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## Some Implications for Monetary Policy of Uncertain Exchange Rate Pass-Through

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Research Department

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**Abstract**

The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.
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The paper uses MULTIMOD to examine the implications of uncertain exchange rate pass-through for the conduct of monetary policy. From the policymaker's perspective, uncertainty about exchange rate pass-through implies uncertainty about policy multipliers and the impact of state variables on stabilization objectives. When faced with uncertainty about the strength of exchange rate pass-through, policymakers will make less costly errors by overestimating the strength of pass-through rather than underestimating it. The analysis suggests that pass-through uncertainty of the magnitude considered does not result in efficient policy response coefficients that are smaller than those under certainty.

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## I. INTRODUCTION

One of the puzzles that warrants more attention in the literature on policy rules is an apparent inconsistency between two sets of findings. One strand of the literature has focused on analyzing the properties of simple policy instrument rules in various macroeconomic models, and on using stochastic simulation exercises and other techniques to derive optimal calibrations for such rules. Other studies have analyzed the historical behavior of monetary policy, concluding that it can be summarized quite well econometrically by simple instrument rules, but also inferring that monetary policy has been much more timid historically than the literature on optimal calibrations suggests it ought to be.

While several possible explanations have been advanced for this apparently slower-than-optimal adjustment of the policy instrument, the one that has received the most focus is uncertainty about the structure of the economy and the nature of the disturbances that influence economic behavior.<sup>1</sup> The view that uncertainty should make policymakers do less than would be prescribed under certainty equivalence was spawned by the seminal work of Brainard (1967). This has since become conventional wisdom,<sup>2</sup> as summed up a few years ago by Blinder (1998): Under uncertainty, policymakers “should compute the direction and magnitude of their optimal policy move in the way described by Tinbergen-Theil and then do less.” Such conventional wisdom has not gone unquestioned, however. Recent contributions to examining the implications of uncertainty have challenged the robustness of the conclusion that policy attenuation is the appropriate response to uncertainty, emphasizing that the appropriate response depends on the source and nature of the uncertainty, as well as the objectives of the policymaker.<sup>3</sup>

In this paper we use the IMF’s multicountry macroeconomic model MULTIMOD to consider the implications for monetary policy of one specific source of uncertainty: the pass-through of movements in the nominal exchange rate into import prices and domestic price levels. As elaborated below, the literature suggests a relatively high degree of uncertainty about the magnitude of pass-through effects, and there is evidence that the sensitivity of domestic prices to exchange rate changes declined significantly from the 1980s to the 1990s. If this reflects an ongoing structural change, then conducting policy during the transition will offer

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<sup>1</sup> Other conjectures advanced in the literature are that slow policy adjustment simply reflects the preferences of policymakers, and that imparting persistence to instrument settings exploits an expectations channel that works very effectively to stabilize the economy. For example, see Woodford (1999) and Sack and Wieland (2000).

<sup>2</sup> Examples from the literature confirming Brainard’s policy attenuation result include Sack (1998), Smets (1999), and Rudebusch (2001).

<sup>3</sup> For examples of uncertainty resulting in anti-attenuation, see Shuetrim and Thompson (1999), Onatski and Stock (2000), Gaduich and Hunt (2001), and Tetlow and von zur Muehlen (2002).

challenges to monetary authorities whose policy frameworks are built around inflation forecast targeting.

To examine the implications for monetary policy rules, we use two alternative calibrations of the pass-through effects in MULTIMOD. We focus on the country blocs for the United States and the United Kingdom, two economies that differ considerably in their degree of openness and, consequently, in the role played by the exchange rate in macroeconomic adjustment. The base-case calibration incorporates MULTIMOD's point estimates of the pass-through effects of exchange rate changes on import and export prices. The alternative calibration cuts the estimated pass-through effects in half. We use simple deterministic simulations to illustrate how altering the pass-through effects changes both the policy multipliers and the dynamic adjustment structures of the economies. Given the different multipliers and adjustment structures associated with the two calibrations, we then use stochastic simulations to derive the efficient policy frontiers for three classes of simple Taylor-type monetary policy reaction functions under certainty equivalence. The efficient frontiers are also computed for cases in which the monetary authorities are assumed to misperceive the magnitude of the short-run exchange rate pass-through effects.

The results confirm many of those in the literature and provide some additional insights. We find that Taylor-type policy rules that are based on *forecasts* of inflation and the output gap allow for considerably better inflation and output variability trade-offs than do similar rules that respond only to the observed *outcomes* for inflation and the output gap. Further, under certainty, the magnitudes of efficient response coefficients are larger than both those proposed by Taylor and those estimated from the data. However, we do not find evidence that uncertainty about exchange rate pass-through should lead to policy responses that are more timid than the optimal responses for the certainty case. Although uncertainty reduces the relative advantage that forecast-based rules enjoy over outcome based rules, forecast-based rules still appear to dominate under the nature and magnitude of the uncertainty we consider. Further, for a policymaker who is uncertain whether the structure of the economy has shifted to one with weaker exchange rate pass-through, and under a fairly wide range of policymaker preferences over inflation and output variability, the probability of such a structural shift needs to be greater than 60 percent before it becomes optimal for the policymaker to incorporate weaker pass-through into its policy model. The more the policymaker cares about inflation variability relative to output variability, the higher that required probability becomes.

The remainder of the paper is organized as follows. In Section II we provide an overview of the structure of MULTIMOD. Some simple deterministic simulations are presented in Section III that illustrate the implications of different specifications of the short-run exchange rate pass-through for the dynamic adjustment properties of the model. In Section IV the efficient frontiers are derived under both certainty equivalence and uncertainty. Section V concludes the paper.

## II. MULTIMOD – AN OVERVIEW

This section provides an overview of MULTIMOD, the IMF's multicountry model of the world economy. The interested reader is directed to Laxton and others (1998) for a more complete description of the model's structure, estimation, and properties.<sup>4</sup>

MULTIMOD has a two-tiered structure. The first tier is a static representation that describes the long-run equilibrium of the economy where countries can be characterized as either net debtors or net creditors. The steady-state model is derived in a manner that makes it exactly consistent with the behavioral structure that determines the dynamic adjustment towards this full stock-flow equilibrium. This steady-state representation can be used to conduct comparative static analysis of the impact of permanent shocks to the economy. It also provides the terminal conditions exploited by the solution algorithm for solving the complete model. MULTIMOD's second tier is a dynamic representation that describes the transition path that the economy takes to the long-run equilibrium.

The simulations presented in this paper use MULTIMOD Mark IIIB, which contains individual models for six industrial countries/blocs: the United Kingdom, the United States, Japan, Canada, the euro area, and the group of other industrial countries. Each industrial country/bloc has an identical structure, but the estimated parameter values may vary. Developing countries are aggregated into two blocs. The main developing country bloc is made up of net debtor countries. The other consists of net creditor developing countries, which in most cases are countries that export large quantities of oil. Both developing country blocs have very simple specifications, with the key distinguishing feature being that the net debtor countries face a borrowing constraint. Analysis can be done with either individual industrial countries/blocs or the complete model of the world economy.<sup>5</sup>

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<sup>4</sup> Several changes have been made to the Mark III model since the 1998 paper was prepared, and several variants of Mark III are now available. The main changes include the incorporation of a euro-area bloc, a respecification of monetary policy behavior as an instrument rule in which the short-term interest rate reacts to (either predetermined or forecast) inflation and output, a respecification of fiscal behavior to better capture the countercyclical workings of automatic stabilizers, the incorporation of new estimates of the aggregate supply equations (Phillips curves), and a general recoding of the model equations to facilitate convergence in cases where different countries "choose" different steady-state rates of inflation.

<sup>5</sup> The emphasis that MULTIMOD has given to modeling the large industrial countries reflects the fact that it was developed for the primary purpose of exploring alternative scenarios for the IMF's *World Economic Outlook*, which often focus on the spillover effects of policy changes or other shocks emerging from large countries. Moreover, because it is linked to the *World Economic Outlook*, MULTIMOD is confined to analyzing annual data and is not designed to generate a baseline forecast; rather, it takes as given an "exogenous" control solution produced by combining forecasts for individual countries as generated (under various controls for consistency) by the IMF's area department staff.

Each industrial country/bloc models the behavior of five types of economic agents: households, firms, nonresidents, fiscal authorities, and monetary authorities. Each industrial country produces a single composite tradable good. Nonresidents perceive this composite to be an imperfect substitute for their own home-produced composite tradable good. The main developing country model, as well as the international trade accounts of the industrial country models, distinguish among three types of tradable goods: the composite good, oil, and non-oil primary commodities. The main developing country model also includes a nontradable manufactured good.

### **Households**

In MULTIMOD, households consume the traded goods, supply labor, and accumulate assets in the form of government bonds and claims on the capital used by firms. In the industrial country blocs, household behavior is based on an extended version of the Blanchard (1985) finite-planning-horizon model. Because current generations are disconnected from future generations, the model embodies non-Ricardian features where changes in government saving can affect national saving, interest rates, and asset accumulation.

The basic Blanchard framework for household behavior has been extended along several dimensions. First, households are split between those whose consumption in each period is equal to a fraction of their combined financial and human wealth and those that can consume only their disposable income each period. The latter households face liquidity constraints that prevent them from borrowing against their human wealth (the present value of their expected life-time labor income). Further, households' labor income profiles are age dependent. These extensions allow changes in taxes to have a greater short-term impact on economic activity and allow for population dynamics to have important implications for consumption and saving. Households' supply of labor is assumed to be perfectly inelastic with respect to the real wage.

### **Firms**

Firms in MULTIMOD combine labor and capital under Cobb-Douglas production technology with the objective of maximizing the net present value of their expected future streams of profits. Firms are assumed to be perfectly competitive. Capital accumulation is based on the  $q$ -theory of Tobin (1969) with the addition of costly adjustment. Adjustment costs are quadratic around the steady-state level of investment. Differences between the market price of capital and its replacement cost lead firms to change their desired levels of capital. Costly adjustment means that firms adjust investment flows gradually to achieve the new desired levels for their capital stocks.

### **Nonresidents and International Trade**

In contrast with consumption and investment behavior, which derive from explicit theories of optimizing households and firms, international trade is based on a conventional reduced-form framework. Export and import volumes are modeled as functions of economic activity and relative prices under the implicit assumption that nonresidents view a country's composite good as being an imperfect substitute for their own home-produced composite



good. Activity variables are constructed from input/output tables, allowing for different import propensities in consumption, investment, government expenditure, and exports. Domestic activity is the scale variable driving imports, and nonresident activity is the scale variable driving exports. In addition to trading, nonresidents either hold domestic financial assets or, alternatively, supply foreign financial assets to domestic residents, depending on whether the country is a net debtor or net creditor. It is assumed that the financial assets held or supplied by nonresidents are government bonds. Global consistency is imposed to ensure that worldwide trade flows balance, and that global net foreign asset positions sum to zero.

