDEBTV	69	Current total government debt
JGDP	55	Gross domestic product - 1980 prices
JGNP	56	Gross national product - 1980 prices
JIF	37	Total fixed investment - 1980 prices
JII	38	Inventory investment - 1980 prices
JK	68	Total net capital stock
JMB	39	Monetary base
JMGSNI	52	Imports - NIA basis - 1980 prices
JNFAV	70	Net foreign assets
JPA	58	Gross domestic product deflator - 1980=100.00
JPGNP	40	Gross national product deflator - 1980=100.00
JPGNPW	67	Trade weighted foreign gross national product deflator - 1980=100.00
JPMGSNI	53	Import deflator - NIA basis - 1980=100.00
JPXGSNI	44	Export deflator - NIA basis - 1980 prices
JRS	48	3-month Treasury bill rate
JTAU	51	Actual income tax rate
JTAXV	62	Nominal tax revenues
JTBAR	63	Equilibrium Tax Rate
JTIV	61	Nominal taxable income
JXGSNI	43	Exports - NIA basis - 1980 prices
JYD	57	Disposable income - 1980 prices
RA	89	Absorption
RAW	100	Trade weighted foreign absorption
RBRATIO	85	Target ratio of government bonds to taxable income
RC	71	Private consumption expenditure - 1980 prices
RCAP	76	Total capacity output
RCAPW	101	Trade weighted foreign total capacity output
RCU	99	Capacity utilization rate
RDPA	94	Rate of inflation of absorption prices
RDPGNP	95	Rate of inflation of output prices
RER	77	Spot exchange rate - US$/DM
RG	84	Real government purchases - 1980 prices
RGDEBTV	104	Current total government debt
RGDP	90	Gross domestic product - 1980 prices
RGNP	91	Gross national product - 1980 prices
RIF	72	Total fixed investment - 1980 prices
RII	73	Inventory investment - 1980 prices
RK	103	Total net capital stock
RMB	74	Monetary base
RMGSNI	87	Imports - NIA basis - 1980 prices
RNFAV	105	Net foreign assets

MNEMONIC	EQUATION	DEFINITION
RPA	93	Gross domsetic product deflator - 1980=100.00
RPGNP	75	Gross national product deflator - 1980=100.00
RPGNPW	102	Trade weighted foreign gross national product deflator - 1980=100.00
RPMGSNI	88	Import deflator - NIA basis - 1980=100.00
RPXGSNI	79	Export deflator - NIA basis - 1980 prices
RRS	83	3-month Treasury bill rate
RTAU	86	Actual income tax rate
RTAXV	97	Nominal tax revenues
RTBAR	98	Equilibrium tax Rate
RTIV	96	Nominal taxable income
RXGSNI	78	Exports - NIA basis - 1980 prices
RYD	92	Disposable income - 1980 prices
UA	123	Absorption
UAW	135	Trade weighted foreign absorption
UBRATIO	119	Target ratio of government bonds to taxable income
UC	106	Private consumption expenditure - 1982 prices
UCAP	111	Total capacity output
UCAPW	136	Trade weighted foreign total capacity output
UCU	133	Capacity utilization rate
UDPA	128	Rate of inflation of absorption prices
UDPGNP	129	Rate of inflation of output prices
UG	118	Ueal government purchases - 1982 prices
UGDEBTV	139	Current total government debt
UGDP	124	Gross domestic product - 1982 prices
UGNP	125	Gross national product - 1982 prices
UIF	107	Total fixed investment - 1982 prices
UII	108	Inventory investment - 1982 prices
UK	138	Total net capital stock
UMB	109	Monetary base
UMGSNI	121	Imports - NIA basis - 1982 prices
UNFAV	140	Net foreign assets
UPA	127	Gross domestic product deflator - 1982=100.00
UPGNP	110	Gross national product deflator - 1982=100.00
UPGNPW	137	Trade weighted foreign gross national product deflator - 1980=100.00
UPMGSNI	122	Import deflator - NIA basis - 1982=100.00
UPXGSNI	113	Export deflator - NIA basis - 1980 prices
URS	117	3-month Treasury bill rate
UTAU	120	Actual income tax rate
UTAXV	131	Nominal tax revenues
UTBAR	132	Equilibrium tax rate
UTIV	130	Nominal taxable income
UXGSNI	112	Exports - NIA basis - 1982 prices
UYD	126	Disposable income
XGJS	11	Share of German exports destined for Japan
XGRS3	12	Share of German exports destined for ROW
XGUS	10	Share of German exports destined for US
XJGS	46	Share of Japanese exports destined for Germany
XJRS3	47	Share of Japanese exports destined for ROW
XJUS	45	Share of Japanese exports destined for US
XRGS3	81	Share of ROW exports destined for Germany
XRJS3	82	Share of ROW exports destined for Japan
XRUS3	80	Share of ROW exports destined for US
XUGS	114	Share of US exports destined for Germany
XUJS	115	Share of US exports destined for Japan
XURS3	116	Share of US exports destined for ROW

