III

Econometric Policy Evaluation

6

Design of Policy Systems

This chapter considers the design of macroeconomic policy systems. Three questions are addressed. First, is a worldwide system of fixed exchange rates between the major currencies desirable? Second, are there gains from designing monetary policy rules in coordination with other countries? Third, does a price rule, a nominal-income rule, or some other rule for monetary policy give the best domestic economic performance? The first two questions relate to international monetary policy, the third to domestic monetary policy. If one could reliably answer all three questions, and if there *was* a consensus about the answers, then policymakers would have a pretty good fix on what a macroeconomic policy system should look like in today's economy. Hence, these questions seem like a good place to begin an investigation of policy design.

In principle, the three questions are not separable. For example, the choice of a domestic policy rule (Question 3) affects the choice of an exchange-rate system (Question 1). One could imagine a poorly designed rule for domestic monetary policy that would make either a fixed or a flexible exchange-rate system look bad. However, it is a monumental task to consider all three questions simultaneously within one grand policy-optimization problem, and the complexity of the task would make for a nearly impossible interpretation of the results. Hence, the analysis does not attempt to address all three questions at once. Rather, it is a sequential analysis: first, the exchange-rate system, second, international coordination, and finally, the optimal domestic monetary policy rule. As will become clear, the order has some logic to it and makes the analysis easier.

The multicountry model with the stochastic shocks and the dynamic policy effects described in the previous three chapters is used for each of the design problems. The method of analysis—stochastic simulation of the multicountry model—is directly analogous to both the simple theoretical evaluation of policy using the stylized model in Chapter 1 and the empirical evaluation using the model of the United States in Chapter 2. However, because of the size and the nonlinearity of the model, the method may appear more opaque.

The stochastic simulations are conducted over a representative future ten-year period—the particular period makes little difference for the analysis. The shocks for the stochastic simulation are drawn from the estimated distribution of shocks described in detail in Chapter 4. The performance of the seven countries is examined under the different macroeconomic policy systems. The alternative policy systems are ranked according to how successful they are in reducing the fluctuations in inflation, real output, the components of spending, exports, and imports. Of course, other factors may be relevant for policy decisions, such as the impact on long-term growth, income distribution, and even national security.

This approach deals explicitly with several issues raised by the Lucas critique of traditional econometric policy-evaluation methods. In fact, the three examples used in the original critique paper of Lucas—consumption demand, price determination, and investment demand—are part of the multicountry model. Endogenizing expectations by using the rational expectations assumption, as Lucas did in his original paper, is precisely what automatically happens in the multicountry model. To be sure, the equations of the model could benefit from more theoretical research, and the rational expectations assumption may not be appropriate in periods immediately following a policy reform (when market participants are learning about the policy). The transition to new policy systems is the focus of Chapter 7. Nevertheless, the approach does seem appropriate for estimating the long-term effects of policy regimes.

Another advantage with the approach—and an important methodological innovation for international monetary policy research—is the use of a statistically estimated distribution of shocks. In contrast, the stylized analysis of international monetary systems presented in Chapter 1 was based on *assumed parameter values* for the equations and *assumed distributions* for the shocks to the equations. However, this is also true of many previous attempts to evaluate international policy rules from a stochastic viewpoint.[1] These previous theoretical studies are useful for highlighting key parameters that affect the answers. For example, in a static non-rational expectations model that can be put into an ISLM framework, a fixed exchange-rate system will work better if country-specific shocks to the *LM* equations have a relatively large variance. In that case, a fixed exchange-rate system offers the same advantages as interest-rate targeting. On the other hand, a flexible exchange-rate system will work better if country-specific shocks to the *IS* equations have a relatively large variance. To get any further than this

[1] See Carlozzi and Taylor (1985), McKibbin and Sachs (1989), or Fukuda and Hamada (1987). Poole (1970) was one of the first to study the effect of different types of shocks in a single-country, theoretical ISLM framework without rational expectations.

requires estimates of the size of the shocks. Moreover, the proofs of these theoretical results depend on a number of simplifying assumptions that are most likely unrealistic. For example, it is typically assumed that the *IS* and *LM* shocks are either uncorrelated or perfectly correlated between countries and that there are no other shocks—such as labor-market shocks, exchange-rate shocks, or commodity-price shocks. The proofs also require that the demand and supply elasticities be in a certain range (usually the same in all countries). An empirical framework provides guidance about such assumptions. The estimated parameters and estimated distributions of the shocks used in this chapter are based on real-world data. As will be discussed below, applying this technique raises several new and interesting issues—such as how the probability distribution of the shocks may change when policy changes—and it is not without its own shortcomings.

The policy-design issues considered in this chapter focus entirely on monetary policy. The study of fiscal policy rules—automatic stabilizers or budget-balancing strategies—could be considered by using the same approach. For this analysis, however, we take government purchases as exogenous and assume that other components of the government budget—tax revenues and transfers—affect income and thereby private spending as they did during the sample period of the multicountry model. For example, automatic stabilizers affect the response of disposable income to changes in national income and, thereby, affect the response of consumption to national income incorporated in the consumption equations discussed in Chapter 3.

The design of fiscal policy rules is an important element of macroeconomic policy analysis, despite the well-known problems with discretionary fiscal policy. Automatic stabilizers remain an important part of macroeconomic policy and help mitigate recessions. However, automatic stabilizers in most countries are affected by goals that go well beyond those of macroeconomic policy. For example, changes in the progressivity of the tax system affect the responsiveness of the automatic stabilizers but are not made with stabilization policy in mind.

6.1 The International Monetary System: Fixed or Flexible Rates?

One of the most important questions about the design of international monetary policy concerns the role of the monetary authorities in stabilizing exchange rates. The classic question is simply, "Should exchange rates be fixed or flexible?" In reality, the question is less black and white. Target zones—in which the monetary authorities permit exchange rates to fluctuate within rather wide margins around a fixed parity—are frequently proposed as a more practical alternative to fixed rates. Fixing exchange rates among a group of countries (such as the countries in the European Monetary System) while allowing the exchange rate for members of the group to fluctuate freely against other countries is another alternative. Despite the continuing importance of the exchange-rate questions, surprisingly few empirical studies have attempted to evaluate the effects of fixed-versus-flexible exchange rates. In particular, there have been no econometric policy evaluations that have addressed these questions while dealing with expectational issues and capital mobility, both of which are widely viewed as crucial to exchange-rate behavior. Policy advisors, therefore, have had to rely on the ambiguous theoretical studies or on intuitive judgments.

Assumptions about Monetary Policy Rules

In comparing the fixed-versus-flexible exchange-rate system, I assume that monetary policy is conducted according to a particular policy rule in which the short-term interest rate is assumed to be the primary instrument of monetary policy. In recent years, the short-term interest rate—the federal funds rate in the United States, for example—has been used in practice by central bankers much more frequently than money supply as the operating instrument for monetary policy decisions. Although the money supply has been used as a guide to monetary policy in varying degrees from time to time, deciding on a setting for interest rates is a better characterization of how policy is operated today in most countries. At an early stage of my research, I investigated fixed-versus-flexible exchange rates within the context of money-supply rules. The results on the choice of an exchange-rate system are similar, but interest-rate rules provide a cleaner comparison because they automatically eliminate velocity shocks, which are quite large in some of the equations.

For all the policy rules considered in this section, the interest rate is assumed to react to deviations of a price index from a target level. Alternatives in which the interest rate reacts to other indicators—such as real output—are considered later in the chapter when discussing the design of an optimal domestic monetary policy rule. The comparisons of fixed-versus-flexible rates described in this chapter could also be made for these alternative assumptions about the monetary policy rule. The results do not appear to be sensitive to this assumption, although an extensive analysis has not yet been performed.

According to the multicountry model, sterilized intervention in the foreign-exchange markets—that is, for which the monetary base does not change—has no effect on exchange rates. International financial markets are characterized by perfect capital mobility and perfect substitution between domestic and international assets. Fundamental changes in monetary or fiscal policy are required to move exchange rates. This property is realistic for the quarterly time interval for which the model is estimated and simulated. Under flexible exchange rates, the nominal interest-rate spread between each pair of countries is equal to the expected depreciation of the exchange rate between the same two countries. In this model, expectations of exchange-rate changes are forward-looking, computed by using the entire model. Although capital flows among countries may be quite large with perfect capital mobility, the accumulated stocks of foreign assets do not affect the analysis.

Interest-Rate Rules under Flexible Rates

For the flexible exchange-rate regime, I assume that each central bank adjusts its short-term interest-rate target in response to changes in the price level. This type of response for monetary policy is sometimes called a price rule. To be specific, I assume that a 1-percent rise in the domestic price level—measured by the output (GNP or GDP) deflator—brings about a monetary response of about a 1½ percentage point rise in the short-term interest rate.[2] For example, suppose that the inflation rate in the United States rises to 5 percent and that this is above the U.S. target of, say, 3 percent. Hence, the price level rises by 2 percent above its target level. According to the policy rule, the Federal Reserve Bank responds by taking actions to raise the federal funds rate by 3 percentage points. The same is true for the other countries. To give another example, if the price level in Japan falls by 1 percent below its target, then the Bank of Japan lowers the call-money rate by about 1½ percentage points. Such interest-rate adjustments should be made in real terms; that is, the central bank's target interest rate should be higher if there is a higher expected inflation rate than if there is a lower expected inflation rate. In general, therefore, the interest-rate rule for each country (i) can be written algebraically as

$$RS_i - RS_i^* = LP_i(+4) - LP_i + g(LP_i - LP_i^*) \tag{6.1}$$

if $RS_i > .01$ and $RS_i = .01$ otherwise. The notation of Equation (6.1) is essentially the same as that of Chapter 3; RS is the short-term interest rate and LP is the log of the price level. The target for the (log of the) price level is LP^* and g is the reaction coefficient. RS^* is the (real) interest rate consistent with the price level being on target. Note that $LP(+4)$ is the rational forecast of the (log of the) price level four quarters ahead. Hence, $LP(+4) - LP$ is the expected inflation rate, and Equation (6.1) is effectively a real interest-rate rule. Of course, this does not mean that the central bank is attempting to peg the real interest rate. The interest rate adjusts depending on what happens to the price level. The real interest rate is the *ex ante* real interest rate based on the rational forecast of inflation from the multicountry model. Without truncation from below, the semi-log functional form in Equation (6.1) does not rule out the possibility that the nominal interest rate RS becomes negative. If the price level falls 10 percent below the target, for example, then the functional form could call for a negative nominal interest rate. Since negative nominal interest rates are not

[2]The exact interest-rate response in the simulations is 1.6 percentage points. The precise value for this response coefficient does not matter for the choice between fixed and flexible exchange rates. Alternative values are considered below.

feasible, Equation (6.1) must be truncated below some nonnegative value, which is taken to be 1 percent in this analysis ($RS_i = .01$). In other words, whenever the function in Equation (6.1) calls for a nominal interest rate below 1 percent, the nominal interest rate is set to 1 percent. This truncated form of Equation (6.1) is the policy rule that the monetary authorities are assumed to follow.