### **Fiscal Authorities**

The fiscal authorities in MULTIMOD purchase goods and services and provide transfers that they finance through taxation or debt issue. The fiscal authorities have targets for expenditures, transfers, and debt as ratios to GDP. Cyclical variation in economic activity leads to deviations from target ratios. To restore government debt gradually to its target relative to GDP, the fiscal authority gradually adjusts the tax rate on labor income. Because households supply labor inelastically, this labor income tax is effectively a lump-sum tax. Transfer and expenditure target ratios are automatically restored as economic activity stabilizes.

### **Monetary Authorities**

In MULTIMOD, the role of monetary authorities is to provide a nominal anchor. The Mark IIIB version characterizes monetary policy as a Taylor-type reaction function. The short-term nominal rate is adjusted relative to a neutral nominal rate in response to the gap between inflation in the non-oil GDP deflator and its target rate and the gap between current output and potential output. The model user can choose whether the monetary authority responds to lagged inflation, model-consistent current inflation, or the model-consistent one-year ahead forecast of inflation.<sup>6</sup>

### **Prices**

The relative prices within each industrial country/bloc of MULTIMOD are functions of up to four key terms: the world price of oil, the world price of non-oil primary commodities, non-oil GDP deflators, and exchange rates. The world price of oil is exogenous and the world price of non-oil primary commodities adjusts instantaneously to clear the non-oil commodities market. As elaborated below, the rate of change of the non-oil GDP deflator is described by a reduced-form Phillips curve, and exchange rate behavior is determined by the uncovered interest parity condition. How these prices are combined to generate the full set of

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<sup>6</sup> There is a body of research that illustrates that in the face of nonlinearities in the inflation process and lags in the monetary transmission mechanism, adjusting the interest rate in response to model-consistent forecasts of inflation can improve the stabilization properties of monetary policy. For examples, see Isard and others (1999) and Drew and Hunt (2000).

relative prices depends on the trading relationship between the individual country/bloc and the rest of the world.

MULTIMOD, like most macroeconomic policy models, relies on a reduced-form Phillips curve to characterize the behavior of core inflation in the industrial countries. Core inflation—i.e., the rate of change in the non-oil GDP deflator—is a function of lagged inflation, expected future inflation, and goods market disequilibria. The natural-rate hypothesis is imposed in the estimation of parameter values. The model user can choose whether goods market disequilibria have a linear or nonlinear impact on expected inflation. In the nonlinear specification, inflation is more responsive to excess demand in the goods market than it is to excess supply. Although the specification does not include explicit wage rates, the dynamics of inflation and inflation expectations are characterized in a manner that implicitly recognizes important features of wage-setting behavior (in particular, contracting lags and wage-push elements).

The behavior of nominal exchange rates is governed by uncovered interest parity. Each bilateral exchange rate deviates from its expected future value in proportion to the gap between the corresponding domestic and foreign short-term interest rates. All bilateral exchange rates are expressed in terms of the U.S. dollar.

### **Expectations**

The agents in MULTIMOD are required to form expectations about the future evolution of many variables. For example, households must form expectations about future labor income and firms must form expectations about future profit streams. In MULTIMOD, it is assumed that expectations of all future variables are perfectly rational (model-consistent), except for expectations about core inflation. Here the model relies on a mixture of backward-looking and model-consistent expectations to generate the empirically observed persistence in inflation. In addition, MULTIMOD can be simulated with more persistence in the expected exchange rate than arises under the fully-rational-expectations option. If the model user chooses the more persistent expectations structure for the exchange rate, the expected exchange rate becomes a weighted average of the previous period's exchange rate and the one-year-ahead model-consistent exchange rate.<sup>7</sup>

### **III. EFFICIENT POLICY FRONTIERS UNDER ALTERNATIVE SPECIFICATIONS OF SHORT-RUN EXCHANGE RATE PASS-THROUGH**

The estimated magnitude of the short-run pass-through of exchange rate changes into import prices has an important influence on simulations of open-economy macro models containing reduced-form trade equations. Moreover, the literature suggests a relatively high degree of uncertainty about the magnitude of short-run pass-through coefficients. For a number of years following the survey by Goldberg and Knetter (1997), it was generally believed that

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<sup>7</sup> The weights have been estimated from the data.

pass-through of currency depreciation to prices of imported manufactures was about 50 percent on average over a one-year horizon. More recently, Campa and Goldberg (2002) have presented estimates of short-run and long-run pass-through coefficients that vary fairly widely across OECD countries and in some cases show significant changes between the 1980s and 1990s. And in another recent paper that focuses on U.S. data for a wide range of manufactured goods, Olivei (2002) also documents a change in the responsiveness of import prices to the exchange rate between the 1980s and 1990s, with pass-through elasticities averaging around 50 percent in the former decade and 25 percent in the latter.

In seeking a better understanding of pass-through effects, one question that arises is why pass-through is incomplete. The literature provides insights from a microeconomic perspective. Because tradable goods produced in different countries appear to be quite imperfect substitutes in demand,<sup>8</sup> and because there are costs and other barriers to wholesale arbitrage of goods across markets (i.e., transportation costs and monopolies over distribution licenses), there is scope for producers to charge different common-currency-equivalent prices for the same good in different markets. Evidence of such pricing-to-market (PTM) has been strongly established by Marston (1990) and others. PTM is now regarded as widely prevalent in trade of manufactured goods, and this provides a conceptual basis for incomplete pass-through, at least in the short-run. In cases where import prices are contracted in the importer's currency, stickiness in price adjustment can also contribute to incomplete short-run pass-through.<sup>9</sup>

A second question is why pass-through appears to have declined from the 1980s to the 1990s. Several contributions to the literature have shed light on this issue from a macroeconomic perspective by addressing the role of monetary policy in influencing the pass-through of exchange rate changes to consumer prices.<sup>10</sup> This literature argues that a credible monetary policy commitment to keep inflation low reduces the extent to which inflation expectations rise in response to currency depreciation, thereby tending to lower the pass-through into wages and producer and consumer prices. While such an effect would not have direct implications for pass-through into import prices, a lower sensitivity of producer (exporter) costs to exchange rate changes could result in lower pass-through into import prices.

With the recent blossoming of new open-economy macroeconomics, a number of academic economists and policy institutions, including the IMF, have begun to develop multicountry

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<sup>8</sup> As noted by Krugman (1990), this can be inferred from the fact that econometric estimates of import demand equations generally find price elasticities in the range of 0 to 2.

<sup>9</sup> Although retail prices for imported goods are generally set in local currency, most international trade invoicing tends to be in the producer's (exporter's) currency; see Obstfeld and Rogoff (2000).

<sup>10</sup> For example, Gagnon and Ihrig (2001) and Choudhri and Hakura (2001). Taylor (2000) was influential in putting forth the view that recent declines in pass-through to aggregate price indices could be attributable to a low inflation environment.

versions of stochastic dynamic general equilibrium (SDGE) models. Because these models are based on fully-optimizing behavior (in the context of various frictions or adjustment costs), they present an appealing framework for studying pass-through issues and their policy implications.<sup>11</sup> It may be some time, however, before such models are sufficiently well developed and persuasive for policymakers to be willing to rely upon them for policy analysis. For the time being, accordingly, there is still a case for using models like MULTIMOD to explore the policy implications of uncertainty about pass-through coefficients and other key reduced-form parameters.

To consider the implications of uncertain exchange rate pass-through, we employ both the estimated version of MULTIMOD and an alternative version with half the short-run exchange rate pass-through of the estimated version. A comparison of the two versions' responses to temporary shocks to the exchange rate, monetary policy, and aggregate demand are presented in Figures 1 through 3.<sup>12</sup> The responses are presented for both the U.S. and the U.K. blocs of the model. The solid lines are the paths under the base-case specification of the model and the dashed lines are the paths under the alternative weaker pass-through specification.

The dynamic adjustment paths for the key macro variables in Figure 1 illustrate that exchange rate shocks have considerably less impact on output, inflation and the policy instrument under the weaker pass-through specification. The adjustment paths in Figure 2 illustrate that the monetary policy multiplier is smaller under the weaker pass-through specification. However, the adjustment paths in Figure 3 suggest that the smaller monetary policy multiplier does not appear to dramatically affect the strength of the monetary policy adjustment required to stabilize the economy in response to a demand shock, even in the more open United Kingdom.

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<sup>11</sup> In the IMF's Global Economy Model (still under development—see Pesenti (2002)), imperfect exchange rate pass-through is the endogenous outcome of two factors: the presence of distribution costs (labor requirements) in moving goods, and a dynamic response to changes in fundamentals that reflects the costs of adjusting export prices.

<sup>12</sup> The shocks—each imposed for one year and then reversed—are a 10 percent depreciation of the real effective exchange rate, a 100 basis point increase in the short-term nominal interest rate, and a change in the marginal propensity to consume that increases aggregate demand by 1 percent.

Figure 1. Exchange Rate Shock  
(Percent or Percentage Point Deviation from Baseline)

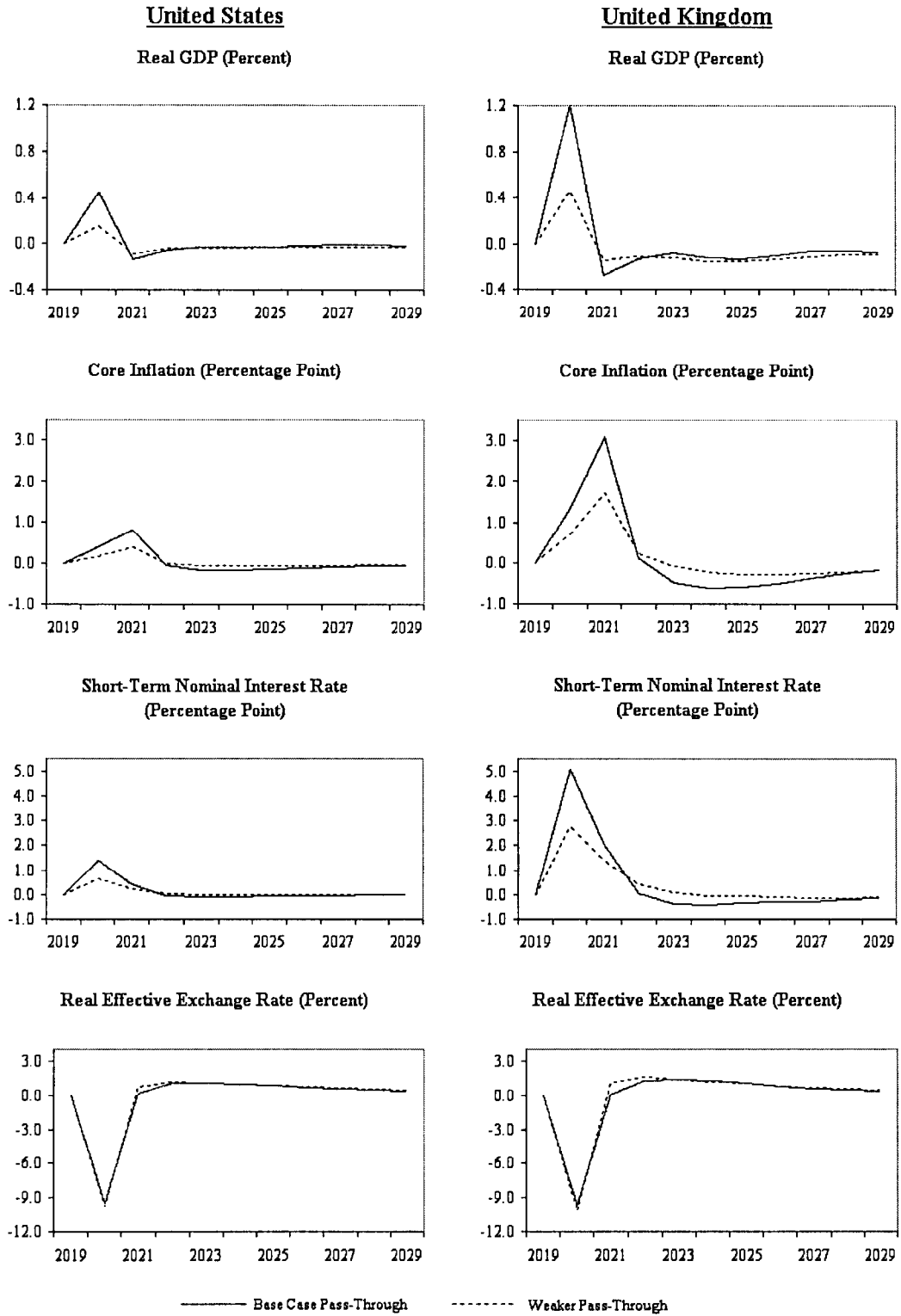


Figure 2. Monetary Policy Impulse  
(Percent or Percentage Point Deviation from Baseline)