ALPHABETICAL LIST OF EXOGENOUS VARIABLES FOR MODEL

MNEMONIC	DEFINITION
CAPTOT_ERR	Residual term in CAPTOT equation
GA_ERR	Residual term in GA equation
GAW_ERR	Residual term in GAW equation
GBRATIO_ERR	Residual term in GBRATIO equation
GC_ERR	Residual term in GC equation
GCAP_ERR	Residual term in GCAP equation
GCAPW_ERR	Residual term in GCAPW equation
GCU_ERR	Residual term in GCU equation
GDPA_ERR	Residual term in GDPA equation
GDPGNP_ERR	Residual term in GDPGNP equation
GER_ERR	Residual term in GER equation
GG_ERR	Residual term in GG equation
GGDEBTV_ERR	Residual term in GGDEBTV equation
GGDP_ERR	Residual term in GGDP equation
GGNP_ERR	Residual term in GGNP equation
GIF_ERR	Residual term in GIF equation
GII_ERR	Residual term in GII equation
GK_ERR	Residual term in GK equation
GLF	Labor force
GMB_ERR	Residual term in GMB equation
GMGSNI_ERR	Residual in GMGSNI equation
GNFAV_ERR	Residual in GNFAV equation
GPA_ERR	Residual in GPA equation
GPGNP_ERR	Residual in GPGNP equation
GPGNPW_ERR	Residual in GPGNPW equation
GPMGSNI_ERR	Residual in GPMGSNI equation
GPXGSNI_ERR	Residual in GPXGSNI equation
GQ	Production technology
GRS_ERR	Residual in GRS equation
GTAU_ERR	Residual in GTAU equation
GTAXV_ERR	Residual in GTAXV equation
GTBAR_ERR	Residual in GTBAR equation
GTIV_ERR	Residual in GTIV equation
GXGSNI_ERR	Residual in GXGSNI equation
GYD_ERR	Residual in GYD equation
JA_ERR	Residual term in JA equation
JAW_ERR	Residual term in JAW equation
JBRATIO_ERR	Residual term in JBRATIO equation
JC_ERR	Residual term in JC equation
JCAP_ERR	Residual term in JCAP equation
JCAPW_ERR	Residual term in JCAPW equation
JCU_ERR	Residual term in JCU equation
JDPA_ERR	Residual term in JDPA equation
JDPGNP_ERR	Residual term in JDPGNP equation
JER_ERR	Residual term in JER equation
JG_ERR	Residual term in JG equation
JGDEBTV_ERR	Residual term in JGDEBTV equation
JGDP_ERR	Residual term in JGDP equation
JGNP_ERR	Residual term in JGNP equation
JIF_ERR	Residual term in JIF equation
JII_ERR	Residual term in JII equation
JK_ERR	Residual term in JK equation
JLF	Labor force
JMB_ERR	Residual term in JMB equation
JMGSNI_ERR	Residual in JMGSNI equation
JNFAV_ERR	Residual in JNFAV equation
JPA_ERR	Residual in JPA equation
JPGNP_ERR	Residual in JPGNP equation
JPGNPW_ERR	Residual in JPGNPW equation
JPMGSNI_ERR	Residual in JPMGSNI equation
JPXGSNI_ERR	Residual in JPXGSNI equation
JQ	Production technology
JRS_ERR	Residual in JRS equation
JTAU_ERR	Residual in JTAU equation
JTAXV_ERR	Residual in JTAXV equation
JTBAR_ERR	Residual in JTBAR equation
JTIV_ERR	Residual in JTIV equation
JXGSNI_ERR	Residual in JXGSNI equation
JYD_ERR	Residual in JYD equation
RA_ERR	Residual term in RA equation
RAW_ERR	Residual term in RAW equation
RBRATIO_ERR	Residual term in RBRATIO equation
RC_ERR	Residual term in RC equation
RCAP_ERR	Residual term in RCAP equation
RCAPW_ERR	Residual term in RCAPW equation
RCU_ERR	Residual term in RCU equation
RDPA_ERR	Residual term in RDPA equation
RDPGNP_ERR	Residual term in RDPGNP equation
RER_ERR	Residual term in RER equation
RG_ERR	Residual term in RG equation
RGDEBTV_ERR	Residual term in RGDEBTV equation
RGDP_ERR	Residual term in RGDP equation
RGNP_ERR	Residual term in RGNP equation
RIF_ERR	Residual term in RIF equation
RII_ERR	Residual term in RII equation

