

## MONETARY POLICY AND THE STABILITY OF MACROECONOMIC RELATIONSHIPS

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### SUMMARY

Estimates of the effect of different international monetary regimes on the parameters of the Phillips curve, the Keynesian consumption function, and other reduced-form macroeconomic relationships are given. The estimates provide a quantitative assessment of the importance of the Lucas critique for such regime shifts. The estimates are calculated by stochastically simulating an estimated multicountry economic model with rational expectations under a fixed exchange rate regime and a flexible exchange rate regime. In both regimes interest rates are the primary instrument of monetary policy. Noticeable shifts occur in most of the macroeconomic relationships, especially in the consumption function and the Phillips curve, and these shifts have simple economic interpretations based on the changes in the variance and the serial correlation of income and prices in the two regimes. However, in most cases the shifts are not large quantitatively. At least, as implemented here, this type of regime shift does not seem to generate much instability in the conventional macroeconomic relationships. Several possible reasons for this finding are discussed in the paper.

In this paper I plan to follow in a tradition pioneered by A. W. Phillips almost 40 years ago. Phillips (1954) evaluated monetary and fiscal policy by examining the operating properties of simple policy rules in a fully specified economic model. He did this by applying control theory ideas from the engineering literature. By examining the performance of the model economy under different types of policy rules—for example, proportional, derivative, and integral rules—he attempted to determine which policy rule would work well and which would not work well in practice.

Following in the Phillips tradition does not mean that I will use the same theoretical models, econometric methods, or computational techniques that Phillips used. To do so would, in my view, pass by fundamental developments in dynamic economic theory, econometrics, and solution procedures that have been achieved since the time that Phillips wrote. Phillip's (1954) analysis was based on Keynesian ISLM–multiplier–accelerator models that were popular in the early 1950s. The policy evaluation I describe in this lecture differs from Phillips's policy evaluation in several ways. First, it makes use of a dynamic rational expectations model with forward-looking behaviour in consumption, investment, wage-setting, and interest rates. Second, the model is international and exchange rate determination reflects the current high degree of international capital mobility which did not exist when Phillips wrote. Third, the model is empirically estimated; most of Phillips's work was based on simulation models with 'calibrated' parameters. Fourth, the simulations are done stochastically with an empirically

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estimated variance–covariance matrix; Phillips’s calculations were based on deterministic simulations.

All these differences reflect important technical advances since the original work of Phillips. These technical advances represent some of the most important innovations in macroeconomic research during the past 20 years and will probably have as lasting an impact as the debates about the theoretical microfoundations of the Phillips curve. Of course, it is the Phillips curve for which Phillips became world-famous, rather than for his pioneering work on engineering control methods in macroeconomics. The Phillips curve would appear to be an excellent subject for the Phillips Lecture. It would give me an opportunity to talk about staggered contracts, imperfect competition, efficiency wages, menu costs and other recently developed theoretical underpinning of the Phillips curve. It would also give me the opportunity to discuss the current state of the macroeconomic controversy between new-Keynesians, new-classicals, and real business cycle theorists which grew out of the Phillips curve controversy.

In my focus on quantitative macroeconomic policy evaluation issues that are closer to Phillips’s less well-known contributions, I will, however, examine an important methodology issue that is closely related to the Phillips curve. I attempt to estimate the effect of different policy regimes on the ‘reduced form’ parameters of the Phillips curve as well as the Keynesian consumption function and other ‘conventional’ relationships. The estimates provide a quantitative assessment of the importance of the Lucas critique for such regime shifts. For the regime shifts that I consider, noticeable shifts occur in most of the macroeconomic relationships, and these shifts have simple economic interpretations based on the changes in the variance and the serial correlation of income and prices in the different regimes. However, in most cases the shifts are small. At least as implemented here, the regime shifts do not seem to generate much instability in the conventional macroeconomic relationships. I discuss some possible explanations for this finding in the paper.

The paper is organized as follows. In the first part I discuss the general rational expectations modelling framework that I use to evaluate the policy rules. In my view this type of framework, though not necessarily the particular model, is representative of a new generation of econometric models that are being developed for policy evaluation research. In addition to the model that I discuss here, Warwick McKibbin of the Reserve Bank of Australia and Christopher Murphy of Australian National University are using similar frameworks in their policy research. The International Monetary Fund has recently developed a similar model.

In the second part of the paper I do a simple macroeconomic policy evaluation using the model. The evaluation is related to the types of issues addressed by Phillips in the 1950s. It concerns the use of derivative versus proportional terms in interest rate rules for the monetary authorities.

In the third part I estimate the effect of different international monetary regimes on the parameters of the Phillips curve, the Keynesian consumption function and other relationships. The estimates are calculated by stochastic simulations of the model under a fixed exchange rate regime and a flexible exchange rate regime. In both regimes interest rates are the primary instrument of monetary policy.