When the model is simulated under the flexible exchange-rate regime, the interest-rate rules in Equation (6.1) replace the inverted money-demand equations that would be in operation if money-supply rules were used as the policy variable. Money is now endogenous and the behavior of the money supply can be computed directly from the money-demand equations. Recall that the money supply only enters the model through the interest-rate effects captured in Equation (6.1).

Interest-Rate Rules in the Fixed Exchange-Rate System

For the fixed exchange-rate system, the interest rates in the individual countries cannot be set independently of one another. For example, if the Federal Reserve raised the federal funds rate above the Japanese call-money rate, funds would flow quickly into the United States, putting upward pressure on the dollar and threatening the fixed rate unless the Bank of Japan likewise raised the call-money rate. In order to keep exchange rates from fluctuating, therefore, a common target for the "world" short-term interest rate must be chosen. Short-term interest rates with similar maturities and risk characteristics cannot diverge from one another. Hence, short-term interest rates are equated throughout the world, and a policy rule for the "world" short-term interest rate is needed. Analogously with the flexible exchange-rate case, it is assumed that world short-term interest rates rise if the world price level rises above the target. That is,

$$RS_i - RS_i^* = LP_w(+4) - LP_w + g(LP_w - LP_w^*) \tag{6.2}$$

if $RS_i > .01$ and $RS_i = .01$ otherwise. The log of the world price level LP_w is defined as a weighted average of the price levels in the G-7 countries, and LP_w^* is the target value.[3] Note that according to Equation (6.2), the interest rates are the same in all the countries. Several alternative sets of weights for computing world average price LP_w are possible. For the results reported here, I focus on the following set of weights: United States = .3, Canada = .05, France = .05, Germany = .2, Italy = .05, Japan = .3, United Kindgom = .05. The weights were chosen after some preliminary simulations. As explained below, the relatively high weight on Japan was chosen in order to reduce the size of the output fluctuations in Japan. Lower weights on Japan will increase fluctuations in Japan and tend to worsen the performance of the fixed exchange-rate system. The values for the short-term

[3]As in the flexible exchange-rate case, the exact value of g used in the simulations is 1.6.

interest rates are truncated in Equation (6.2) as in Equation (6.1) to rule out negative nominal interest rates.

As in the case of flexible exchange rates, the interest-rate rules in Equation (6.2) replace the inverted money-demand equations. However, because the interest rates in different countries are equated in Equation (6.2), the interest-rate differentials in the interest-rate parity equations are set to zero. Therefore, the expected change in the exchange rate is zero, which is implied by a credible fixed exchange-rate system.

Baseline and Targets for Price Levels and Real Output

The baseline for these experiments (that is, for the path for the world economy with no shocks to any equations) was chosen so that real output growth in all countries is the same rate as potential output growth. The measure of performance is based on the mean square distance of the economy from this baseline. However, the actual baseline position of the economy for these experiments does not appear to matter much. On the baseline, the actual price level P equals the target price level P^*, so that the interest rate RS equals RS^*. If there were no shocks, there would be no movements in the interest rate away from this baseline value.[4]

For the purposes of stochastic simulation, the model is solved using the extended path algorithm discussed in Chapter 1. For every period and for each stochastic shock, the model is solved dynamically with future disturbances set to their mean values.

The Stochastic Structure under Alternative Regimes

The preceding section described how the interest-rate equations of the model are changed for the stochastic simulation. Here we consider the covariance matrix and how it is modified. Recall that for stochastic simulation, it is necessary to estimate the variance-covariance matrix of the shocks to the structural equations. The exchange-rate equations are part of the structural equation system, along with interest rates, consumption, investment, wages, and so on. As described in Chapter 4, the covariance matrix was estimated from the residuals of the ninety-eight stochastic structural equations over the period from 1972:1 through 1986:4. The variance-covariance matrix was summarized in Tables 4-1 and 4-2. It is useful to look through those tables again with the following policy analysis in mind.

One of the most difficult questions concerning a possible change in regime from flexible exchange rates to fixed exchange rates concerns the behavior of the shocks to the interest-rate parity equations that link interest-

[4] The target price levels need not be fixed, and in the simulations they were assumed to rise at a constant inflation rate. If the target price levels grow at different rates in the different countries, then the target exchange rates in the "fixed" exchange-rate case should change at a preannounced deterministic rate of crawl. In this case, there would be an average differential between the short-term interest rate that would depend on the inflation-rate differentials.

rate differentials to expected changes in the exchange rate in different countries. Would the behavior of these shocks remain stable across exchange-rate regimes? The question is made more difficult by the fact that the reason for the shocks is not clear and by the fact that we have never had a full fixed-rate system in operation along with the high degree of capital mobility that we now find in the G-7 countries. If the shocks are due to time-varying risk premia, then a fully credible fixed-exchange rate regime should eliminate the shocks. If the exchange-rate system was not fully credible, then the risk premia would persist. Similarly, if the shocks are due to speculative bubbles, a credible fixed exchange-rate system should eliminate the shocks. Indeed, a frequently stated advantage of a fixed exchange-rate system is that speculative swings would be mitigated. However, it is not clear that the shocks are due to speculative bubbles.

In any case, the assumption made here is that the shocks disappear under fixed exchange rates. In other words, when I simulate the flexible exchange-rate case, I assume that the exchange-rate shocks have the standard deviations shown in Table 4-1, but when I simulate the fixed exchange-rate case, I assume that the exchange-rate shocks have zero variances. It is not clear what the relationship among interest rates would be if exchange rates were fixed permanently and if capital markets were unrestricted, but the best guess is that short-term interest rates would be equal in different countries. In any case, this is the assumption made here.

This assumption tends to disadvantage a flexible exchange-rate system in comparison with a fixed exchange-rate system. If one did not make this assumption and instead left the shocks in the interest-rate parity equations for the fixed exchange-rate simulations, the performance of the fixed exchange-rate system would deteriorate. Fluctuations in interest rates would be required to stabilize the exchange rates in the face of risk-premium shocks. The fluctuations in interest rates would lead to fluctuations in output and prices.

Drawing the Shocks

Shocks were drawn from the covariance matrix by using a normal random-number generator. In other words, the shocks are assumed to have a normal distribution with zero mean and the sample covariance matrix of the structural residuals. For the stochastic simulations, ten draws were made over the forty quarter periods, and the model was dynamically simulated with these draws. Each of the draws represented one realization of the stochastic process, and the performance of the macroeconomic variables were averaged across the draws. For each of the ten draws of forty quarters, both the fixed and the flexible exchange-rate systems were examined. In other words, the specific question being addressed is whether a flexible exchange-rate system or a fixed exchange-rate system would work better over a representative ten years, assuming that the shocks to the economy will be drawn from the same universe that shocked the world during the 1970s and early 1980s.

As described in Chapter 4, an alternative simulation procedure, also reported here, is to use the actual structural residuals directly in the simulations, rather than to first use these residuals to estimate the covariance matrix and then take draws from the covariance matrix. The direct approach has the advantage of not relying on normality—during the sample period, the shocks are not normal, and there were some large "outliers." Simulating with the actual shocks may therefore bring in important nonnormalities.

Macroeconomic Performance

The results for the comparison of the flexible exchange-rate system with the fixed exchange-rate system are shown in Table 6-1. As stated above, averages are taken over ten stochastic simulations for the forty-quarter period. There are three columns in the table. The first two columns list the standard deviation of the percentage deviation from the baseline of real output, the output deflator, the price level, the exchange rate, and so on. Also shown is the standard deviation of the percentage-point deviation of the short-term interest rate from the baseline. The third column shows the number of times out of the ten simulations in which the variance under the fixed-rate system is greater than the variance with the flexible-rate system.

The main results can be summarized as follows. The fluctuations in real output are much larger in the United States, France, Germany, Italy, and especially Japan when exchange rates are fixed, compared with when they are flexible. The fluctuations are also larger in the United Kingdom under fixed rates, though the differences are not so large as in the other countries. The standard deviation of output nearly doubles in Germany and Japan under fixed exchange rates in comparison with flexible exchange rates. The fluctuations in real output in Canada are slightly less under fixed rates than under flexible rates. But, as discussed below, there is a deterioration of price stability in Canada under fixed exchange rates. A change in the Canadian domestic policy rule under flexible exchange rates (for example, lowering the response coefficient g in the policy rule) could easily match the output stability of the fixed exchange rate case with more price stability. In this sense, the flexible exchange-rate system dominates.

The deterioration of performance under the fixed exchange-rate regime for Germany and Japan comes from all components of demand as shown in Table 6-1. In Germany, the standard deviation of investment around the baseline sharply rises under fixed exchange rates. The variance of imports also increases. The variance of exports decreases, although by a very small amount. Exports vary slightly less in Germany under fixed exchange rates, despite the general deterioration of economic performance. In Japan, the variance of consumption and investment also increases with fixed exchange rates, but the variance of imports is not affected much by the regime change.

