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REPMOD: A Smaller Sibling for MULTIMOD

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Abstract

This paper describes a small macroeconomic model based on a representative industrial-country block of MULTIMOD, the IMF's multi-country simulation model. REPMOD is designed to provide a more flexible and accessible tool for analysis by individual country desks than the full version of MULTIMOD. It also allows the construction of model-consistent baseline paths, in addition to conventional shock-minus-control experiments. After discussing the model's general structure and properties, some distinctive aspects are illustrated via simulations that explore the implications of Japan's liquidity trap.

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I. Introduction

The IMF's macroeconomic simulation model, MULTIMOD, has been used extensively to analyze global policy issues since the late 1980s. MULTIMOD possesses a number of properties that make it particularly suitable for such exercises, including behavioral relationships derived from strong theoretical underpinnings, the close attention paid to forward-looking expectations, and the consistency of its international linkages. The use of MULTIMOD, however, has been largely confined to specialists in the IMF's Research Department, and individual country desks at the Fund have had relatively little involvement in its development or application. Several factors may explain why the model has not been more widely employed within the Fund: the simulation software has been viewed as difficult to access and operate; the size and complexity of the full model have deterred casual users; the absence of individual country blocks beyond the G-7 has limited its applicability to other countries; and the somewhat "generic" quality of the model's database and country specification have reduced its relevance to some of the practical issues faced by individual country desks.

This paper presents a representative single-country version of the Mark II version of MULTIMOD—REPMOD—that has been developed to address some of these obstacles. It forsakes the global aspects of MULTIMOD by focusing on an individual country block that embodies the key structural features of the full model. As a single-country model, REPMOD is not suitable for examining the international spillovers of policies. At the same time, such spillover effects are generally not of primary interest in examining the impact on the home country of policy shocks. Furthermore, in practice, the spillover effects of shocks to individual countries tend to be quantitatively small in MULTIMOD for all but the largest countries.

Offsetting the lack of global linkages, the focus on a single country allows a significant reduction in the size and complexity of the model. This has a number of advantages: simulation times and computing resources are sharply reduced; the model can be much more readily understood and modified by nonspecialists; it is more easily "tuned" to individual country circumstances without worrying about the effects on global consistency; and it can be flexibly adapted to countries that are not incorporated in the full version of MULTIMOD without making wholesale revisions to the model.

In the spirit of making the model more accessible and relevant to country desks at the Fund, programs have been created that construct the model database directly from a typical World Economic Outlook (WEO) submission for an industrial country. The data construction and manipulation processes are handled on individual PCs in AREMOS, a software package that is more familiar to many Fund economists than TROLL, the program that has traditionally been used to simulate the model. These features facilitate the use of REPMOD by country desks to assess issues related to baseline forecasts, in addition to its more traditional function as a policy simulation tool.

The paper is structured as follows. The next section describes the main differences in the structure of REPMOD from the Mark II version of MULTIMOD, focusing on the version that has been used extensively for analysis of the Japanese economy. The third section discusses some practical issues regarding how the model is simulated, including the use of a steady-state version of the model and the treatment of "terminal conditions" in forward-looking simulations. The fourth section describes the results of representative fiscal and monetary shocks to illustrate some of the model's general properties. The fifth section presents applications of the Japan-specific version of REPMOD that explore the implications of the "liquidity trap"—i.e. the constraint that nominal interest rates cannot become negative—on the model's simulation properties. The last section provides concluding remarks.

II. DIFFERENCES FROM MULTIMOD MARK II

The structure of REPMOD is based closely on a representative industrial-country block in the Mark II version of MULTIMOD. As MULTIMOD is described in detail in Masson and others (1990), a full review is not provided here. Rather, we focus on the changes made to meet the design objectives of REPMOD. These include:

- introducing a nonlinear Phillips curve that causes the pressure on inflation from changes in aggregate activity to vary depending on the initial level of activity;

- disaggregating the domestic demand deflators in the model to incorporate differences in trend growth rates;

- incorporating a more flexible monetary reaction function that permits inflation or exchange rate targeting;

- introducing a liquidity trap that prevents the level of nominal interest rates from becoming negative;

- changing the trade equations to simplify the treatment of the rest of the world;

- adjusting the expected wealth relationships to permit the construction of a model-consistent baseline path.

This section reviews these changes to the model specification from the original version of MULTIMOD. Other changes are summarized in Appendix I, while a listing of the model equations and mnemonics is presented in Appendix II.

A. Inflation and Price Determination

Aggregate prices in REPMOD are determined, as in MULTIMOD, by a reduced-form Phillips curve. Inflation—measured by growth in the GDP deflator—is driven by both past and expected future inflation, the level of the output gap and changes in the gap, and terms-of-trade shocks. The main innovation in REPMOD is the introduction of a nonlinear specification that causes the effect of demand pressures on inflation to vary according to the initial level of output relative to potential. In particular, a given increase in output exerts more upward pressure on inflation the higher is the initial level of output. Conversely, under conditions when output is well below potential, the effect is attenuated.

The rationale for introducing a nonlinear output-inflation tradeoff and empirical support for the G–7 countries are provided in Laxton and others (1995) and Chadha and others (1992). The nonlinear Phillips curve enhances the richness of the model's simulation properties, as responses to shocks depend on the baseline level of the output gap. For example, in situations where output is initially well below potential, the increase in inflation and interest rates resulting from fiscal stimulus measures would be smaller than when the economy is operating at a high level of capacity. This type of "baseline dependence" is absent from linear models, and is particularly important in situations such as that currently faced by Japan, where output is well below potential. It also provides a rationale for policy measures designed to stabilize fluctuations in output: as discussed in Laxton and others (1995), a nonlinear Phillips curve implies that the longer-run noninflationary *level* of output can be raised if output *volatility* can be reduced by appropriate policy actions.

The specification of the inflation equation in REPMOD is as follows, where the dependent variable, π, is the change in the logarithm of the GDP delator:

$$\pi_t = \gamma\, \pi_{t-1} + (1 - \gamma)\, \pi_{t+1}^{e} + \lambda\, (\pi_t^{d} - \pi_t) + \delta\, press_t + \rho\, \Delta\, press_t\,. \tag{1}$$

As discussed in Chadha and others (1990), current inflation is linearly homogeneous in its backward- and forward-looking components, represented by π_{t-1} and π_{t+1}^{e} respectively, where the latter is the expected rate of inflation in period t+1.[2] The difference between growth in the domestic demand deflator (denoted by π^{d}) and the GDP deflator is included to capture the effect of terms-of-trade shocks, which drive a wedge between final demand and output prices. To the extent that wage bargaining reflects the behavior of final demand prices, shocks to this relative price will tend to put upward pressure on the GDP deflator.

Demand pressures, as represented by the terms in *press* and Δ*press*, are determined by a nonlinear function of the ratio of actual to potential GDP. The nonlinearity is introduced in the form of a rectangular hyperbola:

$$press = \kappa^2 / (\kappa - gap) - \kappa\,, \tag{2}$$

where κ is a parameter that controls the degree of nonlinearity, and gap is the (logarithmic) difference between actual and potential output.[3] As discussed in Laxton and others (1995),

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[2]In simulations, expectations of forward-looking variables are solved to be consistent with the model's future simulated values—in other words, expectations are fully "model consistent." The solution technique is the stacked-time Newton-based method described in Juillard and others (1998), as implemented in Portable Troll version 1.03.

[3]At the limit, setting κ to a very large value yields a roughly linear relationship, while setting κ

(continued...)

this function has the property that inflationary pressures rise without bound as the output gap approaches κ. As a result, κ represents an upper limit for the output gap in the model, as demand shocks will be fully "crowded out" by higher prices as the output gap approaches this level. At the other extreme, the effect of changes in the output gap on inflation approaches zero as the gap becomes increasingly negative.[4]

The choice of parameters in equations (1) and (2) will depend on the specifics of the country under consideration. In general, the more forward-looking are inflationary expectations and the less inertia there is in nominal wage contracts, the greater the weight on the forward-looking component of inflation expectations. The response of inflation to demand pressures depends on labor market institutions and the sensitivity of price markups to market conditions. The effect of shocks to final demand prices on output prices will depend on factors such as how wage contracts are indexed. For the Japan-specific version of REPMOD, the parameters reflect updated estimates based on the results in Laxton and others (1995). The value for γ is 0.6 (implying a somewhat larger weight on the backward- than the forward-looking component of inflation); λ is 0.15; δ is 0.1; ρ is 0.1; and κ is 0.06 (constraining positive output gaps in the model to be less than 6 percent of potential GDP).

With the overall level of prices determined by the Phillips curve, and trade prices determined by domestic and foreign prices, MULTIMOD derives the deflator for domestic demand residually. There is no disaggregation of domestic demand deflators—while real domestic demand is modeled by separate relationships for private consumption, private investment, and government spending, all three components are aggregated into a single good with a unique price. This aggregation has typically not been a drawback in performing simulations on a shock-minus-control basis. It becomes more problematic, however, in dealing with baseline forecasting issues, particularly given the significant trend decline in investment goods prices relative to other prices since the 1970s. This decline is likely to continue into the foreseeable future given advances in computer technology, and has an important impact on the baseline path for real investment in the model.

To capture the effect of such secular price trends in REPMOD, the domestic demand deflator is disaggregated into private consumption, private investment, and government spending. In addition to allowing for differences in trend growth, this approach corresponds more closely to the breakdown in the staff's WEO framework, allowing a closer link between the model specification and WEO projections. Stochastic equations describe the behavior of the deflators for private investment and government spending; the private consumption deflator is then derived residually, as the prices of the three components must be consistent with the overall domestic demand deflator.

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[3](...continued)
to a very small value yields a reverse "L"-shaped function.

[4]A similar nonlinearity has been introduced to the Mark III version of MULTIMOD, as discussed in Laxton and others (1998).

The two stochastic equations are expressed in error-correction form. In particular, growth in each deflator relative to the aggregate domestic demand deflator is regressed on a linear time trend and the lagged relative price:

$$\Delta\,(p_{i,t} - p_t) = \alpha + \beta\,T + \delta\,(p_{i,t-1} - p_{t-1})\,, \tag{3}$$

where p_i is the log of the deflator for each component of demand and p is the aggregate deflator. In the Japan-specific version of REPMOD, these equations are estimated using OLS with annual data from 1975–97. The estimates for the investment deflator are of most relevance: the estimate for β is -0.006, while δ is -0.646. Taken together, these coefficients imply a downward trend in the relative price of investment of about 1 percent per year.[5] Deviations of the price ratio from the underlying trend level decay at an annual rate of about two thirds—i.e., about two thirds of the lagged deviation between the lagged level of the relative price and its underlying trend is closed each year.[6]

The downward trend in the relative price of investment goods raises the baseline growth rate of real investment spending in the model. Under the assumption that the production function is Cobb-Douglas, the downward trend of 1 percent per year in the relative price raises real investment growth by a similar amount. Given a capital share in the aggregate production function of about one third, potential output growth is increased by about ½ percent per year over time due to the declining relative price of investment. This significantly boosts the model's baseline predicted growth path for real output, investment, and capital formation.