## 1. THE POLICY EVALUATION FRAMEWORK

For quantitative policy evaluation one needs a model. As was argued persuasively by Lucas (1976), the parameters of the model should be invariant to changes in the policy rule. In other

words, the model should be structural. Whether this invariance property holds in practice in a given application depends on the type of policy that one is considering. For example, by modelling consumer behaviour as in the life-cycle permanent income model with rational expectations, one knows that changes in policy which change the time-series property of income would also change the marginal propensity to consume. Such a model of consumer behaviour would, in principle, be more appropriate than a simple Keynesian consumption function or a model with adaptive expectations where the marginal propensity to consume is assumed to be invariant to changes in policy.

In this paper I want to consider changes in the policy rule for monetary policy. I generally consider policy rules in which the central bank adjusts the short-term interest rate up and down according to how far the price level deviates from a target path. One such change involves a shift from a flexible exchange rate system, in which each central bank determines its own interest rate rule, to a fixed exchange rate system in which each central bank cannot independently adjust its interest rate. Another change involves adding a derivative correction term to a central bank's interest rate rule in which the rate of change, as well as the level of the price level, affects the setting for interest rates.

To evaluate these types of monetary policy rule changes quantitatively, one obviously needs an economic model which is international in scope and which is invariant to such changes. It was with such policy changes in mind that I developed a multicountry model with forward-looking behaviour for consumption, investment, wages, interest rates and exchange rates. In my view the model stands a good chance of being invariant against monetary policy changes of this sort, and for this reason I use the model for this paper. But it is unlikely to be invariant against all monetary policy changes. In order to assess the adequacy of such a model for the task at hand, it is, of course, necessary to examine briefly the characteristics of the model.

### **General Characteristics of the Model**

The model is a multicountry model fit to data from the so-called G-7 countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The sample period is from 1972 through 1986. The most important property of the model is rational expectations. This assumption seems appropriate for evaluating the effects of changes in policy rules which are meant to be in place for a long period of time. Note that rational expectations does not mean perfect foresight; because there are stochastic shocks to the model, people make errors in forecasting the future. On average, over a long span of time, these errors average out to zero.

Although the model assumes rational expectations, it is not a new-classical model. The model assumes that nominal wages and prices are sticky and are determined according to the specific staggered wage setting model of Taylor (1980). Aggregate demand then determines the level of production in the short run. In the long run the model would return to the potential level of real GNP, but since it is constantly hit by shocks, the economy fluctuates around the potential level.

Capital is perfectly mobile across countries, but there are time-varying risk premia that affect the behaviour of exchange rates. Bond markets within each country are assumed to be efficient, but there are time-varying risk premia in the term structure of interest rates as well.

The main instrument of macroeconomic policy is assumed to be monetary policy, and the monetary policy rule is stated in terms of the interest rate. Government spending is taken to be exogenous.

### Brief Description of the Equations

In order to describe the model in somewhat more detail, I introduce the following notation.<sup>1</sup> Each variable refers to a given country: Canada, France, Germany, Italy, Japan, the UK and the US.

#### *Summary of notation used in the model equations*

<i>RS</i>	short-term interest rate
<i>RL</i>	long-term interest rate
<i>RRL</i>	real interest rate ( <i>RL</i> less expected inflation)
<i>E<sub>i</sub></i>	exchange rates (US cents per unit of currency <i>i</i> )
<i>Y</i>	real GNP (or GDP)
<i>C</i>	consumption (total)
<i>CD</i>	durables consumption
<i>CS</i>	services consumption
<i>CN</i>	nondurables consumption
<i>INS</i>	non-residential structures investment
<i>INE</i>	non-residential equipment investment
<i>IR</i>	residential investment
<i>II</i>	inventory investment
<i>IF</i>	fixed investment (total)
<i>IN</i>	non-residential investment (total)
<i>IR</i>	residential investment (total)
<i>EX</i>	exports in income–expenditure identity
<i>IM</i>	imports in income–expenditure identity
<i>G</i>	government purchases of goods and services
<i>YP</i>	permanent income, a geometric distributed lead of <i>Y</i> over eight future quarters with a decay factor of 0·9
<i>YW</i>	weighted foreign output (of the other six countries)
<i>YT</i>	trend or potential output
<i>YG</i>	percentage gap between real GNP and trend GNP (defined as $YG = LY - LYT$ and coded as a fraction)
<i>W</i>	average wage rate
<i>X</i>	‘contract’ wage rate
<i>P</i>	GNP (or GDP) deflator
<i>PIM</i>	import price deflator
<i>PEX</i>	export price deflator
<i>PW</i>	trade weighted foreign price (foreign currency units)
<i>EW</i>	trade weighted exchange rate (foreign currency/domestic currency)
<i>FP</i>	trade weighted foreign price (domestic currency units)

All variables in the model except for government purchases *G* and potential output *YT* are endogenously determined within the model. Note that the model does not have an endogenous model for aggregate supply or potential GNP. There are a total of 98 stochastic equations each of which is estimated with historical data and then shocked in the policy simulations.