Table 6-2 shows a variance decomposition of the components of real output that takes account of the relative size of each component. In the United States, Germany, and Italy, consumption, investment, and net exports all contribute to the lower output stability under the fixed exchange-rate

TABLE 6-1 Comparison of Fixed and Flexible Exchange Rates

The monetary policy rules are given in Equations (6.1) and (6.2). The world price level for fixed exchange rates has weights of .3 for the United States, .2 for Germany, .3 for Japan, and .05 for each of the other countries. (Results are averages over ten stochastic simulations. Each entry in the table shows the root mean squared percentage deviation of the variable from its baseline path.)

	Fixed	*Flexible*	*Number of Simulations (with fixed greater than flexible)*
Output			
U.S.	3.52	2.13	9
Canada	8.20	10.16	1
France	5.61	3.85	8
Germany	5.96	2.78	9
Italy	5.21	3.48	9
Japan	8.03	4.56	9
U.K.	2.71	2.23	7
Prices			
U.S.	2.82	1.33	10
Canada	9.09	4.93	10
France	8.33	3.79	10
Germany	4.24	1.80	9
Italy	9.43	3.57	9
Japan	9.09	3.99	9
U.K.	4.88	3.45	8
Interest Rates			
U.S.	0.021	0.019	5
Canada	0.021	0.063	0
France	0.021	0.058	0
Germany	0.021	0.022	4
Italy	0.021	0.042	1
Japan	0.021	0.044	0
U.K.	0.021	0.047	0
Exchange Rates			
Canada	0.00	11.09	0
France	0.00	19.61	0
Germany	0.00	23.27	0
Italy	0.00	14.78	0
Japan	0.00	19.72	0
U.K.	0.00	14.93	0
Real Net Exports (% of real output)			
U.S.	1.24	1.01	8
Canada	2.25	2.44	4
France	1.51	2.74	1
Germany	3.48	2.70	9
Italy	2.34	1.74	7
Japan	2.62	2.70	5
U.K.	1.59	1.77	2

Table 6-1 *(Continued)*

	Fixed	Flexible	Number of Simulations (with fixed greater than flexible)
Investment			
U.S.	15.62	9.99	10
Canada	23.14	32.14	1
France	7.07	8.69	3
Germany	22.83	13.05	9
Italy	24.10	16.76	9
Japan	21.96	13.29	9
U.K.	7.25	7.66	4
Exports			
U.S.	6.50	6.30	5
Canada	12.05	12.38	6
France	11.02	10.61	6
Germany	9.27	9.65	7
Italy	6.39	6.17	6
Japan	10.45	11.25	5
U.K.	5.74	5.47	5
Imports			
U.S.	8.37	5.52	9
Canada	10.23	13.52	1
France	7.51	4.98	8
Germany	10.76	5.18	9
Italy	10.15	6.69	9
Japan	7.87	7.77	5
U.K.	4.94	4.59	8
United States			
CD	5.39	3.73	10
CN	2.89	1.61	9
CS	2.24	1.36	8
Canada			
CD	12.03	16.02	1
CN	4.08	5.35	1
CS	4.99	6.05	4
France			
CD	10.55	8.50	8
CN	4.47	2.82	9
CS	5.60	2.85	8
Germany-C	6.53	2.48	9
Italy-C	3.80	2.05	9

Table 6-1 *(Continued)*

	Fixed	*Flexible*	*Number of Simulations (with fixed greater than flexible)*
Japan			
CD	16.73	9.28	9
CN	3.21	2.05	9
CS	6.43	3.61	9
United Kingdom			
CD	6.01	5.43	8
CN	2.21	1.95	6
CS	2.26	2.17	3
Wages			
U.S.	2.97	1.12	10
Canada	19.93	14.49	10
France	9.85	3.72	10
Germany	7.10	2.32	10
Italy	18.41	10.59	9
Japan	58.54	29.65	9
U.K.	6.74	5.96	8
Import Prices			
U.S.	9.76	10.11	3
Canada	12.56	13.08	5
France	19.61	18.10	6
Germany	13.12	14.48	4
Italy	9.32	12.09	1
Japan	12.19	14.64	2
U.K.	10.43	13.04	2
Real Interest Rates			
U.S.	0.025	0.023	6
Canada	0.058	0.076	1
France	0.028	0.060	1
Germany	0.038	0.032	8
Italy	0.079	0.066	6
Japan	0.076	0.058	7
U.K.	0.044	0.062	1

system. In France and Japan, net exports tend to add to the variance, but this is offset by declines in the variability of the other components or in changes in the covariances. Changes in the covariance terms have a big impact on the differences between output volatility across the two regimes.

The source of the large deterioration in the performance of the Japanese and the German economies is obviously related to monetary policy. But how? The intuitive explanation is that the fixed rate system does not permit the Bank of Japan and the Bundesbank to react enough to internal price developments. For example, if there is a rise in inflation in Japan, the

Table 6-1 *(Continued)*

	Fixed	*Flexible*
Nominal GNP		
U.S.	5.6	2.5
Canada	10.0	6.8
France	11.9	5.3
Germany	8.7	3.1
Italy	12.2	3.5
Japan	11.5	3.9
U.K.	5.3	3.5
Money		
U.S.	9.6	9.2
Canada	17.1	23.8
France	15.2	13.1
Germany	11.2	5.1
Italy	16.2	10.4
Japan	10.9	6.5
U.K.	11.7	24.5
Velocity		
U.S.	10.0	9.1
Canada	16.6	20.9
France	14.2	15.4
Germany	6.6	5.4
Italy	9.4	10.3
Japan	6.6	7.4
U.K.	12.2	26.4
Velocity/Money Correlation		
U.S.	−0.76	−0.95
Canada	−0.68	−0.97
France	−0.84	−0.96
Germany	−0.59	−0.79
Italy	−0.60	−0.93
Japan	−0.22	−0.82
U.K.	−0.83	−0.98

Bank of Japan cannot immediately tighten by raising interest rates as much as it could under a flexible exchange-rate system. According to the rules of the fixed exchange-rate system, the run-up in prices must first have an impact abroad and thereby raise world prices and foreign interest rates. This intuitive explanation is supported by the finding that the variance of short-term nominal interest rates is generally lower under the fixed exchange-rate regime (see Table 6-1).

Inflation performance is also better with the flexible exchange-rate system than with the fixed-rate system. Price volatility—as measured by the standard deviation of the output deflator around its target—is greater in all

TABLE 6-2 Variance Decompositions for Output in Fixed and Flexible Exchange-Rate Simulations

The simulations are the same as those in Table 6-1.

	Variances and Covariances of Components (weighted)						
Fixed	*Y*	*C*	*I*	*NX*	*C, I*	*C, NX*	*I, NX*
U.S.	12.4	3.3	7.3	1.7	13.5	−21.6	−5.1
Canada	67.3	9.7	25.0	5.7	8.6	1.5	1.2
France	31.5	13.0	2.5	2.2	−56.9	1.6	0.7
Germany	35.6	12.9	22.0	10.1	2.7	−73.0	−27.2
Italy	27.1	5.9	20.5	4.6	−60.7	−52.0	−16.1
Japan	64.5	10.0	29.5	6.8	28.4	−31.6	−16.0
U.K.	7.3	2.0	1.7	2.4	−26.6	−4.3	−1.1
Flexible	*Y*	*C*	*I*	*NX*	*C, I*	*C, NX*	*I, NX*
U.S.	4.5	1.1	3.0	1.1	2.9	−8.9	−2.4
Canada	103.3	15.9	48.1	5.8	−27.3	−28.0	−9.7
France	14.8	4.2	3.8	7.8	−14.5	−24.3	−9.0
Germany	7.7	1.9	7.2	7.5	5.4	−32.2	−11.1
Italy	12.1	1.7	9.9	2.8	−12.4	−22.7	−6.2
Japan	20.8	3.0	10.8	7.3	−6.9	−25.0	−11.4
U.K.	5.0	1.6	1.9	3.1	33.8	−8.7	−2.5

countries under fixed exchange rates (see Table 6-1). Japan and Germany have more than twice as much price volatility under the system that fixes their exchange rate with the dollar.

A reduction in wage variability under flexible rates apparently explains the reduction in price variability (see Table 6-1). Not surprisingly, import prices are usually more volatile when exchange rates are flexible. For all countries except France, import prices were on average more volatile under flexible rates. Hence, greater wage stability outweighs greater import price volatility and yields more stable prices under flexible exchange rates. Why are wages more stable under flexible rates? According to the contract-wage equations, smaller wage variability could be due to the smaller variability of demand.

Note in Table 6-1 that the variance of nominal income is reduced for all countries including Canada. The breakdown of nominal GNP variability between money variability and velocity variability and the correlation between money and velocity indicate that money is used to offset velocity shocks more freely under the flexible rate system. The negative correlation between velocity and money is larger in the flexible exchange-rate system than in the fixed exchange-rate system for all countries.

Not all aspects of the fixed exchange-rate system are inferior to the flexible exchange-rate system. Nominal interest rates are more volatile under the flexible exchange-rate system, presumably because the monetary authorities are able to react more to internal developments. Real interest rates are also more variable. And, of course, there is much more nominal exchange-rate volatility under the flexible exchange-rate system.

The difference in exchange-rate stability is clear in Table 6-1. It is very important to observe, however, that most of the increase in exchange-rate volatility under flexible rates is due to the fact that I am shocking the exchange rates more heavily; recall that the shock to interest-rate parity is assumed to have zero variance in the fixed exchange-rate regime. It is possible that a credible monetary policy rule would eliminate much of this exchange-rate volatility even under the flexible exchange-rate system. It should also be emphasized that at least part of the estimated variance of shocks to interest-rate parity was due to restrictions on capital mobility during the sample period. Most of these restrictions are now lifted. Taking all these factors into account indicates that a flexible exchange-rate system may generate considerably more exchange-rate stability than indicated in the tables.