B. Monetary Reaction Function and Interest Rates

In the Mark II version of MULTIMOD, the monetary reaction function caused short-term nominal interest rates to adjust in response to deviations in observed money balances from a prespecified target.[7] More recent contributions to the literature on policy rules have shifted the emphasis from monetary targets to either inflation targets, or more eclectic rules that place weights on both inflation and output in the reaction function. The specification in REPMOD has been generalized to allow considerable flexibility in the choice of policy rules within this general class. The general form of the reaction function is as follows:[8]

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[5]The relative price grows in the long run at rate β/δ.

[6]The estimated equation for the government spending deflator implies an upward trend in the relative price of roughly 0.5 percent per year, with a speed of adjustment of about one quarter at an annual frequency.

[7]This monetary targeting rule could, however, be overridden by an exchange-rate targeting mode by placing a high weight on deviations in the exchange rate from a prespecified target.

[8]The Mark III version of MULTIMOD incorporates a similar generalization of the reaction

(continued...)

$$rs_t - \gamma\,\pi_t = \beta\,(\pi_t - \pi_t^*) + \delta\,(\pi_{t+1}^e - \pi_t^*) + \alpha\, gap_t + \lambda\,\Delta\, gap_t$$

$$+ \rho\,(er_t - er_t^*) + \kappa\,(rs_{t-1} - \gamma\,\pi_{t-1})\,, \tag{4}$$

where *rs* is the short-term interest rate, π^* is an assumed target inflation rate, *gap* is the output gap, *er* is the exchange rate (in logs), and er^* is an exchange rate target.[9]

Specific parameter choices yield more restricted versions of this general function. For instance, the well-known Taylor rule (Taylor (1993)) is obtained by setting γ=1, β=0.5, α=0.5, and the other parameters to zero. Exchange rate targeting can be modeled by setting ρ to a large value and the other parameters to zero. For the Japan-specific version of REPMOD, a formulation similar to the Taylor rule is used. The main difference is that κ, the parameter on the lagged interest rate, is set to unity, implying that inflation and output determine the *change* in the real short-term interest rate as opposed to its level. This choice was motivated by evidence that the model was generally more stable with this rule than the original Taylor formulation. It also has the practical advantage that one does not have to solve for the equilibrium (and presumably time-varying) level of the real interest rate in the model, which is represented by a constant term in equation (4) in the original Taylor formulation.[10]

A notable feature of equation (4) is that the response of the short-term interest rate to innovations in the right-hand side variables is independent of the initial *level* of the short-term rate. While this may be appropriate under normal circumstances, it ignores an obvious constraint, specifically that nominal interest rates cannot become negative. As they reach zero, households and firms would choose to hold all of their financial wealth in the form of cash, implying that the supply of loanable funds would vanish.[11] This is an example of what Keynes referred to as the "liquidity trap," referring to a situation in which changes in money balances would have no effect on nominal interest rates. While liquidity traps have not been a common feature of industrial economies,[12] the concept is relevant in the situation currently facing Japan, where short-term rates have fallen virtually to zero.

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[8](...continued)
function.

[9]By convention, the exchange rate is expressed as the bilateral rate versus the U.S. dollar. Because all other bilateral exchange rates versus the dollar are exogenous in REPMOD, exchange rate targeting versus the dollar is equivalent to targeting versus any other exchange rate.

[10]While the assumption of a constant equilibrium real interest rate may be adequate for the analysis of short-term policy issues, it becomes much more tenuous when looking at baseline model solutions over periods of several decades.

[11]We abstract here from possible storage costs of holding cash.

[12]Two exceptions being the United States in the 1930s and Switzerland in the 1970s.

To incorporate this constraint in the model, a function was added that determines the actual short-term interest rate as the maximum of two values: the rate generated by the monetary reaction function, and the lower bound of zero implied by the liquidity trap. In addition, a parameter was included that allows the trap to be turned "on" or "off" in simulations, such that:

$$rs_t = \lambda \max(0, rs_t') + (1-\lambda)\, rs_t', \tag{5}$$

where rs is the actual level of short-term interest rates and rs' is the level generated by the monetary reaction function. When λ=1, the liquidity trap is binding: rs equals rs' as long as the latter is non-negative, but equals zero when rs' assumes negative values. In contrast, when λ=0, the liquidity trap is ignored and rs always equals rs'. The choice between these values for λ, then, allows an analysis of the role played by the liquidity trap in simulations. Generally speaking, the liquidity trap introduces a strong nonlinearity into the model that has important consequences under certain circumstances, as the scope for interest rate movements to buffer negative demand shocks is eliminated when nominal interest rates become zero. The implications for Japan are analyzed in Section IV.

C. Trade Sector

External trade in MULTIMOD is disaggregated into oil, primary commodities, and a "residual" category that includes manufactures and services. The main motivation for separate treatment of oil and commodities is to capture the effects on developing countries of shocks in these markets. This disaggregation is less relevant for the industrial countries, as oil and commodities play no explicit role in their domestic production, consumption, or exports. At the same time, modeling three separate components of imports significantly complicates the trade specification, and imposes data requirements beyond those normally provided in the WEO exercise. To reduce the complexity of the trade sector in REPMOD, then, imports were aggregated into a single commodity. Consistent with the treatment of exports, this is represented by real imports of goods and services on a national income accounts (NIA) basis. The price is the corresponding NIA deflator.

The empirical specification for import volumes is similar to that used for manufactured imports in Mark II. The activity variable is a weighted average of real domestic demand and exports, with the latter capturing the direct import component of domestic exports. Relative price effects are captured by including the aggregate import deflator relative to the domestic demand deflator. The equation is expressed in error-correction form as:

$$\Delta\, im_t = \alpha + \beta\, \Delta\, act_t + \delta\, \Delta\, (p_t^{im} - p_t^{dd}) + \gamma\, (act_{t-1} - im_{t-1}) + \lambda\, (p_{t-1}^{im} - p_{t-1}^{dd}), \tag{6}$$

where im is the log of imports, act is the log of the activity variable, and $p^{im} - p^{dd}$ is the log of the relative price term. For the Japan version of REPMOD, estimation of equation (6) from 1970–97 yielded a short-run elasticity of imports relative to activity (β) of 1.47. The short-run relative price elasticity was small and the sign perverse—as a result, δ was set to zero. The long-run activity elasticity is constrained to unity, with a speed of adjustment (λ) estimated at 0.31. Combined with the parameter on the lagged relative price term of -0.21, the implied long-run relative price elasticity of imports is roughly two thirds. On the whole, the estimated parameters are broadly consistent with other empirical work on Japanese trade flows.[13]

The import price equation models the import deflator as a function of the manufactured export prices of trading partners (aggregated using WEO trade weights), as well as world oil and commodity prices. A time trend is included to capture secular differences in the growth rate of home-country import prices relative to external prices, reflecting, inter alia, differences in commodity composition. The estimated equation is:

$$\Delta p_t^{m} = \alpha + \beta \Delta p_t^{wx} + \gamma \Delta p_t^{woil} + \sigma \Delta p_t^{wcom} +$$

$$\lambda (p_{t-1}^{wx} - p_{t-1}^{m}) + \omega (p_{t-1}^{woil} - p_{t-1}^{m}) + \sigma (p_{t-1}^{wcom} - p_{t-1}^{m}) + \kappa T , \qquad (7)$$

where all variables except the time trend are in logarithms, p^m is the import deflator, p^{wx} the foreign price of manufactures, p^{woil} the world oil price, and p^{wcom} the world commodity price. Estimation using Japanese data over 1970–97 yielded values for β of 1.09 and σ of 0.13, while γ was small and insignificant. Thus, import prices are slightly more that unit elastic with respect to changes in all external prices in the short run, while in the long run, linear homogeneity is imposed. The coefficients on the lagged levels of foreign prices are 0.25, 0.10, and 0.08 on manufactures, oil, and commodity prices respectively. The time trend is significantly positive, with a value of 0.004, reflecting a secular rise in Japanese import prices relative to external prices over the estimation period.

D. Wealth Relationships

Wealth is an important determinant of private spending in MULTIMOD. Total wealth consists of the value of net financial assets, as well as the discounted value of the net earnings streams expected to accrue to capital and labor. The present value of these earnings streams are referred to as "capital wealth" and "human wealth" respectively. In simulations, the expected income streams are constructed to be fully consistent with the model's predictions for future income accruing to capital and labor, similar to the treatment of other forward-looking variables.

This approach proved problematic in constructing a baseline path for REPMOD, however. The problem is that the (unobserved) current values of human and capital wealth depend on (unobserved) expectations of future income. Because the wealth variables cannot be directly observed—unlike other forward-looking variables such as exchange rates and long-term interest rates—a unique historical series for human and capital wealth cannot be constructed independent of the model's predictions for future earnings. This introduces circularity into the construction of the baseline path—historical wealth data are required to estimate the model and project future earnings, but wealth cannot be constructed without first projecting future earnings.

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[13]See Meredith (1993) for a discussion of Japanese trade estimates.

In this respect, the use of REPMOD to construct baseline scenarios raises issues that are not faced in using MULTIMOD, which is simulated exclusively in shock-minus-control mode. In the latter mode, the baseline is exogenously created by a database generation program, and the baseline values of human and capital wealth are then constructed to be consistent with these exogenous data. In other words, because the baseline is exogenous, one does not need to first estimate wealth to construct it.

To deal with this issue in REPMOD, the baseline values of human and capital wealth are constructed using a technique employed in a pre–Mark II version of MULTIMOD (Masson and others (1988)). Rather than using the model predictions for the future paths of income in the wealth definitions, it is assumed that current income will revert to its trend level at an exogenous rate determined by the historical experience. Thus, expected income growth can be modeled as:

$$\Delta y_t^e = \gamma + \lambda (y_t^* - y_t), \tag{8}$$

where γ is the growth rate of trend income (indicated in logs by y^*) and λ is the speed of adjustment of actual to trend income. It can then be shown that "permanent" income (i.e. the annuity value of the future expected income stream) can then be represented by a weighted average of y_t^* and y_t, where the weights depend on λ, γ, and the assumed discount rate on future income streams (δ):

$$y_t^p = ((\lambda + \gamma) / (\delta + \lambda))\, y_t^* + (((\delta - \gamma) / (\delta + \lambda))\, y_t, \tag{9}$$

where y^p is the log of permanent income. Estimation of equation (8) for Japan over 1970–97 yielded a value for λ of 0.28. Combined with a typical annual discount rate on future income in REPMOD of about 0.15, and a real growth rate of about 0.03, expression (9) yields a weight on y^* of about two thirds and on current income of about one third.