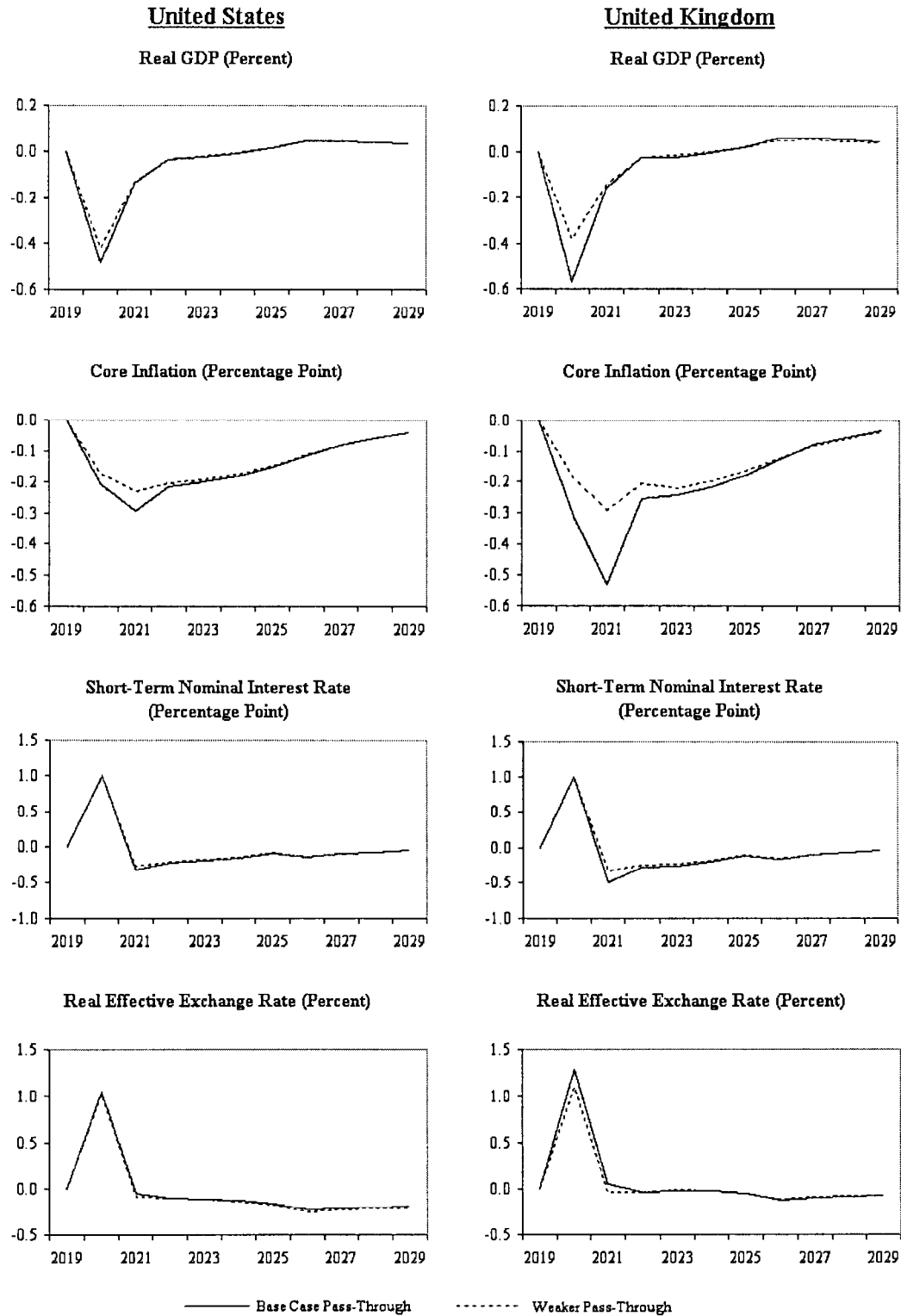
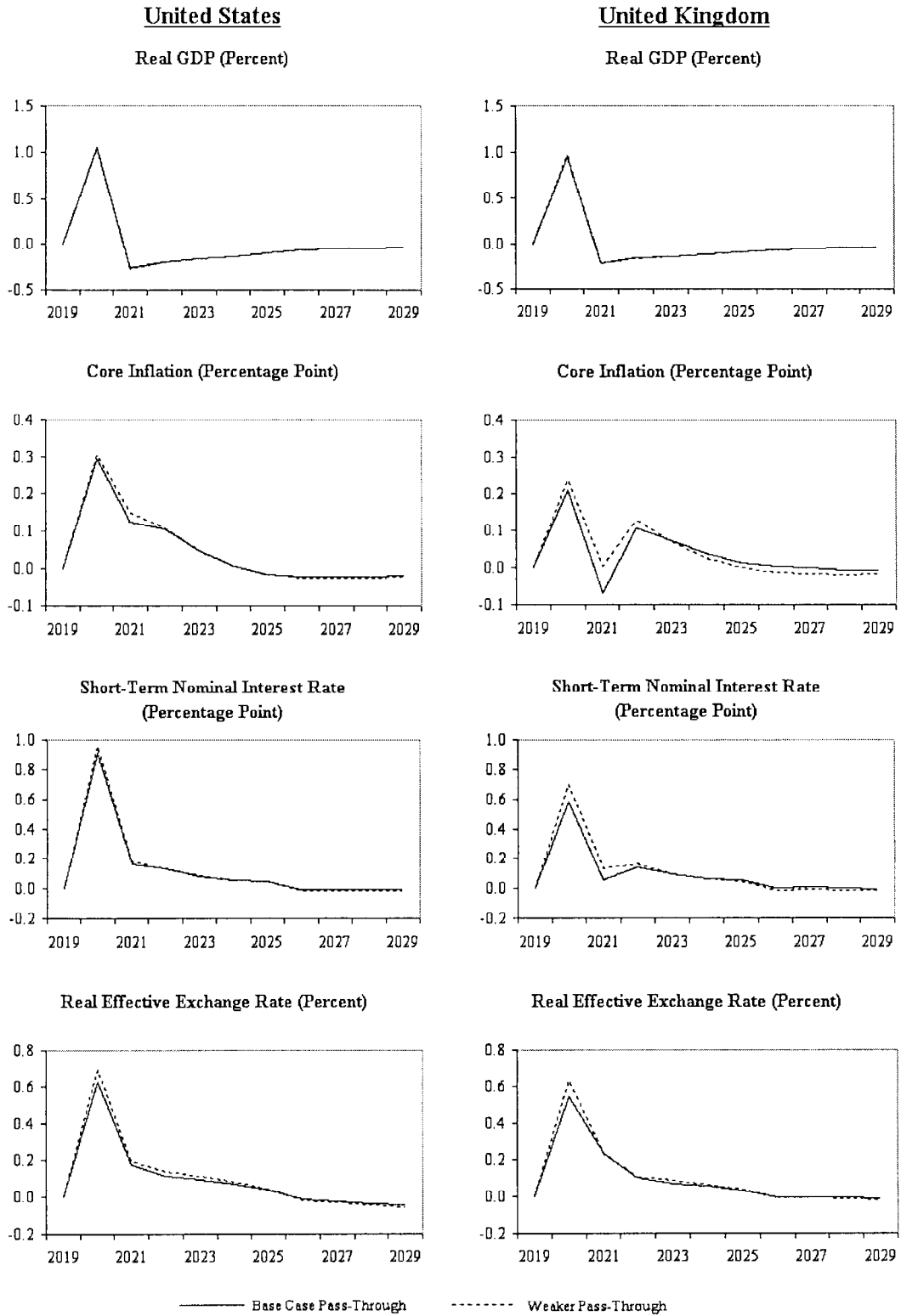


Figure 3. Demand Shock  
(Percent or Percentage Point Deviation from Baseline)



To consider the implications of alternative short-run exchange rate pass-through effects on the operation of monetary policy, we derive the efficient policy frontiers achievable under a set rules for guiding monetary policy actions. The efficient frontier is defined in the spirit of Taylor (1979). The frontier traces out the locus of the lowest achievable combinations of inflation and output variability, where variability is measured by the root-mean-squared deviations of inflation around the inflation target and actual output around potential output.<sup>13</sup> The frontiers are constructed under the assumption that there is a commitment technology that allows the policymaker to credibly commit to following a specific policy instrument rule.

It is important to clarify our philosophy and motivation at the outset. We subscribe to the view that simple Taylor-type forecast-based rules usefully summarize what policy makers appear to do and what policymakers ought to do, provided that the forecast incorporates all the relevant information available. This is consistent with monetary policy in practice reaping the benefits of conditioning expectations by following a rule based approach while taking account of all information that is relevant for achieving its objectives—an approach that Mishkin (2000) refers to as an “information-inclusive strategy.” Such an approach avoids a major pitfall associated with fully optimal policy instrument rules. It has been well established that such rules—derived by solving for the first-order conditions of explicit optimization problems—are not very robust to small changes in model specification or the distribution of shocks.<sup>14</sup> Further, it has been shown that simple Taylor-type instrument rules, which are considerably more robust to model uncertainty, can closely approximate the stabilization properties of fully optimal rules.<sup>15</sup> A number of empirical studies have also suggested that such simple rules are accurate descriptions of the way policymakers actually behave.<sup>16</sup>

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<sup>13</sup> Consistent with this definition of the efficiency frontier, and as elaborated below, we evaluate alternative calibrations of policy rules with a loss function defined in terms of the same root-mean-squared deviations, rather than in terms of conventional variance measures. This distinction is important in evaluating the performance of policy rules in a stochastic environment, and particularly so when behavior reflects significant nonlinearities (such as nominal interest rate floors or convex Phillips curves). Evaluating policy with a loss function specified in terms of conventional variance measures does not penalize policy rules that allow average inflation to drift away from target, or the path of output to drift away from the path of potential output.