Comparative Performance for One Draw of Shocks

A visual picture of the macroeconomic performance in four of the countries—the United States, Japan, Germany, and the United Kingdom—is given in Figure 6-1 for one of the ten stochastic draws. Real output and the price level are shown in the diagrams. The picture clearly shows that output and the price level are more stable in the flexible exchange-rate regime. With this set of shocks, output and prices hover close to target for a number of quarters in the simulations before they are sent off-course. A comparison of Japan with the other three countries during the latter half of the simulation gives some indication of why the flexible exchange-rate system works better. Look first at the United States and Japan. Real output deviates from potential in opposite directions in Japan and in the United States. The deviations of the price level from the target are also in opposite directions. There is an inflationary boom in Japan and a disinflationary slump in the United States. However, the fixed exchange-rate regime does not permit U.S. and Japanese monetary policy to deviate from each other—short-term interest rates must move in tandem. The Bank of Japan would have been better off with a tighter monetary policy than with fixed exchange rates, and the Federal Reserve would have been better off with an easier monetary policy. When the two central banks are able to run independent monetary policies—the case of flexible exchange rates, the boom in Japan is moderated as is the slump in the United States. The fixed-exchange-rate policy also leads to a larger slump in Germany and in the United Kingdom than could have been achieved with a flexible exchange-rate system.

Sensitivity Analysis—1: Simulation with Actual Residuals

Figure 6-2 shows a comparison of the same two regimes with the shocks drawn directly from the structural residuals estimated during the sample period of the multicountry model. The ten-year period for the estimated

(continued on p. 244)

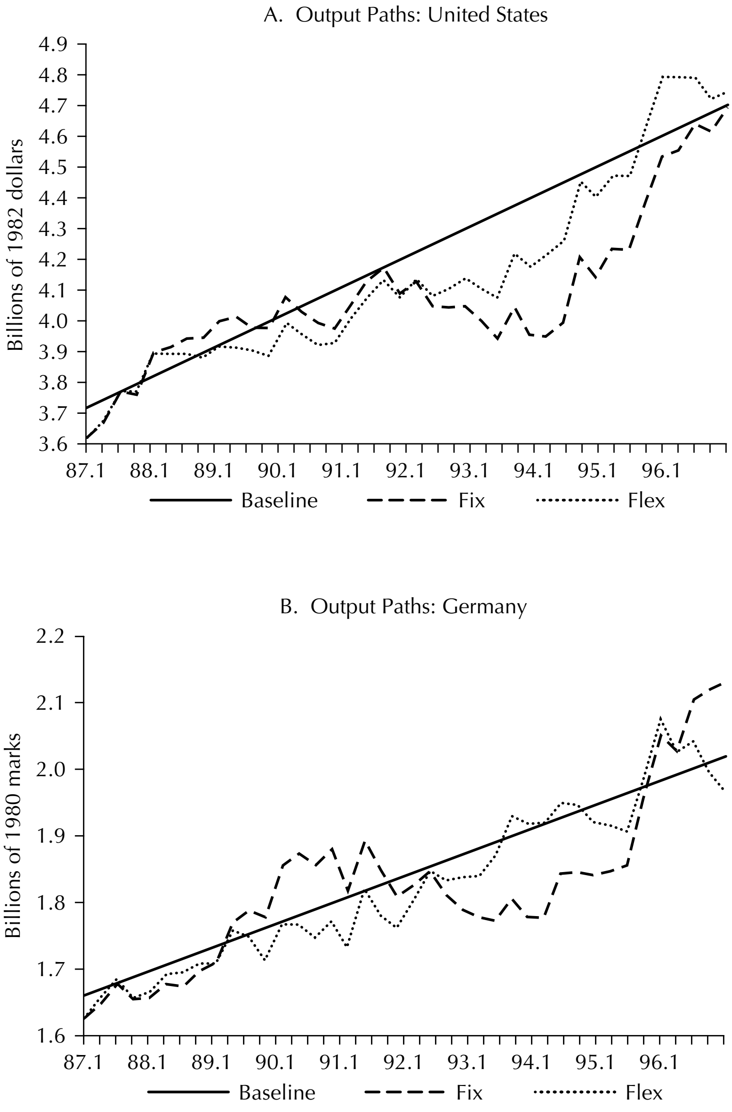
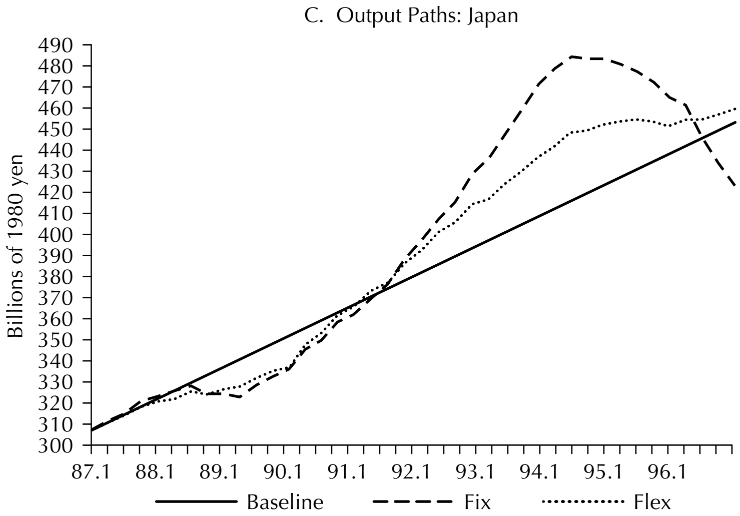


Figure 6-1 Comparison of Fixed and Flexible Exchange Rates (with one realization of the shocks)



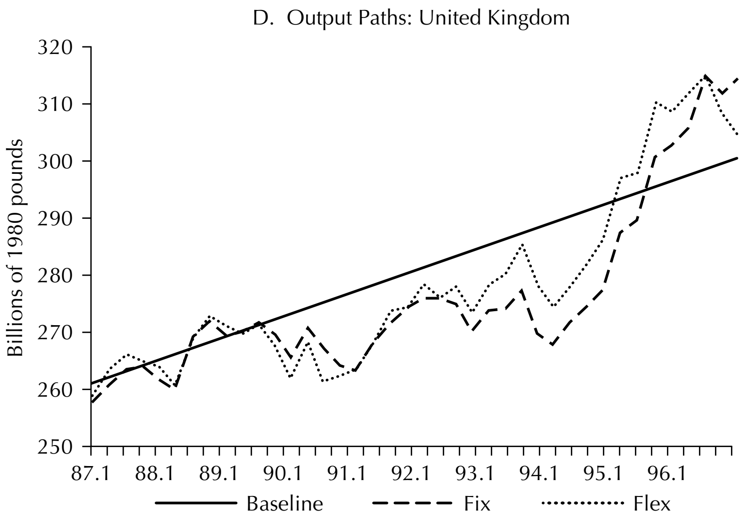
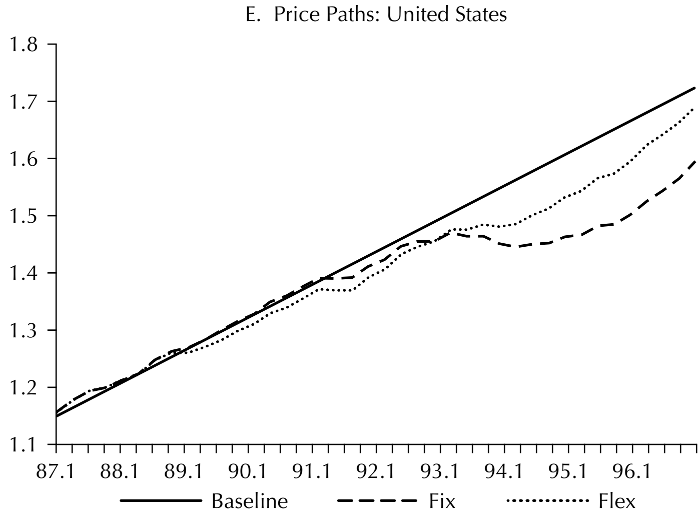


Figure 6-1 *(Continued)*



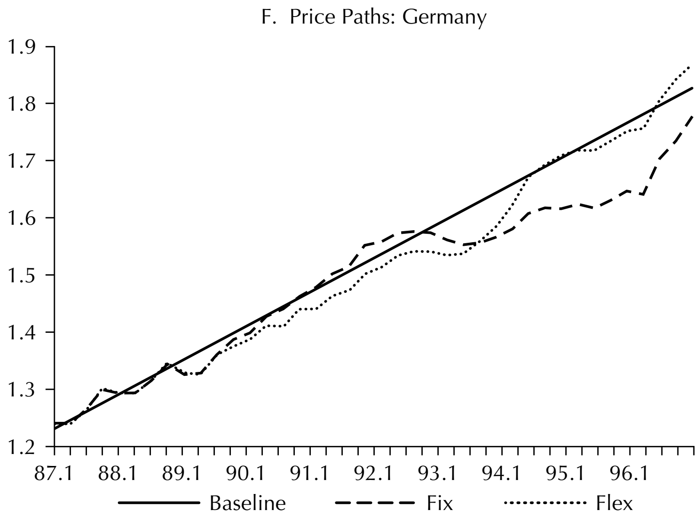
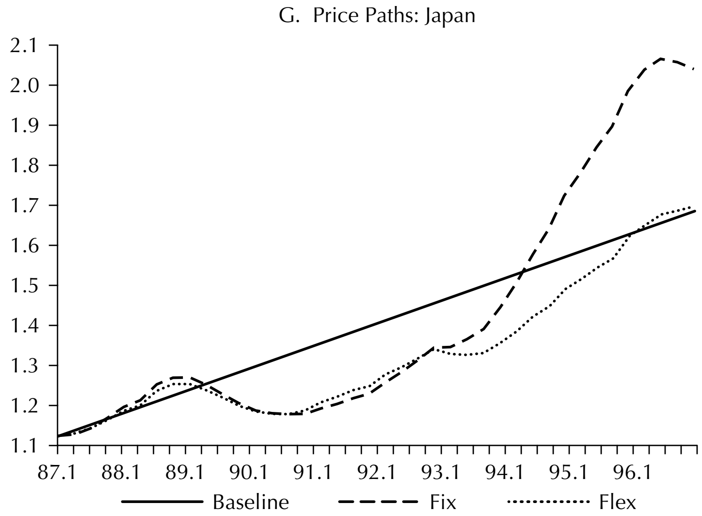