After constructing the baseline paths for human and capital wealth using this definition of expected income, fully forward-looking wealth paths can be calculated that are consistent with this baseline, as is done in the full version of MULTIMOD. Alternative policy simulations around the baseline can then be conducted using either the fully forward-looking wealth equations, or the modified "backward-looking" wealth equations that were used to construct the baseline.

III. Simulating REPMOD

This section discusses how the REPMOD database is generated and issues involved in simulating the model. It also describes the construction of a steady-state analogue to the dynamic model, and how the model's "terminal conditions" are determined for forward-looking variables.

A. Database Generation

REPMOD is designed so that almost all of the data are available from a standard industrial-country WEO submission. The only non-WEO variables are the stock of net foreign assets (NFA) and the ratio of the working-age to the total population.[14] For NFA, only a recent historical benchmark is needed, as the model cumulates the current account balance to endogenously project the future NFA path. The demographic ratio, in contrast, is exogenous in the model, and projections are needed to the end of the long-run simulation horizon (typically 2070). For the Japan-specific version of the model, long-run demographic projections produced by the Ministry of Health and Welfare have been used. For other industrial countries, World Bank projections are available that extend well into the next century.

The key external exogenous variables in the model include the levels of activity and prices in trading partners, world oil and commodity prices, and the interest rate on external assets. For these variables, historical data and projections to the end of the WEO's medium-term projection horizon are available from the global assumptions data base.[15] To extrapolate over the model's long-run horizon, growth rates of foreign activity and prices are typically held constant at the levels projected toward the end of the medium term; world oil and commodity prices are held constant in real terms, as is the real interest rate on foreign assets. Of course, different paths can be imposed to construct alternative scenarios, although growth rates should converge over the long run so that the model has a well-defined steady state.

From a policy perspective, the exogenous variables include the target ratios of government spending and debt to GDP, and the target inflation rate of the monetary authorities. For government spending and debt, the baseline ratios are set to equal WEO projection levels through the end of the medium-term horizon, and are then held constant in the long run. The inflation target could be similarly defined to equal the projected inflation path over the medium term. Alternatively, it can be exogenously imposed starting in the first year of the simulation. The latter approach has been taken for Japan, with the baseline target inflation rate assumed to be one percent per year.[16]

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[14]In addition, a benchmark for the share of capital taxes in total taxation is needed. But the model is not particularly sensitive to this value, and a rough estimate will suffice. Average historical data from the OECD have been used for Japan.

[15]The WEO medium-term forecasts generally extend five years beyond the current period.

[16]This approach has been adopted because recent WEO forecasts have projected outright declines in the GDP deflator for Japan. Rather than assuming that deflation was the objective of monetary policy, it is instead supposed that this represents temporary deviations from a longer-run objective of low but non-negative inflation.

The above steps generate a database that contains WEO projection values for the model's endogenous variables to the end of the WEO medium-term projection, and extrapolations of the exogenous variables over the full simulation horizon. At this stage, all add factors in the model's stochastic equations are initialized to zero. REPMOD could simulate a baseline path on the basis of these zero add factors. But such a path would generally exhibit implausible characteristics, particularly in the initial years of the simulation. This is common using macro models in the absence of judgmental adjustments—even those specifically designed for short-term forecasting.

To generate a more plausible baseline path, judgmental add factors are applied to several of the model's stochastic equations. These add factors are calculated such that each endogenous variable would equal its WEO projection value if the right-hand-side variables were also identical to WEO values. In other words, the equations are "tuned" to replicate the WEO medium-term projection values. Financial variables in the model, however, are treated differently. Specifically, the REPMOD baseline reflects fully model-consistent, forward-looking paths for financial variables, in contrast to the mechanical assumptions underlying the WEO projections.[17] This approach generates baseline values for interest rates and the exchange rate that differ from those in the WEO, with implications for the baseline values of the other endogenous variables.

B. Steady-State Model

The programs that generate the conventional dynamic version of REPMOD have also been designed to create a steady-state version of the model. This steady-state analogue to the dynamic model was originally developed to tie down the terminal conditions needed to solve for the model's forward-looking variables over finite horizons.[18] Although the steady-state model is no longer needed for this purpose (as discussed below), it plays an important role in initializing the long-run data required to construct the baseline path.[19] It is also a useful analytical tool in its own right, as shocks to the steady-state model can yield powerful insights into the properties of the dynamic model.

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[17]See Box 2 in the October 1997 World Economic Outlook for a discussion of these issues in the context of the projected path for the Japanese yen.

[18]The development of the original steady-state version of MULTIMOD Mark II is discussed in Meredith (1991).

[19]As discussed above, values for the endogenous variables from the WEO projections extend only to the end of the medium-term horizon. The TROLL simulator, however, requires initial values for these variables to the end of the model's long-run horizon. The steady-state model is used to generate these initial values, which are then overwritten by values generated by the dynamic model.

Conceptually, a steady state is defined when all of the model's real variables are growing at the same constant rate, and prices are also rising at a constant rate.[20] As discussed above, the baseline paths for the model's exogenous variables—and the model equations themselves—are constructed such that these conditions will hold in REPMOD over the long run. In other words, the equation specification and database ensure that the dynamic model converges to a steady-state solution.

Constructing the steady-state model involves replacing lags and leads of variables by current values adjusted for the associated steady-state growth rates. Consider, for example, the following illustrative dynamic equation for endogenous variable x, where z is an exogenous forcing variable (both are expressed in logs):

$$x_t = (1-\beta-\alpha)\, z_t + \beta\, x_{t-1} + \alpha\, x_{t+1} \;. \tag{10}$$

In the steady state, x will grow at the same rate as z, given the linear homogeneity imposed in the parameter values. As the variables are in logs, this growth rate corresponds to $z_t - z_{t-1}$, which we call λ. Then the lags and leads on x on the right-hand side of equation (10) can be substituted out in the steady state as follows:

$$x_t^{ss} = (1-\beta-\alpha)\, z_t^{ss} + \beta\, (x_t^{ss} + \lambda) + \alpha\, (x_t^{ss} - \lambda)\,, \tag{11}$$

implying:

$$x_t^{ss} = z_t^{ss} + (\beta - \alpha)\, \lambda \,/\, (1 - \beta - \alpha)\,. \tag{12}$$

Thus, the steady-state model can be expressed exclusively in terms of contemporaneous values of endogenous and exogenous variables and their steady-state growth rates. This model is static, and can be simulated on a period-by-period basis without reference to historical data values or future expectations.

As an example of the properties of the steady-state model, consider the effects of a permanent shock to the "risk premium" on a country's domestic assets. Mechanically, a risk premium of this type is introduced as an additional term in the uncovered interest parity condition, which otherwise equates the expected depreciation of the home country exchange rate to the differential between domestic and foreign interest rates. The presence of such a risk premium drives a wedge between the expected return on domestic assets and that on foreign assets, when both returns are expressed in a common currency. The following tabulation compares the effects of a permanent increase of 100 basis points in this risk premium on a few key variables in the dynamic version and the steady-state version of the model (the effects are expressed in percent difference, shock minus control, unless otherwise indicated):

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[20]Prices expressed in different currencies, however, can grow at different rates as long as nominal exchange rate movements are offsetting—i.e., real exchange rates are constant in the steady state.

	Dynamic model (first-year effect)	Steady-state model
Real GDP	0.0	-0.7
GDP deflator	0.2	1.1
Real domestic absorption	-0.4	0.8
Real exchange rate	-7.7	2.9
Short-term interest rate (percentage point)	0.2	1.0
Net foreign assets (percent of GDP)	0.2	16.5

On impact, an increase of 100 basis points in the risk premium in the dynamic model causes the short-term interest rate to rise by 20 basis points, as output and prices are little affected in the short run. Because the risk-adjusted yield on domestic assets falls, the real exchange rate depreciates by 7.7 percent. Real domestic absorption declines as a result of the rise in interest rates, but the effect on overall GDP is offset by higher real net exports due to exchange rate depreciation, leaving the level of GDP unchanged.

The long-run effects of this shock are quite different from the short-run effects, however, as indicated by the steady-state responses. Over time, higher trade surpluses cause net foreign assets to rise such that the ratio of NFA to GDP increases by 16½ percentage points in the steady state. The associated increase in wealth raises domestic spending and thus real absorption, even though interest rates end up 1 percentage point higher in the steady state (i.e., there is full pass through of the risk premium shock to interest rates). The real exchange rate actually *appreciates* in the steady state, as higher net foreign assets yield greater net foreign investment income, allowing a lower trade balance. Real GDP falls, as higher interest rates crowd out domestic capital formation, but real incomes are higher due to the increase in foreign investment income and terms-of-trade gains resulting from real exchange rate appreciation.

This shock, then, illustrates how the short-run and long-run responses of the model to the same shock can be quite different. In particular, the model's short-run responses tend to be dominated by cyclical dynamics due to stickiness in price adjustment dynamics, and by the fact that flows as opposed to stocks adjust on impact to shocks. In the steady state, in contrast, prices are fully flexible, implying that output is always equal to potential; in addition, dynamic flow adjustments to shocks have fully played out, and the solution reflects a full stock-flow equilibrium.

C. Terminal Conditions

Solution paths for rational expectations models such as REPMOD require that current expectations of future variables be consistent with the model's prediction of their future values.[21] Consider, for instance, the uncovered interest parity condition for the exchange rate:

$$e_t = e_{t+1}^e - (i_t - i_t^*) - \eta_t , \tag{13}$$

[21]See Fair and Taylor (1983) for a discussion of these issues.

where e_t is the spot exchange rate (defined as the price of foreign currency), e_{t+1}^e is the expected exchange rate in the next period, i_t - i_t* is the difference between domestic and foreign interest rates, and η_t is a risk premium on domestic assets. The simulation algorithm generates a path for the exchange rate such that equation (13) holds for all periods within the simulation horizon, where e_{t+1}^e is the model's prediction for the future exchange rate. At the end of this horizon, however, the simulator needs information that the model itself cannot directly provide—specifically, an expected value for the exchange rate in the first period beyond the simulation horizon. If the simulation ends in 2070, for instance, the simulator needs a value for the exchange rate in 2071 to solve for the exchange rate path up to 2070. For the solution path in the last years of the simulation to be meaningful, it is also important that this "terminal" value be broadly consistent with what the model would have predicted had the simulation been performed over a longer horizon.

The question, then, is how to choose these terminal values for the baseline path, and how to adjust them when shocks are applied that change the solution path. With MULTIMOD, the issue of how to set the baseline terminal conditions is not relevant, as the baseline is determined exogenously. The issue is important for REPMOD, however, as the baseline is generated endogenously using the model. Inappropriate choices of terminal conditions can distort the solution path in the final years of baseline simulations. As mentioned above, one approach to deriving the terminal conditions would be to use the steady-state model. Experience with this approach, however, has indicated that the *levels* of some key variables (including the exchange rate) do not converge to their steady-state values except over very long horizons. The *growth rates* of these variables, in contrast, converge much more quickly to rates close to steady-state rates.

