A comparison of alternative monetary policy rules in the Federal Reserve Board's Multi-Country Model[1]

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Introduction

In recent years, monetary policy rules have received increasing attention from academic economists and policymakers.[2] Most analysts do not believe that the underlying structure of industrialised economies is sufficiently well understood to obtain an optimal policy rule that could be used to fine-tune an economy in every conceivable situation. Instead, monetary policy rules have primarily been designed to serve as an approximate gauge in determining an interest rate target consistent with stable inflation and sustainable real economic growth. The announcement of such a rule may also enhance the public's understanding of current monetary policy actions, and thereby strengthen the overall credibility of the central bank.

This note reviews recent modifications of the Federal Reserve Board's Multi-Country Model (FRB/MCM) that have facilitated the comparison of alternative monetary policy rules under model-consistent expectations (often referred to as forward-looking or "rational" expectations) as well as under VAR-based expectations (also referred to as backward-looking or "adaptive" expectations).[3] These modifications have mainly involved renormalisation of equations for the term structure of interest rates, the determination of overlapping wage contracts, and uncovered interest parity in the foreign exchange market.

The updated FRB/MCM has been used to evaluate three specific monetary policy rules, each of which prescribes a short-term interest rate target based on the current output deviation from potential and either (a) the current price level deviation from a specified target path; or (b) the current inflation deviation from a specified target rate. Dynamic simulations of the global model in response to US aggregate supply and demand shocks generally confirm the favourable properties of a policy rule considered by Henderson and McKibbin (1993). By targeting inflation rather than the price level, the H-M rule generates greater output stability and similar inflation stability compared with a policy rule based on nominal GDP targets. By prescribing larger interest rate adjustments in response to the current output gap and current inflation deviation from target, the H-M rule generates more stable economic activity and inflation compared with the monetary policy rule analysed by Taylor (1993). Similar simulation experiments for Germany and Japan do not yield such clear-cut differences between the alternative monetary policy rules, and highlight the importance of assumptions about expectation formation.

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1 Joe Gagnon, Jaime Marquez and Ralph Tryon were primarily responsible for the initial formulation of the FRB/MCM; its current development has been undertaken by Shaghil Ahmed, John Rogers and the author with the invaluable research assistance of Asim Hussain, Jonathan Otting and Sebastian Thomas. Simulations are performed in Troll 1.02, using innovative multi-tasking solution procedures developed by Jon Faust and Ralph Tryon. The VAR-based expectations algorithm was developed by David Bowman and Jonathan Otting. This research has also benefited greatly from the comments and suggestions of Dale Henderson, Will Melick, Dave Reifschneider, Volker Wieland and participants in the December 1995 Econometrician's Conference at the Bank for International Settlements. Finally, the views expressed in this note are those of the author and should not be interpreted as representing the views of the Federal Reserve Board of Governors or other members of its staff.

2 See, for example, Bryant, Hooper and Mann (1993).

3 In a previous paper, Tryon (1994) analysed the monetary transmission properties of the FRB/MCM.

The remainder of this paper is organised as follows: Section 1 outlines the general features of the FRB/MCM, with particular emphasis on the treatment of expectations. Section 2 outlines recent modifications of the FRB/MCM that have facilitated the analysis of inflation targets under model-consistent expectations. Section 3 analyses the essential properties of the three monetary policy rules under consideration. Section 4 reports the results of dynamic simulations of the FRB/MCM, and compares the performance of these monetary policy rules in response to country-specific fiscal and productivity shocks. Finally, Section 5 indicates several issues to be considered in future work on the FRB/MCM.

1. General features of the FRB/MCM

1.1 Country coverage

The FRB/MCM is a dynamic global economic model with nearly 1400 equations. As in the Federal Reserve Board's previous multi-country model, the FRB/MCM is comprised of twelve country/regional sectors. Each of the Group of Seven industrial economies (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) is represented by about 35 behavioural equations and 100 accounting identities. The specification of these equations is fairly similar for all seven countries/sectors; the differences are mainly with respect to the estimated regression coefficients and bilateral trade weights. Three other sectors - Mexico, the newly industrialising economies (NIEs), and other OECD economies (ROECD) - are modelled on a more aggregated and stylised basis, with about 20 behavioural equations and 75 accounting identities each. Finally, a total of about 45 equations are used to represent the behaviour of OPEC members and of other developing and transition economies (ROW).

1.2 Long-run properties

Like its immediate predecessor, the MX-3 model[4], the FRB/MCM is designed to exhibit long-run stability and balanced growth, similar to that of a standard neoclassical growth model. As discussed further below, these long-run properties are particularly important in performing simulations with model-consistent expectations.

Thus, each consumption equation incorporates error-correction mechanisms to ensure that the level of consumption (in natural logarithms) is cointegrated with disposable income and the real interest rate. In other words, conditional on the long-term real interest rate, the savings rate is stationary (perhaps around exogenous trends related to demographics or other factors). Similarly, imports are cointegrated with domestic absorption and the real exchange rate, while exports are cointegrated with foreign absorption and the real exchange rate.

The long-run stability of the FRB/MCM is also facilitated by explicitly incorporating stock-flow relationships for physical capital and present-discounted-value constraints for government and net external debt. Thus, private investment exhibits short-run accelerator-type effects in response to output fluctuations. In the longer run, however, the investment rate adjusts to equate the marginal product of capital to its real rate of return. This adjustment effectively serves as an error-correction mechanism, ensuring that the level of investment and the capital stock are each cointegrated (in natural logarithms) with gross output and with the long-term real interest rate (net of depreciation).

Long-run fiscal solvency is maintained by an endogenous tax rate reaction function, which adjusts the income or sales tax rate when the nominal government debt/GDP ratio deviates

4 See Gagnon (1991) and Gagnon and Tryon (1992).

from a specified target. In the FRB/MCM, government expenditures and tax revenues are subject to cyclical movements as well as exogenous shocks. Since budget deficit fluctuations affect the stock of debt and hence subsequent interest payments, the tax rate adjustment must be sufficiently large to prevent an explosive path of government debt. Thus, given an appropriate specification of the tax rate reaction function, the model ensures that the stock of government debt is cointegrated (in natural logarithms) with nominal GDP.

Finally, changes in the net external debt/GDP ratio lead to corresponding movements in the sovereign risk premium. Thus, through uncovered interest parity, a deterioration of the current account induces an increase in the domestic real interest rate and/or a depreciation of the real exchange rate. A reasonable degree of sovereign risk premium adjustment ensures that improved net exports of goods and non-factor services will outweigh the higher net factor payments resulting from the initial increase in external debt, and thereby prevents an explosive path for the current account and net external debt.

1.3 The role of expectations

The explicit treatment of expectations has played an important role in the formulation of the FRB/MCM. In all sectors except OPEC and ROW, expected values of future variables directly influence the determination of interest rates, consumption and investment expenditures, the aggregate wage rate, and the nominal exchange rate. First, the long-term nominal interest rate and long-term expected inflation rate are each determined as geometric weighted averages of future short rates. Second, consumption, residential investment, and business fixed investment each depend on the *ex ante* long-term real interest rate (the long-term nominal interest rate less expected inflation), while business and petroleum inventory investment each depend on the *ex ante* short-term real interest rate. Third, the aggregate nominal wage rate is defined in terms of the current and past values of overlapping four-quarter wage contracts, where each wage contract depends on expected future aggregate wages and expected deviations of unemployment from its natural rate. Finally, each bilateral nominal exchange rate (local currency/$US) is determined by uncovered interest parity; i.e., the expected rate of depreciation depends on the current bilateral interest rate differential, adjusted by the endogenously determined sovereign risk premium described above.

The FRB/MCM can be simulated under two alternative assumptions about expectations formation: VAR-based expectations (referred to as backward-looking or "adaptive" expectations), and model-consistent expectations (also referred to as forward-looking or "rational" expectations). Since assumptions about expectations formation can have important implications for the simulation results, it is useful to review the implementation of these assumptions in some detail.

1.4 VAR-based expectations formation

The implementation of adaptive expectations formation in the FRB/MCM closely parallels the approach followed in the FRB/US quarterly model (cf. Kozicki, Reifschneider, and Tinsley 1995). In particular, regression equations have been estimated for each of the Group of Three economies (Germany, Japan, and the United States) using historical data on the output gap (i.e., the deviation of real GDP from potential), the GDP price deflator, the short-term Treasury bill rate, and the average wage rate. The current output gap and the current price inflation rate are each regressed on up to eight quarters of lagged output gaps, inflation rates, and interest rates; and the wage inflation rate is regressed on its own lags as well as lags of the other three variables.

For a given simulation experiment, a monetary policy rule must also be specified, in which the short-term interest rate is determined as a linear function of the current output gap and the price inflation rate; e.g., the rule analysed by Taylor (1993), or the rule considered by Henderson and

McKibbin (1993).[5] The interest rate reaction function is combined with the reduced-form output gap and price inflation equations to create a three-variable VAR model. For any forecasting horizon $N \geq 0$, the VAR model can be evaluated recursively to obtain a forecasting equation for each variable, in which the N-step-ahead forecast is expressed in terms of the current and lagged values of all three variables. An algorithm developed by David Bowman and Jonathan Otting is used to compute the geometric weighted average of these forecasts over all horizons, yielding reduced-form equations for the long-term nominal interest rate and long-term expected inflation in terms of the current and lagged values of the output gap, inflation rate, and short-term interest rate.

In each period of a dynamic simulation, current and lagged variables are used to evaluate each reduced-form equation and obtain new expectations of future variables. For example, the reduced-form price inflation equation is used to determine short-term expected inflation, which is needed to calculate the *ex ante* short-term real interest rate for each of the inventory investment equations. The reduced-form equations for the long-term interest rate and long-term expected inflation are used to calculate the *ex ante* long-term real interest rate, which enters the consumption, fixed investment, and uncovered interest parity equations. Finally, the aggregate wage rate is determined directly from the reduced-form wage equation.

1.5 Model-consistent expectations formation

For each dynamic simulation of the FRB/MCM, model-consistent expectations are implemented by obtaining the perfect foresight solution path for all endogenous variables. To understand how this solution is obtained, it is useful to define the set of "expectations variables" as those endogenous variables whose expected future value enters into one or more equations in the model. The solution algorithm requires the long-run stability of all expectations variables: i.e., after a shock occurs, each expectations variable must eventually return to the baseline (or to some other known steady-state value). In this case, the baseline or steady-state values can serve as terminal conditions for the expectations variables at some date sufficiently far into the future.

Thus, the perfect foresight solution algorithm determines the paths of all endogenous variables over the simulation period, using prespecified values for the terminal conditions as well as for the initial conditions and the exogenous variables.

For example, suppose that one wishes to evaluate the effects of an exogenous change in government spending over the period 1996, Q1 to 1999, Q4. If the model is reasonably stable, one might expect that all variables would return to baseline within about 25 years.[6] Thus, the use of model-consistent expectations would typically require a dynamic simulation over the period 1996, Q1 through 2025, Q4. In this case, the required initial conditions would be the pre-1996, Q1 values of all lagged variables in the model, which can be specified using historical data and/or an extrapolated baseline. The required terminal conditions would be the post-2025, Q4 values of all expectations variables in the model, which would be specified based on the long-run properties of these variables.

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5 The solution algorithm also permits the interest rate reaction function to include lags of the interest rate, output gap, price inflation, and wage inflation, but this possibility has not yet been investigated.

6 It is straightforward to determine whether a given simulation horizon is appropriate by simulating the model over a longer period and checking the extent to which the simulation results differ from those obtained using the shorter horizon (cf. Fair and Taylor 1983).

2. Recent modifications of the FRB/MCM

2.1 Implications of inflation rate targets

In most multi-country models, such as the IMF's Multimod and the Taylor MCM, each country's monetary policy rule has incorporated a target path for the price level, thereby ensuring that prices eventually return to the target path after a shock. Since the real wage and real exchange rate are stationary in these models, price level targets ensure that consistent terminal conditions can also be specified for the nominal wage rate and the nominal exchange rate. Given these terminal conditions, one of the standard solution algorithms can be used to perform simulations with model-consistent expectations.