Figure 6-1 *(Continued)*



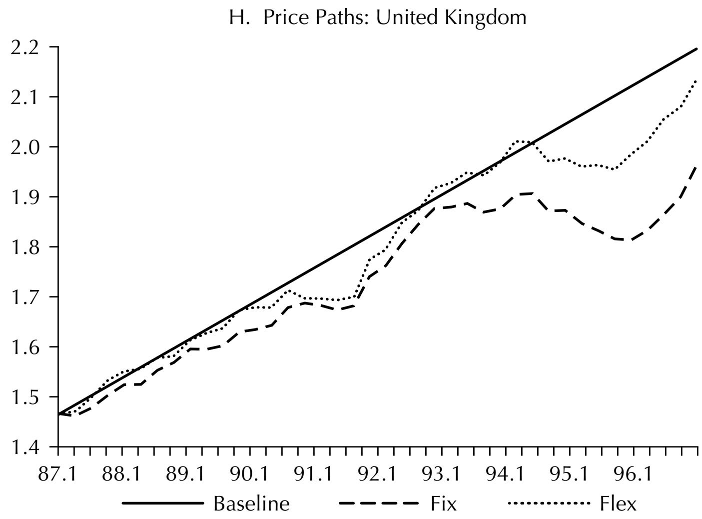


Figure 6-1 *(Continued)*

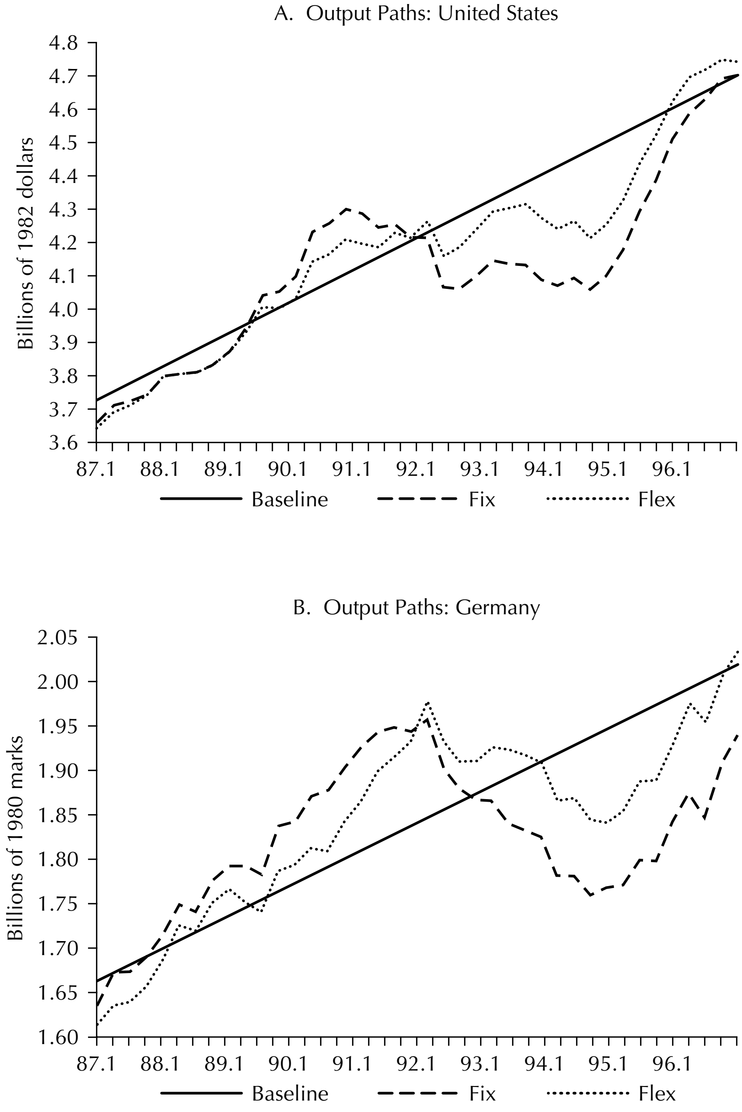


FIGURE 6-2 Comparison of Fixed and Flexible Exchange Rates (with actual shocks)

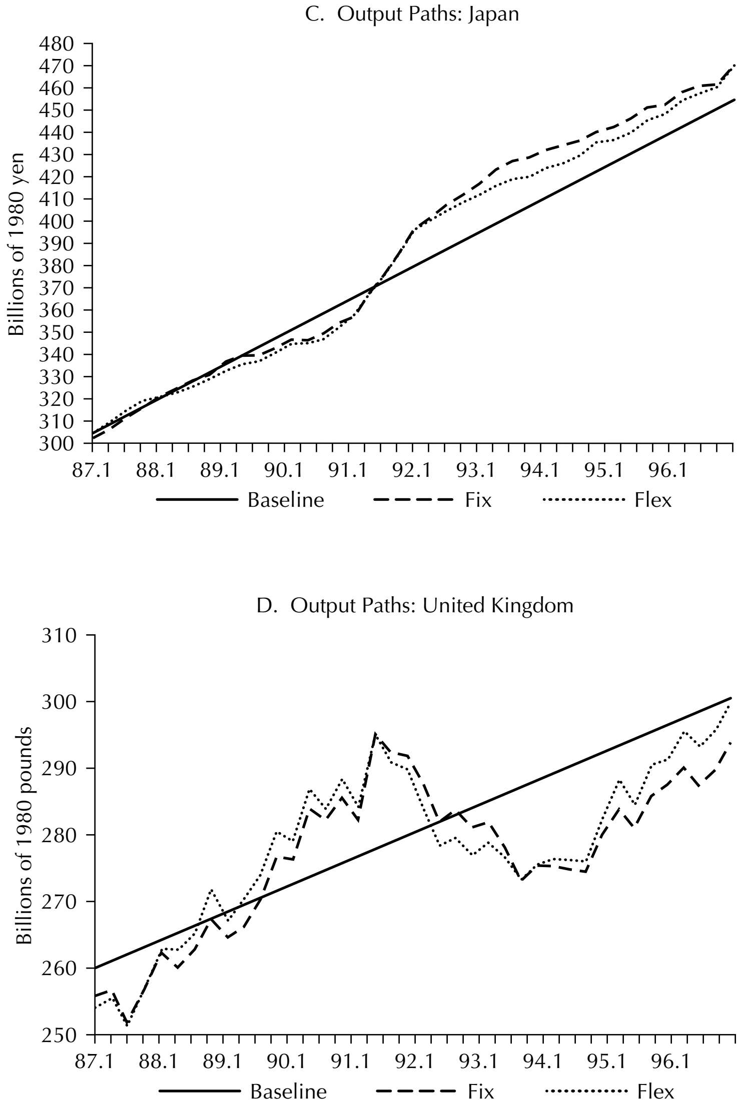
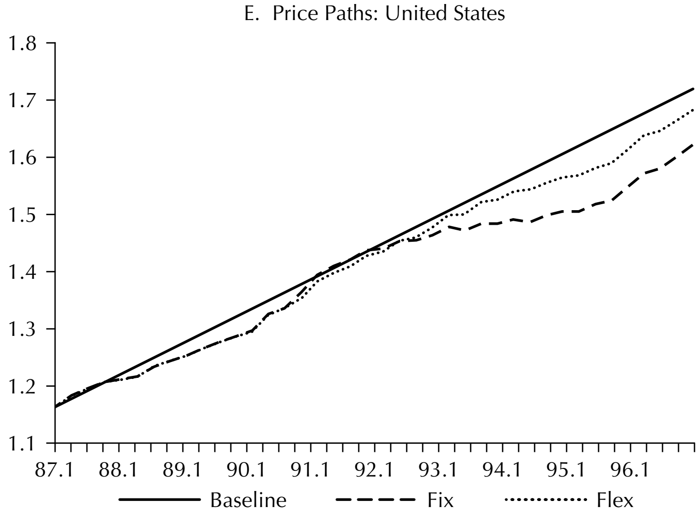


Figure 6-2 *(Continued)*



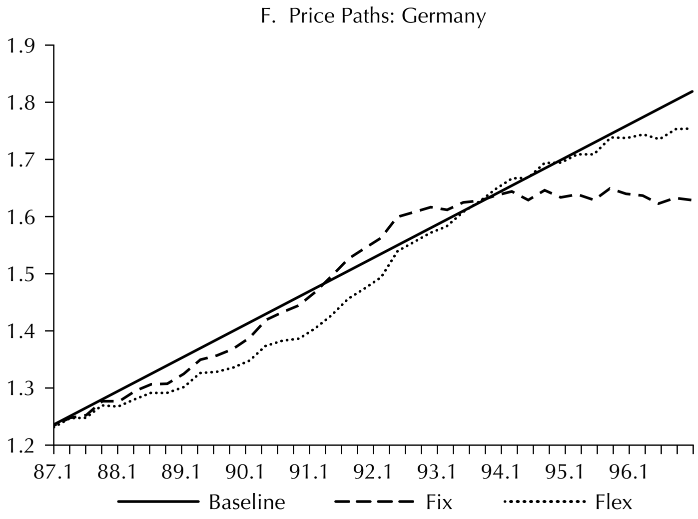
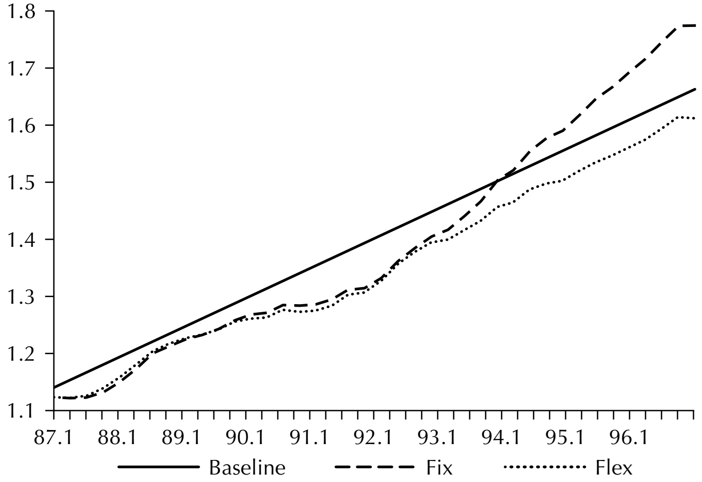