The equations for each of the seven countries in the model can be described as follows. The

<sup>1</sup> More details about the model can be found in Taylor (1988b).

symbol  $L$  indicates the logarithm. Any time a future variable appears, the conditional expectations of the variable is implicit. The *ex ante* interest rate parity equation characterizes the perfect capital mobility assumption

$$LE_i = LE_i(+1) + 0.25 * (RS_i - RS), \quad (1)$$

for each currency ( $i =$  Canada, France, Germany, Italy, Japan, and the United Kingdom) against the US dollar. Here  $RS$  indicates the US interest rate and  $RS_i$  indicates one of the foreign interest rates. The residuals to these equations (not shown explicitly in this or other equations) are interpreted as exogenous, time-varying risk premia. They follow an AR(1) process estimated from the estimated structural residuals.<sup>2</sup>

The term structure equations are given by

$$RL_i = b_{i0} + (1 - b_i)/(1 - b_i^9) \sum_{s=0}^8 b_i^s RS_i(+s). \quad (2)$$

Note that this term structure relationship is completely forward-looking. The long rate depends on expectations of future short rates. If equation (2) holds, then a reduced form relationship relating long rates to past variables should shift if there is a regime shift.<sup>3</sup>

Consumption is disaggregated by durables, nondurables, and services in some, but not all of the countries. The general form for all the consumption equations is:

$$CX_i = c_{i0} + c_{i1}CX_i(-1) + c_{i2}YP_i + c_{i3}RRL_i, \quad (3)$$

where  $CX_i = CD_i$ ,  $CN_i$ , or  $CS_i$ . Note that both permanent income  $YP$  and the real interest rate  $RRL$  are forward-looking variables in the consumption equation.

Fixed investment expenditures are disaggregated into non-residential equipment, non-residential structures, and residential structures in some of the countries. The general form for all the fixed investment equations is as follows:

$$IX_i = d_{i0} + d_{i1}IX_i(-1) + d_{i2}YP_i + d_{i3}RRL_i, \quad (4)$$

where  $IX_i = INE_i$ ,  $INS_i$ , or  $IR_i$ . Again, this is a forward-looking equation because both  $YP$  and  $RRL$  involve expectations for the future. Inventory investment is given by

$$II_i = e_{i0} + e_{i1}II_i(-1) + e_{i2}Y_i + e_{i3}Y_i(-1) + e_{i4}RRL_i. \quad (5)$$

Another part of the model in which there is much explicit forward-looking behaviour is in wage determination. Wages are determined according to the following staggered contract equations

$$LX_i = \pi_{i0}LW_i + \pi_{i1}LW_i(+1) + \pi_{i2}LW_i(+2) + \pi_{i3}LW_i(+3) \\ + \alpha_i(\pi_{i0}YG_i + \pi_{i1}YG_i(+1) + \pi_{i2}YG_i(+2) + \pi_{i3}YG_i(+3)), \quad (6)$$

where the aggregate wage is defined by an identity:

$$LW_i = \pi_{i0}LX_i + \pi_{i1}LX_i(-1) + \pi_{i2}LX_i(-2) + \pi_{i3}LX_i(-3). \quad (7)$$

<sup>2</sup> The interpretation that the residuals are risk premia depends on the computation of the expectation  $LE_i(+1)$  as being the conditional rational forecast. In this paper the value of  $LE_i(+1)$  is computed by solving the entire model each period.

<sup>3</sup> In principle, the number of leads in this equation should be greater than 8. If the number is infinite, then the equation can be transformed into an equation with a single value of  $RL_i(+1)$  on the right. I had little luck estimating the equation in this transformed form.

Expectation of both future wages and future demand conditions (as indexed by the output gap  $YG$ ) determine the current contract wage  $LX$ .

There is no explicit forward-looking behaviour in exports, imports or in the price of exports and imports. Real exports are given simply by

$$LEX_i = f_{i0} + f_{i1}LEX_i(-1) + f_{i2}(LPEX_i - LPIM_i) + f_{i3}LYW_i, \quad (8)$$

and real imports are given by

$$LIM_i = g_{i0} + g_{i1}LIM_i(-1) + g_{i2}(LPIM_i - LP_i) + g_{i3}LY_i. \quad (9)$$

The import price equations are

$$LPIM_i = k_{i0} + k_{i1}LPIM_i(-1) + k_{i2}PFP_i + U_{mi}, \quad (10)$$

where  $U_{mi} = \delta_{mi}U_{mi}(-1) + V_{mi}$  with  $k_{i1} + k_{i2} = 1$ .