Nevertheless, it is useful to be able to consider other monetary policy rules in which the price level is non-stationary. For example, Taylor (1993) analysed a policy rule that adjusts the short-term interest rate in response to deviations of current inflation from a specified target rate, and considered the extent to which this rule provides a reasonably accurate description of the Federal Reserve Board's actions over the past decade. Henderson and McKibbin (1993) utilised small-scale theoretical models and the large-scale MSG-2 model to analyse the properties of a wide range of monetary policy rules based on inflation rate targets.

Under these types of monetary policy rules, a shock to the model can induce a permanent change in the price level: the central bank's target inflation rate determines the long-run slope of the price path, but the specific level of the path is dependent on the initial conditions and the particular shock(s) hitting the economy. Thus, different initial conditions or shocks generate price paths which eventually become parallel to the baseline path.

2.2 Renormalised equations

To facilitate the analysis of inflation target rules under model-consistent expectations, the behavioural equations in the FRB/MCM have been renormalised so that expected future levels of nominal variables do not enter the model. This renormalisation ensures that all expectations variables in the FRB/MCM are stationary under both price level targets and inflation rate targets. Simulations involving permanent changes in the inflation target can also be performed, since the appropriate terminal conditions can be easily derived from the steady-state inflation target.

The key feature of this renormalisation is that the behavioural properties of the model have not been changed: under a price level target, the output of the model is identical to that of the previous version of the FRB/MCM. An alternative approach would be to express all nominal variables in terms of rates of change (as in the model of Fuhrer and Moore 1995), but such a model would ignore key long-run relationships between the levels of the nominal variables, and would not retain the properties of the earlier version of the FRB/MCM. In particular, a model expressed only in terms of nominal price inflation, wage inflation, and exchange rate depreciation would not ensure a stationary path for the real wage or the real exchange rate.[7]

As seen in the Appendix, the renormalisation of the FRB/MCM has mainly involved the modification of three behavioural equations and the addition of several identities to the model. After defining the one-period inflation rate (DPABS), the long-term expected inflation rate (DPEXP) can easily be expressed in terms of stationary variables, using essentially the same term structure formula as for the long-term interest rate.

7 This outcome corresponds exactly to the excluded-variable bias that results from estimating a vector autoregression in first-differences when some of the variables are actually cointegrated in levels (cf. Granger 1981; Engle and Granger 1987).

The aggregate nominal wage rate (W) can still be expressed in terms of current and lagged four-quarter wage contracts (WX). However, each wage contract depends on expected wage levels and unemployment over the life of the contract. By defining the absorption price-adjusted real wage and the contract wage/aggregate wage differential and then rearranging terms, the contract wage equation can be expressed solely in terms of stationary variables: the contract wage/aggregate wage differential (XDW) depends on the expected short-term price inflation rate (DPABS), expected real wages (WDPABS), and expected unemployment deviations from the natural rate (UN - UNNAT).

As noted in Section 1, each bilateral nominal exchange rate is determined by uncovered interest parity, subject to an endogenously determined sovereign risk premium. By defining the bilateral CPI-adjusted real exchange rate (RER) and then rearranging terms, each uncovered interest parity equation can be renormalised to express expected bilateral real exchange rate changes (log(RER) - log(RER(1))) as a function of the differential between the US short-term real interest rate (URS - UDPABS(1)) and the domestic short-term real interest rate (RS - DPABS(1)).[8]

2.3 Perfect foresight solution algorithm

The choice of solution algorithm has a large impact on the computational resources required to simulate the renormalised FRB/MCM. Using version 1.02 of TROLL, either the Fair-Taylor algorithm or the new stacked Newton algorithm can be used to obtain a solution for an individual country model. However, the Fair-Taylor algorithm converges much more slowly in simulating price level target rules for the renormalised country models, compared with the previous versions of these models. In this case, although the price level returns to the baseline path after a shock, the Fair-Taylor algorithm must determine this result through numerous iterations, rather than by using the price levels as terminal conditions as in the earlier version of the FRB/MCM. In contrast, the rapid convergence rate of the stacked Newton algorithm does not appear to be sensitive to the renormalisation of the model or to the choice of monetary policy rule.

At this point, the stacked Newton algorithm cannot be used to simulate the entire FRB/MCM due to memory constraints. However, the global model can be solved very efficiently (in less than 5 minutes of CPU time) by an iterative procedure, using multi-tasking on a midsize Unix workstation with four processors. Starting with an initial guess for the solution path, each country model is solved using the stacked Newton algorithm, and the output is stored to disk, where it can be accessed by each of the other country models in the next iterative step. A main control program ensures that all individual country model solutions have been obtained prior to initiating the next iteration.

In contrast, the Fair-Taylor algorithm appears to be a highly computationally intensive and somewhat unreliable method of solving the current FRB/MCM. Lack of convergence occurs if an insufficient number of Fair-Taylor iterations are applied to each country model prior to sharing the output with other country models, whereas performing a large number of Fair-Taylor iterations at each step can require several hours of CPU time, even using the multi-tasking procedure.

8 In light of the econometrics literature (cf. previous footnote), the real wage (WDPABS), contract wage/aggregate wage differential (XDW), and the real exchange rate (RER) may be viewed as error correction terms which reflect three cointegrating relationships among the absorption price, nominal aggregate wage, nominal contract wage, and nominal bilateral exchange rate. In the FRB/MCM, the non-stationarity of all four variables is explained by a single integrated common factor that results from the monetary policy rule.

3. Alternative monetary policy rules

3.1 Nominal GDP target

A large literature has considered the properties of a monetary policy rule which adjusts the short-term interest rate in response to deviations of nominal GDP from a specified target path:

$$i = \bar{r} + \pi^* + \alpha(PGAP + YGAP) \quad (1)$$

where i indicates the nominal short-term interest rate, $\bar{r}$ the equilibrium real short-term interest rate, π^* the target inflation rate for the domestic absorption price deflator, *PGAP* the current deviation of the absorption price deflator from its target path, and *YGAP* the current deviation of real GDP from potential (all variables are expressed in terms of percentage points). The sum *(PGAP + YGAP)* indicates the deviation of nominal GDP from target, so that the monetary policy parameter α can be interpreted as the partial elasticity of the short-term interest rate in response to nominal GDP deviations from target.[9] In the simulations reported here, the parameter α is set equal to 2.

The equilibrium real rate is defined as the real short-term interest rate at which the inflation rate remains constant and output remains at potential. Thus, when the price level is on target, expected inflation is at the target rate π^*, and real GDP is at potential, the nominal GDP rule yields an *ex ante* real interest rate, $i - \pi^*$, equal to the equilibrium real rate, $\bar{r}$.

It is important to note that the nominal GDP rule generates a trend-stationary path for the price level. For example, if nominal GDP rises one percent above target (due to a higher price level and/or an increase in output above potential), then the nominal interest rate is raised by α percentage points, thereby putting downward pressure on economic activity and prices until nominal GDP returns to its target path. If the price level is above target and real GDP is below potential, then nominal GDP can still be on target, so that the nominal interest rate remains unchanged. In this case, however, the output gap corresponds to a relatively high unemployment rate, which depresses wage and price inflation. Thus, the nominal GDP rule implies a unique equilibrium path in which the price level is on target and real GDP is at potential.

To illustrate this feature of the nominal GDP rule, it is useful to consider the case where $\pi^* = 0$, so that the aggregate price level is stable around a constant level. As the parameter α becomes arbitrarily large, the nominal GDP rule functions somewhat like a gold standard, except that this rule targets the price of a basket of goods and services rather than a single commodity. For smaller values of α, the nominal GDP rule also permits temporary price deviations from target, whereas the price of gold is essentially constant under the gold standard.

3.2 Taylor's rule

Taylor (1993) analysed the properties of the following monetary policy rule, which adjusts the short-term interest rate based on deviations of inflation from its target rate and on deviations of output from potential:

$$i = \bar{r} + \pi^* + 1.5 INFGAP + 0.5 YGAP \quad (2)$$

where *INFGAP* is defined as the deviation of current inflation from its target rate, $\pi - \pi^*$. Taylor calculated the US federal funds rate implied by this rule using $\bar{r} = 2$ and $\pi^* = 2$, and found that the

9 If *PGAP* were computed using the GDP price deflator, then *(PGAP + YGAP)* would equal the deviation of nominal GDP from its target path. In the simulations reported here, however, all monetary policy rules are expressed in terms of the domestic absorption price deflator, so that the relationship is only approximate.

implied interest rate followed a path quite similar to that of the actual federal funds rate over the period 1983-92.

If both current and expected inflation are at the target rate, and output is at potential, then Taylor's rule implies that the *ex ante* real interest rate is at the equilibrium rate, $\bar{r}$, yielding steady inflation and sustainable real GDP growth. If current inflation exceeds the target rate by one percentage point, Taylor's rule prescribes a 1.5 percentage point increase in the nominal interest rate, which will typically raise the *ex ante* short-term real interest rate by about 50 basis points. (The exact increase in the *ex ante* real interest rate depends on short-term expected inflation, but this is typically quite close to the current inflation rate.) The increase in the real interest rate dampens economic activity, thereby depressing employment and placing downward pressure on wages and prices until inflation returns to its target rate.

Taylor's rule also indicates that the federal funds rate should be adjusted in response to deviations of output from potential. When economic activity is relatively weak, this component of Taylor's rule reflects the effect of an interest rate cut in stimulating economic activity. However, this component also serves to reduce fluctuations in the inflation rate: when output exceeds potential, raising the nominal interest rate can help avoid an overheated economy and the associated upward pressure on wages and prices.

In contrast to the trend-stationary price path generated by a nominal GDP target, Taylor's rule induces a non-stationary price level, sometimes referred to as "price level drift". Thus, a zero inflation target is not the same as a constant price level target: when $\pi^* = 0$, the price level follows a random walk under Taylor's rule, whereas the nominal GDP rule induces long-run price stability. On the other hand, maintaining a price level target can be expected to involve greater costs in terms of output volatility compared with maintaining an inflation target.

These considerations can be illustrated by considering the monetary policy response to a one-time positive price level disturbance that leaves aggregate demand unchanged. In this case, if the *ex ante* real interest rate remains at its equilibrium value, then output stays at potential, and the inflation rate stays on target (apart from the deviation during the period of the shock). Thus, apart from an initial blip, Taylor's rule maintains a relatively constant nominal interest rate, and permits a permanent increase in the aggregate price level. In contrast, the nominal GDP rule prescribes an interest rate hike that depresses aggregate demand and places downward pressure on wages and prices until the aggregate price level falls back to its target path.

3.3 The H-M rule

Henderson and McKibbin (1993) studied the performance of a wide range of monetary policy rules in response to various shocks, and found that the following rule performed quite well in generating stable inflation and sustainable real growth:

$$i = \bar{r} + \pi^* + 2INFGAP + 2YGAP \tag{3}$$

The H-M rule and Taylor's rule have the same functional form, and prescribe fairly similar interest rate adjustments in response to inflation deviations from target. However, the H-M rule prescribes a much stronger interest rate adjustment in response to the current output gap. In principle, an excessively strong interest rate adjustment in response to output deviations could lead to oscillating or even explosive outcomes; i.e., real GDP continually overshooting its potential level in response to interest rate changes. In most macroeconomic models, however, real GDP exhibits a relatively high degree of inertia, so that a higher partial interest rate elasticity with respect to output deviations can be expected to generate greater output stability.

Thus, the key question is whether the H-M rule obtains greater output stability at the cost of substantially higher inflation volatility compared with Taylor's rule.[10] The possibility of a highly favourable output-inflation volatility trade off is less surprising if one views the current output gap as a proxy for near-term inflationary pressures which are not yet reflected in the current inflation rate. Given a sufficient degree of nominal inertia, changes in aggregate demand will tend to have strong initial effects on output and employment, leading to subsequent pressure on wages and prices. Thus, by promptly adjusting the nominal interest rate, it might be possible to offset the aggregate demand shock, and thereby stabilise both economic activity and inflation.