To exploit this faster convergence of growth rates, the model was written so that future expectations are expressed in terms of growth rates rather than levels. Taking equation (13) as an example, the uncovered interest parity condition can be rewritten as:

$$edot_{t+1}^e = (i_t - i_t^*) - \eta_t , \qquad (14)$$

where:

$$edot_t = e_t - e_{t-1} . \qquad (15)$$

Transforming all of the forward-looking equations in this way and adding identities similar to equation (15) for the associated growth rates means that the terminal conditions can be defined in terms of growth rates rather than levels. Setting these terminal growth rates to steady-state values generally results in model simulation paths that exhibit plausible and smooth properties toward the end of the simulation horizon that are little affected by variations in the length of this horizon.[22]

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[22]With the terminal conditions set in terms of growth rates, the nominal anchor in the model is provided by the target inflation rate in the monetary reaction function. The simulated path for inflation that is consistent with this reaction function, combined with the historical starting

(continued...)

IV. Effects of Fiscal and Monetary Shocks

To illustrate some of the properties of REPMOD, this section presents shock-minus-control simulation results for two experiments. The first is a fiscal shock, defined as a permanent increase of 5 percent in the ratio of government spending to potential GDP. This is identical to the shock performed on the Mark II version of MULTIMOD in Masson and others (1990). The second is a shock to monetary policy, defined as a permanent increase in the target inflation rate of 2 percentage points per year. This differs from the shock performed on Mark II (specifically, a 10 percent increase in the target level of the money supply) because the respecification of the REPMOD monetary reaction function lends itself more naturally to inflation than to money-level targeting.

In both cases, the shocks are run with the liquidity trap turned off. This approach was taken to more clearly illustrate the general properties of the model, in the absence of the strong nonlinearity introduced by the liquidity trap. In general, the role of the liquidity trap is highly dependent on the baseline path for interest rates, which will differ across countries and time periods, and in current circumstances is likely to only be directly relevant for Japan. Section V below discusses the implications for Japan of the liquidity trap.

A. Government Spending Shock

Table 1 presents shock-minus-control results for the government spending shock starting in 1998. Real GDP rises by about 5 percent on impact, implying a multiplier effect of permanent government spending shocks of unity. The stimulative effect on the level of GDP dies out after three years, however, and, over the longer run, GDP is reduced by about 3 percent. This decline reflects crowding out of the private capital stock, as higher public spending leads to higher taxes over time, reducing investment incentives.[23] The short-term interest rate rises by 300 basis points on impact, as higher output and inflation lead to immediate monetary tightening, although the increase in long-term interest rates is less pronounced. Higher domestic interest rates push up the real exchange rate by 12 percent on impact, underscoring the large, front-loaded movements that can occur in financial variables in the face of long-lived shocks. The current account deteriorates, but by only about one third of the short-run increase in the fiscal deficit, as public-sector dissaving in partially offset by higher private-sector saving.

The short-run government spending multiplier in REPMOD of unity exceeds the value of about two thirds generated by the Mark II version of MULTIMOD. This difference is due to several factors: household consumption is more sensitive to current disposable income in REPMOD; expected increases in future taxes cause a smaller reduction in current wealth

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[22](...continued)
point for the price level, then ties down the steady-state price level.

[23]The fiscal reaction function in the model causes taxes to rise over time to prevent an explosive rise in the ratio of public debt to GDP.

given a higher discount rate on future after-tax income; and the effects of higher interest rates on spending are smaller in REPMOD than in Mark II, so there is less financial crowding out of fiscal shocks. Short-term interest rates also respond much more quickly in REPMOD given the Taylor-type inflation targeting rule, whereas interest rates in Mark II only increased gradually over time as the money stock rose above its target level.

B. Target Inflation Shock

Table 2 presents the simulation results for a 2 percentage point increase in the target inflation rate. Actual inflation only increases by 0.6 percentage points in the first year, reflecting stickiness in the inflation adjustment process. Short-term nominal interest rates initially decline given that inflation is below the new, higher, target level, and real interest rates fall even more sharply as lower nominal rates are reinforces by rising inflation. Lower interest rates, in turn, cause a sharp depreciation of the real exchange rate. The combined effect of lower real interest rates and a weaker exchange rate cause a surge in output in the first years of the shock.

Inflation temporarily overshoots its target level after 4–5 years, but eventually converges to its new target level. Nominal interest rates also stabilize at about 2 percentage points above control, consistent with real interest rates returning close to their baseline levels. Indeed, while the short-run effects of raising the inflation target are highly nonneutral in terms of real variables, in the longer run this monetary shock has little effect on the real quantities, leaving the model's "real" equilibrium essentially unchanged.

It should be noted that the results of this shock depend on the choice of the baseline path for the output gap. This is because, with a nonlinear Phillips curve, the feedback effect on inflation of the initial boost in output depends on the initial level of the output gap. The results shown here are based on the baseline path for the output gap for Japan, where actual output is well below potential and thus inflation is less sensitive to output fluctuations than would otherwise be the case. Alternative simulations in which the initial level of output was set equal to potential indicated that the initial rise in output would only be about one half as large as shown in Table 2, illustrating the important role that the nonlinearity in the Phillips curve can play in influencing the effects of policy actions.

V. Applications to Japan

This section discusses some applications of REPMOD to issues currently facing the Japanese economy. The simulations have been designed to illustrate the model's distinctive features, in particular the role of the liquidity trap.[24] In Japan, nominal short-term interest rates are already virtually zero, implying that the liquidity trap is a binding constraint on policies. The simulations address the following questions: How does the lower bound of zero on nominal interest rates affect the model-generated paths for key variables? What role do

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[24]The implications of Japan's liquidity trap are examined in a more stylized framework by Krugman (1998).

different longer-term inflationary expectations play in affecting the simulation paths? How do aggregate demand shocks affect the economy in the face of a liquidity trap?

A. Impact of the Liquidity Trap

The first exercise illustrates the impact of the liquidity trap on the baseline projection generated by REPMOD. For this purpose, two simulations are performed. In the first, the liquidity trap is binding, and thus nominal interest rates are prevented from becoming negative regardless of the projected paths for output and inflation. In the second, we assume that the liquidity trap is not operative, and thus short-term interest rates follow the path generated by the monetary reaction function without a lower bound of zero being imposed.

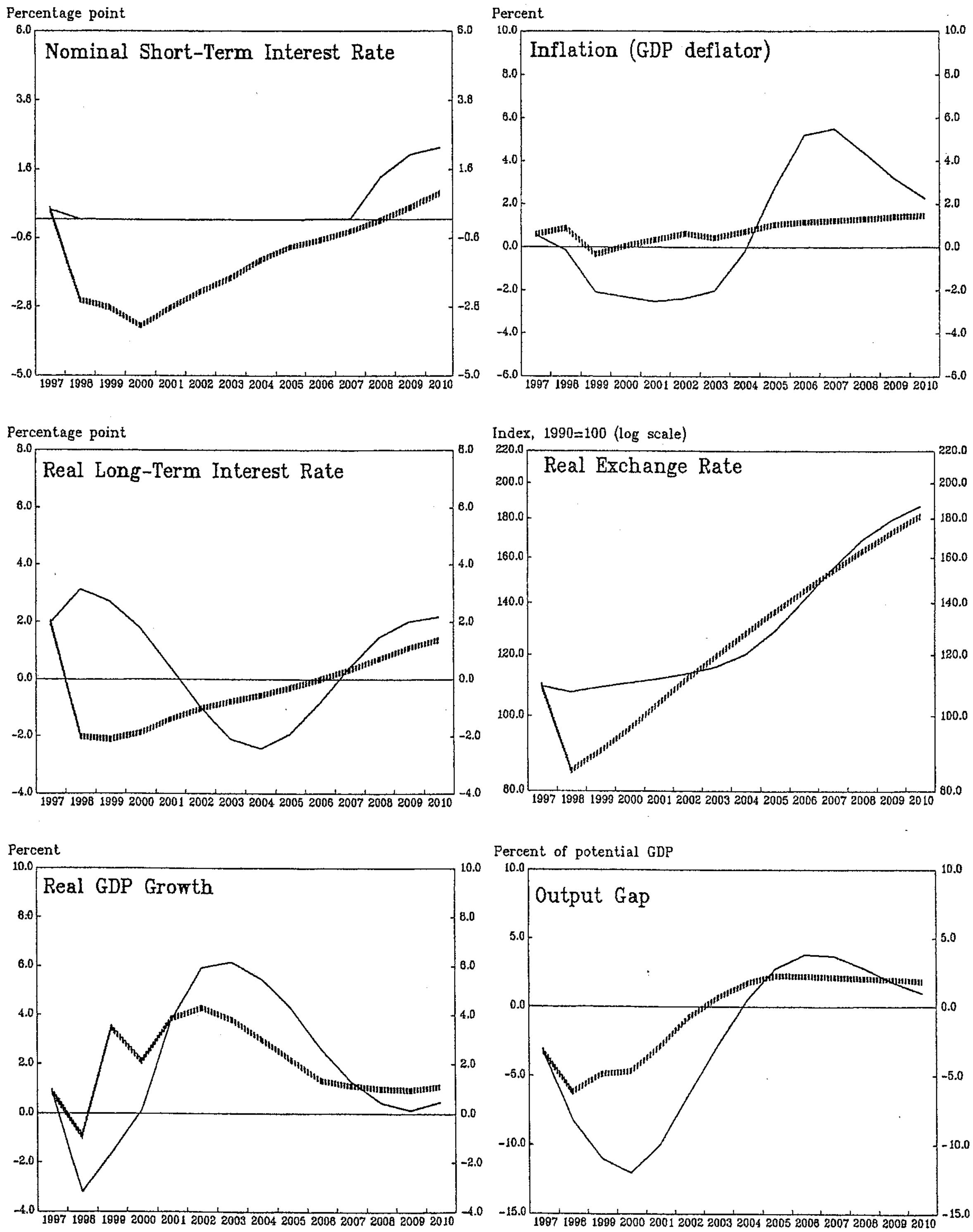
The alternative projections for some key variables are shown in Figure 1 under these two assumptions (both simulations start in 1998). The differences in the paths for the short-term nominal interest rate are particularly striking. In the absence of a liquidity trap, the interest rate would fall sharply in the initial years of the simulation, as the monetary reaction function generates a sustained policy easing given the large output gap. The real long-term interest rate would also quickly turn negative as a result of this monetary easing, and the real exchange rate would depreciate significantly at the start of the simulation. Negative real interest rates and exchange rate depreciation would boost aggregate demand, causing output growth to turn positive in 1999 following a year of negative growth in 1998.

When the liquidity trap is operative, however, the nominal short-term interest rate quickly hits the floor of zero and cannot decline further, notwithstanding weaker activity than in the "no-trap" scenario. With the large output gap pulling down prices and inflation turning significantly negative in the early years of the simulation, the real long-term interest rate is forced up, in contrast to the decline observed in the unconstrained scenario. Higher real interest rates, in turn, result in a stronger real exchange rate, exacerbating the contractionary effect on activity. In the event, output stagnates for an extended period before a recovery eventually materializes.