<sup>14</sup> See, for example, Hunt, Isard, and Laxton (2002).

<sup>15</sup> See Batini and Haldane (1999), Rudebusch and Svensson (1999), and Tetlow and von zur Muehlen (1999) among others.

<sup>16</sup> See, for example, Clarida, Gali, and Gertler (1998). See also Minford, Perugini, and Srinivasan (2002), who caution against an overly strict interpretation of interest rate regressions.



Our consideration of efficient policy frontiers is restricted to those achievable under three classes of the following simple Taylor-type policy rule:

$$rs_t = rr\_eq_t + \pi_{t+i}^c + \delta_\pi \cdot (\pi_{t+i}^c - \pi^*) + \delta_y \cdot (ygap_{t+i}),$$

where  $rs$  is the short-term nominal interest rate,  $rr\_eq$  is the equilibrium real short-term interest rate,  $\pi^c$  is core inflation,  $\pi^*$  is the target rate of inflation,  $ygap$  is the output gap, and  $\delta_\pi$  and  $\delta_y$  are response coefficients. Under these rules, the nominal short-term interest rate is adjusted relative to a neutral nominal interest rate in proportion to the deviation of a measure of inflation from target and the deviation of a measure of output from potential output. The class of the rule is distinguished by the value of  $i$  in the time subscript. In the first class of rules, the measures of inflation and the output gap that policy responds to are entirely predetermined, ( $i = -1$ ). In the second class of rules, the measures of inflation and output are the current-year values ( $i = 0$ ). In MULTIMOD, these values are not predetermined and will depend on current policy actions as well as the stochastic disturbances. In the third class of rules, policy responds to the current output gap and the one-year-ahead forecast of inflation ( $\pi_{t+1}^c$ ). We follow the convention in Levin, Weiland and Williams (2001) and refer to the first class of rules as *outcome-based rules* and the second two classes as *forecast-based rules*.<sup>17</sup>

To generate the efficient policy frontiers, we use stochastic simulations of the relevant country bloc of MULTIMOD. The stochastic simulations incorporate a range of temporary demand and supply shocks. The distributions for the stochastic disturbances are derived from the estimated residuals of the model's key behavioral equations. Each point on the frontier is based on 10,000 artificially-generated annual outcomes for inflation and the output gap.<sup>18</sup> The simulations are structured such that model agents see the current period disturbance and assume that all future disturbances will be zero. Consequently, when there is no uncertainty about model parameters, the model-consistent forecasts of current period outcomes turn out to be correct. However, even with no uncertainty about model parameters, model-consistent forecasts beyond the current period generally will turn out, ex post, to be incorrect in a stochastic environment.

The efficient policy frontiers for the U.S. bloc—showing root-mean-squared deviations (RMSD) of inflation around target and output around potential under the three classes of policy rules and the two alternative specifications of pass-through—are presented in Figure 4. The parallel frontiers for the U.K. bloc are presented in Figure 5. These frontiers are

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<sup>17</sup> Although we consider both the current period's inflation forecast and the one-year-ahead forecast, MULTIMOD was constructed to analyze annual data and, consequently, it is not well suited for analyzing the horizon of the inflation forecast that policymakers should optimally build into their reaction functions. The new IMF Global Economy Model is being calibrated to quarterly data.

<sup>18</sup> Previous research work with MULTIMOD indicates that 10,000 observations are sufficient to generate stable moments.

consistent with many of the results in the literature. As illustrated for a range of macroeconomic models of the U.S. economy in Levin, Wieland and Williams (2001), the forecast-based (FB) rules result in more favorable frontiers than do the outcome-based (OB) rules, while among the different classes of FB rules, there appears to be no advantage to responding to an inflation forecast that has a relatively long horizon. The first result reflects the fact that simple FB rules incorporate considerably more information about all the relevant state variables than do simple OB rules. The second result suggests that only a very short-forecast horizon is required to effectively incorporate that information. These results are also consistent with the analysis in Giannoni and Woodford (2001), who illustrate that simple Taylor-type targeting rules that rely on one-period-ahead projections closely approximate fully-state-contingent optimal rules, and that very little is gained by adding additional leads of the projections.

Figures 4 and 5 also indicate, consistent with the results presented in Adolfson (2001), that when the pass-through of exchange rate movements into domestic prices is weaker, the achievable combinations of inflation and output variability are considerably more favorable. This suggests that the reduction in macroeconomic variability arising from exchange rate shocks under the weaker pass-through structure outweighs the decrease in the strength of the transmission of monetary policy actions via the exchange rate channel. The improvement in the efficient frontier is larger for OB rules than it is for FB rules in both the United States and the United Kingdom. Interestingly, the extent of the improvement in the frontiers appears to be very similar for both the United States and the United Kingdom, even though the latter is a more open economy.

The efficient frontier is constructed under the assumption that the policymaker is minimizing a loss function of the form:

$$L = \sum_{t=0}^{\infty} \lambda_{\pi} \cdot (\pi_t - \pi^*)^2 + \lambda_y \cdot (ygap_t)^2,$$

where the  $\lambda$ s capture the policymaker's relative dislikes for inflation and output variability.<sup>19</sup> Assuming different values for the loss function weights, one can examine the characteristics of the policy rules that lie on different points on the frontier. Tables 1 and 2 present the characteristics of efficient policy rules under three sets of loss function weights. The first point to note about these rules is that they all have larger response coefficients than those suggested by Taylor (i.e., than  $\delta_{\pi} = 0.5$  and  $\delta_y = 0.5$  or  $1.0$ ). These response coefficients are also larger than those that are typically estimated from the data.<sup>20</sup> While the magnitudes of the optimal response coefficients for the OB rules are also very similar to those reported

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<sup>19</sup> Assuming policymakers preferences can be represented by a quadratic loss function of this form is conventional in the literature on optimal monetary policy.

<sup>20</sup> See Clarida, Gali and Gertler (1998) and English, Nelson, and Sack (2002), among others.

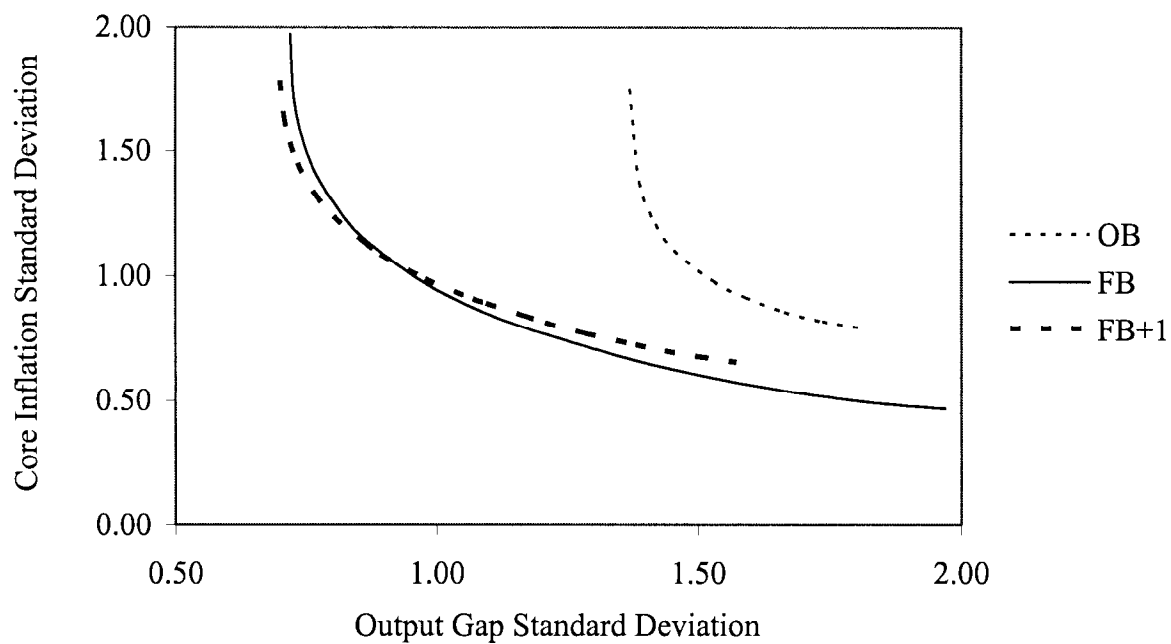
elsewhere in the literature,<sup>21</sup> the optimal response coefficients for the FB rules appear to be larger than those found in other studies. Constraints that are imposed on interest rate variability in those studies largely explain the differences. The intuition derives partly from the fact that, on the one hand, the reductions in inflation and output variability diminish rapidly as the magnitudes of the response coefficients are increased. For example, under equal distastes for inflation and output variability in the U.S. bloc, the loss under FB rules is reduced by 46 percent by moving from weights of  $\delta_\pi = \delta_y = 0.5$  to weights of  $\delta_\pi = \delta_y = 5$ . However, the loss only declines a further 4 percent by moving to weights of  $\delta_\pi = \delta_y = 20$ . On

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<sup>21</sup> See for example Rudebusch and Svensson (1999), Smets (1999), and Williams (1999).