These considerations raise the possibility that Taylor's rule could be dominated by another monetary policy rule possessing the same functional form but with different *INFGAP* and *YGAP* coefficients; i.e., a different rule (possibly even the H-M rule) might yield both lower output volatility <u>and</u> lower inflation volatility compared with Taylor's rule. Evaluating this possibility requires the analysis of macroeconomic model simulations like the ones performed by Henderson and McKibbin (1993) and those reported in the following section of this paper.

4. FRB/MCM simulation results

4.1 Simulation design

Using the renormalised equations discussed in Section 3, simulations of the FRB/MCM can be used to evaluate the properties of alternative monetary policy rules under either model-consistent or VAR-based expectations. This section analyses simulation experiments in which one of the Group of Three economies (the United States, Germany, and Japan) experiences a temporary unanticipated shock to either aggregate demand or aggregate supply. The aggregate demand shock consists of an exogenous change in real government purchases of goods and services, which rise 5 percent above baseline during 1996 and 1997, and then gradually return to baseline by the end of 1999. The aggregate supply shock consists of an exogenous change in total factor productivity, which rises 0.5 percent above baseline during 1996 and 1997 and then returns to its baseline path at the beginning of 1998.

The country experiencing the exogenous shock follows one of the three interest rate rules described in Section 4, while the monetary policy rules of all other countries remain unchanged. In particular, a hybrid interest rate rule is followed by Italy, the United Kingdom, and the two other Group of Three economies (i.e., the two which have not experienced the exogenous government spending or total factor productivity shock). This hybrid rule has the same functional form as Taylor's rule and the H-M rule, with an *INFGAP* coefficient of 2 and a *YGAP* coefficient of 1. In all simulations, Mexico, the NIEs, OPEC, and ROW maintain a fixed exchange rate with respect to the US dollar; while France and other OECD economies maintain a constant exchange rate with respect to the German mark.

Every simulation is performed over the period 1996 through 2022, and the results are examined to verify that all economic variables have returned sufficiently close to the baseline by the end of the simulation period. The simulation results are shown in the attached table and charts. Only the first ten years of each simulation are shown to make the output more readable. The results for all price and expenditure variables are reported in terms of the relative deviation from baseline, in percentage points (indicated by the % symbol); while results for other variables such as the interest rate, inflation rate, and tax rate are reported in terms of the absolute deviation from baseline, in percentage points (indicated by the +/- symbol).

10 The output-inflation volatility trade off was originally discussed by Taylor (1980) based on the properties of a small macroeconomic model with forward-looking staggered wage contracts.

Table 1a

Country-specific aggregate demand shocks

Temporary 5% change in government spending

Country	Expectations formation	Output volatility[1]			Inflation volatility[2]		
		Nominal GDP target	Taylor's rule	H-M rule	Nominal GDP target	Taylor's rule	H-M rule
United States	Model-consistent	0.108	0.178	0.105	0.023	0.058	0.035
	VAR-based	0.145	0.204	0.137	0.033	0.060	0.037
Germany	Model-consistent	0.263	0.663	0.451	0.032	0.275	0.192
	VAR-based	1.573	0.386	0.464	0.785	0.091	0.185
Japan	Model-consistent	0.167	0.388	0.218	0.077	0.135	0.089
	VAR-based	0.380	0.528	0.390	0.190	0.202	0.188

Table 1b

Country-specific aggregate supply shocks

Temporary 0.5% change in total factor productivity

Country	Expectations formation	Output volatility[1]			Inflation volatility[2]		
		Nominal GDP target	Taylor's rule	H-M rule	Nominal GDP target	Taylor's rule	H-M rule
United States	Model-consistent	0.722	0.820	0.645	0.132	0.301	0.152
	VAR-based	0.762	0.790	0.736	0.132	0.159	0.121
Germany	Model-consistent	0.602	0.474	0.504	0.076	0.134	0.118
	VAR-based	1.153	0.504	0.430	0.633	0.132	0.195
Japan	Model-consistent	0.386	0.440	0.385	0.037	0.061	0.035
	VAR-based	0.361	0.399	0.366	0.071	0.072	0.070

1 Measured as the standard deviation of the real GDP gap over the first 40 quarters of the simulation experiment.

2 Measured as the standard deviation of the absorption price inflation rate over the first 40 quarters of the simulation experiment.

4.2 Results for US country-specific shocks

Chart 1 provides detailed simulation results for US macroeconomic variables in response to a temporary US aggregate demand shock, under the assumption of model-consistent expectations. As seen in the upper-right panel of Chart 1a, the shock consists of an exogenous increase in real government purchases above baseline during 1996 through 1999. The upper-left panel of Chart 1a shows the response of US real GDP under each of the alternative monetary policy rules. Under all three rules, output rises above baseline during the first several years, and subsequently falls below baseline near the end of the fiscal expansion.

However, real GDP exhibits less volatility under the H-M rule compared with either the nominal GDP rule or Taylor's rule. Under the H-M rule, output initially rises about 0.3 percent above baseline, and then returns fairly smoothly to baseline over the next four years. The nominal GDP rule generates a similar initial output response, but then causes output to fall below baseline for several years to ensure that the price level returns to its target path. Finally, output exhibits a larger initial increase of about 0.4 percent under Taylor's rule, and then displays very persistent cyclical behaviour during its return to baseline over the next decade.

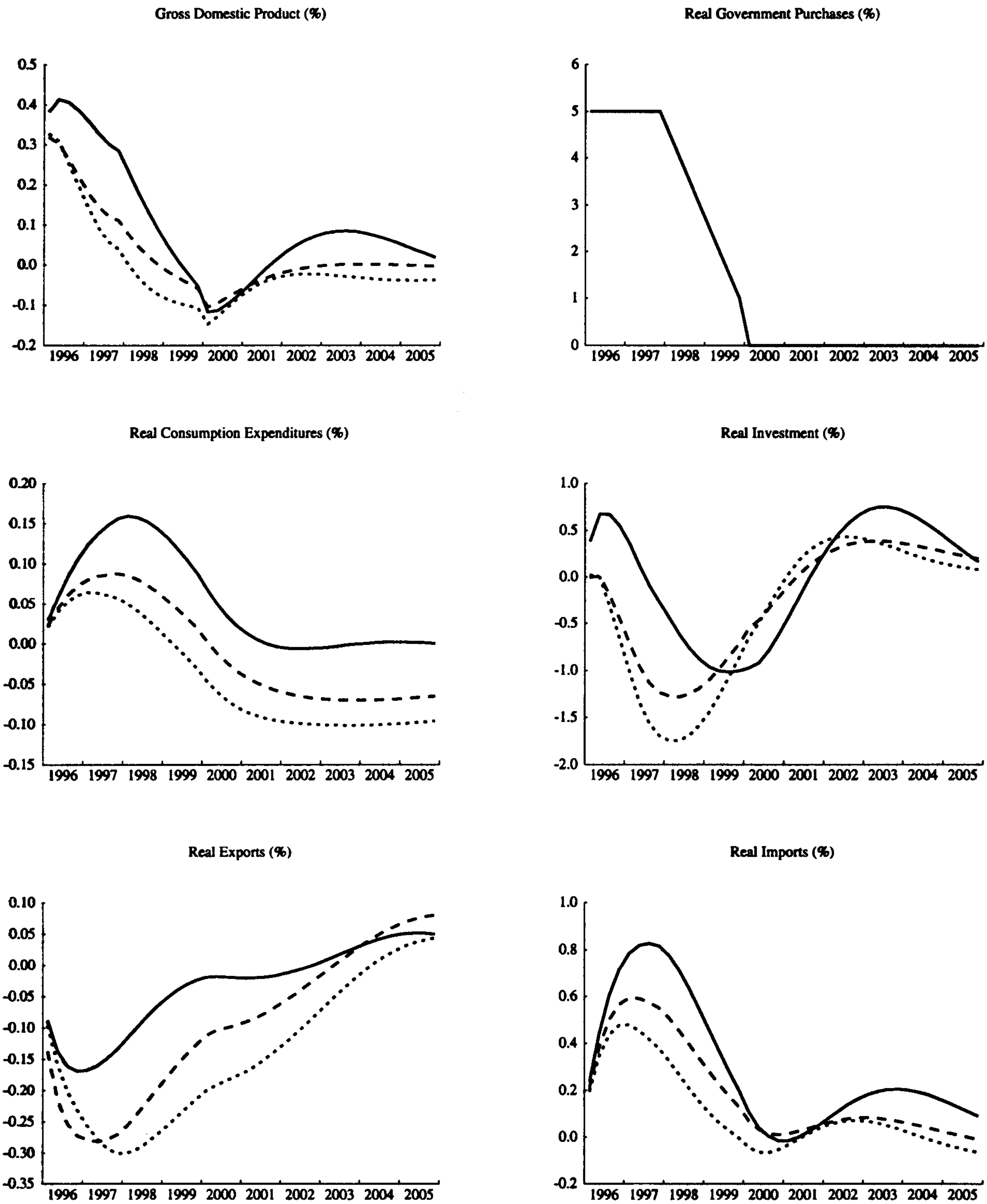
The remainder of Chart 1a shows the response of other components of aggregate demand. Consumption expenditures increase modestly during the first several years and then return toward baseline, mainly due to changes in disposable income. Investment exhibits a sharp initial rise under Taylor's monetary policy rule, due to the strong accelerator effect. The nominal GDP rule and the H-M rule generate larger increases in the long-term real interest rate compared with Taylor's rule. Thus, under the nominal GDP and H-M rules, investment does not exhibit any initial increase, and falls below baseline almost two years earlier than under Taylor's rule. The H-M rule also generates a stronger initial real exchange rate appreciation compared with the nominal GDP rule and Taylor's rule, and thereby induces a larger initial contraction of real exports. Imports expand rapidly during the first several years under all three rules, due to higher domestic demand as well as the real exchange rate appreciation.

The top-left panel of Chart 1b shows how the US short-term interest rate is adjusted under each of the three monetary policy rules. The price level and inflation rate respond slowly to the shock, due to nominal wage and price inertia. Thus, the initial interest rate adjustments prescribed by all three rules mainly reflect the rapid rise of real GDP above potential. Due to the use of a much higher *YGAP* coefficient, the nominal GDP and H-M rules prescribe an immediate 75 basis point increase in the federal funds rate, nearly twice the adjustment prescribed by Taylor's rule. As seen in the lower-right panel of Chart 1b, these short-term interest rate movements cause the long-term real interest rate to jump about 20 basis points above baseline under the nominal GDP and H-M rules, compared with about 10 basis points above baseline under Taylor's rule. As noted above, these higher real interest rates dampen investment and net exports during the first several years, thereby offsetting a substantial fraction of the aggregate demand stimulus associated with higher government expenditures.

As seen in the top two panels of Chart 1c, the nominal GDP rule succeeds in keeping the aggregate price level relatively close to its target path, whereas the H-M rule and Taylor's rule both permit the price level to deviate permanently from baseline. Under all three monetary policy rules, the CPI-adjusted real exchange rate gradually moves back toward baseline; i.e., long-run purchasing power parity holds in this case. However, since Germany, Italy, Japan, and the United Kingdom are following independent monetary policies based on inflation targets rather than price level targets, the trade-weighted foreign price level does not return to baseline. Thus, as shown in the left centre panel of Chart 1c, the trade-weighted value of the dollar deviates permanently from baseline, even when the United States follows a nominal GDP rule. Due to persistent current account deficits, the ratio of net external debt to nominal GDP rises by about one percent under all three monetary policy rules. Thus, the sovereign risk premium on US securities increases by about 5 basis points by 2005, thereby contributing to slightly higher US real interest rates.