The export price equations are

$$LPEX_i = \beta_{i0} + \beta_{i1}LPEX_i(-1) + \beta_{i2}LP_i + \beta_{i3}PFP_i + \beta_{i4}T + U_{xi}, \quad (11)$$

where  $U_{xi} = \delta_{xi}U_{xi}(-1) + V_{xi}$  with  $\beta_{i1} + \beta_{i2} + \beta_{i3} = 1$ .

Finally, the aggregate price is given by

$$LP_i = h_{i0} + h_{i1}LP_i(-1) + h_{i2}LW_i + h_{i3}LPIM_i(-1) + h_{i5}T + U_{pi}, \quad (12)$$

where  $U_{pi} = \delta_{pi}U_{pi}(-1) + V_{pi}$  with  $h_{i1} + h_{i2} + h_{i3} = 1$ .

The remaining equations of the model are straightforward identities that describe the average world price  $LPW$ , the weighted exchange rate  $LEW$ , the weighted price of the other countries  $PFP$ , the weighted output of the other countries  $LYW$ , and the trend output paths  $LYT$ .

When policy rules for the short-term interest rate, described in the next part of the paper, are added to these equations, the system fully determines the behaviour of the endogenous variables. The model can then be solved by iterative techniques such as the extended-path method developed by Fair and Taylor (1983). Different policy rules are described in the following two sections. For stochastic simulation, all the right-hand-side variables are shocked with disturbances that have the same distribution as the estimated disturbances during the sample period. The only exogenous variables are government purchases in each country.

## 2. PROPORTIONAL RULES VERSUS DERIVATIVE RULES

In order to illustrate how the policy evaluation technique works in this sort of model, consider two alternative simple rules for policy of the type that Phillips considered.

First, suppose that the central banks in each country set their interest rates according to the following simple proportional rule:

$$RS_i - RS_i^* = LP_i(+4) - LP_i + g(LP_i - LP_i^*), \quad (13)$$

In other words, when the price level rises above a target, the interest rate is increased in real terms. The real interest rate is set in proportion to the percentage deviation of the price level from a target. For this reason, the rule is a proportional rule using A. W. Phillips's terminology.

Alternatively, suppose that the central banks also look at the rate of change in the price level according to the following rule:

$$RS_i - RS_i^* = LP_i(+4) - LP_i + g(LP_i - LP_i^*) + h((LP_i - LP_i(-1)) - (LP_i^* - LP_i^*(-1))). \quad (14)$$

In other words, the interest rate rises by  $g$  per cent when the price level moves by 1 per cent away from target, and by another  $h$  per cent when the price level is rising 1 per cent faster than the target. The latter effect is a derivative term (using Phillips's terminology) in that it incorporates the percentage *change* in the price level.

How would the economy be expected to operate under these two rules? An answer is obtained by stochastically simulating the model many times with shocks estimated over the sample period, first for one rule and again for the other. Note the similarity between this approach and that of Phillips (1954). Phillips used deterministic simulation and noted the speed at which the variables returned to their steady state after a single perturbation. Here I use stochastic simulation and look at the properties of the stochastic steady state.

Table I. Macroeconomic performance under proportional and derivative price rules

	Proportional no derivative	Proportional derivative ( $h = 1$ )	Proportional derivative ( $h = 4$ )
<i>Output</i>			
US	2.18	2.13	1.98
Canada	8.09	7.97	7.57
France	5.00	4.83	4.35
Germany	3.20	3.03	2.61
Italy	7.45	7.24	6.70
Japan	3.40	3.36	3.30
UK	3.00	2.91	2.67
<i>Prices</i>			
US	1.25	1.26	1.31
Canada	3.13	3.20	3.48
France	4.85	4.95	5.28
Germany	1.82	1.83	1.89
Italy	6.27	6.31	6.56
Japan	2.55	2.76	3.51
UK	4.46	4.41	4.28
<i>Interest rates</i>			
US	0.018	0.020	0.028
Canada	0.038	0.041	0.048
France	0.049	0.050	0.054
Germany	0.024	0.026	0.032
Italy	0.085	0.086	0.093
Japan	0.023	0.025	0.029
UK	0.057	0.061	0.079
<i>Exchange rates</i>			
Canada	6.78	6.77	6.70
France	10.79	10.82	10.90
Germany	12.71	12.68	12.64
Italy	9.05	9.12	9.32
Japan	11.54	11.50	11.41
UK	13.60	13.57	13.58

Each country follows an interest rate rule. In each case the rule is a function of the deviation of the price level from a target with a coefficient of 1.6. In column one this deviation is the only factor. In column two the rate of change in the price level is also a factor with a coefficient of 1.0. In column three the rate of change in the price level is given a higher coefficient of 4.0. The figure reported in each case is the standard deviation of the percentage deviation of each variable from a trend.