Figure 4. United States

Base Case Pass-Through



Weaker Pass-Through

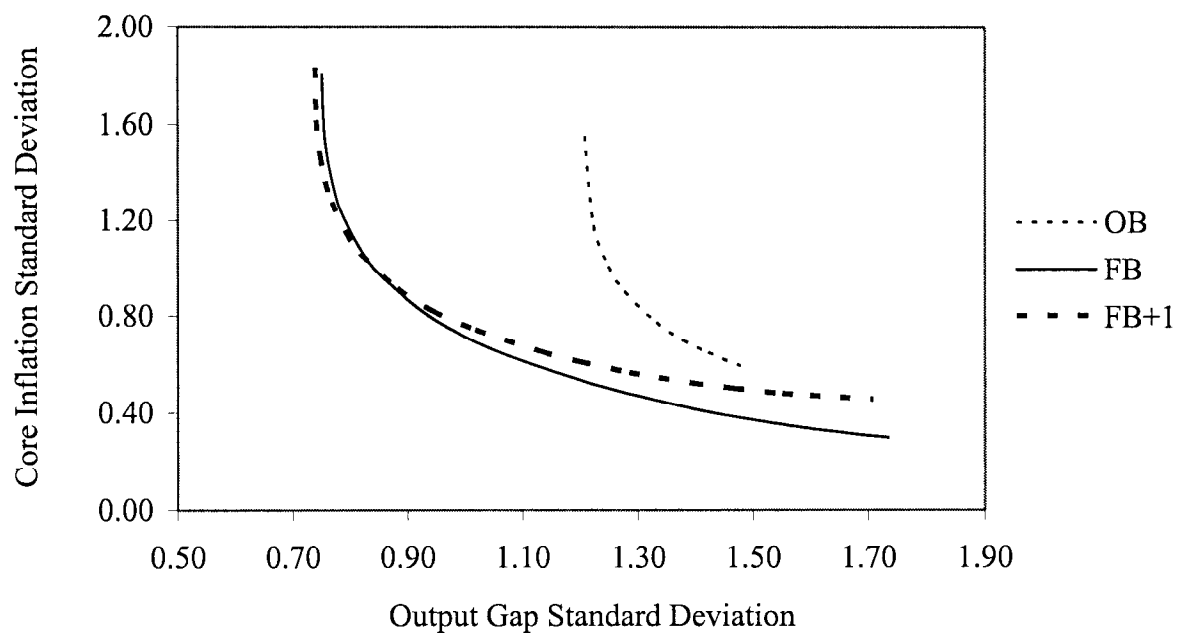
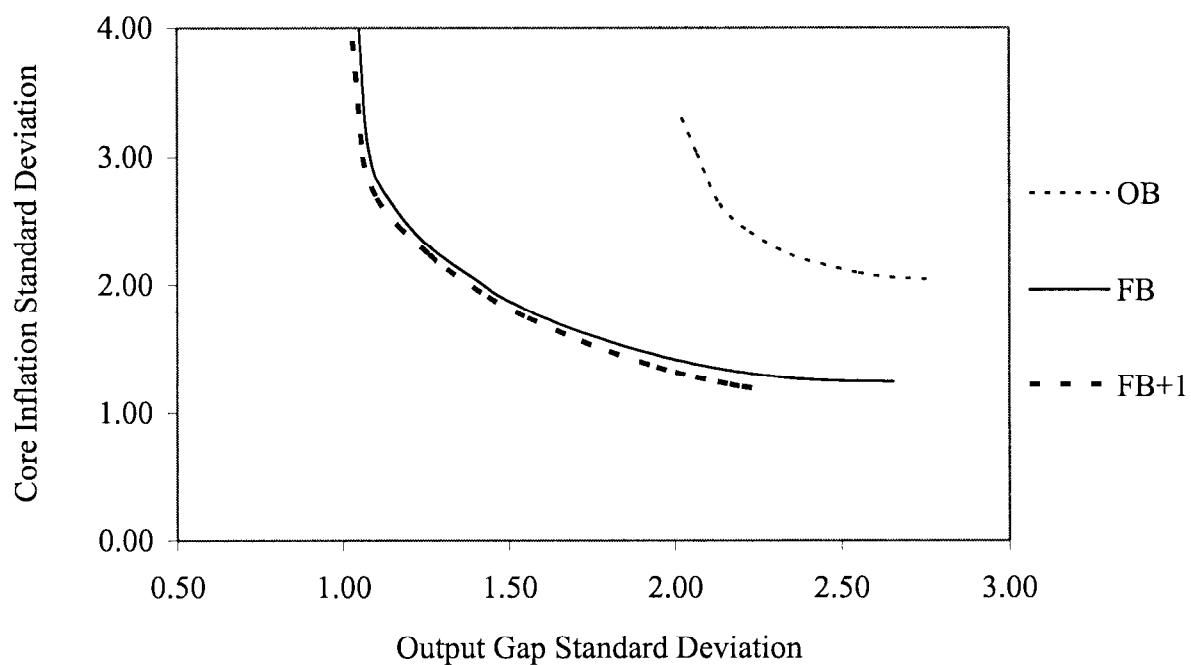
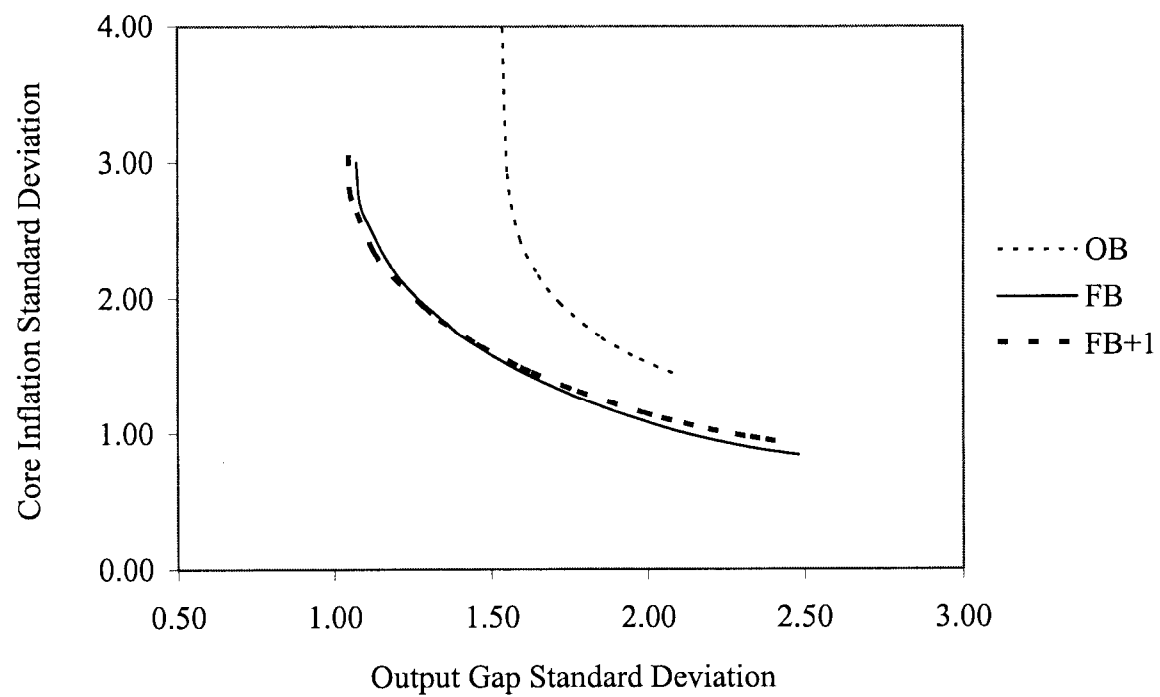


Figure 5. United Kingdom

Base Case Pass-Through



Weaker Pass-Through



the other hand, the increase in interest rate variability diminishes at a much slower rate as the magnitude of the response coefficients is increased and, consequently, a very mild distaste for interest rate variability in the policymaker's loss function results in optimal FB rules with considerably smaller response coefficients.<sup>22</sup>

In summary, our analysis of the performance and characteristics of efficient simple Taylor-type policy rules under the two alternative specifications of exchange rate pass-through supports the following views. First, reliance on forecast-based rules rather than outcome-based rules appears to significantly improve the available inflation-output variability trade-off that policymakers face. Second, with forecast-based rules, adjusting policy in response to the outcomes expected for the first non-predetermined period (in a model where periods correspond to years) appears to efficiently incorporate the information from state variables that influence the inflation forecast but are not directly included in the rule. Third, when uncertainty about model parameters is not taken into account, estimates of the optimal calibrations of simple rules suggest that policymakers could considerably improve macroeconomic stabilization if they responded more aggressively to inflation and output gaps than would be dictated by the response coefficients recommended by Taylor, or by existing empirical estimates of how aggressively they have responded in the past. Finally, to the extent that structural change has resulted in a weakening of exchange rate pass-through over time, it would appear to imply a favorable shifting of the efficient frontier for inflation and output variability.

We now turn to analyzing how these conclusions are affected when it is recognized that policymakers are uncertain about the strength of exchange rate pass-through.

#### IV. THE IMPLICATIONS OF UNCERTAINTY

In this section we first consider the implications of the policymaker misperceiving the strength of exchange rate pass-through for the simple case in which pass-through can have either of the two values considered above. Under this set-up, policymakers can make two possible errors. First, they could *overestimate* the strength of the pass-through, believing it to be given by the model's point estimates when in fact it had declined to half of that amount. Alternatively, they could *underestimate* the pass-through, believing that it had declined to half of the point estimates when in fact the pass-through remained as estimated. After comparing the costs of policy errors conditional on alternative "true values" of the pass-through parameters, we turn to analyzing how policymakers should optimally behave conditional on different perceived probability distributions for the pass-through parameters.

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<sup>22</sup> If the loss-function is extended to include a term in the first difference of the short-term interest rate, with weights, for example, of 0.1 on that term and 1.0 on both inflation and output variability, the optimal FB rule response coefficients on inflation and the output gap decline from 20 to 2 (in the MULTIMOD variant with the estimated base-case pass-through parameters). It remains the case, however, that for given loss-function parameters, the optimal response coefficients for the FB rules are generally larger than those for the OB rule.

Table 1: Efficient policy rules for the United States

Base-case exchange rate pass-through						
	$\lambda_\pi=1, \lambda_y=0.5$		$\lambda_\pi=1, \lambda_y=1$		$\lambda_\pi=1, \lambda_y=2$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
<b>OB</b>	3	2	3	3	2	3
<b>FB</b>	15	10	20	20	10	20
<b>FB+1</b>	15	8	20	20	15	20

Weaker exchange rate pass-through						
	$\lambda_\pi=1, \lambda_y=0.5$		$\lambda_\pi=1, \lambda_y=1$		$\lambda_\pi=1, \lambda_y=2$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
<b>OB</b>	5	3	3	3	2	3
<b>FB</b>	15	10	20	20	15	20
<b>FB+1</b>	15	8	20	20	15	20

Table 2: Efficient policy rules for the United Kingdom

Base-case exchange rate pass-through						
	$\lambda_\pi=1, \lambda_y=0.5$		$\lambda_\pi=1, \lambda_y=1$		$\lambda_\pi=1, \lambda_y=2$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
<b>OB</b>	3	2	2	2	2	3
<b>FB</b>	10	5	20	20	15	20
<b>FB+1</b>	20	5	20	10	20	20

Weaker exchange rate pass-through						
	$\lambda_\pi=1, \lambda_y=0.5$		$\lambda_\pi=1, \lambda_y=1$		$\lambda_\pi=1, \lambda_y=2$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
<b>OB</b>	4	2	3	2	3	3
<b>FB</b>	10	4	10	8	15	20
<b>FB+1</b>	20	8	20	15	15	20

## Outcome-Based Rules

Under OB rules, the policymaker does not rely on forecasts and sets policy purely based on predetermined variables. Consequently, in evaluating the implications of misperceiving the pass-through, there is no need to generate any more data than was generated under certainty. Consider first the case where the policymaker overestimates the pass-through. The outcome in this case is the inflation and output variability that the rule optimized under the base-case pass-through achieves under weaker pass-through. For example, the U.S. policymaker calculates optimal response coefficients of  $\delta_\pi = 3$  and  $\delta_y = 2$  if it believes the point estimates and has twice the distaste for inflation variability than it has for output variability (table 1,  $\lambda_y=0.5$ ). Under the alternative weaker pass-through specification, this policy rule results in a loss that is only 2 percent higher than that achieved with the rule optimized for this structure ( $\delta_\pi = 5$  and  $\delta_y = 3$ ). If the policy rule optimized under the weaker exchange rate pass-through is followed when the pass-through is as estimated, the loss increases by only 1 percent above the minimum achievable loss. Under the other two assumptions about the U.S. policymaker's preferences ( $\lambda_\pi=1$  and  $\lambda_y=2$ ), the optimal values of the reaction parameters<sup>23</sup> are identical under the two alternative pass-through structures, and the lowest achievable loss is always realized regardless of the strength of the pass-through. The story for the United Kingdom is much the same: the realized values of the losses deteriorate relative to the lowest achievable by only 0.2 to 5 percent if the policymaker has optimized under the incorrect pass-through structure. The result that misperceiving the pass-through is somewhat more costly in the United Kingdom reflects the fact that it is a more open economy than the United States. With respect to this specific type of model uncertainty, OB based rules for both the United States and the United Kingdom appear to be very robust.