Figure 6-2 *(Continued)*

G. Price Paths: Japan



H. Price Paths: United Kingdom

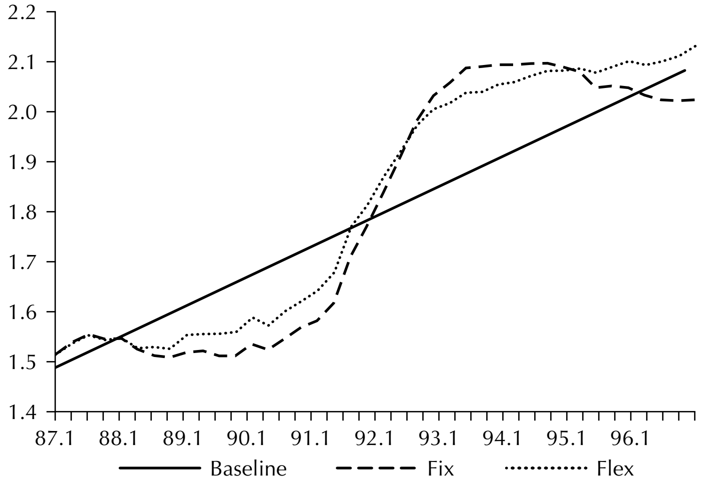


Figure 6-2 *(Continued)*

shocks is 1975:1 to 1984:4. The results confirm the findings from the stochastic simulation. Output and price fluctuations are larger with fixed exchange rates. The intuitive explanation again appears to be related to monetary independence. Asymmetric booms and slumps in the different countries require different monetary policies. The fixed exchange-rate system prevents this from happening.

Sensitivity Analysis—2: Altering the Weights on the World Price Index

Consider the effects of shifting the weights on the world price index in the price rule under fixed exchange rates. Could the performance of the fixed exchange-rate system be improved by altering the weights? Table 6-3 shows the results for raising the weight on Japan from .3 to .5. The weights on U.S. and German prices are lowered by .1 each in order to keep the sum of the weights equal to 1. Raising the weight on Japanese prices makes Japanese macroeconomic performance significantly better under fixed exchange rates. The standard deviation of both output and price fluctuations is reduced.

However, raising the weight on Japan leads to less price stability in some of the other countries, and the flexible exchange rate continues to dominate by a large margin. The basic conclusions are not changed.

Sensitivity Analysis—3: Changing the Response Coefficients

Finally, I consider the robustness of the results to changing the response coefficient g in the policy rule. Table 6-4 shows the macroeconomic performance with simulations based on the actual estimated residuals but with $g = 1.0$ and $g = 2.5$. (Recall that the results thus far show $g = 1.6$.) For both these values of g, there appears to be generally more stability under flexible exchange rates than under fixed exchange rates. The variance of both output and prices are lower in the case of flexible exchange rates in the United States, Germany, Japan, and the United Kingdom. In Canada, France, and Italy, price stability is also lower under fixed exchange rates, but for these values of g and this set of shocks, there is an improvement in output stability, so there is a trade-off in these countries.

In the next two sections I examine a broader policy question: can the central banks improve economic performance by (1) coordinating policy with other countries or (2) choosing a policy rule other than the price rule considered thus far? In light of the previous results, in answering this question I will maintain the flexible exchange-rate regime.

6.2 Coordination in the Design of Policy Rules?

When one thinks of macroeconomic policy coordination, one usually thinks of the annual Economic Summit involving the heads of government of the G-7 countries or the more frequent meetings of the G-7 finance ministers and central bank governors. The coordination, or negotiation, in these

TABLE 6-3 Sensitivity Analysis: Changing the Weights for the World Price Level in the Fixed-versus-Flexible Exchange-Rates Comparison

The first and third columns correspond to Table 6-1. The second column lowers the weight for the United States and Germany by .1 and raises the weight for Japan by .2. (Results are averages over ten stochastic simulations. Each entry in the table shows the root mean squared percentage deviation of the variable from its baseline path.)

	Fixed (1)	*Fixed (2)*	*Flexible*
Output			
U.S.	3.52	3.33	2.13
Canada	8.20	8.08	10.16
France	5.61	5.34	3.85
Germany	5.96	5.73	2.78
Italy	5.21	5.73	3.48
Japan	8.03	5.20	4.56
U.K.	2.71	2.71	2.23
Prices			
U.S.	2.82	2.80	1.33
Canada	9.09	8.82	4.93
France	8.33	8.74	3.79
Germany	4.24	4.55	1.80
Italy	9.43	12.02	3.57
Japan	9.09	5.42	3.99
U.K.	4.88	5.14	3.45
Interest Rates			
U.S.	0.021	0.026	0.019
Canada	0.021	0.026	0.063
France	0.021	0.026	0.058
Germany	0.021	0.026	0.022
Italy	0.021	0.026	0.042
Japan	0.021	0.026	0.044
U.K.	0.021	0.026	0.047
Exchange Rates			
Canada	0.00	0.00	11.09
France	0.00	0.00	19.61
Germany	0.00	0.00	23.27
Italy	0.00	0.00	14.78
Japan	0.00	0.00	19.72
U.K.	0.00	0.00	14.93
Real Net Exports (% of real GNP)			
U.S.	1.24	1.15	1.01
Canada	2.25	2.20	2.44
France	1.51	1.46	2.74
Germany	3.48	3.21	2.70
Italy	2.34	2.52	1.74
Japan	2.62	2.16	2.70
U.K.	1.59	1.52	1.77

TABLE 6-4 Sensitivity Analysis: Changing the Response Coefficients in the Fixed-versus-Flexible Exchange-Rates Comparison

The response coefficient g in the policy rules is shown at the top of each column. Results are from single stochastic simulations using the actual residuals from 1975:1 to 1984:4. (Each entry in the table shows the root mean squared percentage deviation of the variable from its baseline path.)

	$g = 1.0$		$g = 2.5$	
	Fixed	*Flexible*	*Fixed*	*Flexible*
Output				
U.S.	4.41	2.37	3.89	2.01
Canada	4.95	7.49	5.62	8.57
France	4.43	4.94	4.42	5.00
Germany	5.34	3.32	5.32	3.26
Italy	5.89	7.04	6.59	7.65
Japan	4.78	3.41	4.71	3.81
U.K.	3.14	2.75	3.07	3.23
Prices				
U.S.	3.37	1.43	3.20	1.09
Canada	6.28	3.67	5.53	2.80
France	8.10	5.75	7.73	4.32
Germany	3.74	2.16	3.90	1.58
Italy	15.07	8.04	15.42	5.19
Japan	5.08	3.40	2.97	2.24
U.K.	6.26	4.98	6.31	3.96
Interest Rates				
U.S.	0.018	0.014	0.023	0.024
Canada	0.018	0.029	0.023	0.046
France	0.018	0.044	0.023	0.052
Germany	0.018	0.020	0.023	0.029
Italy	0.018	0.081	0.023	0.088
Japan	0.018	0.020	0.023	0.028
U.K.	0.018	0.040	0.023	0.079
Exchange Rates				
Canada	0.00	6.61	0.00	6.96
France	0.00	11.21	0.00	10.51
Germany	0.00	12.98	0.00	12.46
Italy	0.00	9.44	0.00	8.91
Japan	0.00	11.84	0.00	11.42
U.K.	0.00	13.40	0.00	14.17
Real Net Exports (of real GNP)				
U.S.	1.68	1.33	1.54	1.51
Canada	1.95	1.83	2.04	2.07
France	1.76	1.91	1.78	1.99
Germany	2.20	1.46	2.08	1.71
Italy	3.73	1.98	3.92	2.62
Japan	1.73	1.46	1.52	1.42
U.K.	1.60	1.62	1.63	1.67

meetings is most frequently about the settings of the instruments of policy—for example, whether the United States should reduce its budget deficit, whether the Bank of Japan should ease, whether the Bundesbank should tighten, and so on. Hence, the coordination is more about the implementation or operation of policies rather than about the design of policies as I have defined the terms in this book. Proposals to change the exchange rate system arise in international discussion from time to time and could be thought of as international policy coordination. That was the subject of the previous section.

In this section I consider a broader set of international coordination issues that are essentially questions of policy design. The questions take as given the result of the preceding section that the exchange-rate system among the major industrial countries must retain some degree of flexibility. Given a flexible exchange-rate system, they ask whether there should be coordination or negotiation in designing domestic monetary policy rules. For example, is it necessary or helpful for the United States and Japan to come to some agreement about the choice of the response coefficient g in their respective Equation (6.1), their policy rule? If so, how should they come to agreement? Should there be a grand multilateral negotiation—like a trade negotiation—where the United States asks Japan and Europe to use, for example, a lower g, by offering to use a lower g itself? Asking whether coordination or negotiation is needed or helpful here is equivalent to asking the following type of specific question: "Are there economic gains to jointly setting the response coefficients of monetary policy rules—whether price rules such as those of Equation (6.1), or nominal income rules, or something else?" This is the specific design question I take up in this section.[5]

Table 6-5 shows the results of stochastic simulations of the multicountry model that are aimed at the question. It shows the effect on price and output stability in each country when the policy rule in another country is changed. I focus on policy rules in Table 6-5 that are nominal-income rules, rather than price rules. The interest rate is increased or decreased according to whether nominal income is above or below a target. The algebra of a nominal-income rule is as follows:

$$RS_i - RS_i^* = LP_i(+4) - LP_i + g(LP_i - LP_i^*) + g(LY_i - LY_i^*) \qquad (6.3)$$

if $RS_i > .01$ and $RS_i = .01$ otherwise. The last term in Equation (6.1) is the log of real income less the log of target real income. The sum of the last two terms is equal to the deviations of nominal income from a target, and this is why Equation (6.3) is called a nominal-income rule. Equation (6.3) makes it clear that a nominal-income rule differs from a price rule in that

[5]The closest that practical discussions have come to this type of design issue of which I am aware is the proposal in the late 1980s to use "conjunctural" indicators to guide policy. Conjunctural indicators are simply economic data from each country around which policymakers at the OECD or the G-7 agree to center their discussions. They are usually tabulated and presented by the staff of the OECD or of the IMF.