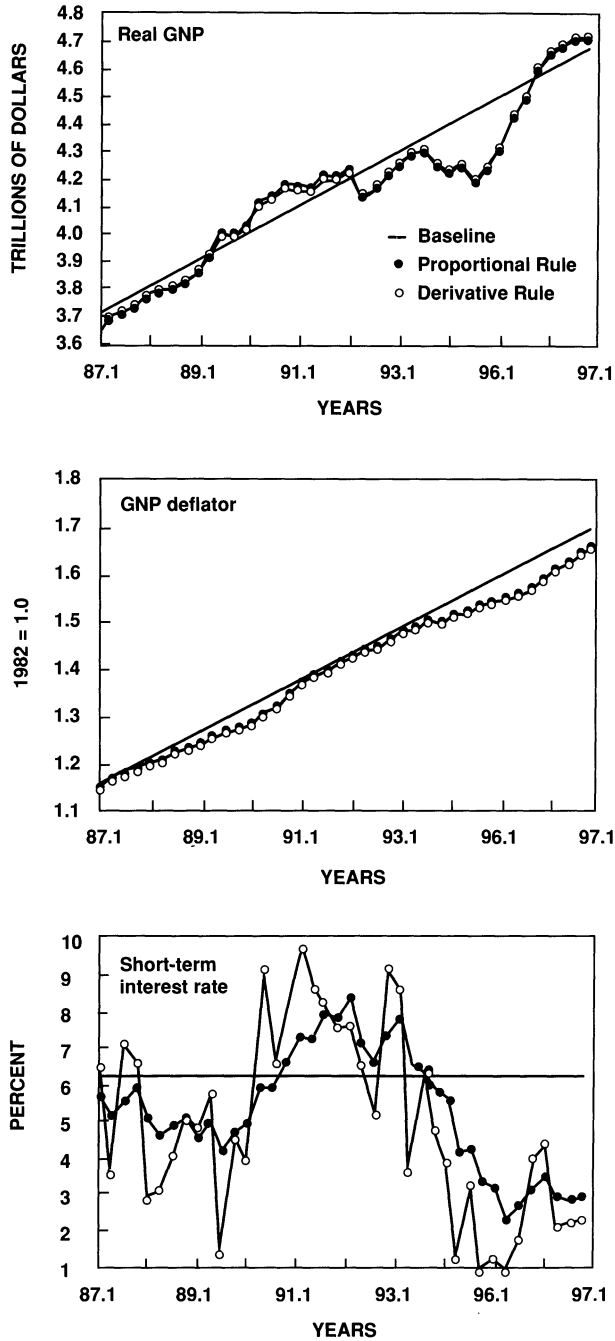


Figure 1. Paths for U.S.A.