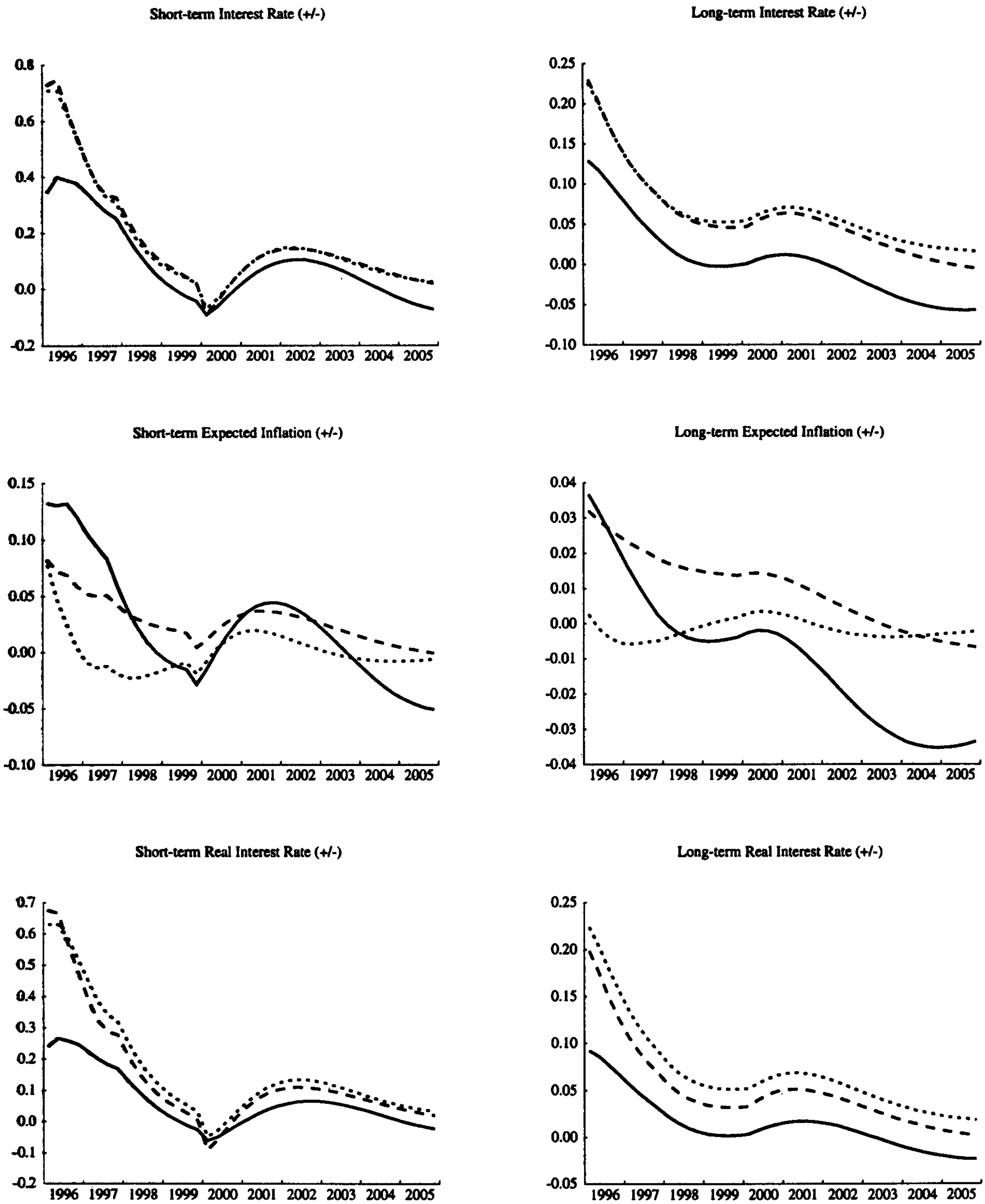
Finally, Charts 1d and 1e give additional details on US fiscal and aggregate supply variables, and provide further insight into the long-term error-correction mechanisms built into the FRB/MCM. For example, the exogenous increase in government spending causes the budget deficit and the stock of government debt to rise above baseline. In response, the tax rate reaction function generates an increase in the personal income tax rate of 0.3 to 0.7 percent, thereby gradually pushing the government debt/GDP ratio back toward its target value.

Chart 1a
US aggregate demand shock: model-consistent expectations
US aggregate demand variables



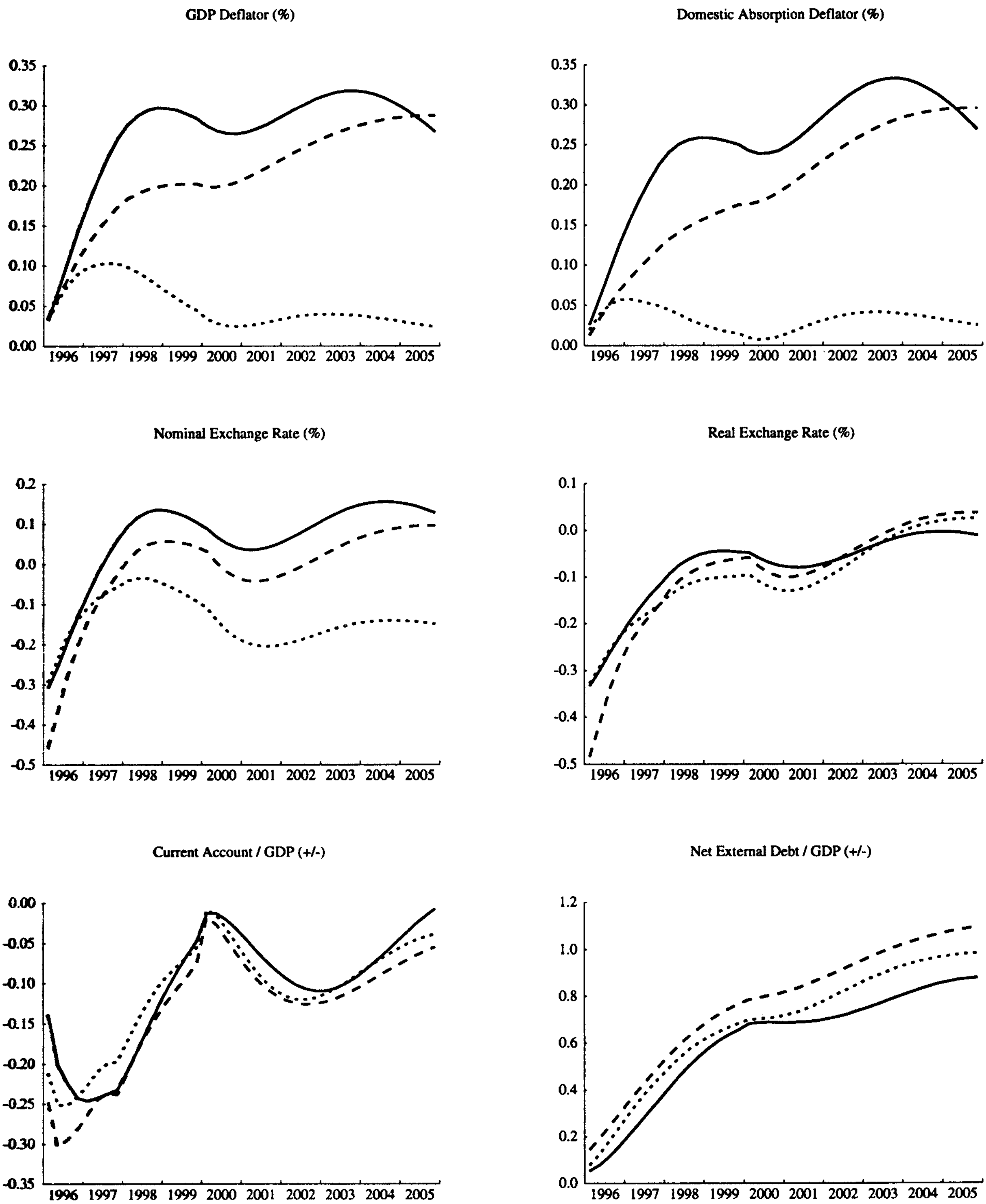
Alternative U.S. Monetary Policy Rules
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dot-Dashed: Nominal GDP Target

Chart 1b
US aggregate demand shock: model-consistent expectations
US interest rates and expected inflation



Alternative U.S. Monetary Policy Rules
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dot-Dashed: Nominal GDP Target

Chart 1c
US aggregate demand shock: model-consistent expectations
US prices, exchange rates and current account



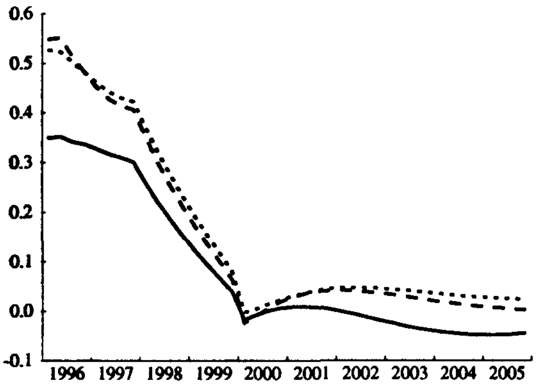
<u>Alternative U.S. Monetary Policy Rules</u>
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dot-Dashed: Nominal GDP Target

Chart 1d

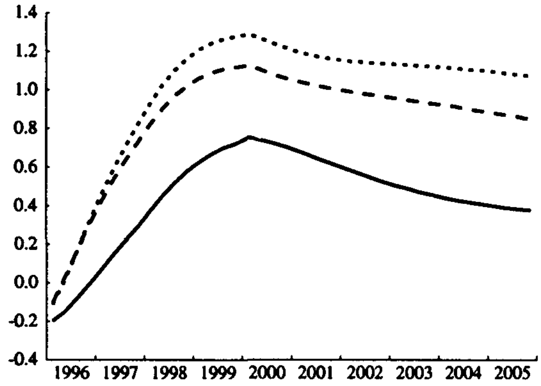
US aggregate demand shock: model-consistent expectations

US fiscal variables

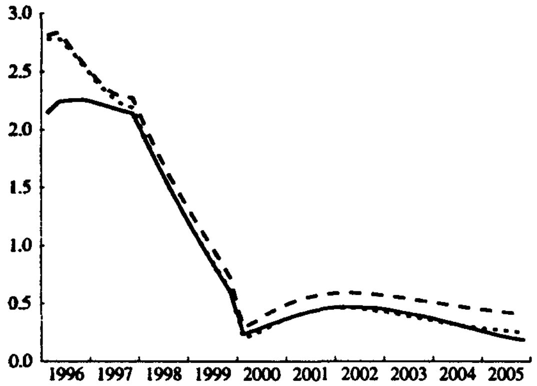
Government Deficit / Nominal GDP (+/-)



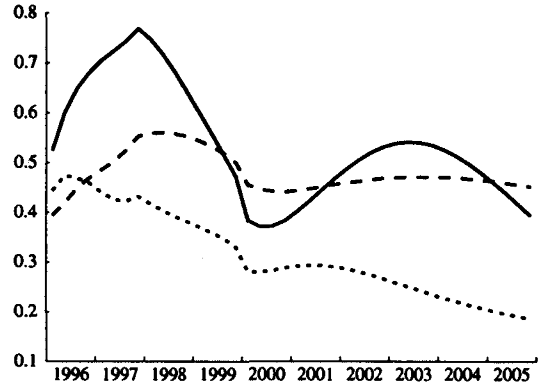
Government Debt / Nominal GDP (+/-)



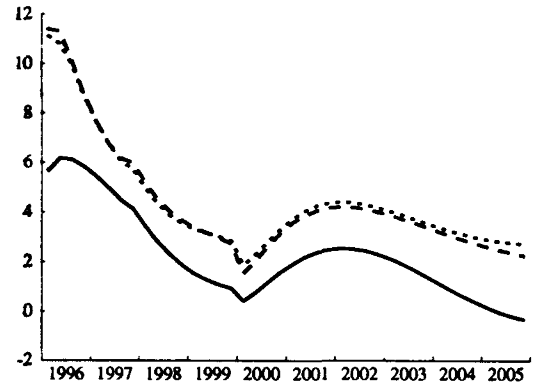
Nominal Government Expenditures (%)



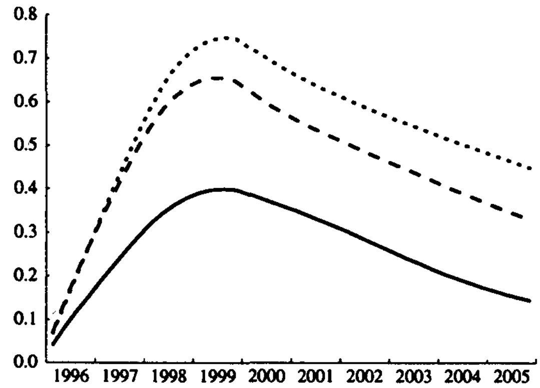
Interest Paid on Debt (%)