MNEMONIC	DEFINITION
RK_ERR	Residual term in RK equation
RLF	Labor force
RMB_ERR	Residual term in RMB equation
RMGSNI_ERR	Residual in RMGSNI equation
RNFAV_ERR	Residual in RNFAV equation
RPA_ERR	Residual in RPA equation
RPGNP_ERR	Residual in RPGNP equation
RPGNPW_ERR	Residual in RPGNPW equation
RPMGSNI_ERR	Residual in RPMGSNI equation
RPXGSNI_ERR	Residual in RPXGSNI equation
RQ	Production technology
RRS_ERR	Residual in RRS equation
RTAU_ERR	Residual in RTAU equation
RTAXV_ERR	Residual in RTAXV equation
RTBAR_ERR	Residual in RTBAR equation
RTIV_ERR	Residual in RTIV equation
RXGSNI_ERR	Residual in RXGSNI equation
RYD_ERR	Residual in RYD equation
TIME	Time trend
UA_ERR	Residual term in UA equation
UAW_ERR	Residual term in UAW equation
UBRATIO_ERR	Residual term in UBRATIO equation
UC_ERR	Residual term in UC equation
UCAP_ERR	Residual term in UCAP equation
UCAPW_ERR	Residual term in UCAPW equation
UCU_ERR	Residual term in UCU equation
UDPA_ERR	Residual term in UDPA equation
UDPGNP_ERR	Residual term in UDPGNP equation
UG_ERR	Residual term in UG equation
UGDEBTV_ERR	Residual term in UGDEBTV equation
UGDP_ERR	Residual term in UGDP equation
UGNP_ERR	Residual term in UGNP equation
UIF_ERR	Residual term in UIF equation
UII_ERR	Residual term in UII equation
UK_ERR	Residual term in UK equation
ULF	Labor force
UMB_ERR	Residual term in UMB equation
UMGSNI_ERR	Residual in UMGSNI equation
UNFAV_ERR	Residual in UNFAV equation
UPA_ERR	Residual in UPA equation
UPGNP_ERR	Residual in UPGNP equation
UPGNPW_ERR	Residual in UPGNPW equation
UPMGSNI_ERR	Residual in UPMGSNI equation
UPXGSNI_ERR	Residual in UPXGSNI equation
UQ	Production technology
URS_ERR	Residual in RRS equation
UTAU_ERR	Residual in UTAU equation
UTAXV_ERR	Residual in UTAXV equation
UTBAR_ERR	Residual in UTBAR equation
UTIV_ERR	Residual in UTIV equation
UXGSNI_ERR	Residual in UXGSNI equation
UYD_ERR	Residual in UYD equation
XGJS_ERR	Residual in XGJS equation
XGRS3_ERR	Residual in XGRS3 equation
XGUS_ERR	Residual in XGUS equation
XJGS_ERR	Residual in XJGS equation
XJRS3_ERR	Residual in XJRS3 equation
XJUS_ERR	Residual in XJUS equation
XRGS3_ERR	Residual in XRGS3 equation
XRJS3_ERR	Residual in XRJS3 equation
XRUS3_ERR	Residual in XRUS3 equation
XUGS_ERR	Residual in XUGS equation
XUJS_ERR	Residual in XUJS equation
XURS3_ERR	Residual in XURS3 equation

Construction of the Database

Most data are taken from the OECD's Quarterly National Accounts. The trade shares are computed using data from the IMF's Direction of Trade Statistics. The exchange rate, interest rate, monetary base, and labor force are obtained directly from national sources.