The top panels in figures 6 and 7 contain the efficient frontiers achievable following OB rules under certainty and the frontiers that would be achieved if the policymaker followed the frontier rules optimized for the incorrect pass-through structure. The barely-visible differences between the two frontiers illustrate the small deterioration in macroeconomic stability that would arise from following OB rules that had been optimized under an incorrect structure for exchange rate pass-through.

## Forecast-Based Rules

To evaluate the implications of misperceptions about exchange rate pass-through under FB rules, it is necessary to generate some new artificial data that captures the effect of policy responding to erroneous forecasts of inflation and the output gap. Each new artificial data point generated with the model now requires two model simulations. In the first simulation, the policymaker sets the policy instrument based on its perceived model of the economy, the (correctly-perceived) distribution of the shocks, and the calibration of the policy reaction function that is optimal for the model perceived by the policymaker. The second simulation is based on the policy setting solved for in the first simulation along with the same drawing

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<sup>23</sup> When rounded to the units of the grid over which we searched.



of the shocks and the true model of the economy. This technique assumes that all agents in the economy other than the policymaker have fully accurate information about the model and distribution of shocks, including correct perceptions about the strength of the pass-through.<sup>24</sup> Beginning with the second period, the policymaker sees that the outcome is not as forecast in the previous period, but it does not understand why. The difference is attributed to the (misperceived) realization of the shocks, and the policymaker proceeds to set policy in response to new forecasts that are based on outcomes in the previous period (new initial conditions) along with its unchanged perception of the structure of the economy and the distribution of shocks.<sup>25</sup>

In Figures 6 and 7, the frontiers that result when policymakers misperceive the exchange rate pass-through are compared with those that arise under certainty. The column heads define the true model, and the dashed (solid) curves describe the outcomes that would be achieved if the policymaker followed the rules found to be efficient under misperceived (accurate) beliefs about the pass-through structure. For example, under the base-case pass-through in the first column of panels, the misperceived outcomes are what would be achieved if the policymaker followed the rules found to be efficient under the weaker pass-through. Further, for FB rules, the forecasts entering the rules are also generated with a model of the economy with weaker exchange rate pass-through. As noted above, uncertainty does not result in a significant deterioration in performance under OB rules. This is illustrated by the closeness of the two frontiers in the top panels in Figures 6 and 7. However, misperceiving the strength of exchange rate pass-through results in a significant deterioration in the lowest achievable combinations of inflation and output variability under FB rules. This deterioration in outcomes is most noticeable for the United States under FB rules when the policymaker underestimates the strength of the exchange rate pass-through. In that case the outcomes are actually worse than those achieved under the OB rules. For the United Kingdom, the deterioration is most significant under FB rules when the policymaker underestimates the strength of the exchange rate pass-through, as well as under FB+1 rules when the policymaker overestimates the strength of the pass-through. In the latter case the outcomes are worse than those achieved under OB rules.

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<sup>24</sup> To ensure that the simulations for each individual period converge, it is necessary to assume that private agents believe that the policymaker will eventually understand the true strength of the pass-through and set policy accordingly. We assume here that private agents expect policymakers to make mistakes for two periods and to correctly perceive the true strength of pass-through thereafter.

<sup>25</sup> Clearly the policymaker would eventually realize that the structure of the economy had changed and would adjust its forecasting framework accordingly.

Figure 6. United States

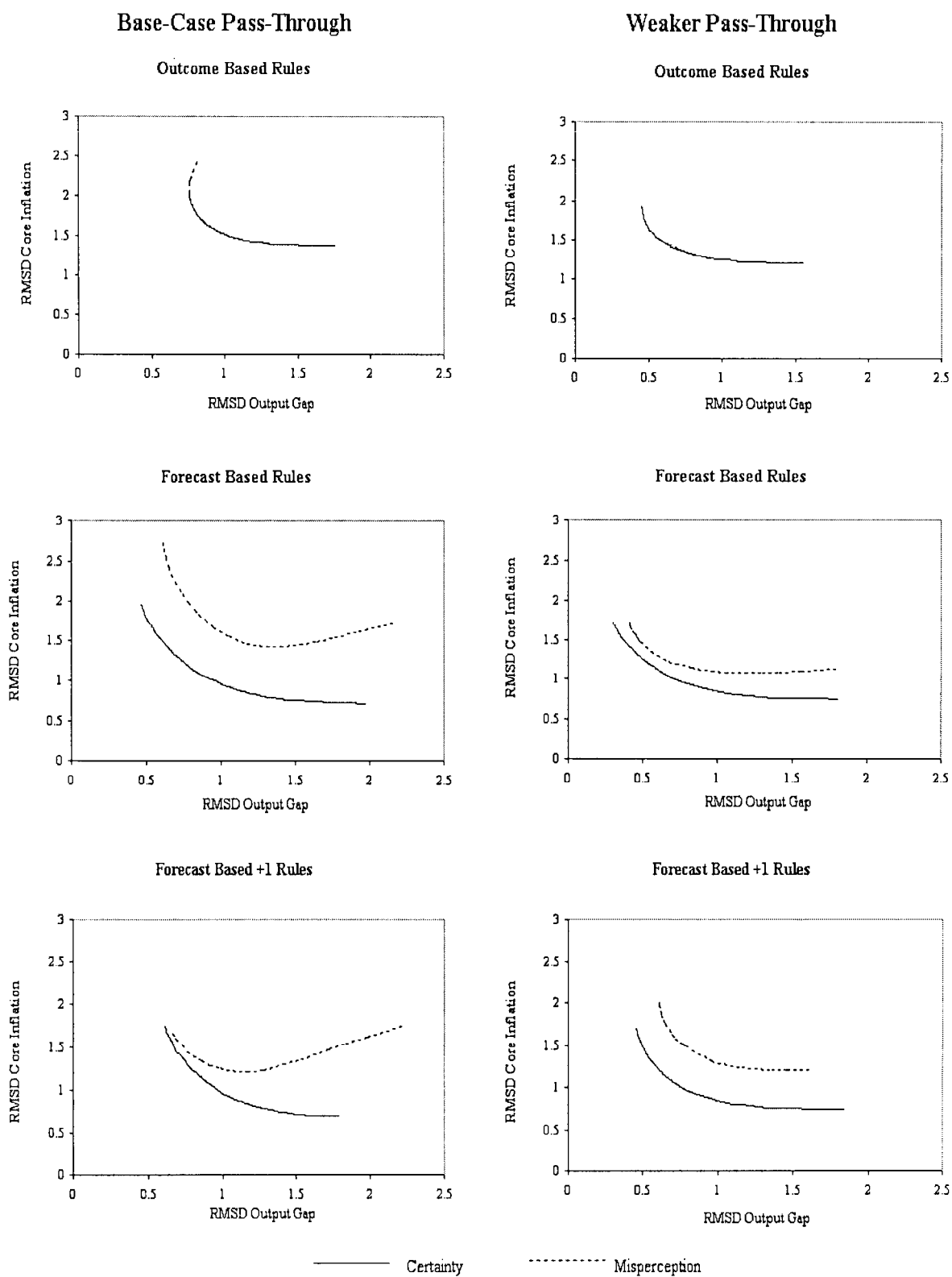
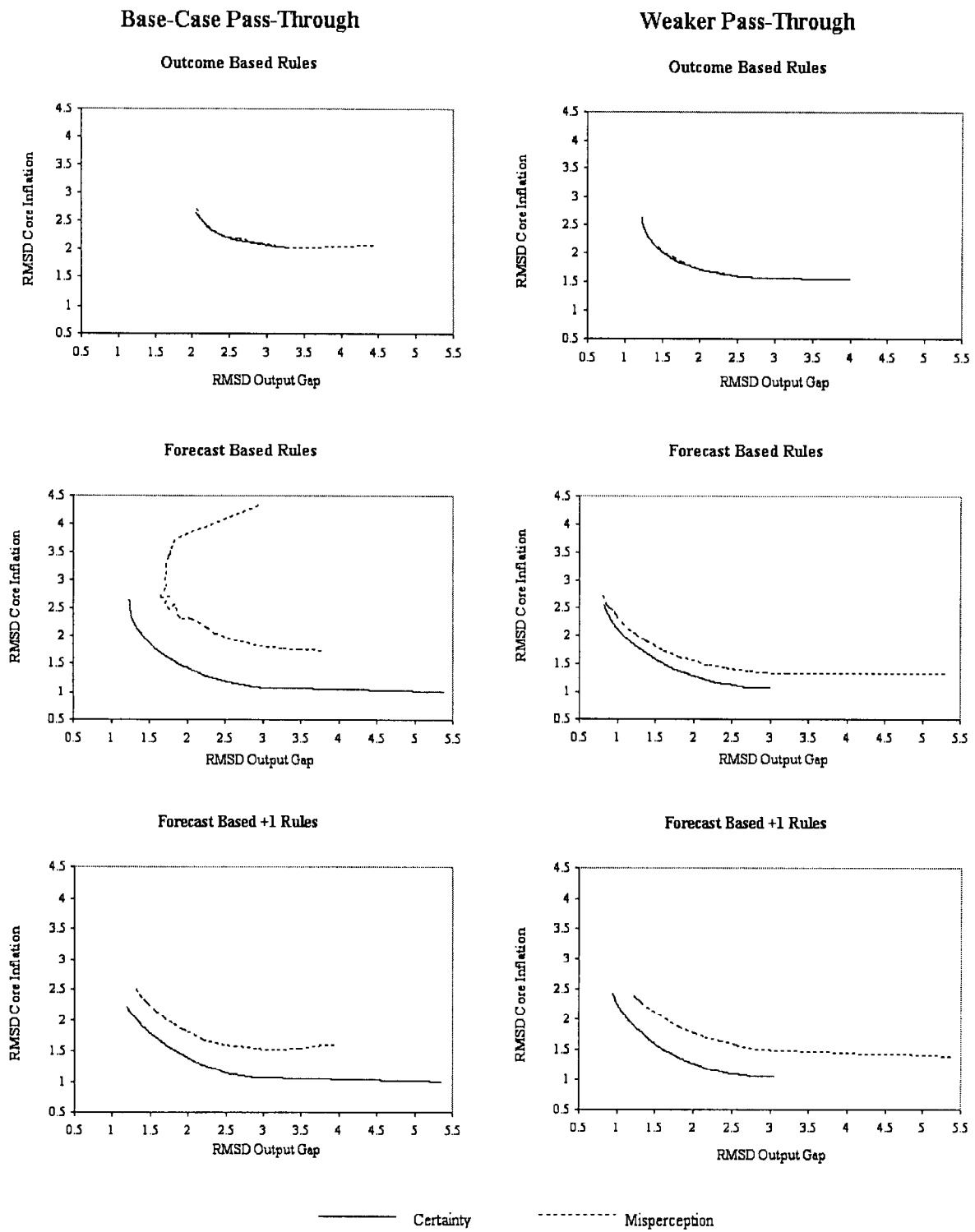


Figure 7. United Kingdom



We next refine the analysis to consider circumstances in which the policymaker recognizes that there is uncertainty about the strength of the exchange rate pass-through and seeks to determine the optimal strategy to follow under a given probability that the base-case pass-through assumption is correct. We are interested in exploring the sensitivity of the optimal strategy to the probability that the base-case assumption is true.