Nominal Government Receipts (%)



Tax Rate (%)



Alternative U.S. Monetary Policy Rules

Solid: Taylor's Rule

Dashed: Henderson-McKibbin Rule

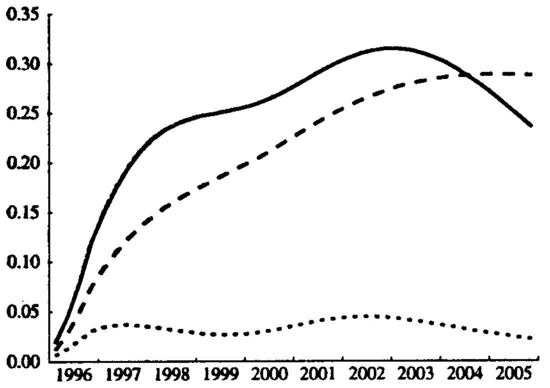
Dot-Dashed: Nominal GDP Target

Chart 1e

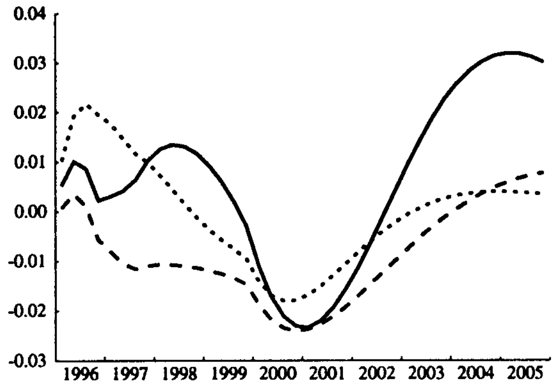
US aggregate demand shock: model-consistent expectations

US aggregate supply variables

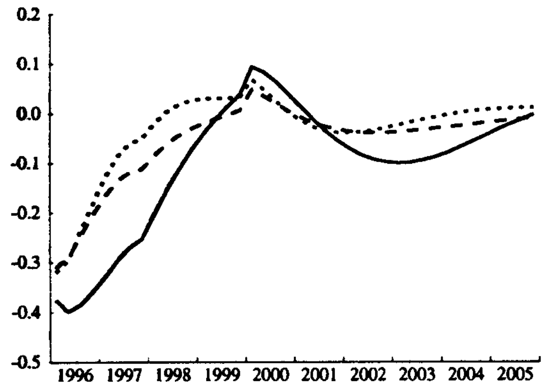
Nominal Wage Rate (%)



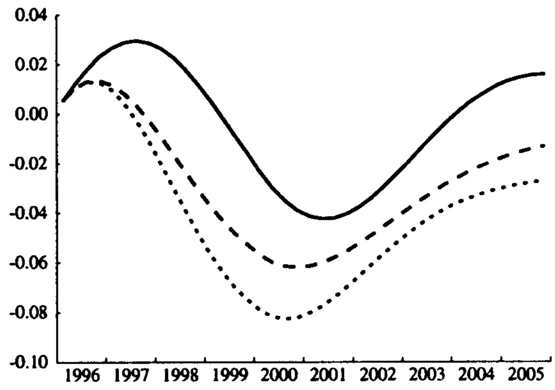
Real Wage Rate (%)



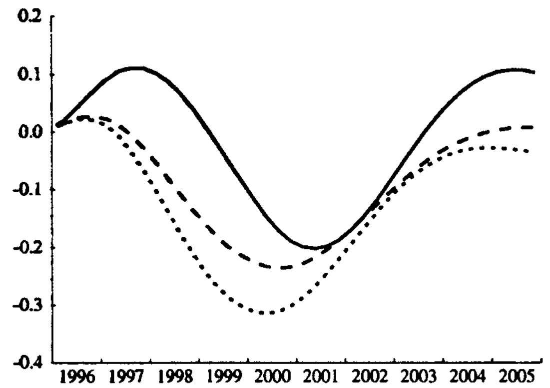
Unemployment Gap (+/-)



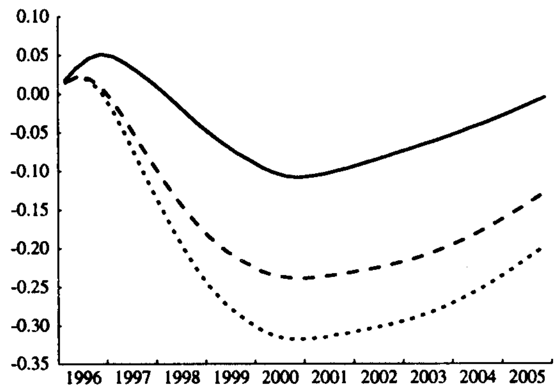
Potential GDP (%)



Non-Residental Capital (%)



Residental Capital (%)

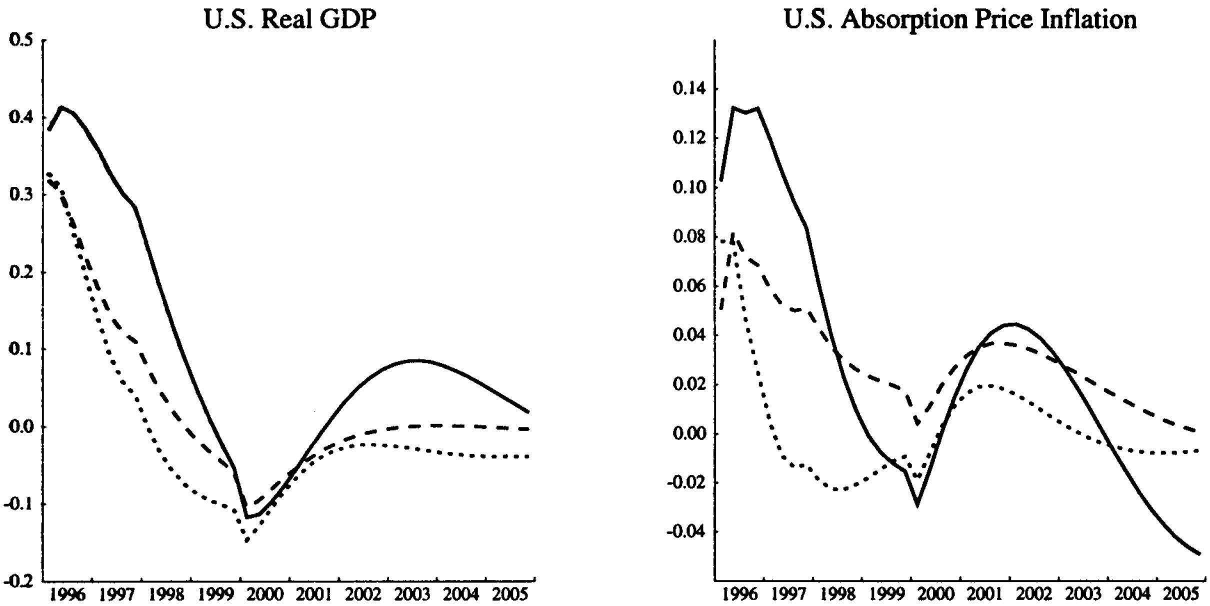


Alternative U.S. Monetary Policy Rules
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dot-Dashed: Nominal GDP Target

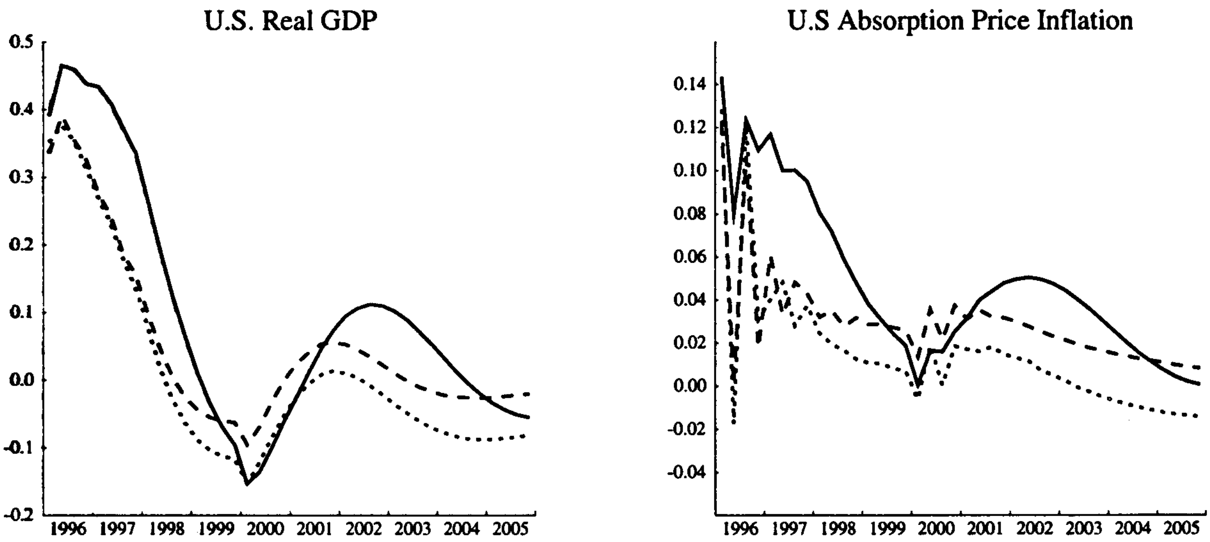
Chart 2

US aggregate demand shock: temporary 5% change in government spending

Model-Consistent Expectations



VAR-Based Expectations



Alternative U.S. Monetary Policy Rules

Solid: Taylor's Rule

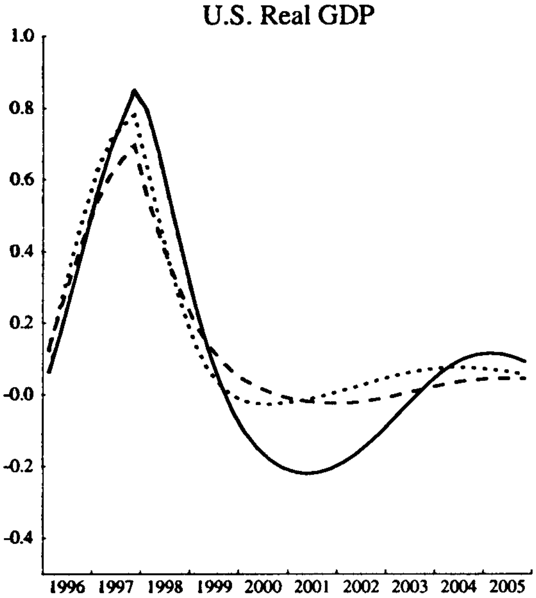
Dashed: Henderson-McKibbin Rule

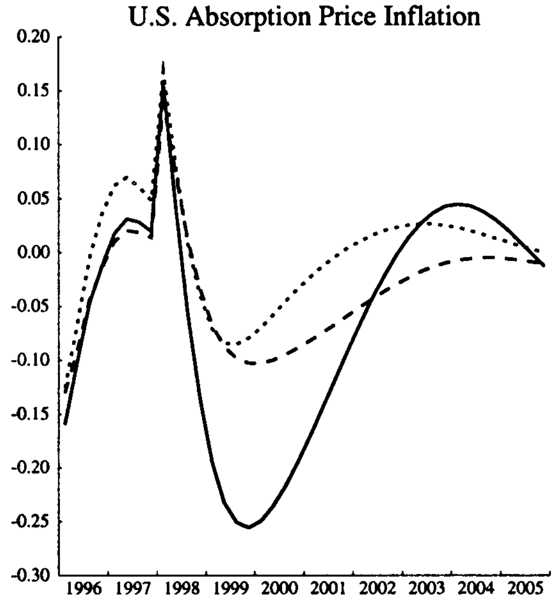
Dotted: Nominal GDP Target

Chart 3

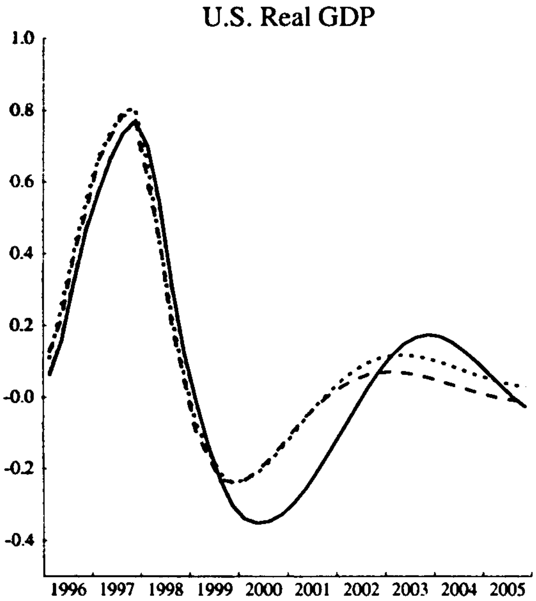
US aggregate supply shock: temporary 1% change in production