All data are seasonally adjusted at annual rates.[2] Interest rates are expressed in percents, not decimals.[3] The data are expressed in billions of local currency units, except for data from Italy and Japan, which are expressed in trillions. Real quantities are expressed at 1982 prices for U.S. data, 1981 prices for Canadian data, and 1980 prices for all other data. Price deflators are equal to 100 in the base year.[4] Exchange rates are the number of U.S. dollars required to purchase a unit of the currency in question, except for the cases of Italy and Japan, where the exchange rates are the number of U.S. dollars required to buy 1000 lire or yen.

The newly revised Italian national accounts data are not available prior to 1980. MX3 has spliced the old series onto the new series for the years 1976-1979.

The United States government consumption series differs from all other MX7 government consumption series because it includes public gross fixed capital formation. Thus, in the United States gross fixed capital formation refers to private investment only.

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2. Most of the data are available only on a seasonally adjusted basis. When the data are not available seasonally adjusted, we have adjusted them using Census X-11 as implemented by the SEASAQ command in TROLL.

3. For expositional purposes, the text assumes that interest rates are expressed in decimals. This convention allows for simpler notation.

4. For expositional purposes, the text assumes that deflators equal 1 in the base year.

To create the ROW national accounts data, series from Canada, France, Italy and the United Kingdom were multiplied by their respective purchasing power parity (PPP) exchange rates in 1980 and then summed. The only exception is the Canadian data which are also rescaled from a 1981 base year to 1980. The PPP exchange rates were obtained from OECD National Accounts.

Factor payments abroad and factor receipts from abroad are available on an annual basis only, and they were interpolated to yield quarterly figures. The nominal factor receipts and payments were deflated by either PGNP or PGDP, depending on availability, a procedure which ensures that PGNP will be identical to PGDP. For countries that report quarterly GDP, net factor receipts were added to obtain GNP. For countries that report quarterly GNP, factor payments were subtracted from reported imports and factor receipts were subtracted from reported exports. GDP in these countries is obtained by subtracting net factor receipts from GNP.

The share of U.S. exports to each trading partner is obtained by dividing nominal bilateral exports to that partner by total nominal U.S. exports. Japanese and German export shares are computed in the same manner. The rest of world (ROW) bilateral exports are the residual exports from those countries other than the United States, Japan, and Germany. Thus, ROW's export share to the United States is the total exports of ROW countries to the United States divided by total ROW exports to the G-3. For the purpose of computing trade shares, ROW includes all countries reported on the IMF Direction of Trade Statistics.

All trade weighted series are geometric averages and use the average bilateral trade shares over the period 1976-1987 as weights. The construction of each of these series is described in the text.

The short-term interest rate is the 3-month Treasury bill rate where available. In France it is the 3-month interbank rate. In Japan it is the 2-month Treasury bill rate.

Where not explicitly available, the monetary base is computed as the sum of all currency outside the central bank plus deposits held by private banks as reserves at the central bank.

In certain countries the labor force is computed as the sum of employment and unemployment. In France the labor force is reported on an annual basis and has been interpolated.

The capital stock series have been constructed by interpolating annual net capital stock series.[5] The primary source is the OECD's Flows and Stocks of Fixed Capital, 1960-1985. Missing components of these series have been approximated using estimates of gross capital stocks from the OECD's Sectorial Database and the ratios of net to gross capital for similar series in other countries as reported in Flows and Stocks of Fixed Capital. Capital stocks after 1985 were extrapolated by cumulating fixed investment less depreciation at the estimated depreciation rate.

Except for Germany and Japan, the outstanding stock of government debt has been computed from a benchmark value by cumulating the public sector deficits (at a quarterly rate) in successive quarters. The benchmark values are net public sector debt stocks at yearend 1982 and were obtained from OECD Economic Studies, No. 7, 1986, pp. 103-153. For Germany and Japan public sector debt series were obtained from national sources.

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5. The net increment to the capital stock over the year was allocated to each quarter in a manner proportional to the measured flow of gross fixed investment in that quarter.

Similarly, the stock of net foreign assets was computed by cumulating the current account balances over time. The benchmark values for these series are yearend 1982 from the IMF's World Economic Outlook, April 1988, pp. 88-90. The current account balance is the sum of nominal net exports and nominal net factor receipts.