These dynamics illustrate the risk of an economy falling into a "deflationary spiral" in the face of a liquidity trap. To the extent that output declines pull down inflation and thus raise real interest rates, there is a tendency for demand to contract further, adding to the weakness in output in a self-reinforcing manner. Indeed, it is possible to construct scenarios with REPMOD in which precisely this type of feedback results in model instability and failure of the simulations. Why is this instability not evident in the liquidity-trap scenario shown here? Essentially because the model has three stabilizing factors that reduce the likelihood of deflationary spirals. The first is that private-sector expectations of the longer-run inflationary objectives of the monetary authorities are tied down—by assumption—to a low but positive rate (in these scenarios, one percent per year). So the temporary period of deflation observed in the early years of the simulation does not lead to expectations of permanent deflation. The second factor is the nonlinearity in the Phillips curve, which implies that deflationary pressures are not as intense when output falls below potential as would be the case with a linear relationship. The third factor is that, over time, deflation reduces the real exchange rate which

Figure 1
Japan: Alternative Baseline Scenarios, 1998-2010

——— Baseline with liquidity trap.
▪▪▪▪▪▪▪ Baseline without liquidity trap.



in turn boosts aggregate demand, offsetting the impact of higher real interest rates.[25] Notwithstanding these stabilizing factors, the model is unstable under the liquidity trap when expectations of deflation become sufficiently pronounced. In practice, this materializes in REPMOD when agents expect permanent deflation of 2 percent or more per year.

B. Alternative Long-Run Inflation Targets

The second set of simulations illustrates the role played in the model by the expected inflation objective of the monetary authorities. The monetary reaction function causes interest rates to respond to deviations in inflation from an exogenous target path, where the latter is assumed to be expected with certainty by all agents. Expectations of this target path are not affected by the short-run behavior of inflation, and thus it provides a constant anchor for longer-term inflation expectations. Given uncertainty, however, about the appropriate value to assume for the expected inflation objective, it is interesting to explore the implications of the model of alternative choices.[26]

Figure 2 compares simulations based on a zero percent expected inflation target and a two percent target with the baseline assumption of a one percent target. In all three cases, the liquidity trap is binding in the initial years of the simulation, implying that nominal short-term interest rates are identically equal to zero. The inflation paths are quite different, however, with the zero percent target yielding much stronger initial deflation than the original baseline, and the two percent target generating only mild and short-lived deflation. Consequently, the real long-term interest rate is much higher in the zero percent scenario, and the real exchange rate rises sharply in 1998. With the two percent target assumption, in contrast, the real interest rate declines steadily and the real exchange rate initially falls. These differences are reflected in the output paths, with higher inflation targets being associated with progressively smaller output declines.

It is apparent, then, that raising expectations about the authorities' longer-run inflation objective can have beneficial consequences from a macroeconomic perspective in the face of a liquidity trap. The question of what actions can be taken to influence inflation expectations, however, is more problematic. In the absence of a liquidity trap, policymakers would normally lower interest rates to signal an increase in the inflation objective—lower interest rates would be expansionary, and demand pressures would push up inflation to the new target. (Nominal interest rates would, of course, rise in the new equilibrium relative to the baseline.) There is no scope for lowering nominal interest rates in the face of the liquidity trap, however, so recourse would be needed to less direct policy actions. Alternatives might include explicit announcement of a positive target, or actions to expand the central bank's balance sheet to signal a more accommodative policy stance. But the efficacy of these alternatives is unclear,

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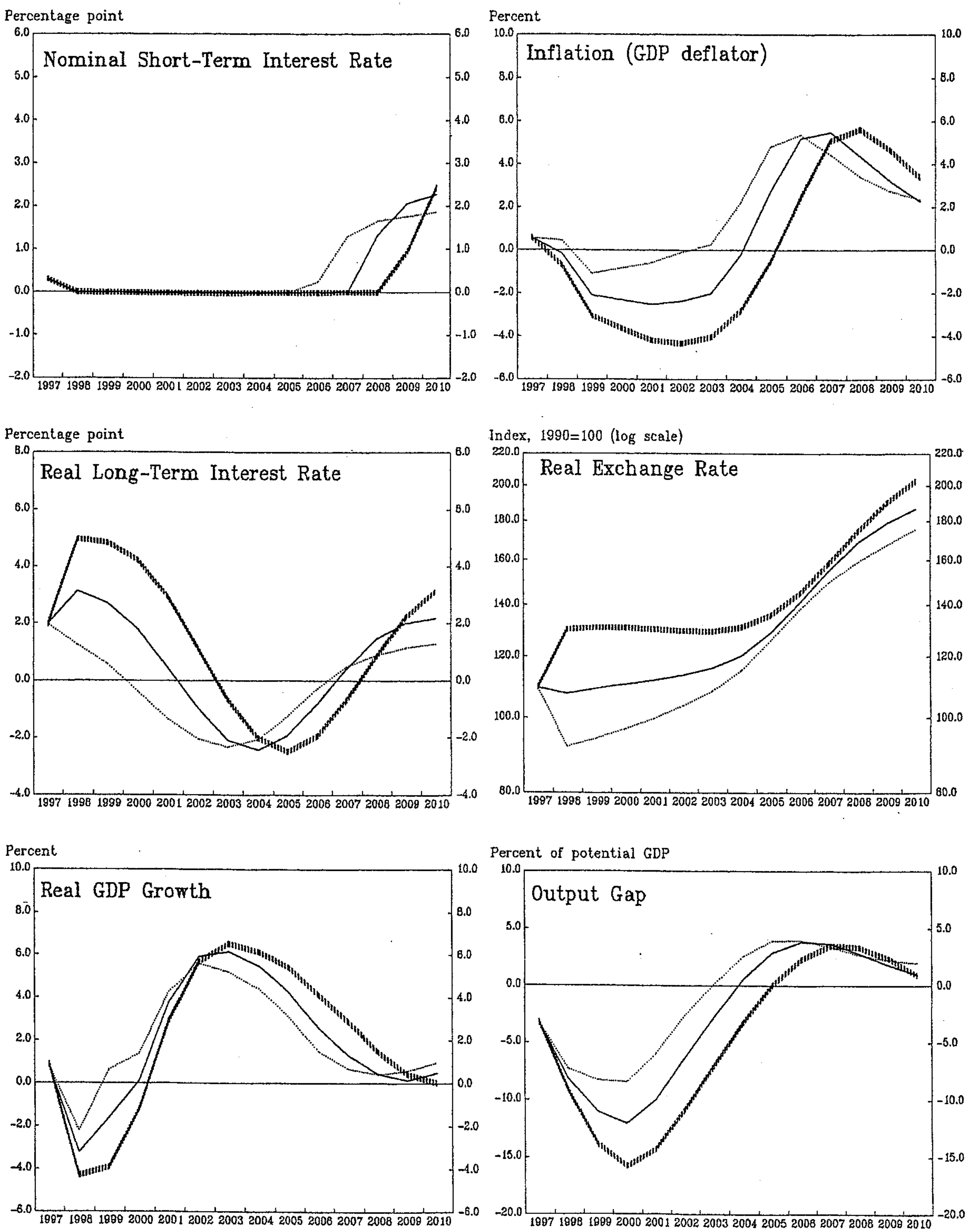
[25]The effect of a lower real exchange rate is only felt with a lag because the *level* of prices determines the real exchange rate, while the *rate of change* of prices determines the real interest rate.

[26]Similar scenarios are presented in the IMF's World Economic Outlook (1998).

Figure 2
Alternative Long-Run Inflation Expectations, 1998-2010

Scenario 1: one percent long-term inflation target.
Scenario 2: zero percent long-term inflation target.
Scenario 3: two percent long-term inflation target.



and either approach could have negative side effects by raising uncertainty about the longer-run course of policies. These options, though, could become more attractive in situations where there were clear signs that deflationary expectations were becoming entrenched.

C. Aggregate Demand Shocks

In the absence of a liquidity trap, the impact of shocks to aggregate demand tends to be buffered by changes in financial variables. For instance, in the case of a negative demand shock, the direct effect on output will be partially offset by lower interest rates and exchange rate depreciation. These financial effects moderate the output decline and, more generally, stabilize the cyclical behavior of the economy. In line with this reasoning, it is common to suppose that, on the basis of economic "fundamentals," a weakening in economic activity should be associated with declines in real interest rates and exchange rate depreciation.

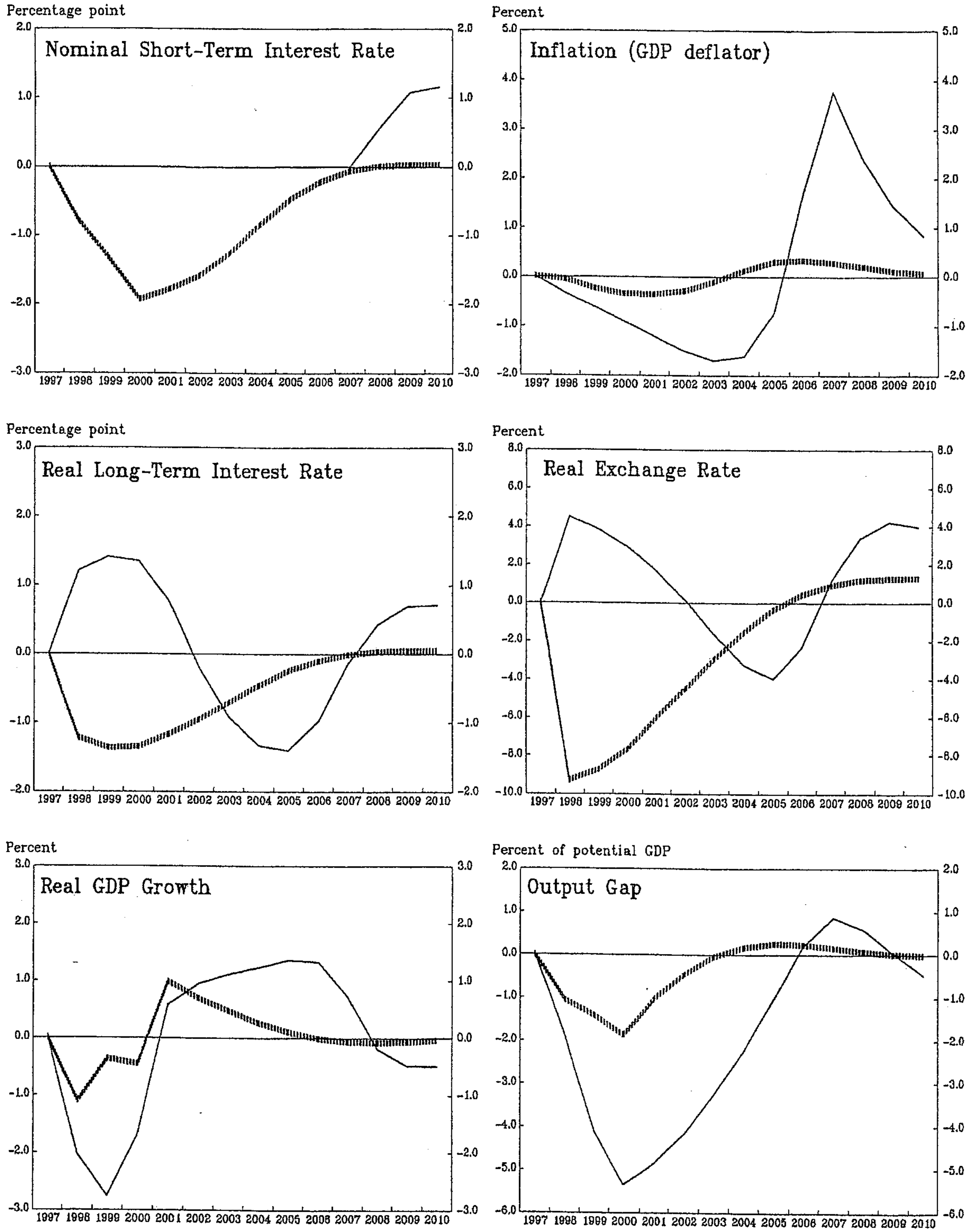
In the presence of a liquidity trap, this presumption no longer holds. With no scope for nominal interest rates to fall in the face of weak activity, the decline in inflation that results from weaker output actually causes real interest rates to rise. The real exchange rate will also move perversely compared with the conventional analysis, as lower activity will *increase* the relative attractiveness of holding domestic assets. This point can be seen by observing that the expected domestic yield, expressed in foreign currency, equals the domestic interest rate plus the expected appreciation of the exchange rate. Under a liquidity trap, nominal interest rates do not decline when activity weakens. But downward pressure on prices increases domestic competitiveness over time, causing the nominal exchange rate to appreciate at a faster pace over the longer run than if there had not been a negative demand shock.