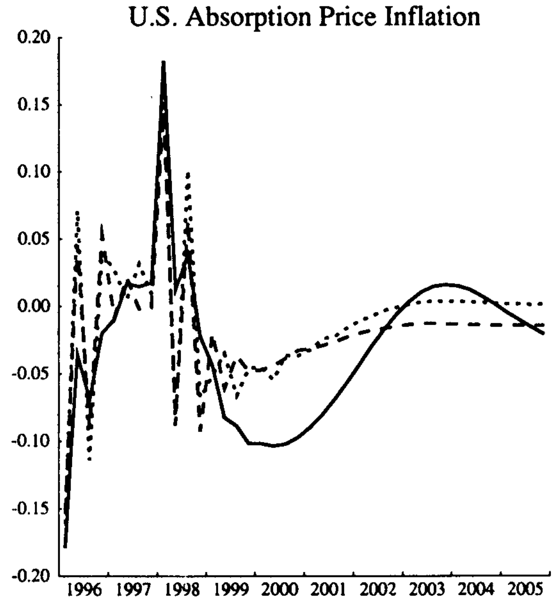
Model-Consistent Expectations





VAR-Based Expectations





Alternative U.S. Monetary Policy Rules
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dotted: Nominal GDP Target

Chart 2 reports simulation results for US output and inflation in response to a US aggregate demand shock under alternative assumptions about expectations formation. The upper panels of Chart 2 reproduce the results from Chart 1 for the case of model-consistent expectations, while the lower panels of Chart 2 report simulation results for the case of VAR-based expectations. The three alternative monetary policy rules have roughly similar features under both assumptions about expectations formation. The most striking difference is that the nominal GDP and H-M rules induces substantial initial volatility under VAR-based expectations, but not under model-consistent expectations; whereas Taylor's rule generates fairly similar paths for the inflation rate under both expectations assumptions.

Chart 3 reports the response of US output and inflation to a temporary US aggregate supply shock under alternative monetary policy rules and alternative assumptions about expectations formation. As indicated above, this shock consists of an exogenous 0.5 percent increase in US total factor productivity (TFP) during 1996 and 1997. All three interest rate rules have fairly similar implications during the first two years of high productivity: real GDP is initially below potential, which generates downward pressure on wages and prices until aggregate demand rises to the level of potential output. After TFP returns to its baseline path, aggregate demand suddenly exceeds potential output, generating positive inflationary pressure. At this point, the interest rate hikes prescribed by the nominal GDP and H-M rules are large enough to push aggregate demand back toward baseline fairly smoothly, whereas Taylor's rule yields a much longer and more cyclical adjustment path for both output and inflation.

4.3 Other country-specific shocks

Charts 4 and 5 report simulation results for German output and inflation in response to temporary shocks to German government spending and total factor productivity, respectively. Charts 6 and 7 report simulation results for Japanese output and inflation in response to the corresponding Japanese shocks.

Under the assumption of model-consistent expectations, the H-M rule yields greater output and inflation stability than Taylor's rule, regardless of the type of aggregate shock. Compared with Taylor's rule, the H-M rule prescribes a larger initial increase in the short-term interest rate, which dampens investment and net exports and thereby partly offsets the aggregate demand stimulus of the change in government spending.

Under VAR-based expectations, the comparison is less clear-cut: for the German aggregate demand shock, Taylor's rule yields greater output and inflation stability than the H-M rule; for the German aggregate supply shock, there is an output-inflation volatility trade off in choosing between the two rules; and for both Japanese shocks, the two rules generate fairly similar output and inflation behaviour. These results highlight the importance of the expectations formation mechanism in evaluating alternative monetary policy rules.

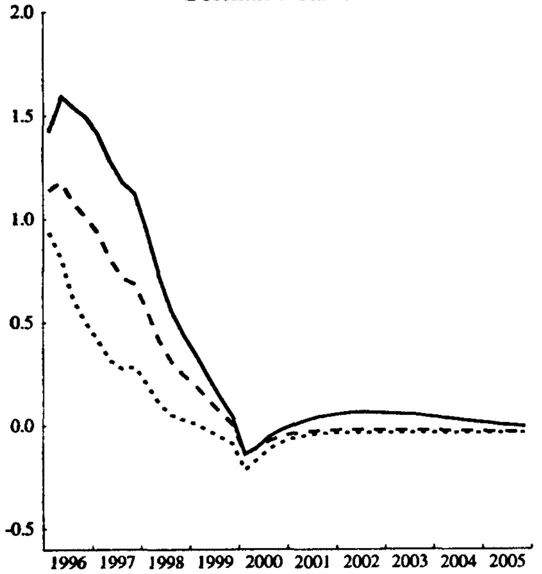
Finally, in contrast to the US results, both the German and Japanese simulation experiments indicate that the nominal GDP rule tends to provides greater output and inflation stability than either the H-M rule or Taylor's rule. This finding suggests that a price level target may be superior to an inflation rate target for economies in which international trade comprises a relatively high fraction of real GDP.

Chart 4

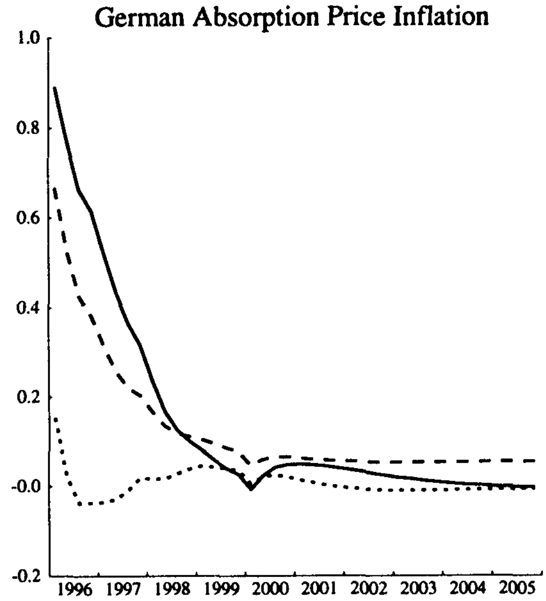
German aggregate demand shock: temporary 5% change in government spending

Model-Consistent Expectations

German Real GDP

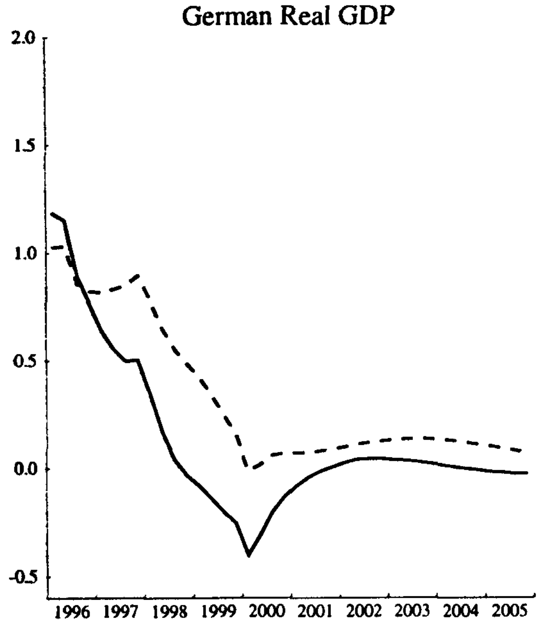


German Absorption Price Inflation

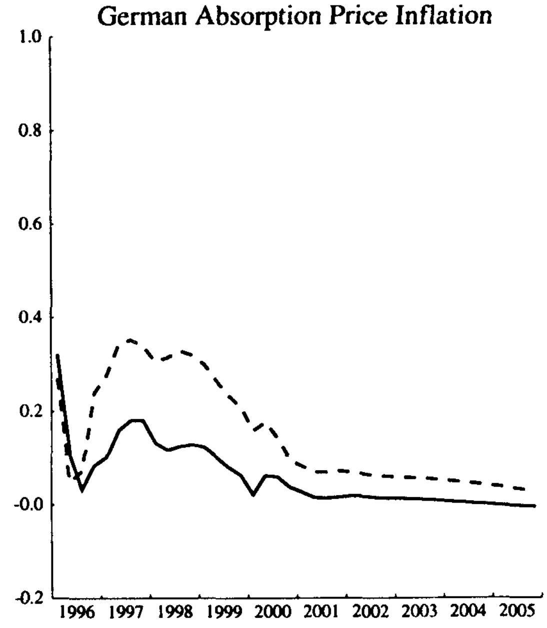


VAR-Based Expectations

German Real GDP



German Absorption Price Inflation

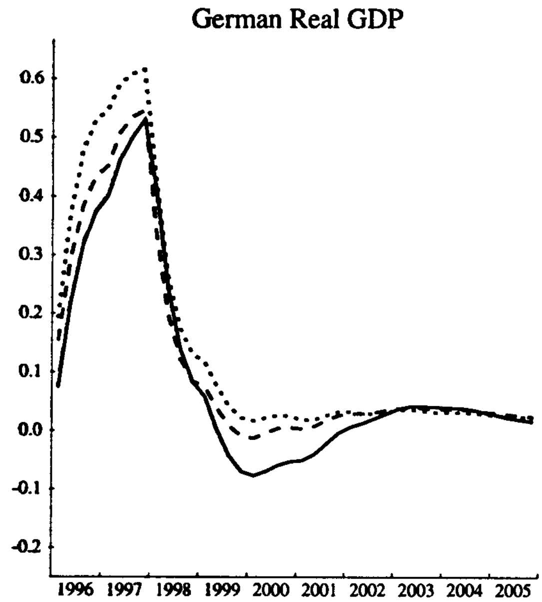


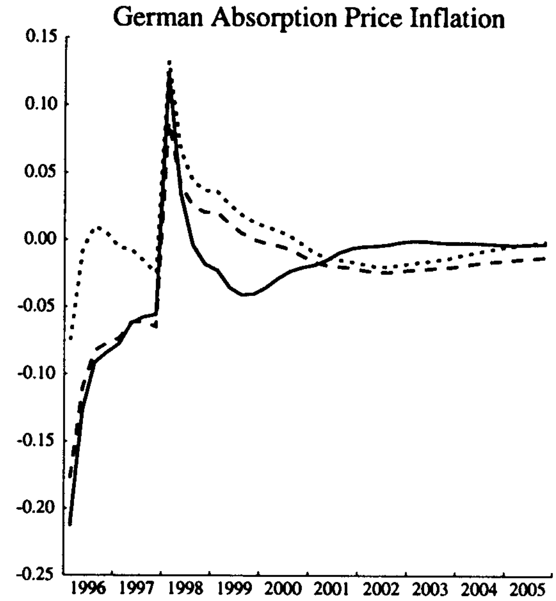
Alternative German Monetary Policy Rules
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dotted: Nominal GDP Target