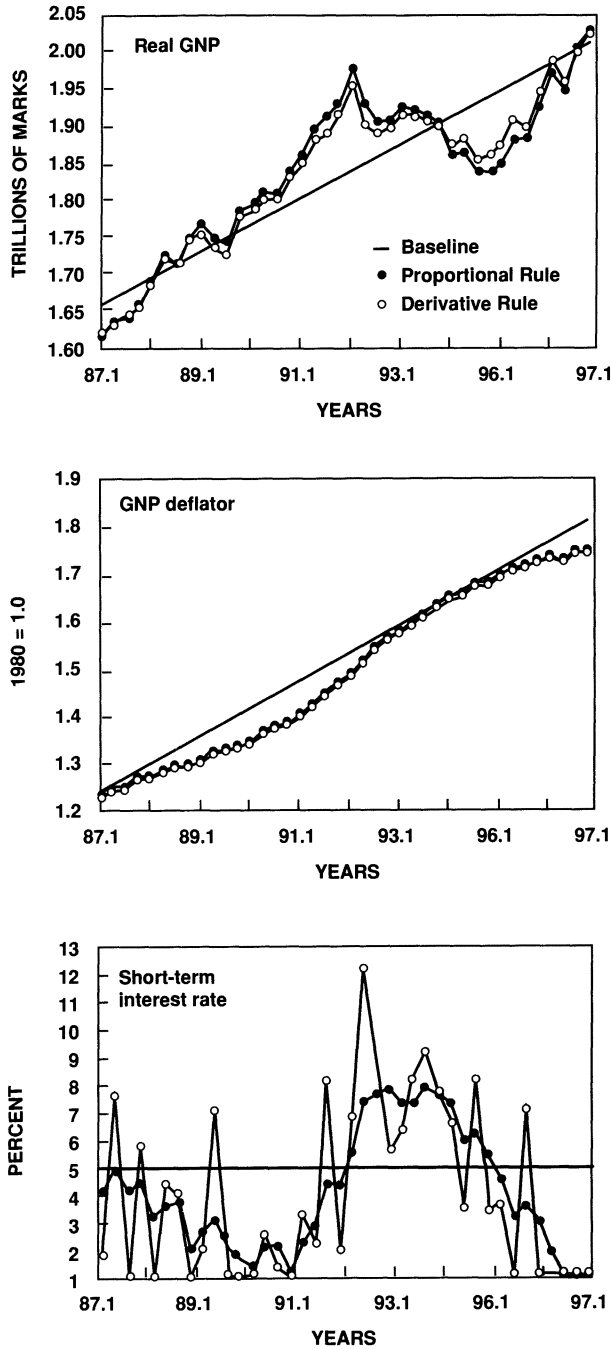


Figure 2. Paths for Germany

To make the comparison as simple as possible for illustrative purposes, I have simulated the model once over the period from 1987.1 through 1996.4 using the actual residuals that I estimated over the sample period from 1975.1 through 1984.4. The paths for real output, the price level and the interest rate are shown for two of the seven countries, the US and Germany, in Figures 1 and 2. Two paths are shown. One for  $g = 1.6$  and  $h = 0.0$  and another for  $g = 1.6$  and  $h = 4.0$ . The standard deviation of the percentage deviation of the variables is shown in Table I for these two rules for all the countries in the model and for another rule with  $g = 1.6$  and  $h = 1.0$ . Although the effect is not large, there is a reduction in output variability and an increase in price volatility in all countries except the UK as the derivative factor is added. In the UK output variability is reduced and price variability is also reduced. However, there is a large increase in the volatility of interest rates in all countries when the derivative factor gets large. This is particularly true for the US and for Germany.

Taking the results literally, the policy implications of this exercise are straightforward. Because of the greater interest rate volatility with the derivative policy, such a policy would probably not be a good idea even if one were not concerned about the slight increase in price instability. The output performance from the simple proportional rule is almost as good as the derivative rule and interest rates are far less volatile. It would, of course, be possible to apply the same technique to evaluate other types of rules such as integral rules or mixed rules as suggested by Phillips.

### 3. PARAMETER SHIFTS AND REGIME SHIFTS

The above simple policy evaluation exercise illustrates how a quantitative rational expectations model can be used in practice. One of the purposes of developing quantitative rational expectations models is that they can deal with the Lucas critique which says that the equations of traditional non-rational expectations models might change if the policy rule changed. Although the Lucas critique is correct in theory, there have been few studies that have assessed its empirical importance for a particular regime shift. Two alternative approaches might be taken. One approach is historical: look at the estimated parameters in two periods between which one feels that there was a regime shift (such as 1979 for US monetary policy). However, a problem with this approach is that other things may also change, and it is difficult to identify such regime shifts.

Here I take a different approach, which to my knowledge has not been tried before. I examine how the parameters of the reduced form of this multicountry model would shift if the monetary regime shifted. I focus on a shift that most economists would say is a big one: from flexible exchange rates to fixed exchange rates.

The policy rules for each of the central banks (recall that  $i$  indicates a country) in the two cases are

$$RS_i - RS_i^* = LP_i(+4) - LP_i + g(LP_i - LP_i^*), \quad (15)$$

in the case of flexible exchange rates, and

$$RS_i - RS_i^* = LP_w(+4) - LP_w + g(LP_w - LP_w^*), \quad (16)$$

in the case of fixed exchange rates, where  $LP_w$  is the weighted log price in each country. Note that for each rule the real interest rate increases or decreases according to how far the price level is from a target price level. In the case of the fixed exchange rate it is not possible to have separate interest rate rules in each country. Hence, the right-hand side of the second equation is the same for all  $i$ .

Although the reduced form cannot be calculated analytically for this model, certain reduced form equations can be computed under these two policy rules by stochastic simulation. For this purpose, I drew 10 40-quarter draws from a normal distribution with the same covariance matrix as the estimated covariance matrix of the model's residuals over the sample period. For each of these simulations I computed least-squares estimates of standard macroeconomic relationships: a consumption equation, a Phillips curve for wage inflation, an accelerator model for investment, a vector autoregression in terms of output and prices, and finally the regression of the long rate in the short rate. The regression estimates were then averaged over the 10 draws to give an estimate of the theoretical reduced form regression coefficients implied by the structural model.

These calculations were performed for both the fixed exchange rate regime and for the flexible exchange rate regime. The magnitude of the shifts in the parameters of these

Table II. Shifts in the Phillips curves under two regimes

Country	Const.	<i>WINF</i> (-1)	<i>YGAP</i>
<i>Fixed exchange rate regime</i>			
US	0.83	0.180	0.096
	4.40	1.14	2.91
Canada	2.14	0.196	0.349
	1.36	1.24	1.78
France	2.72	-0.018	0.274
	4.50	-0.12	3.12
Germany	0.89	0.356	0.099
	2.68	2.11	1.67
Italy	2.49	0.069	0.432
	1.73	0.40	1.68
Japan	2.46	0.258	0.563
	1.50	1.53	2.06
UK	1.13	-0.057	0.237
	2.09	-0.35	1.43
<i>Flexible exchange rate regime</i>			
US	1.11	-0.106	0.087
	5.85	-0.66	2.24
Canada	1.98	0.220	0.220
	1.35	1.41	1.54
France	2.54	-0.023	0.264
	5.56	-0.11	3.53
Germany	1.47	-0.053	0.180
	4.88	-0.34	2.62
Italy	2.35	-0.054	0.738
	1.92	-0.34	2.11
Japan	2.34	0.192	0.599
	1.70	1.17	2.00
UK	1.13	-0.058	0.102
	2.04	-0.36	0.46