These points are illustrated in Figure 3, which compares the simulation results of a temporary negative shock to private consumption spending both with and without the liquidity trap. Unlike the earlier simulations, the results here are presented in terms of the deviations of simulation values from the baseline paths shown in Figure 1. Without a liquidity trap, interest rates (both nominal and real) decline sharply in the face of a contractionary demand shock. The real exchange rate falls by almost 10 percent on impact, reflecting the lower yield on domestic assets. Both effects tend to cushion the effect on real output. When the liquidity trap is binding, in contrast, nominal interest rates remain unchanged in the face of the contractionary shock. Inflation falls, however, pushing up real interest rates and causing the real exchange rate to appreciate. The initial decline in output is amplified by these changes, and the resulting output gap is far larger than when the trap is not operative.

These simulations provide an example of how conventional economic logic may be misleading in the presence of unconventional economic phenomenon. Market participants, for example, have routinely predicted that deepening recession in Japan should cause the yen to depreciate sharply based on economic fundamentals. The above simulations, however, indicate that conventional fundamentals—the relative yield on domestic versus foreign assets, adjusted for expected future exchange rate movements—can move perversely in the face of a liquidity trap, justifying a stronger rather than a weaker yen.

Figure 3
Japan: Effects of a Negative Demand Shock, 1998-2010
(Deviation, shock minus baseline)

——— Liquidity trap binding
▪▪▪▪▪▪▪ No liquidity trap



VI. CONCLUDING REMARKS

This paper has discussed the structure and properties of REPMOD, a single-country version of the IMF's multi-country macroeconomic simulation model. While the philosophy underlying the structure of this smaller model remains the same as that of the larger model, its reduced size and more user-friendly operating environment have been designed to make it more accessible to individual country desks, and more easily adapted to country circumstances. In addition, strong linkages to the World Economic Outlook forecasting process should enhance its relevance to the analysis of ongoing policy issues.

After illustrating the model's standard properties via representative fiscal and monetary shocks, some specific examples are provided of its behavior in the context of Japan's liquidity trap. This constraint implies that nominal interest rates cannot become negative, which has important implications for both the baseline model solution and its response to aggregate demand shocks. Changes in longer-term inflation expectations can have important consequences for activity under these circumstances, but it is less clear what actions can be taken to influence such expectations when there is no scope for further reductions in nominal interest rates.

While the use of REPMOD has thus far been largely confined to the analysis of Japan-specific issues, it is hoped that making it more widely available to IMF staff will encourage the use of macroeconomic models to analyze medium-term forecasting and policy simulation issues. Of course, it remains the case the global implications of policy shocks and international feedback effects on the domestic economy can only be addressed in the context of a complete global model such as MULTIMOD.

Table 1: Effects of Permanent Increase in Japanese Government Spending of 5 Percent of GDP
(Percent deviation, shock minus control, unless otherwise indicated)

	1998	1999	2000	2001	2002	2003	2004	2005	2010	2025	2050	2070
Real GDP	5.1	2.6	0.9	-0.2	-1.0	-1.4	-1.6	-1.7	-1.9	-2.8	-2.9	-2.9
Output gap (% of potential)	4.8	2.6	1.3	0.4	-0.2	-0.4	-0.4	-0.3	0.1	-0.0	0.0	0.0
Potential output	-0.1	-0.2	-0.4	-0.6	-0.8	-1.0	-1.2	-1.4	-2.0	-2.8	-2.9	-2.9
Real GNP	5.0	2.2	0.7	-0.5	-1.2	-1.6	-1.7	-1.8	-2.1	-3.0	-3.0	-3.1
Real disposable income	5.5	1.0	-2.2	-4.7	-6.4	-7.5	-8.2	-8.5	-8.5	-8.4	-8.4	-8.5
Real absorption	6.8	4.1	2.3	0.9	-0.1	-0.6	-1.0	-1.1	-1.3	-2.2	-2.6	-2.6
Consumption	2.7	-0.6	-2.8	-4.3	-5.3	-5.8	-6.1	-6.1	-5.8	-6.8	-7.1	-7.1
Investment	-1.6	-4.6	-6.2	-7.2	-7.7	-7.9	-8.0	-8.1	-8.9	-8.5	-8.4	-8.6
Government spending	31.0	30.1	30.5	30.3	30.1	29.8	29.5	29.2	28.6	27.6	27.2	27.2
Real exports	-3.4	-5.0	-5.5	-5.4	-5.0	-4.5	-4.0	-3.6	-4.0	-3.8	-2.7	-2.8
Real imports	9.4	6.9	5.1	3.5	2.3	1.5	0.9	0.5	0.4	-0.6	-1.3	-1.3
Total real wealth	-3.7	-4.4	-4.9	-5.2	-5.4	-5.6	-5.7	-5.8	-6.7	-8.2	-8.5	-8.5
Human wealth	-4.7	-5.8	-6.6	-7.1	-7.5	-7.7	-7.9	-8.0	-8.3	-8.4	-8.5	-8.6
Capital wealth	-2.9	-3.7	-4.3	-4.9	-5.3	-5.6	-5.8	-6.0	-7.3	-8.3	-8.4	-8.5
Real capital stock	-0.2	-0.6	-1.2	-1.8	-2.4	-3.0	-3.6	-4.1	-5.9	-8.1	-8.4	-8.5
Net foreign assets (% GDP)	-5.9	-5.0	-4.5	-3.9	-3.4	-3.1	-2.9	-2.8	-3.0	-3.9	-4.2	-5.0
GDP deflator	0.5	1.1	1.4	1.7	1.6	1.4	0.9	0.5	0.4	0.6	0.5	0.6
Absorption deflator	-0.2	0.4	0.8	1.1	1.1	0.9	0.5	0.1	-0.2	0.0	0.1	0.2
Export deflator	-4.4	-2.3	-0.7	0.4	1.1	1.4	1.2	0.8	-0.0	0.8	0.5	0.7
Import deflator	-10.3	-7.5	-5.4	-3.6	-2.4	-1.6	-1.4	-1.7	-3.4	-2.1	-1.6	-1.5
Short-term interest rate (% pt.)	3.0	2.3	1.8	1.3	0.7	0.2	-0.2	-0.5	0.0	0.1	-0.0	0.1
Real S-T rate (% pt)	2.4	1.9	1.5	1.2	0.9	0.6	0.2	-0.2	-0.1	0.1	-0.0	0.1
Long-term interest rate (% pt.)	1.8	1.3	0.8	0.3	-0.0	-0.3	-0.4	-0.3	0.1	0.1	-0.0	0.0
Real L-T rate (% pt.)	1.6	1.2	0.9	0.6	0.2	-0.0	-0.2	-0.3	0.0	0.1	-0.0	0.0
Exchange rate (¥/$)	-10.3	-7.5	-5.4	-3.6	-2.4	-1.6	-1.4	-1.7	-3.4	-2.1	-1.6	-1.5
Real effective exchange rate	12.1	9.3	7.2	5.5	4.1	3.1	2.4	2.2	3.9	2.8	2.2	2.1
Primary revenues/GDP	1.1	2.1	3.1	3.9	4.5	5.0	5.3	5.5	5.7	5.1	5.0	5.0
Primary spending/GDP	4.2	4.6	4.9	5.1	5.1	5.0	5.0	4.9	4.9	5.0	5.0	5.0
Net interest payments/GDP	-0.1	0.6	0.7	0.8	0.6	0.3	0.1	-0.0	0.1	0.0	-0.0	0.0
Net debt/GDP	1.8	5.5	8.4	10.5	11.5	11.8	11.6	10.9	5.8	-0.1	-0.2	0.0
Government balance/GDP	-3.1	-3.1	-2.6	-2.0	-1.2	-0.4	0.2	0.6	0.8	0.1	-0.0	0.0
Current account/GDP	-0.9	-1.1	-0.9	-0.7	-0.5	-0.4	-0.3	-0.3	-0.2	-0.2	-0.1	-0.2
Trade balance/GDP	-0.8	-0.8	-0.7	-0.5	-0.4	-0.3	-0.2	-0.1	-0.1	-0.0	0.0	0.0
Real exports/GDP	-1.1	-1.0	-0.9	-0.7	-0.6	-0.4	-0.3	-0.3	-0.3	-0.2	0.0	0.0
Real imports/GDP	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Private investment/GDP	-1.4	-1.4	-1.5	-1.5	-1.4	-1.4	-1.4	-1.4	-1.3	-1.0	-0.8	-0.8
Consumption/GDP	-2.0	-2.4	-2.8	-3.1	-3.3	-3.4	-3.4	-3.4	-3.5	-4.0	-4.3	-4.2
Government spending/GDP	4.2	4.6	4.9	5.1	5.1	5.0	5.0	4.9	4.9	5.0	5.0	5.0

Table 2: Effects of Permanent Increase in Japanese Inflation Target of 2 Percentage Points Per Year
(Percent deviation, shock minus control, unless otherwise indicated)