Table 6-5 Effect on Economic Performance Abroad of Alternative Response Coefficients under Flexible Exchange Rates

The monetary policy rule is shown in Equation (6.3). The value of g is .05 in France and in the United Kingdom and 1.5 in the other countries, unless otherwise indicated. (Results are averages over ten stochastic simulations. Each entry in the table shows the root mean squared percentage deviation of the variable from its baseline path.)

	U.S. Value of g	
	1.5	*2.5*
Output		
U.S.	1.65	1.52
Canada	5.80	5.79
France	3.85	3.83
Germany	1.58	1.57
Italy	2.72	2.71
Japan	3.30	3.33
U.K.	2.15	2.14
Prices		
U.S.	1.38	1.25
Canada	7.02	7.01
France	6.56	6.54
Germany	1.73	1.73
Italy	5.11	5.11
Japan	5.36	5.40
U.K.	4.41	4.39

	Japan Value of g	
	1.5	*1.8*
Output		
U.S.	1.65	1.65
Canada	5.80	5.80
France	3.85	3.90
Germany	1.58	1.58
Italy	2.72	2.72
Japan	3.30	3.12
U.K.	2.15	2.16
Prices		
U.S.	1.38	1.38
Canada	7.02	7.03
France	6.56	6.58
Germany	1.73	1.74
Italy	5.11	5.12
Japan	5.36	4.89
U.K.	4.41	4.41

TABLE 6-5 *(Continued)*

	German Value of g	
	0.5	*1.5*
Output		
U.S.	1.65	1.65
Canada	5.82	5.80
France	3.92	3.85
Germany	2.11	1.58
Italy	2.73	2.72
Japan	3.25	3.30
U.K.	2.18	2.15
Prices		
U.S.	1.39	1.38
Canada	7.03	7.02
France	6.62	6.56
Germany	2.34	1.73
Italy	5.10	5.11
Japan	5.29	5.36
U.K.	4.42	4.41

real output appears in the reaction function along with the price level and with the same coefficient g as the price level.

The nominal-income rules for the United States, Germany, and Japan in Table 6-5 are each changed, while the reaction coefficients in the other countries remain the same. For example, in the top panel of Table 6-5, the United States changes its reaction coefficient from 1.5 to 2.5, while there is no change in the other countries. In the middle panel of Table 6-5, Japan changes its reaction coefficient from 1.5 to 1.8, while the other countries remain the same. In the bottom panel, Germany changes its reaction coefficient from .5 to 1.5, and the other countries remain the same. The table, therefore, shows what happens to the other countries when either the United States, Japan, or Germany change their policy rules. What is most striking about Table 6-5 is that a change in the policy rule within these ranges has a very small impact abroad.[6] For example, changing the U.S. policy rule changes the standard deviation of real output and the price level in the United States by many multiples of the change in all the other countries. Raising the Japanese reaction coefficient from 1.5 to 1.8 reduces both output and price variability in Japan but has virtually no effect on either the United States, Germany, or the other countries. The same is true for a change in the German policy rule.

[6]Recall that this same type of result was found in the stylized two-country model of Chapter 1. Using a less structural modeling approach I found stronger cross-country effects in earlier work (see Taylor [1985]).

The simulation results suggest that there is not much need to coordinate or negotiate on the design of monetary policy rules among countries. Of course, to reduce uncertainty, it is important for each central bank to communicate with other central banks about what type of policy system is guiding the setting of the policy instruments.

This is a surprising result. Recalling the deterministic simulations of the instruments of monetary policy in Chapter 5 might help understand it. Those simulations showed that an increase in the money supply in one country has a much larger effect on real output and prices at home than abroad. The effects abroad are positive, rather than negative as in the Mundell-Fleming models, but in almost all cases they are very small.

The evidence presented here pertains to nominal GNP rules only. Similar simulations (not reported here) show similar results when the reaction coefficients of price rules are varied, but the effect of more drastic changes in the rule has yet to be examined. And it should be emphasized that the result applies to monetary rules only. The deterministic simulations of Chapter 5 indicate that changes in fiscal policy rules—for example, changing the automatic stabilizers—would be likely to have larger effects abroad.

6.3 Looking for a Better Monetary Policy Rule

Aside from the surprising result on coordination, the simulation results discussed above indicate that, for flexible exchange-rate systems, nominal-income rules that weigh output deviations as well as price deviations in the central banks' reaction function frequently perform better than price rules. Compare the output and price variances in Table 6-1 on price rules with Table 6-5 on nominal-income rules. For Germany and the United States, for example, output and price variability are lower when these countries use nominal-income rules rather than price rules. The improvement in real output stability is especially large. Although an improvement for both output and prices is not observed for Japan, this finding suggests that by examining a wider array of policy reaction functions we could find improvements in macroeconomic stability.

In principle, the objective is to search for a monetary policy rule, among a very large class, that maximizes macroeconomic performance along a number of dimensions by using an appropriate social utility function, perhaps by solving a dynamic stochastic optimal control problem.[7] Computationally, such a general optimization approach is not yet possible with a nonlinear rational expectations model of the size used in this research. It is still too expensive to do extensive stochastic simulations. For this reason, I take a simpler approach. The simpler approach also offers the advantage of being somewhat easier to interpret. Future research might take these results as a starting point in a more formal search for optimal policy rules.

[7] This is the approach used in Taylor (1979), where formal dynamic optimization methods were employed to find optimal rules for monetary policy in very simple linear models.

The search for better policy rules in the G-7 countries is made much simpler if we take the findings of the preceding two sections as given: (1) a flexible exchange-rate system works better than a fixed exchange-rate system, and (2) within a flexible exchange-rate regime, the choice of the coefficients of a monetary policy rule in one country has little effect on economic performance in other countries. Thus, one can simply search across policy rules in each country individually and not simultaneously consider reaction functions in other countries.

As a further simplification, rather than optimize across a very general class of policies, I examine a limited, but widely discussed, class of policy rules in which only price and real output appear in the interest-rate reaction function for each central bank. However, the weights on output and the price level need not be the same. These policy rules take the form

$$RS_i - RS_i^* = LP_i(+4) - LP_i + g_1(LP_i - LP_i^*) + g_2(LY_i - LY_i^*) \qquad (6.4)$$

if $RS_i > .01$ and $RS_i = .01$ otherwise. This is a more general class of rules than either price rules, where all the weight is on the price level ($g_2 = 0$), or nominal GNP rules where the weight is the same for both price and output ($g_1 = g_2$).

A summary of results are presented in Table 6-6 and Table 6-7. I focus on the stability of real output and the price level. The results show that it is possible to improve on either the price rule or the nominal-income rule in most of the countries. The more general rule places relatively less weight on real output than the nominal-income rule but more weight than a pure-price rule. Compared to the nominal-income rule, a more general rule seems to work better in most countries. For these calculations, simulations were run using ten sets of shocks from a random-number generator.

A general conclusion from these results is that placing some weight on real output in the interest rate reaction function is likely to be better than a pure price rule. A more general rule that places less weight on real output than a nominal-output rule stabilizes the price level better than a nominal-income rule. Finally, all of these rules seem to result in exchange-rate fluctuations that are not excessive, even though the exchange-rate equations are being shocked by time-varying risk premia. Although these policies focus the reaction functions on domestic indicators, they have the potential of achieving a surprising amount of exchange-rate stability.

6.4 Conclusions

The main objective of this chapter has been to apply the new rational expectations empirical approach to the policy problem of designing monetary policy rules or systems. The approach is novel in its use of empirical measures of the shocks and thereby, the probability distribution of shocks to the economic relations. In addition, the quarterly empirical model incorporates a highly mobile world capital market, rational expectations of the

Table 6-6 Effect on Economic Performance of Alternative Rules

The response coefficients on prices and output under each of the rules are as follows: for the price rule, (1.5, 0.0) for all countries except France and the United Kingdom, where they are (0.5, 0.0); for the nominal-income rule, (1.5, 1.5) for all countries except France and the United Kingdom, where they are (0.5, 0.5); for the general rule, (2.0, 0.8) for all countries except the United States, where they are (2.5, 0.8). Results are averages over ten stochastic simulations. (Each entry in the table shows the root mean squared percentage deviation of the variable from its baseline path.)