Chart 5

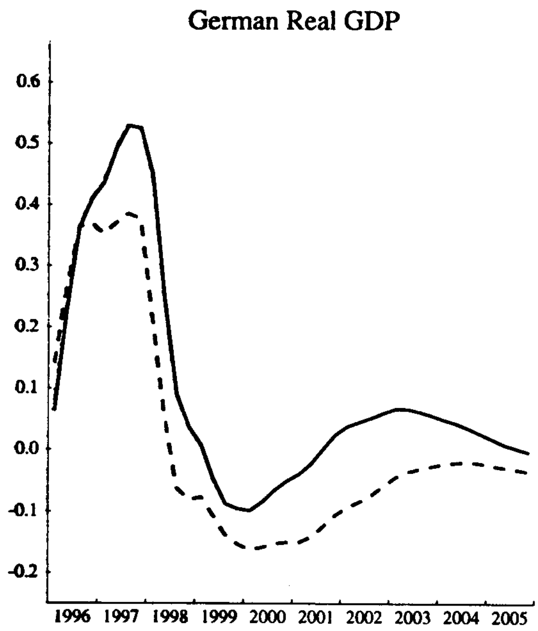
German aggregate supply: temporary 1% change in production

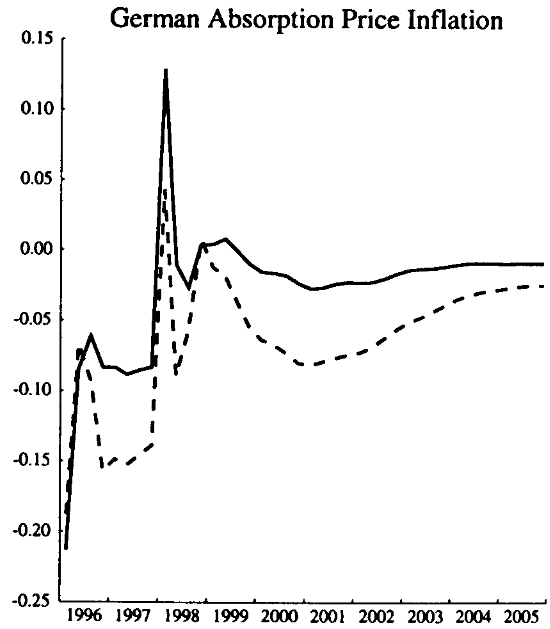
Model-Consistent Expectations





VAR-Based Expectations





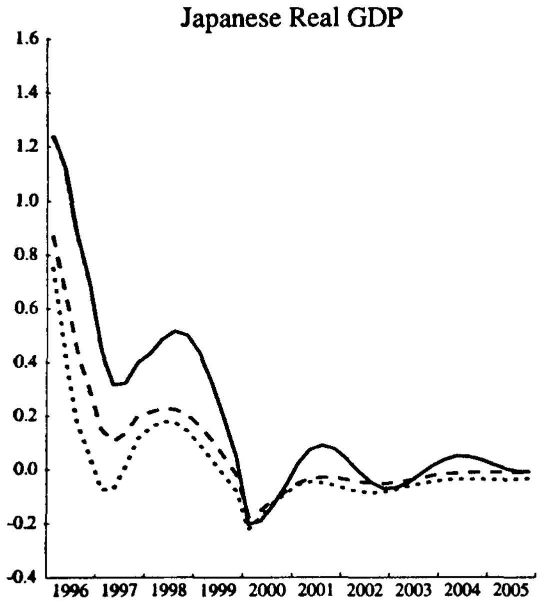
Alternative German Monetary Policy Rules

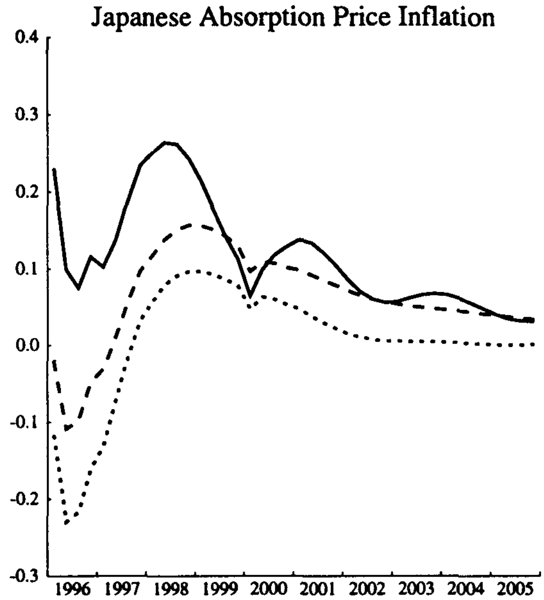
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dotted: Nominal GDP Target

Chart 6

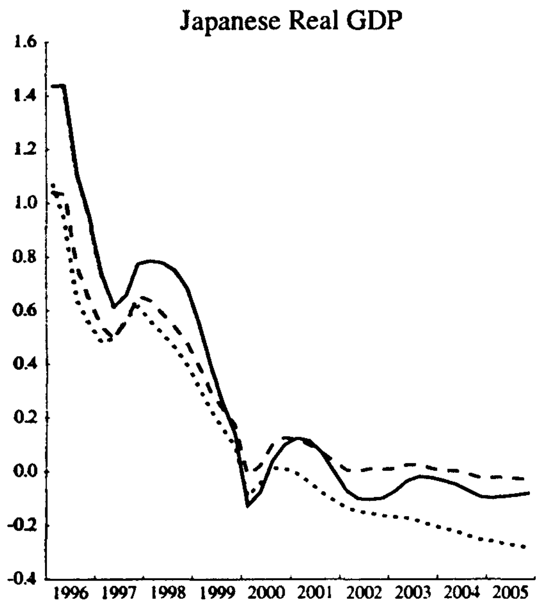
Japanese aggregate demand shock: temporary 5% change in government spending

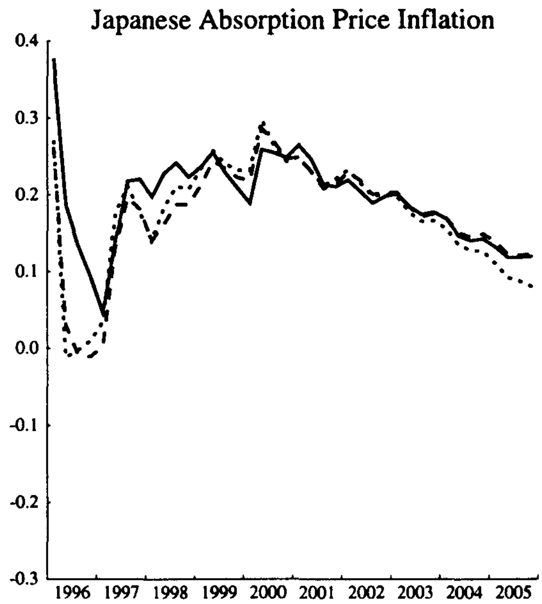
Model-Consistent Expectations





VAR-Based Expectations





<u>Alternative Japanese Monetary Policy Rules</u>

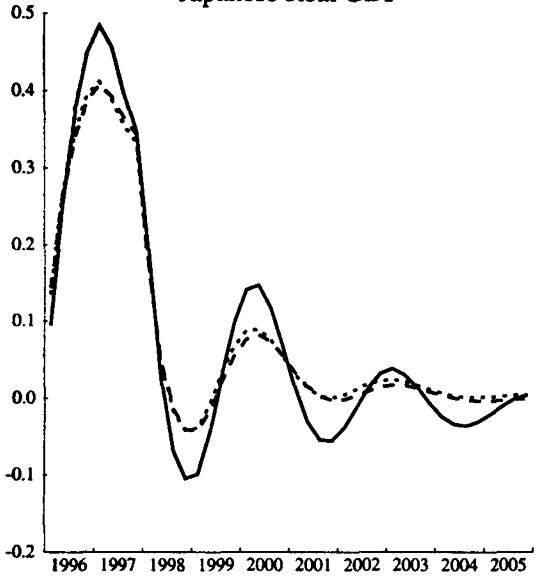
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dotted: Nominal GDP Target

Chart 7

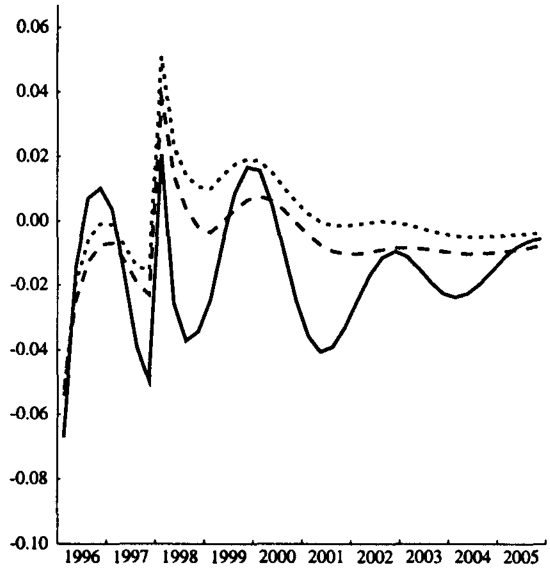
Japanese aggregate supply shock: temporary 1% change in production

Model-Consistent Expectations

Japanese Real GDP

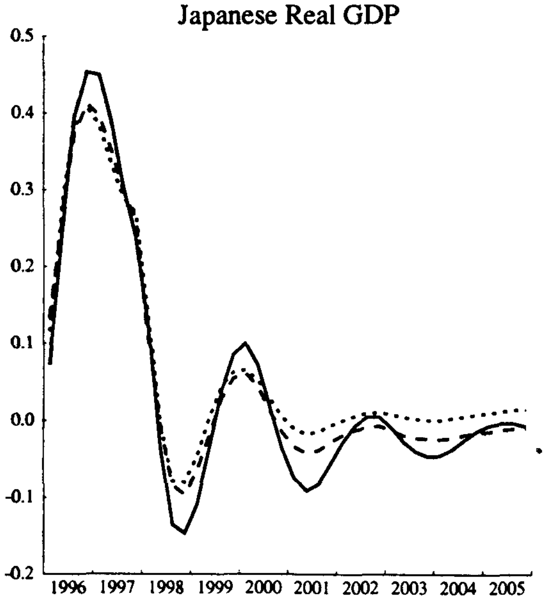


Japanese Absorption Price Inflation

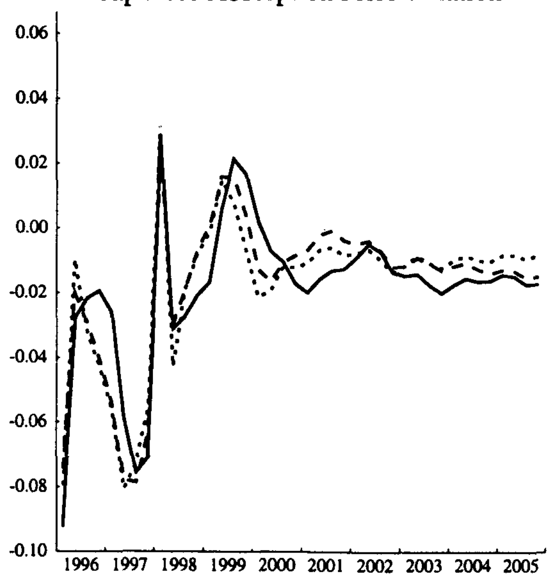


VAR-Based Expectations

Japanese Real GDP



Japanese Absorption Price Inflation



Alternative Japanese Monetary Policy Rules
Solid: Taylor's Rule
Dashed: Henderson-McKibbin Rule
Dotted: Nominal GDP Target

5. Directions for future research

The FRB/MCM simulations of US aggregate demand and aggregate supply shocks generally confirm the favourable properties of the monetary policy rule considered by Henderson and McKibbin (1993). By targeting inflation rather than the price level, the H-M rule generates greater output stability and similar inflation stability compared with a policy rule based on nominal GDP targets. By prescribing larger interest rate adjustments in response to the current output gap and current inflation deviation from target, the H-M rule generates more stable economic activity and inflation compared with Taylor's (1993) rule.