	1998	1999	2000	2001	2002	2003	2004	2005	2010	2025	2050	2070
Real GDP	0.5	1.8	2.2	2.2	1.9	1.3	0.8	0.3	-0.0	0.0	0.1	0.1
Output gap (% of potential)	0.5	1.6	1.9	1.9	1.5	1.0	0.5	0.0	-0.1	0.0	0.0	0.0
Potential output	0.0	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.1	-0.0	0.1	0.1
Real GNP	0.5	1.9	2.3	2.2	1.8	1.3	0.8	0.3	0.1	0.2	0.3	0.3
Real disposable income	0.2	2.0	2.9	3.1	2.9	2.4	1.6	0.8	-0.3	0.2	0.7	0.7
Real absorption	0.2	1.2	1.6	1.6	1.3	0.8	0.3	-0.2	-0.7	-0.3	0.3	0.4
Consumption	0.1	1.2	1.6	1.7	1.4	0.9	0.3	-0.3	-0.9	-0.3	0.3	0.5
Investment	1.0	2.7	2.9	2.7	2.0	1.2	0.4	-0.1	-0.3	-0.1	0.4	0.1
Government spending	-0.5	-0.3	-0.2	-0.1	-0.0	0.0	0.0	-0.0	-0.4	-0.2	0.2	0.3
Real exports	2.8	4.3	4.7	4.3	3.6	2.9	2.3	2.1	2.9	1.1	-0.3	-0.4
Real imports	0.5	0.0	-0.6	-1.0	-1.3	-1.5	-1.6	-1.7	-1.9	-0.6	0.5	0.6
Total real wealth	1.3	1.3	1.0	0.6	0.2	-0.3	-0.6	-0.8	-0.6	-0.2	0.4	0.5
Human wealth	0.8	0.8	0.7	0.6	0.3	0.1	-0.1	-0.2	-0.2	-0.0	0.4	0.5
Capital wealth	1.8	1.9	1.7	1.3	0.9	0.5	0.2	0.1	0.1	-0.0	0.3	0.2
Real capital stock	0.1	0.3	0.6	0.8	0.9	1.0	0.9	0.8	0.3	-0.0	0.2	0.3
Net foreign assets (% GDP)	2.7	1.7	1.0	0.5	0.2	0.3	0.6	0.9	1.9	3.3	4.5	5.1
GDP inflation (% pt.)	0.6	1.1	1.7	2.3	2.9	3.0	2.9	2.5	1.8	2.0	2.0	2.1
Absorption inflation (% pt.)	1.2	1.0	1.7	2.3	2.8	3.0	2.9	2.5	1.8	2.0	2.0	2.1
Export price inflation (% pt.)	4.8	-0.1	0.5	1.3	2.0	2.6	2.8	2.7	1.7	2.0	2.0	2.1
Import price inflation (% pt.)	10.3	-0.6	-0.3	0.3	1.2	2.0	2.7	2.8	1.7	1.9	2.0	2.2
Short-term interest rate (% pt.)	-0.6	-0.3	0.3	1.1	2.0	2.6	2.8	2.7	1.7	2.0	2.0	2.4
Real S-T rate (% pt.)	-1.6	-1.9	-1.9	-1.5	-0.9	-0.2	0.3	0.5	-0.2	-0.0	-0.0	0.2
Long-term interest rate (% pt.)	0.5	1.1	1.8	2.2	2.5	2.5	2.4	2.1	1.8	2.0	2.0	1.9
Real L-T rate (% pt.)	-1.6	-1.3	-0.9	-0.4	0.0	0.3	0.3	0.2	-0.2	-0.1	-0.0	0.3
Exchange rate (¥/$)	10.3	9.6	9.3	9.7	11.0	13.2	16.2	19.5	33.0	74.8	183.4	321.5
Real effective exchange rate	-8.8	-7.2	-5.4	-3.4	-1.8	-0.9	-0.6	-1.0	-2.5	-0.4	0.4	0.1
Primary revenues/GDP	-0.0	-0.1	-0.3	-0.4	-0.5	-0.5	-0.5	-0.4	-0.0	-0.0	-0.0	0.1
Primary spending/GDP	-0.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1	-0.0	0.0	-0.0	-0.0	-0.0
Net interest payments/GDP	-0.0	-0.1	0.0	0.2	0.5	0.8	1.0	1.0	0.8	0.9	0.9	1.0
Net debt/GDP	-0.3	-1.2	-1.9	-2.3	-2.4	-2.1	-1.6	-0.9	0.4	-0.1	-0.0	0.1
Government balance/GDP	0.1	0.2	0.1	-0.3	-0.7	-1.1	-1.4	-1.4	-0.8	-1.0	-0.9	-1.0
Current account/GDP	-0.2	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Trade balance/GDP	-0.2	0.1	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	-0.0	-0.1
Real exports/GDP	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.2	-0.1	-0.2
Real imports/GDP	-0.0	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.1	0.1	0.1
Private investment/GDP	0.2	0.2	0.2	0.2	0.1	0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0
Consumption/GDP	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1	0.0	0.1
Government spending/GDP	-0.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1	-0.0	0.0	-0.0	-0.0	-0.0

Other Changes to REPMOD from MULTIMOD Mark II

Beyond the changes discussed in the main text, the following modifications have been made to the consumption and investment relationships REPMOD from MULTIMOD Mark II:

- **Consumption and wealth**: The "excess" discount rate on future labor earnings in the calculation of human wealth has been raised significantly. In MARK II, this value was based on an assumed population turnover rate of 3.5 percent per year, consistent with the Blanchard-Yaari consumption framework. In contrast, the excess discount rate in REPMOD is set at 10 percent—a value that yields a marginal propensity to consume out of financial wealth closer to the central tendency of empirical estimates.[1] In addition, the effect of the demographic ratio on consumption has been reduced considerably to correspond with more recent econometric evidence, and the dynamics of the consumption response have been "decoupled" from those implied by the error-correction specification of the equation.[2] Finally, the direct effect of interest rates on consumption has been set at zero in REPMOD, consistent with evidence that the income and substitution effects of interest rate changes on consumption are roughly offsetting for Japan.

- **Investment**: The main change from MULTIMOD Mark II is to reduce the interest sensitivity of investment by defining the real interest rate in the market value of the capital stock (capital wealth) as a weighted average of the observed real interest rate and an underlying constant real interest rate. This dampens the response of capital wealth and thus private investment to interest rate changes. The weights on the observed and constant real interest rates are chosen to yield an interest-rate response that is broadly consistent with an elasticity of substitution between capital and labor of one half (versus unity in Mark II).[3] In addition, a term has been added to the capital stock adjustment equation that causes the equilibrium capital stock to grow at the same rate as smoothed growth in potential output in the absence of deviations in the market value of the capital stock from its replacement cost.

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[1]Specifically, the MPC out of financial wealth is about 0.05 in REPMOD compared with 0.02 in Mark II.

[2]See, for instance, Masson and others (1995) and Meredith (1995).

[3]This approach was taken rather than imposing a non-unitary elasticity of substitution between capital and labor in the production function because the latter approach led to problems with nonstationary capital and labor shares in output.

REPMOD Equation and Mnemonic Listing

The REPMOD equations are listed below, followed by a description of the model mnemonics. Residuals in stochastic equations have been suppressed to simplify the description. Parameter values apply to the Japan-specific version of the model, as reflected in the simulations reported in Section IV of the main text. Prices are generally indexed to equal 1 in 1990, and quantities are expressed in constant 1990 national currency units.

AGGREGATE DEMAND

Real private consumption (NCP_R):

```
Δ log(NCP_R) = -0.462
               + 0.173 * log((WT(-1)*NTDD_D(-1)) / (NCP_R(-1)*NCP_D(-1)))
               + 0.500 * Δ log(YD) + 0.350 * (DEM - (1-0.173)*DEM(-1))
```

Real net private capital stock (NK_R):

```
Δ log(NK_R) = -0.006 + 1.000 * (1/3) * log((NPGDP / NPGDP(-3))
                 * NTDD_D/NTDD_D(-3)) / (NIP_D/NIP_D(-3)))
              + 0.047 * log((WK*NTDD_D(-1)) / (NK_R(-1)*NIP_D(-1)))
              + 0.070 * log((WK(-1)*NTDD_D(-2)) / (NK_R(-2)*NIP_D(-2)))
```

Gross private investment (NIP_R):

```
NK_R = (1-DELTA) * NK_R(-1) + NIP_R
```

Real exports (NX_R):

```
Δ log(NX_R) = 4.920 + 0.578 * Δ log(WGDP) - 0.542 * Δ log(NX_D / (PWXX*ENDA))
              + 0.453 * log(WGDP(-1) / NX_R(-1))
              - 0.586 * log(NX_D(-1) / (PWXX(-1)*ENDA(-1)/ENDA90))
              + 0.010 * TME
```

Real imports (NM_R):

```
Δ log(NM_R) = -0.763 + 1.477 * Δ log(NTDD_R**0.95 * NX_R**(1-0.95))
              - 0.212 * log(NM_D(-1) / NGDP_D(-1))
              + 0.343 * log((NTDD_R(-1)**0.95 * NX_R(-1)**(1-0.95)) / NM_R(-1))
```

NATIONAL INCOME IDENTITIES

Real domestic demand (NTDD_R):

```
NTDD_R = NCP_R + NIP_R + NG_R
```

Real GDP (NGDP_R):

$$NGDP\_R = NTDD\_R + NX\_R - NM\_R$$

Nominal GDP (NGDP):

$$NGDP = NGDP\_R*NGDP\_D$$

Nominal GNP (NGNP):

$$NGNP = NGDP + BI$$

WEALTH AND INCOME RELATIONSHIPS

Total wealth (WT):

$$WT = WH + WK + (FMN + GGND + BNFA) / NTDD\_D$$

Human wealth (WH):

$$WH = ((((1\text{-}BETA)*NGDP**0.35*(NPGDP*NGDP\_D)**(1\text{-}0.35)\text{-}TAXH)/NTDD\_D) + RPREM*WK) / ((1+RBAR+PDTH)/(LPROD/LPROD(\text{-}1)) - 1)$$

or forward-looking variant (see main text):

$$WH/LLF = ((((1\text{-}BETA)*NGDP - TAXH) / NTDD\_D + RPREM*WK)/LLF + ((WH*WHDOT(+1))/(LLF*LLFDOT(+1))) / (1+RBAR+PDTH))$$

Capital wealth (WK):

$$WK = ((BETA*NGDP**0.35*(NPGDP*NGDP\_D)**(1\text{-}0.35)\text{-}TAXK) / NTDD\_D) / (0.3*FIGBR+0.7*RBAR+DELTA+RPREM),$$

or forward-looking variant (see main text):

$$WK/NK\_R = (((BETA*NGDP\text{-}TAXK)/NTDD\_D - RPREM*WK)/NK\_R + ((WK*WKDOT(+1)) / (NK\_R*NKDOT(+1))) / (1 + 0.3*FIDRR + 0.7*RBAR + DELTA))$$