Average coefficients and *t*-statistics across 10 simulations are reported in the first and second entry, respectively. *WINF* is the rate of change in the wage rate (quarterly in percent) and *YGAP* represents the proportional deviation of real GNP from trend (in percentages). The dependent variable in all the equations in *WINF*.

relationships gives an assessment of the importance of the Lucas critique for this particular policy change. As the change from fixed to flexible exchange rate is clearly a major regime shift, one would expect to see some major shifts in the reduced form relationships.

The results of this exercise are reported in Tables II–VI. Before discussing the results it is important to mention that the overall economic performance, measured in terms of the variance of output and prices, is much different between the two regimes. The variance of output is less under the flexible exchange rate regime in all countries except Canada. The differences are particularly large in the US, Germany and Japan. The variance of the price level is less under flexible exchange rates in all countries. According to these measures the flexible exchange rate system has significant advantages over the fixed exchange rate system. For more details on the difference between fixed and flexible exchange rates, see Taylor (1989).

How do the reduced form relationships change over the two regimes? Table II shows the Phillips curve estimates in which the output gap replaces the unemployment rate in the equations. A lagged dependent variable is included to allow for the possibility of expectations effects changing the behaviour of wages. Under the fixed exchange rate regime the role for the lagged dependent variable is generally greater than under the flexible exchange rate regime. This is the type of shift one would expect because waves have a larger variance and are somewhat

Table III. Vector autoregressions under two exchange rate regimes

Country	Const.	$Y(-1)$	$Y(-2)$	$P(-1)$	$P(-2)$
<i>Fixed exchange rates (dependent variable: Y)</i>					
US	-0.13	0.717	0.140	0.226	-0.400
	-0.40	4.00	0.72	0.39	-0.69
Canada	0.06	0.672	0.148	-0.277	0.080
	-0.01	3.83	0.87	-0.88	0.31
France	1.03	0.753	0.085	-0.433	0.290
	1.23	4.43	0.46	-0.84	0.51
Germany	0.03	0.793	0.129	-0.000	-0.310
	0.12	4.65	0.73	-0.07	-0.67
Italy	-0.18	0.878	0.090	-0.314	0.238
	-0.49	5.10	0.48	-1.57	1.25
Japan	0.09	1.276	-0.248	-0.437	0.321
	0.40	8.35	-1.60	-2.45	1.76
UK	-0.08	0.547	0.139	-0.097	-0.014
	-0.18	3.23	0.82	-0.37	-0.10
<i>Flexible exchange rates (dependent variable: Y)</i>					
US	0.19	0.465	0.062	-0.410	0.185
	0.39	2.64	0.36	-0.58	0.22
Canada	0.92	0.690	-0.006	-0.881	0.451
	0.95	3.54	-0.01	-1.85	0.98
France	1.22	0.445	0.242	-0.917	0.613
	1.47	2.68	1.33	-1.47	0.79
Germany	0.16	0.481	0.189	-0.432	0.016
	0.37	2.80	1.08	-1.22	0.07
Italy	0.33	0.588	0.097	-0.429	0.234
	0.74	3.45	0.58	-2.98	1.42
Japan	0.01	1.151	-0.232	-0.397	0.262
	0.03	7.00	-1.55	-2.32	1.29
UK	0.13	0.376	0.098	-0.181	0.046
	0.28	2.18	0.54	-0.78	0.20

more persistent under the fixed exchange rate regime. Note that the lagged dependent variable has a negative sign of several instances. The slope of the Phillips curve also shifts, but there is no general effect across the countries. The short run Phillips curve gets flatter in the US, Canada, and the UK, and it gets steeper in France, Germany, Italy and Japan. However, the effects are not very large except, perhaps, in Germany. It appears that the quantitative magnitude of the Lucas critique is small for this regime change, at least in terms of the Phillips curve.

Table III shows estimates of vector autoregressions for prices and output. There is some evidence of less output persistence in the flexible exchange rate case, the coefficients on the lagged dependent variable are smaller. In addition, the negative effects of prices on output are stronger in the flexible exchange rate case, perhaps indicating a less accommodative policy in that case. In general, however, the equations for prices show relatively small changes with no noticeable pattern across countries. This corresponds with the relatively small effects for the wage Phillips curves.