	Price Rule	*Nominal-Income Rule*	*General Rule*
Output			
U.S.	2.23	1.65	1.90
Canada	9.21	5.80	7.67
France	4.76	3.85	3.22
Germany	2.74	1.58	1.98
Italy	3.96	2.72	3.56
Japan	4.06	3.30	3.60
U.K.	2.45	2.15	2.19
Prices			
U.S.	1.39	1.38	1.16
Canada	5.10	7.02	5.66
France	7.54	6.56	3.20
Germany	1.74	1.73	1.59
Italy	4.30	5.11	4.39
Japan	3.76	5.36	3.87
U.K.	4.57	4.41	3.08
Interest Rates			
U.S.	0.019	0.029	0.026
Canada	0.060	0.052	0.055
France	0.045	0.053	0.063
Germany	0.020	0.029	0.026
Italy	0.043	0.041	0.048
Japan	0.041	0.043	0.043
U.K.	0.029	0.033	0.047
Exchange Rates			
Canada	11.27	9.42	10.19
France	21.00	20.60	20.07
Germany	22.94	22.99	22.78
Italy	14.33	14.40	14.10
Japan	19.89	19.64	19.64
U.K.	15.56	15.41	14.62
Real Net Exports (% of real GNP)			
U.S.	1.04	1.02	1.07
Canada	2.41	2.53	2.38
France	2.00	2.15	2.71
Germany	2.49	2.47	2.45
Italy	1.75	1.45	1.67
Japan	2.36	2.26	2.24
U.K.	1.61	1.54	1.61

TABLE 6-6 (Continued)

	Price Rule	*Nominal-Income Rule*	*General Rule*
Investment			
U.S.	10.25	8.05	9.61
Canada	29.61	15.58	23.54
France	6.50	5.99	8.24
Germany	12.81	10.74	11.69
Italy	18.77	12.67	17.25
Japan	13.07	11.19	12.10
U.K.	6.57	6.47	6.85
Exports			
U.S.	6.26	5.99	5.90
Canada	11.35	10.97	10.76
France	10.99	9.96	9.56
Germany	8.50	7.94	7.74
Italy	6.01	5.30	5.40
Japan	10.06	9.40	9.15
U.K.	5.52	4.73	4.72
Imports			
U.S.	5.57	5.01	5.51
Canada	12.13	7.90	10.21
France	5.14	3.88	4.56
Germany	5.06	3.25	3.88
Italy	7.81	5.89	7.19
Japan	7.21	7.32	7.37
U.K.	4.39	4.31	4.54
United States			
CD	3.91	3.49	3.65
CN	1.71	1.42	1.57
CS	1.40	1.18	1.24
Canada			
CD	14.58	8.40	11.95
CN	4.86	2.79	4.00
CS	5.19	3.77	4.55
France			
CD	7.80	5.90	7.41
CN	3.76	3.07	2.44
CS	4.42	3.51	2.64
Germany-C	2.58	1.79	2.14
Italy-C	2.53	1.87	2.31
Japan			
CD	8.39	7.11	7.62
CN	1.93	1.86	1.85
CS	3.26	2.99	3.03
United Kingdom			
CD	5.80	5.59	5.64
CN	1.65	1.44	1.90
CS	2.21	2.09	2.15

Table 6-6 *(Continued)*

	Price Rule	Nominal-Income Rule	General Rule
Prices			
U.S.	1.39	1.38	1.16
Canada	5.10	7.02	5.66
France	7.54	6.56	3.20
Germany	1.74	1.73	1.59
Italy	4.30	5.11	4.39
Japan	3.76	5.36	3.87
U.K.	4.57	4.41	3.08
Wages			
U.S.	1.19	1.23	1.01
Canada	14.29	15.46	14.51
France	7.80	6.87	3.55
Germany	2.32	2.09	2.00
Italy	11.65	12.64	12.10
Japan	26.21	26.07	25.46
U.K.	6.58	6.61	6.06
Import Prices			
U.S.	9.81	9.70	9.54
Canada	12.57	11.87	12.12
France	20.99	19.75	16.23
Germany	12.45	12.43	12.48
Italy	9.88	9.91	10.15
Japan	13.23	13.17	13.21
U.K.	13.00	12.69	11.41
Real Interest Rates			
U.S.	0.023	0.028	0.028
Canada	0.075	0.055	0.066
France	0.039	0.045	0.063
Germany	0.031	0.033	0.033
Italy	0.068	0.057	0.070
Japan	0.054	0.048	0.053
U.K.	0.037	0.037	0.062

future, and institutional differences between wage determination in different countries.

Of the several design issues considered, one is particularly striking: the question of fixed-versus-flexible exchange-rate systems. The results indicate that a flexible exchange-rate system works better than a fixed exchange-rate system. Not all countries and not all economic time series perform worse under the fixed exchange-rate system, but, in the vast majority of cases, all the G-7 countries except Canada have significantly worse macroeconomic performance under a fixed exchange-rate system. A policy-evaluation result

TABLE 6-6 *(Continued)*

	Price Rule	Nominal-Income Rule	General Rule
Nominal Income			
U.S.	2.4	2.1	1.9
Canada	6.1	3.1	3.6
France	9.8	8.1	4.1
Germany	3.0	1.9	2.0
Italy	3.6	3.3	2.6
Japan	3.1	4.1	2.5
U.K.	4.9	4.5	2.8
Money			
U.S.	9.4	9.6	9.8
Canada	19.3	14.6	17.2
France	14.0	13.5	13.8
Germany	4.8	4.8	5.0
Italy	10.5	9.2	10.6
Japan	6.1	5.9	6.3
U.K.	10.9	11.4	20.5
Velocity			
U.S.	9.3	10.2	10.0
Canada	16.9	16.3	17.0
France	14.8	15.7	15.7
Germany	4.9	5.9	5.7
Italy	10.1	9.8	10.5
Japan	6.9	7.6	7.2
U.K.	14.4	14.8	22.2
Velocity/Money Correlation			
U.S.	−0.95	−0.97	−0.97
Canada	−0.95	−0.97	−0.97
France	−0.91	−0.92	−0.98
Germany	−0.77	−0.94	−0.92
Italy	−0.94	−0.92	−0.96
Japan	−0.86	−0.80	−0.91
U.K.	−0.92	−0.95	−0.99

of this kind could not be obtained from purely theoretical considerations. It depends on the empirical nature of the economic relations and on the size and correlation of the shocks to these relations.

Of course, neither these three problems nor the model used to address them exhaust the possible applications of the approach. I do not view the analysis presented here as the last word. Improvements in the models, new and better data, or refinement of the questions may indeed lead to different results in future research. At the least the above analysis provides a useful benchmark to assess the impact of the different monetary policy systems.

Table 6-7 Variance Decompositions for Output for Different Rules

Same simulations as Table 6-6. Results are averages over ten stochastic simulations.

	Variances and Covariances of Components (weighted)						
Price Rule	*Y*	*C*	*I*	*NX*	*C, I*	*C, NX*	*I, NX*
U.S.	5.0	1.2	3.1	1.1	3.3	−9.6	−2.5
Canada	84.9	12.6	40.9	5.8	−24.8	−25.5	−9.8
France	22.6	7.7	2.1	4.0	−73.3	−4.8	−1.6
Germany	7.5	2.0	6.9	6.3	−13.2	−29.8	−11.1
Italy	15.7	2.6	12.4	2.6	−24.8	−27.7	−8.2
Japan	16.5	2.5	10.4	5.7	−13.1	−24.9	−11.0
U.K.	6.0	1.5	1.4	2.5	−26.7	−3.1	−0.9
Nominal-Income Rule	*Y*	*C*	*I*	*NX*	*C, I*	*C, NX*	*I, NX*
U.S.	2.7	0.9	1.9	1.0	2.0	−7.6	−2.0
Canada	33.6	4.7	11.3	7.2	17.8	−6.2	−2.4
France	14.9	4.6	1.8	4.7	−61.4	−9.5	−3.2
Germany	2.5	1.0	4.9	6.3	−12.1	−29.9	−11.1
Italy	7.4	1.4	5.7	1.9	−10.7	−14.3	−4.3
Japan	10.9	2.0	7.7	5.2	−11.8	−24.5	−10.8
U.K.	4.6	1.3	1.3	2.3	−3.9	−3.8	−1.1
General Rule	*Y*	*C*	*I*	*NX*	*C, I*	*C, NX*	*I, NX*
U.S.	1.9	1.0	2.8	1.2	3.6	−10.2	−2.7
Canada	7.7	8.8	25.8	6.0	−6.7	−15.7	−6.0
France	3.2	3.2	3.4	7.5	−1.9	−25.0	−8.3
Germany	2.0	1.4	5.8	6.1	−15.1	−30.6	−11.4
Italy	3.6	2.1	10.5	2.4	−22.0	−25.1	−7.4
Japan	3.6	2.1	9.0	5.1	−15.4	−24.2	−10.7
U.K.	2.2	1.6	1.5	2.3	33.8	−5.3	−1.5

Reference Notes

The use of simulation to evaluate policy rules has a long history in macroeconomics, going back at least to simulations by A. W. Phillips (1954) of proportional, integral, and derivative policy rules adopted from the engineering literature. The work focused on dynamic Keynesian models as did the later work by Cooper and Fischer (1974), which performed stochastic simulations on estimated econometric models without rational expectations. Poole (1970) also considered stochastic Keynesian models, though his work focused more on how to cushion the static impact of shocks rather than on the dynamics or propagation effects. Phelps and Taylor (1977) and Fischer (1977) were the first to consider the evaluation of policy rules in theoretical stochastic rational expectations models, where policy is effective; Taylor (1979) considered the optimal policy rule in an estimated econometric model. This model was simple enough that the stochastic behavior of the endogenous variables could be derived analytically.

In the early 1990s there has been an increased interest in the use of stochastic simulations to evaluate policy rules. Bryant et al. (1989) edited a conference volume in which three papers reported results on the evaluation of policy using estimated multicountry models with rational expectations: Taylor (1989b), McKibbin and Sachs (1989), and Frenkel, Goldstein, and Masson (1989). These papers differ in their assessments of different exchange rate regimes. A follow-up Brookings conference focused entirely on the evaluation of policy rules using stochastic simulations of econometric models, although not all were rational expectations models. The results of this conference are reported in Bryant et al. (1992). The debate over fixed-versus-flexible exchange rates is an old one going back at least to Milton Friedman's (1948) proposals. McKinnon (1988) has recently argued in favor of fixed exchange rates, presenting very specific policy rules under which a fixed exchange-rate system would operate.

Although the reduced form of the multicountry model cannot be solved analytically to illustrate the way the coefficients change with change in the policy rules á la the Lucas critique, some reduced-form relationships can be estimated from the data generated by the stochastic simulations. A comparison of such reduced form equations under two regimes—fixed exchange rate and flexible exchange rates as in Section 6.1—was reported in Taylor (1989a). The coefficients of reduced-form consumption functions, Phillips curves, investment functions, and several vector autoregressions changed, as predicted by the Lucas critique, but perhaps less than one might have expected. Similar comparisons with different regime changes would be a good subject for future research.