Real disposable income (YD):

$$YD = (NGDP - GGRGXI - DELTA*NK\_R(\text{-}1)*NIP\_D(\text{-}1)) / NTDD\_D$$

FISCAL SECTOR

Net interest payments on government debt (GGI):

$$GGI = FI * GGND(\text{-}1)$$

Real government spending (NG_R):

$$NG\_R*NG\_D = (GTARG + 0.0*(NGDP\_R/NPGDP\text{-}1)) * (NPGDP*NGDP\_D)$$

Net primary revenues less transfers (GGRGXI):

GGRGXI = TRATE * (NGNP - DELTA*NK_R(-1)*NIP_D(-1) + GGI)

Net government debt (GGND):

Δ GGND = -GGB

Government balance (GGB):

GGB = GGRGXI - NG_D*NG_R - GGI

Taxes on capital (TAXK):

TAXK = BETA * (CTDUM*GGRGXI + (1-CTDUM)*TRATE_K*NGDP)

Taxes on labor (TAXH):

TAXH = GGRGXI - TAXK

Aggregate tax rate (TRATE):

Δ TRATE = TDUM * (0.04 * (GGND/(NPGDP*NGDP_D) - GGNDT)
+ 0.30 * Δ (GGND/(NPGDP*NGDP_D) - GGNDT))
+ 0.00 * (TRBAR(-1) - TRATE(-1))

FINANCIAL SECTOR

Short-term interest rate from monetary reaction function (FIDRX):

FIDRX/100-1.0*(PDOT(1)-1) - (FIDRX(-1)/100-1.0*(PDOT-1))
= MDUM * (0.5 * Δ log(NGDP_R/NPGDP)
+ 1.0 * (log(PDOT)-Δ log(PTARG))
+ 0.0 * (log(PDOT(1))-Δ log(PTARG(1)))
+ 0.0 * log(NGDP_R/NPGDP)
+ 0.0 * log(NGDP_D/PTARG)
+ 0.0 * log(ENDA/ENDAPAR))

Actual short-term interest rate adjusted for liquidity trap (FIDR):

FIDR = 0.999*max(FIDRX,0) + (1-0.999)*FIDRX

Change in the short-term interest rate (FIDOT):

FIDOT = FIDR - FIDR(-1)

Real short-term interest rate (FIDRR):

FIDRR = (1 + FIDR/100) / PDDOT(1) - 1

Long-term bond yield (FIGB):

$$FIGB/100 = 0.010 + ((1+(FIDR/100)) * (1+((FIDR+FIDOT(1))/100)) * (1+((FIDR+FIDOT(1)+FIDOT(2))/100)) * (1+((FIDR+FIDOT(1)+FIDOT(2)+FIDOT(3))/100)) * (1+((FIDR+FIDOT(1)+FIDOT(2)+FIDOT(3)+FIDOT(4))/100)))^{**}0.2 - 1$$

Real long-term bond yield (FIGBR):

$$FIGBR = (1 + FIGB/100) / (PDDOT(1)*PDDOT(2)*PDDOT(3)*PDDOT(4)*PDDOT(5))^{**}0.2 - 1$$

Average interest rate (FI):

$$FI = 0.5 * FIDR(-1)/100 + 0.5 * sum(i = -3 \text{ TO } -1 : FIGB(i))/30$$

Narrow money balances (FMN):

$$\Delta \log((FMN/NTDD\_D)/NTDD\_R) = -0.173 - 1.604 * (FIDR/100) + 0.220 * \log(NTDD\_R(-1) / (FMN(-1)/NTDD\_D(-1))) - 0.002 * TME$$

PRICE SECTOR

GDP deflator (NGDP_D):

$$\Delta \log(NGDP\_D) = (1-0.150)*((1-0.400)*\Delta \log(NGDP\_D(-1)) + 0.400*\Delta \log(PDOT(1))) + 0.150 * \Delta \log(NTDD\_D) + 0.100 * (0.06^{**}2/(0.06-\log(NGDP\_R/NPGDP)) - 0.06) + 0.100 * \Delta (0.06^{**}2/(0.06-\log(NGDP\_R/NPGDP)) - 0.06)$$

GDP inflation ratio (PDOT):

$$PDOT = NGDP\_D/NGDP\_D(-1)$$

Domestic demand inflation ratio (PDDOT):

$$PDDOT = NTDD\_D/NTDD\_D(-1)$$

Private investment deflator (NIP_D):

$$\Delta \log(NIP\_D/NTDD\_D) = 0.234 + 0.646 * LOG(NTDD\_D(-1)/NIP\_D(-1)) - 0.006 * TME$$

Government spending deflator (NG_D):

$$\Delta \log(NG\_D/NTDD\_D) = - 0.038 + 0.214 * \log(NTDD\_D(-1)/NG\_D(-1)) + 0.001 * TME1$$

Private consumption deflator (NCP_D):

$$NTDD\_D*NTDD\_R = NCP\_D*NCP\_R + NIP\_D*NIP\_R + NG\_D*NG\_R$$

Domestic demand deflator (NTDD_D):

$$NGDP\_R*NGDP\_D = NTDD\_D*NTDD\_R + NX\_R*NX\_D - NM\_R*NM\_D$$

Import deflator (NM_D):

$$\begin{aligned}\Delta \log(NM\_D/ENDA) = & \ 0.020 + 1.093 * \Delta LOG(PWXM) + 0.000 * \Delta LOG(PWOIL) \\ & + 0.135 * \Delta LOG(PWCOM) \\ & + 0.247 * LOG(PWXM(-1)) + 0.098 * LOG(PWOIL(-1)) \\ & + 0.083 * LOG(PWCOM(-1)) \\ & - (0.247 + 0.098 + 0.083) * LOG(NM\_D(-1)/(ENDA(-1)/ENDA90)) \\ & + 0.004 * TME\end{aligned}$$

Export deflator (NX_D):

$$\begin{aligned}\Delta \log(NX\_D/NGDP\_D) = & -0.013 + 0.442 * \Delta\log((PWXX*ENDA) / NGDP\_D) \\ & + 0.108 * \log(NGDP\_D(-1) / NX\_D(-1)) - 0.004 * TME\end{aligned}$$

PRODUCTION SECTOR

Potential real GDP (NPGDP):

$$\begin{aligned}NPGDP/NPGDP90 = & \ (BETA90 * (NK\_R/NK\_R90) ** (-rho) \\ & + (1-BETA90) * (LPROD * LLF/LLF90) ** (-rho)) ** ((-1)/rho)\end{aligned}$$

Capital share (BETA):

$$BETA = BETA90 * ((NPGDP/NK\_R) / (NPGDP90/NK\_R90)) ** rho$$

Labor force (LLF):

$$LLF = LP * PART / (1+DEM)$$

EXTERNAL SECTOR

Net interest receipts on NFA (BI):

$$BI = US\_R * BNFA(-1)$$

Trade balance (BT):

$$BT = NX\_R*NX\_D - NM\_R*NM\_D$$

Current account balance (BCA):

$$BCA = BT + BI$$

Net foreign assets (BNFA):

$$BNFA = BNFA(-1)*(ENDA/ENDA(-1)) + BCA$$

Nominal exchange rate versus U.S. dollar (ENDA):

ENDADOT(1) = (1 + (FIDR/100)) / (1+US_RS),

Growth ratio of nominal exchange rate (EDOT):

ENDADOT = ENDA / ENDA(-1)

Real effective exchange rate (EREER):

EREER = (1/(ENDA/ENDA90)) * (NGDP_D/PWGDP)

MNEMONICS

BCA	-	Current account balance
BETA	-	Capital share in production
BETA90	-	1990 value of BETA
BI	-	Net international investment income
BNFA	-	Net foreign assets
BT	-	Trade balance
CTDUM	-	Dummy to adjust corporate tax rate
DELTA	-	Capital depreciation rate
DEM	-	Population dependancy ratio
ENDA	-	Price of U.S. dollars in units of domestic currency
ENDADOT	-	Growth rate of ENDA
ENDAPAR	-	Parity exchange rate for exchange rate targeting
ENDA90	-	1990 value of ENDA
EREER	-	Real effective exchange rate
FI	-	Average short- and long-term interest rate
FIDOT	-	Change in short-term interest rate
FIDR	-	Short-term interest rate
FIDRR	-	Real short-term interest rate
FIDRX	-	Short-term interest rate generated by monetary reaction function
FIGB	-	Government bond yield
FIGBR	-	Real government bond yield
FMN	-	Narrow money balances
GGB	-	Government balance
GGI	-	Net interest pyaments on government debt
GGND	-	Net government debt
GGRGXI	-	Primary government revenues less transfers
GTARG	-	Target ratio of government spending to GDP
LLF	-	Labor force
LLFDOT	-	Labor force growth rate
LLF90	-	1990 value of LLF
LP	-	Total population
MDUM	-	Dummy for turning on money reaction function
NCP_D	-	Private consumption deflator
NCP_R	-	Real private consumption
NG_D	-	Government spending deflator
NG_R	-	Real government spending
NGDP	-	Nominal GDP
NGDP_D	-	GDP deflator
NGDP_R	-	Real GDP
NGNP	-	Nominal GNP
NIP_D	-	Private investment deflator
NIP_R	-	Real gross private investment
NK_R	-	Real net private capital stock
NK_R90	-	1990 value of NK_R
NM_D	-	Import deflator
NM_R	-	Real imports, goods and services
NPGDP	-	Real potential GDP
NTDD_D	-	Total domestic demand deflator
NTDD_R	-	Real domestic demand
NX_D	-	Export deflator
NX_R	-	Real exports, goods and services
PDOT	-	Growth rate of GDP deflator
PDDOT	-	Growth rate of domestic demand deflator
PDTH	-	Excess discount rate on future labor income
PTARG	-	Price target in money reaction function
PWCOM	-	World commodity prices in U.S. dollars
PWOIL	-	World oil price in U.S. dollars
PWXM	-	World export prices in U.S. dollars, import weights
PWXX	-	World export prices in U.S. dollars, export weights
RBAR	-	Constant equilibrium real interest rate
RPREM	-	Risk premium on future capital income
TAXH	-	Taxes on labor income
TAXK	-	Taxes on capital income
TDUM	-	Dummy in tax reaction function
TME	-	Linear time trend
TRATE	-	Average tax rate
TRATE_K	-	Corporate tax rate
TRBAR	-	Target tax rate
US_R	-	Nominal interest rate on average of U.S. short- and long-term assets
US_RS	-	Nominal interest rate on U.S. short-term assets
WGDP	-	World real GDP, export weights
WH	-	Real human wealth
WHDOT	-	Human wealth growth rate
WK	-	Real capital wealth
WKDOT	-	Capital wealth growth rate
WT	-	Total real wealth
YD	-	Real disposable income

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