Based on the German and Japanese simulation experiments, the choice of an appropriate monetary policy is less clear-cut. Under model-consistent expectations, the H-M rule provides greater output and inflation stability than Taylor's rule, just as in the US simulations. Under VAR-based expectations, however, neither rule clearly dominates the other. Furthermore, the nominal GDP target appears to generate a lower degree of output and inflation volatility than either rule based on an inflation rate target. These results highlight the crucial role of assumptions about how economic agents' expectations are formed - an issue that is not very well understood and that deserves further investigation.

A number of prospective modifications of the FRB/MCM could also have significant implications for the performance of alternative monetary policy rules. First, the current version of the FRB/MCM incorporates Taylor's (1980) overlapping contract structure, which yields substantial persistence in the nominal wage level but not necessarily in the wage inflation rate. Thus, it will be useful to consider alternative formulations that yield a higher degree of inflationary inertia; e.g., the contracting structure considered by Fuhrer and Moore (1995). Second, in the current version of the FRB/MCM, consumption and investment are sensitive to the *ex ante* real interest rate and to current and lagged disposable income or aggregate demand. In future research, it will be useful to consider specifications in which expected future changes in real GDP also influence the current levels of consumption and investment. Third, empirical research is already underway to provide estimated values for a much larger number of FRB/MCM parameters, which will tend to generate larger differences in the macroeconomic behaviour of the various sectors of the FRB/MCM. Finally, Federal Reserve staff are in the process of constructing a joint FRB model, which combines the new quarterly domestic model (FRB/US) with the foreign sectors of the FRB/MCM. Since the FRB/US model incorporates a number of innovative modelling features, it will be highly informative to investigate the properties of alternative monetary policy rules using the joint FRB model.

Appendix: Renormalised forward-looking equations in the FRB/MCM

1. Definitions of variables

RS	Short-term nominal interest rate (annual rate).
RL	Long-term nominal interest rate (annual rate).
PABS	Domestic absorption price deflator.
DPABS	Short-term inflation rate (annual rate).
DPEXP	Long-term expected inflation (annual rate).
W	Aggregate nominal wage rate (annual rate).
RW	Aggregate real wage (adjusted by absorption price deflator).
X	Nominal contract wage rate (annual rate).
XW	Contract/aggregate wage differential.
UNDEV	Unemployment deviation from natural rate.
ER	Nominal exchange rate (local currency/US$).
URS	US short-term interest rate (annual rate).
UPABS	US domestic absorption price deflator.
RER	Bilateral domestic/US real exchange rate (adjusted by absorption prices).
NXDEBT	Net external debt (in US$).
GDPPOTV	Nominal potential GDP (in local currency).
ERR.*	Exogenously determined residual for equation*.

2. Identities

Domestic absorption inflation rate

$$DPABS = 400\ [\log(PABS) - \log(PABS(-1))]$$

Aggregate nominal wage rate

$$\log(W) = 0.25\ [\log(X) + \log(X(-1)) + \log(X(-2)) + \log(X(-3))]$$

Real wage rate

$$RW = 100\ [\log(W) - \log(PABS)]$$

Contract wage/aggregate wage differential

$$XW = 100\ [\log(X) - \log(W)]$$

Real exchange rate

$$RER = ER * UPABS/PABS$$

3. Behavioural equations

Long-term interest rate (term structure)

$$RL = 0.05 + 0.05\ RS + 0.95\ RL(+1) + ERR.RL$$

Long-term expected inflation

$$DPEXP = 0.05\ DPABS(+1) + 0.95\ DPEXP(+1) + ERR.DPEXP$$

Contract wage determination

$$\begin{aligned} XW = {} & -0.75\ RW + 0.25\ RW(+1) + 0.25\ RW(+2) + 0.25\ RW(+3) \\ & + 0.1875\ DPABS(+1) + 0.125\ DPABS(+2) + 0.0625\ DPABS(+3) \\ & - 0.005\ [UNDEV + UNDEV(+1) + UNDEV(+2) + UNDEV(+3)] \\ & + ERR.XW \end{aligned}$$

Uncovered interest parity

$$\begin{aligned} \log(RER) = {} & \log(RER(+1)) + [URS - UDPABS(+1) + RS - DPABS(+1)] / 400 \\ & + 0.01\ ER * NXDEBT/GDPPOTV + ERR.RER \end{aligned}$$

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Comments on paper by A. Levin by C. Borio (BIS)

The technical core of A. Levin's paper is the development of an algorithm for models simulated under model-consistent expectations permitting the evaluation of policy rules under which the price level is non-stationary. Taylor's rule, prescribing changes in the short-term rate partly in response to deviations of inflation from its target path, is a popular example of such a reaction function. This the paper does very successfully, making a significant contribution to the existing literature.

The paper then goes on to evaluate the performance of three alternative policy rules (a nominal GDP target as well as Taylor's and Henderson-McKibbin's inflation-cum-output gap targets) in response to two types of shock (an aggregate demand and an aggregate supply shock) for three countries (the United States, Germany and Japan) using the Federal Reserve Board's multi-country model. The evaluation is carried out assuming, alternatively, model-consistent and adaptive (VAR-based) expectations. At least regarding the United States, the author appears to come down in favour of the Henderson-McKibbin rule. For Germany and Japan, the choice is said to depend partly on the expectations formation mechanism assumed. Under adaptive expectations, a nominal income target rule is argued to be preferable.

My remarks will not deal with the technical part of the paper. Rather, they will pay particular attention to its evaluation of policy rules and its possible implications for policy. My first set of comments will take the framework underlying the paper as given and make a few suggestions regarding avenues for improvement and issues that would deserve closer examination. I shall then broaden the horizon a bit and have something to say about the usefulness of the underlying framework itself as a guide to policy making.

The basic framework employed goes back to Poole's (1970) seminal paper on the comparison between interest rate and monetary targets in a simple IS-LM model based on a quadratic "objective" function for the final goal, in that case output. That paper has spawn an enormous literature of increasing degree of sophistication. This piece of work can be thought of as one distant offspring.

Let's take for granted for the moment that the relevant criterion for assessing performance is the volatility of inflation and output from baseline. When no rule is dominant two ingredients necessary to rank rules are:

(a) a representative "objective" function, stating how variability in the goals should be traded off, and

(b) an idea of the historical and likely future evolution of the shocks. Neither of these elements, however, is still present in the paper.

Point (b) would ultimately lead to stochastic simulations, a conceptually appealing but probably computationally overwhelming exercise. Less demandingly, the author could provide some idea of the historical distribution of the shocks. Point (a) could best be addressed by finding out the cut-off parameters that would tip the balance in favour of one type of rule relative to another. Some independent criterion would then be needed to assess how "reasonable" such a cut off could be given the assumed costs of variability in each of the goals.[11]

How far do these objections affect the basic findings of the paper? They do not impinge so much on the choice between Taylor's and Henderson-McKibbin's rules, since the latter tends to dominate in pair-wise comparisons. They do, however, have an impact on the relative ranking of the

11 Of course, steps (a) and (b) could not deal with the issue of *model uncertainty*, in this case resulting from alternative assumptions about the expectations formation mechanism.

nominal GDP target rule (see Table 1)[12], which in fact receives little prominence in the author's conclusions. An analysis of the kind suggested would help to clarify if such an emphasis is indeed justified within the confines of the assumed framework.

A second issue concerns the range of policy rules considered. Two kinds of rules can be distinguished in the literature. The first are "simple rules". In this case the premium is on rules that are not only feasible in practice but also robust across models when the policy maker has little basis for choosing between them ("model uncertainty"). The second are "optimal rules" given the model and the distribution of the shocks. Poole's "combination policy" is one such example. The reaction functions considered in the paper are clearly "simple" ones. Yet this leaves unanswered several teasing questions. If the source of the superiority of the Henderson-McKibbin's rule over Taylor's is the greater weight on the output gap, possibly as a forward-looking indication of inflation, why not raising it still further? Is there not a case, that is, for seeing what parameter values of the simple rules would do better? What is the reason for considering those rules rather than others? This is indeed not such a gratuitous observation, given that at least one country in the sample, Germany, has operated, and is avowedly continuing to operate, a monetary target rule. In fact, to the extent that the nominal GDP target is its closest equivalent out of the reaction functions considered, the authorities may find it surprising that it should perform comparatively poorly.[13] This, of course, raises the issue of the extent to which it may be appropriate or helpful to run such experiments for different countries assuming a similar structures and disregarding country-specific factors.[14]

A third issue concerns the interpretation of the results. A very interesting, possibly surprising, finding of the paper is that the assumption regarding expectation formation mechanisms appears to have little impact on the ranking of policy rules in two out of three countries, viz. the United States and Japan. By contrast, it could have significant implications for Germany, depending on the nature of the shocks. A further, less clear [15], finding is that the most appropriate policy rule may differ between countries. The curious reader would clearly like to know more about the possible reasons for such differences in order to be able to draw more general and robust conclusions. The paper contains little by way of elucidation.[16]

Turning next to the usefulness of the basic framework assumed, I would like to mention here only one neglected issue. This is that, contrary to what it is implicitly assumed in the paper, in most real world circumstances *asymmetries* are important for policy. These asymmetries relate to the "cost function", trading off different goals, as well as to the feasible policy rules. Let me elaborate briefly on each.

Quadratic cost functions focusing on the variance of various goal variables have several nice mathematical properties, not least linear reaction functions. Yet I wonder whether policy makers' objectives should not be better captured by asymmetric functions. In normal circumstances, overriding concerns about the risks of losing control over inflation would result in asymmetric policy rules, as the authorities would be more tolerant of inflation rates below original targets paths than they

12 For clarity, it would be useful if the table was complemented by explicit rankings for each row (country and expectational assumption) and goal (output and inflation variability).

13 The conclusion that for Germany "the nominal GDP target appears to generate a lower degree of output and inflation volatility than either rule based on an inflation rate target" does not appear to correspond to what is shown in Table 1. According to this table, the nominal GDP target rule actually yields the highest output and inflation volatility under adaptive expectations. While generally performing much better under model-consistent expectations, it still yields the highest output volatility in the case of aggregate supply shocks.

14 See eg. BIS (1995).

15 It is not easy to draw such a clear cut inference from Table 1.

16 In fact, the inference that openness favours nominal GDP targeting does not seem warranted. Even assuming that a rigorous ranking would indicate that such a strategy was clearly superior in Japan and Germany but not in the United States, Japan is hardly more open than the United States.

would be of errors in the opposite direction. The authorities, that is, would be prepared to take advantage of any opportunities that arose in order to reduce inflation. An opposite situation could emerge when inflation is already very low. In this case the risk of deflation could tip the balance in favour of greater acceptability of inflation outcomes above original targets. This asymmetry can arise either because the costs of deflation are perceived as larger than those of (moderate) inflation, or because of the possibly more limited room for manoeuvre at very low inflation rates: interest rates may not be able to fall enough to counteract the deflationary effects of shocks, say, to the exchange rate. The recent Japanese experience might well be viewed in this light.

Similar considerations can easily apply to the range of feasible policy rules. Limited credibility can act as a powerful constraint on the range of options available to the authorities. This is clearly illustrated by the Canadian experience.[17] A long history of comparatively high inflation exacerbated by weak public finances, high foreign debt and by an at times uncertain political climate have made it harder for the authorities to ease than to tighten, as the markets have exhibited limited tolerance for easing moves that they perceive as unjustified (Zelmer (1995)). The point here is that credibility and communication issues, so central to policy making, are assumed away in the framework of the paper.

Let me end with a final remark on the role of the output gap in the formulation of monetary policy. The well-known problem for central banks is how to control an economic magnitude (inflation) that responds with an uncertain and long lag to policy. Monetary targets, for a time, had been perceived as a useful compass to guide the authorities' actions. Nowadays, that compass has effectively been lost, at least for most central banks. From this perspective, the paper raises two additional teasing questions. Looking back, given the dominance of the Henderson-McKibbin rule over Taylor's, which appears to be a good approximation to actual Fed policy in the past, I wonder whether the author would like to draw the counterfactual implication that the Fed should de facto have placed even greater weight on the output gap in its decisions. Looking ahead, would he also like to argue that the output gap should perhaps be put on the pedestal from which monetary targets have so embarrassingly been dislodged? I would be surprised if the search for the Holy Grail had ended, for this is search that is bound to fail.

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17 Canada was originally included in the paper.