We define a strategy to be an assumption about the structure of the economy and a class of policy rule to guide actions; accordingly, for our simple two-state world there are six possible strategies for the policymaker. In addition to choosing a strategy the policymaker must also choose a parameterization for the strategy. Table 3 depicts the set of choices that the policymaker faces.

Table 3: Possible Strategies

Strategy	Assumption about the Economy's Structure	Class of Rule	Parameterization of Rule
1 – BCOB	Base case	OB	$\delta_{\pi}, \delta_y$
2 – BCFB	Base case	FB	$\delta_{\pi}, \delta_y$
3 – BCFB+1	Base case	FB+1	$\delta_{\pi}, \delta_y$
4 – WPTOB	Weaker Pass-through	OB	$\delta_{\pi}, \delta_y$
5 – WPTFB	Weaker Pass-through	FB	$\delta_{\pi}, \delta_y$
6 – WPTFB+1	Weaker Pass-through	FB+1	$\delta_{\pi}, \delta_y$

To determine the optimal strategy the policymaker needs to solve the following minimization problem:

$$\begin{aligned} \text{Min}_i \left( \text{Min}_{\delta_\pi, \delta_y | i} L = \sum_{t=0}^{\infty} P_{BC} \cdot (\lambda_\pi \cdot (\pi_t^{i,BC} - \pi^*)^2 + \lambda_y \cdot (ygap_t^{i,BC})^2) + \right. \\ \left. (1 - P_{BC}) \cdot (\lambda_\pi \cdot (\pi_t^{i,WPT} - \pi^*)^2 + \lambda_y \cdot (ygap_t^{i,WPT})^2) \right), \end{aligned}$$

s.t.

$$X_t^f = g^f(Z_t),$$

and

$$X_t^a = g^a(Z_t),$$

and

$$rs_t = rr\_eq_t + \pi_{t+i}^c + \delta_\pi \cdot (\pi_{t+i}^c - \pi^*) + \delta_y \cdot (ygap_{t+i}),$$

where:

$\delta_\pi$  and  $\delta_y$  denote the parameters in the policy rule,

$i$  denotes a strategy composed of an assumption about the structure of the economy and a class of policy rule,

$P_{BC}$  denotes the subjective probability that the base-case exchange rate pass-through is true,

the superscript pair  $i, BC$  denotes the outcome conditional on strategy  $i$  when the actual structure of the economy has the base-case exchange rate pass-through,

the superscript pair  $i, WPT$  denotes the outcome conditional on strategy  $i$  when the actual structure of the economy has the weaker exchange rate pass-through,

$g^f(Z_t)$  represents the structure of the economy, including the assumption about pass-through, that the policymaker uses for forecasting,

$X_t^f$  is the policymaker's forecast for the set of endogenous variables, including the goal variables  $\pi_t$  and  $ygap_t$ ,

$g^a(Z_t)$  represents the actual structure of the economy,

$X_t^a$  is the actual outcomes for endogenous variables, and

$rs_i$  represents the nominal interest rate setting imposed by the class of rules in the policymaker's strategy.

By generating solutions to the first-stage problem, we can plot the minimum achievable loss for each strategy as a function of the policymaker's subjective probability that the actual structure of the economy has the base-case exchange rate pass-through. These minimum loss-function values are shown in Figures 8 and 9 under two different sets of policymaker preference parameters. In the top panel of each chart the policymaker cares twice as much about inflation variability than it does about output variability ( $\lambda_\pi = 1$  and  $\lambda_y = 0.5$ ). In the lower panel the policymaker cares twice as much about output variability than it does about inflation variability ( $\lambda_\pi = 1$  and  $\lambda_y = 2$ ). Each figure contains only five lines, because the minimum achievable losses under the two strategies involving OB rules are essentially identical, as depicted by the OB line. This reflects both the earlier finding that uncertainty does not result in a significant deterioration in performance under OB rules and the further narrowing of performance differences associated with the choice of loss-minimizing policy-rule coefficients under each of the two assumptions about the structure of the economy. The other four lines in the figures are labeled with the mnemonics introduced in table 3. The first part of each mnemonic indicates the policymaker's assumption about the structure of the economy and the second part the class of forecast based rule followed.

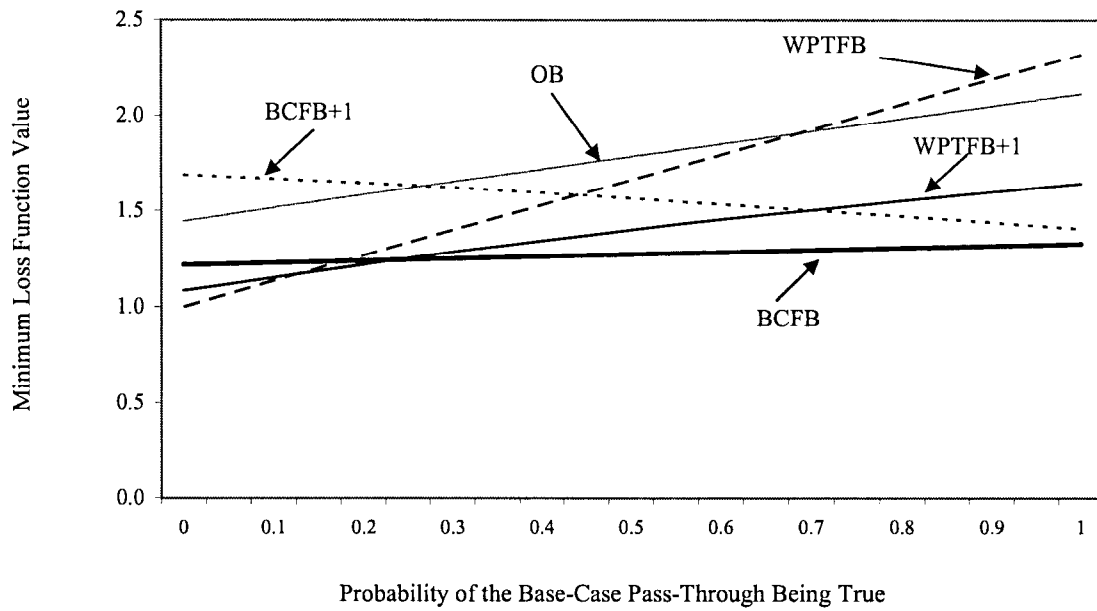
These figures usefully summarize much of the information from Figures 6 and 7. As the probability of the base-case structure being true increases towards one, there is a rising trend in the losses under OB rules. This reflects the fact that the minimum-loss combinations of inflation and output variability involve higher losses under the base-case exchange rate pass-through when policy settings are not based on forecasts and, hence, are not directly affected by any forecast errors associated with misperceiving the structure of exchange rate pass-through. The strategy that consists of assuming the base-case pass-through and using a FB rule (BCFB) appears to be the dominant strategy on average. The loss it delivers is remarkably stable. Only when the probability of the base case being true is low (0.4 or lower) is it ever dominated by strategies that incorporate the assumption of weaker pass-through. When this occurs, the reduction in the loss from switching assumptions is fairly small. For the United Kingdom, the BCFB+1 strategy does marginally better when the probability of the base case being true is very high. However, from a robust control perspective, where the objective is to guard against very bad outcomes occurring, the low and stable loss that the BCFB strategy consistently delivers makes it the clear winner.<sup>26</sup>

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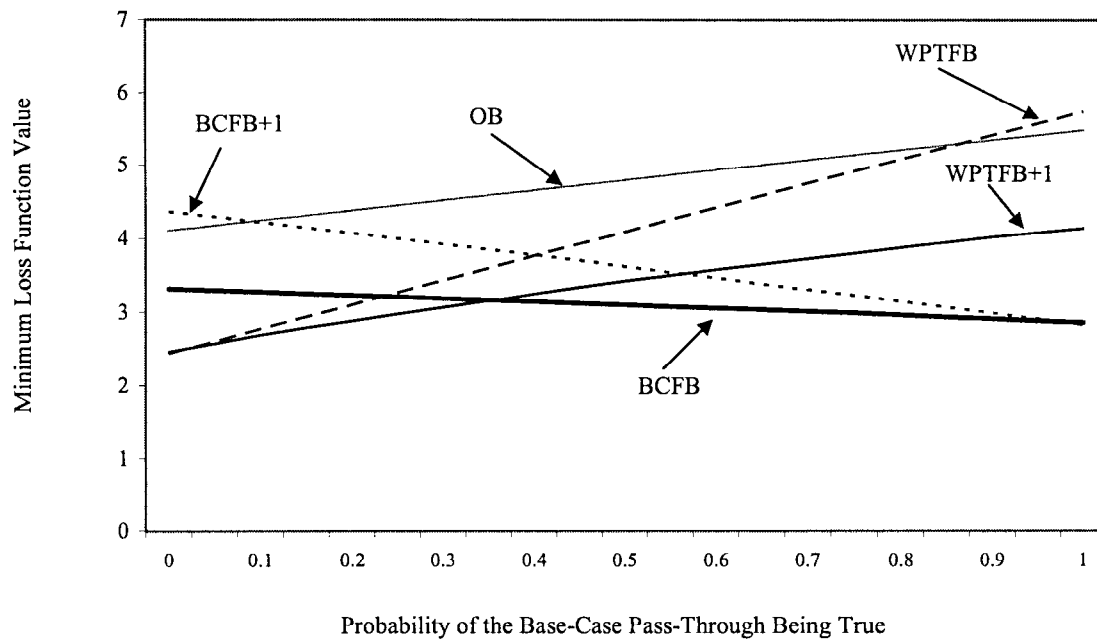
<sup>26</sup> As outlined in Demertzis and Tieman (2002), if policymakers are risk averse then this conclusion becomes even stronger.

Figure 8. United States

Preferences: Twice As Concerned About Inflation Variability



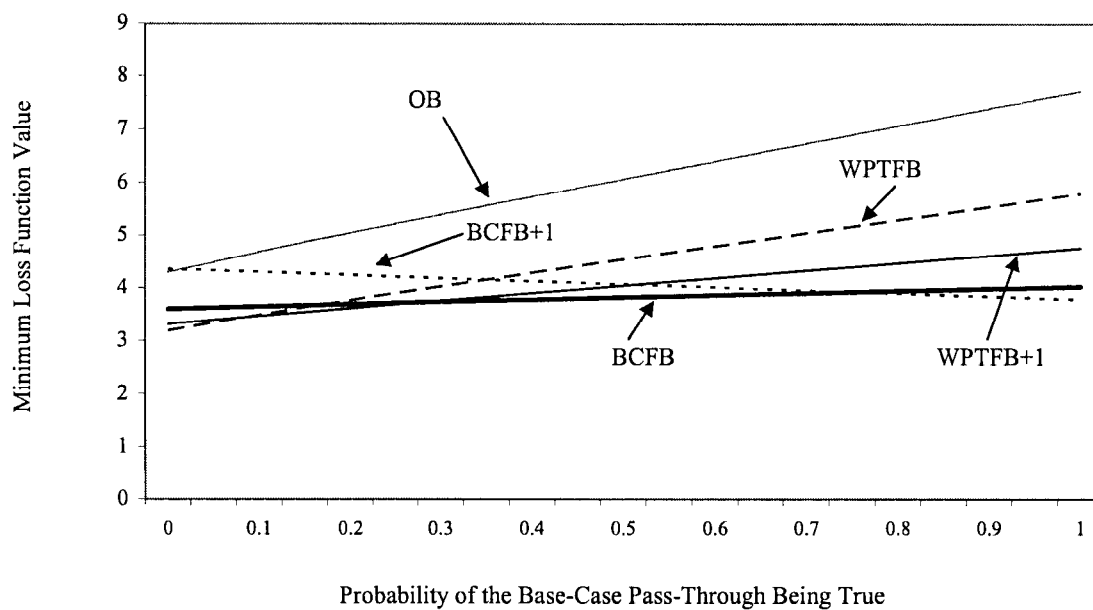
Preferences: Twice As Concerned About Output Variability



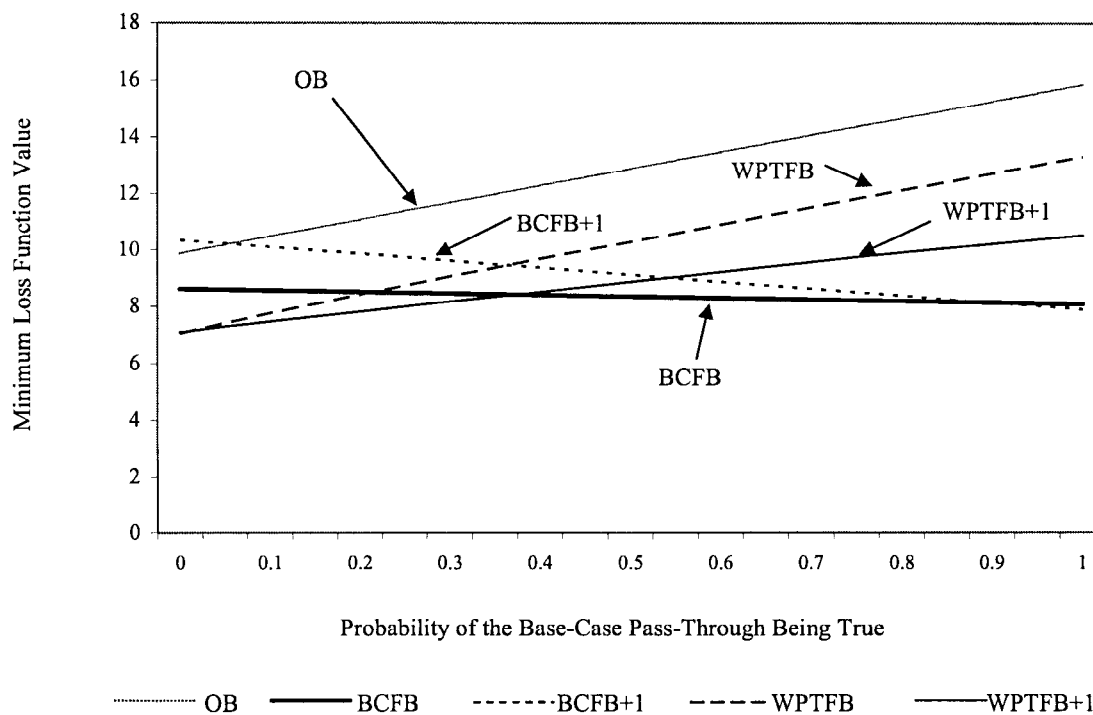
..... OB    — BCFB    - - - - BCFB+1    - - - - WPTFB    — WPTFB+1

Figure 9. United Kingdom

Preferences: Twice As Concerned About Inflation Variability



Preferences: Twice As Concerned About Output Variability



..... OB    — BCFB    ..... BCFB+1    ---- WPTFB    — WPTFB+1



Tables 4 and 5 report the values of the reaction coefficients associated with the loss-minimizing strategies, conditional on selected subjective probabilities and policy preference parameters. Also shown in each case are the reaction coefficients that would be efficient under the same class of policy rule if there was certainty about the structure of the economy assumed in the uncertainty case. The values for  $\delta_\pi$  and  $\delta_y$  that solve the minimization problem suggest that uncertainty about exchange rate pass-through of the magnitude considered here does not in general lead to attenuation in the strength of the optimal policy response relative to the certainty case. A comparison of these coefficients indicates that anti attenuation is just as likely as attenuation in the efficient policy response coefficient. One possible explanation for the Brainard attenuation result not dominating is that policy multiplier uncertainty is only a very small component of the uncertainty considered here.

Table 4: United States

Efficient Policy Rule Coefficients

Preferences: $\lambda_\pi = 1, \lambda_y = 0.5$						
	$P_{BC} = 0.25$		$P_{BC} = 0.5$		$P_{BC} = 0.75$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
Uncertainty	20	15	20	15	20	15
Certainty	15	10	15	10	15	10
Preferences: $\lambda_\pi = 1, \lambda_y = 1$						
	$P_{BC} = 0.25$		$P_{BC} = 0.5$		$P_{BC} = 0.75$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
Uncertainty	20	15	20	20	20	20
Certainty	20	20	20	20	20	20
Preferences: $\lambda_\pi = 1, \lambda_y = 2$						
	$P_{BC} = 0.25$		$P_{BC} = 0.5$		$P_{BC} = 0.75$	
	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$	$\delta_\pi$	$\delta_y$
Uncertainty	20	20	15	20	10	20
Certainty	15	20	10	20	10	20

Table 5: United Kingdom  
Efficient Policy Rule Coefficients

Preferences: $\lambda_{\pi} = 1, \lambda_y = 0.5$						
	$P_{BC} = 0.25$		$P_{BC} = 0.5$		$P_{BC} = 0.75$	
	$\delta_{\pi}$	$\delta_y$	$\delta_{\pi}$	$\delta_y$	$\delta_{\pi}$	$\delta_y$
Uncertainty	20	8	15	8	15	8
Certainty	20	8	10	5	10	5

Preferences: $\lambda_{\pi} = 1, \lambda_y = 1$						
	$P_{BC} = 0.25$		$P_{BC} = 0.5$		$P_{BC} = 0.75$	
	$\delta_{\pi}$	$\delta_y$	$\delta_{\pi}$	$\delta_y$	$\delta_{\pi}$	$\delta_y$
Uncertainty	15	10	10	8	20	20
Certainty	20	15	20	20	20	20

Preferences: $\lambda_{\pi} = 1, \lambda_y = 2$						
	$P_{BC} = 0.25$		$P_{BC} = 0.5$		$P_{BC} = 0.75$	
	$\delta_{\pi}$	$\delta_y$	$\delta_{\pi}$	$\delta_y$	$\delta_{\pi}$	$\delta_y$
Uncertainty	20	20	15	20	15	20
Certainty	15	20	15	20	15	20

## V. CONCLUSIONS

The implementation of monetary policy is complicated by considerable uncertainty about the structure of the economy and the nature of disturbances that influence economic behavior. This paper has explored the implications of one particular complication—uncertainty about the degree to which movements in the nominal exchange rate are passed through into domestic prices. How much weight should policymakers give to empirical evidence suggesting that over the last decade, the domestic prices of imported manufactured goods may have become more insulated from variability induced by movements in the nominal exchange rate than was previously the case? Is there a danger that they will make significant policy errors if they fail to immediately incorporate weaker exchange rate pass-through into their inflation forecasting frameworks? And should pass-through uncertainty lead them to be more timid in their policy responses than if they were more confident about the impact of exchange rate variability on their goal variables and the transmission of policy actions to their goal variables via the exchange rate?

We have employed MULTIMOD simulations to address these questions, using the blocs for the United States and the United Kingdom, two countries that differ considerably in their degree of openness and, consequently, in the role played by the exchange rate in macroeconomic adjustment. We derive efficient Taylor-type policy rules for both the United States and the United Kingdom and examine their efficacy under both certainty and uncertainty about exchange rate pass-through. Under *certainty*, the characteristics of the derived efficient policy rules are consistent with several results commonly found in the literature. First, efficient response coefficients are considerably larger than those recommended by Taylor, and also considerably larger than the coefficients of estimated rules that mimic the observed behavior of monetary authorities during periods of successful inflation control. Second, forecast-based Taylor-type rules offer improvements in performance over similar outcome-based rules because they incorporate the information from a larger set of relevant state variables than just the lags of inflation and the output gap. Third, the forecast horizon does not need to be very long to reap most of the gains from relying on forecast-based rules rather than outcome-based rules (although this result comes with the qualification that, because MULTIMOD employs annual data, it is not particularly useful for precise analysis of the optimal forecast horizon for the variables entering the policy rule). And fourth, a structural shift in pass-through parameters that leaves domestic import prices more insulated from movements in the nominal exchange rate provides monetary policymakers with a much more favorable trade-off between inflation variability and output variability.

When there is *uncertainty* about whether exchange rate pass-through has weakened, our analysis suggests that it is not important for policymakers to immediately incorporate the possible shift in the structure of the economy into their forecasting frameworks. Indeed, using a forecast-based policy rule within a forecasting framework that does not incorporate weaker exchange rate pass-through appears to be the optimal way to err on the side of caution within the set of simple policy strategies considered. If, on the one hand, the weaker exchange rate pass-through structure turns out to be true, such a strategy would lead to only slightly worse outcomes than if the forecasting framework incorporated the correct structure for pass-through. This holds for both the less open U.S. economy and the more open U.K. economy. On the other hand, the deterioration in macroeconomic performance from making the opposite error—underestimating the strength of exchange rate pass-through—appears to be larger. Together these results imply that, given the uncertainty about exchange rate pass-through, using a forecast-based policy rule and a forecasting framework with the stronger exchange rate pass-through structure is the most robust strategy in the sense that it minimizes the probability of very bad outcomes occurring. Additionally, the magnitudes of the policy response coefficients that minimize the loss arising under this uncertainty do not suggest that policymakers should respond more timidly to their forecasts of inflation and the output gap relative to the certainty case.

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