Table IV shows the results for the consumption functions. There is some evidence that the

Table III. *Continued*

Country	Const.	DY(-1)	DY(-2)	DP(-1)	DP(-2)
<i>Fixed exchange rates (dependent variable: P)</i>					
US	0.01	0.070	0.050	1.239	-0.359
	0.08	1.54	1.13	7.75	-2.38
Canada	-0.04	0.003	0.042	1.652	-0.695
	-0.16	0.01	0.73	13.74	-5.59
France	0.13	0.053	0.060	1.163	-0.208
	0.57	0.95	1.03	6.99	-1.25
Germany	-0.03	0.058	0.088	0.833	0.026
	-0.01	0.98	1.22	4.85	0.19
Italy	0.13	0.254	0.092	0.946	-0.072
	0.09	1.74	0.58	5.86	-0.59
Japan	-0.12	0.128	0.000	1.451	-0.464
	-0.37	1.00	-0.12	9.63	-3.16
UK	-0.13	0.111	0.082	1.366	-0.429
	-0.32	0.90	0.63	8.80	-2.71
<i>Flexible exchange rates (dependent variable: P)</i>					
US	0.07	0.032	0.039	1.194	-0.278
	0.83	0.58	0.88	7.20	-1.59
Canada	0.05	-0.095	0.104	1.243	-0.304
	0.13	-1.30	1.50	7.59	-1.94
France	0.10	0.107	-0.003	1.094	-0.141
	0.52	2.36	-0.14	6.43	-0.77
Germany	0.05	0.076	0.036	0.831	0.022
	0.32	1.12	0.56	4.80	0.17
Italy	0.17	0.064	0.042	0.959	-0.139
	0.42	0.43	0.22	5.85	-0.78
Japan	0.02	-0.002	0.041	1.468	-0.562
	0.17	0.08	0.27	9.55	-3.44
UK	0.03	0.222	-0.041	1.227	-0.300
	0.14	1.63	-0.31	7.18	-1.73

The vector autoregression is for the price level (P) measured as a deviation from the baseline target and real GNP (Y) measured as a percentage deviation from trend. Average coefficients and t-stats across 10 simulations are reported in each entry.

Table IV. Shifts in the Keynesian consumption function under a regime shift

Country	Const.	$C(-1)$	$Y$
<i>Fixed exchange rates</i>			
US	7.42	0.460	0.337
	2.37	7.47	8.81
Canada	1.74	0.789	0.108
	5.83	25.21	7.09
France	1.02	0.174	0.544
	0.79	3.07	13.68
Germany	2.11	0.433	0.307
	1.02	4.46	5.82
Italy	260.35	0.766	0.141
	4.15	19.38	6.97
Japan	1820.56	0.794	0.106
	3.46	6.76	1.79
UK	0.34	0.459	0.328
	1.24	5.22	5.96
<i>Flexible exchange rates</i>			
US	7.69	0.466	0.343
	2.70	8.12	9.61
Canada	1.61	0.736	0.131
	5.11	23.96	8.80
France	1.11	0.203	0.486
	0.94	3.73	15.07
Germany	2.93	0.596	0.205
	1.53	6.03	3.94
Italy	293.29	0.808	0.117
	4.92	19.27	4.71
Japan	1655.32	0.797	0.109
	4.06	7.41	1.64
UK	0.39	0.503	0.311
	1.32	5.49	5.27

Real consumption ( $C$ ) is regressed on lagged consumption ( $C_{-1}$ ) and on current real income ( $Y$ ). Average coefficients and  $t$ -statistics across 10 simulations.

short-run marginal propensity to consume is lower under the flexible exchange rate regime. This is especially true in Germany. This change may reflect the relatively smaller persistence of income under the flexible exchange rate regime that is evidenced in the vector autoregressions. At least, according to the forward-looking consumption equation that are in the structural model, less persistent income fluctuations should reduce the short-run marginal propensity to consume. As with the Phillips curve, however, the effects are not quantitatively large. An econometrician estimating these consumption equations would probably find it difficult to distinguish between them.

Similar results are found for the investment equations in Table V. There are shifts in the accelerator across the two regimes, but the effect is not very large.

Finally, Table VI shows the simple regression of the long-term interest rate on the short-term rate under the two regimes. Short-term interest rates are more volatile for all countries under the flexible exchange rate regime. However, there is no uniform effect on the term structure correlation across the two regimes. In the US, Canada, France, Italy and the UK, the coefficient

Table V. Shifts in an 'accelerator' investment function under a regime shift

Country	Const.	$I(-1)$	$Y - Y(-1)$
<i>Fixed exchange rates</i>			
US	14.47	0.959	0.713
	0.33	30.13	15.60
Canada	1.01	0.970	0.735
	0.26	29.52	14.19
France	23.88	0.921	0.305
	1.16	18.14	6.41
Germany	18.33	0.937	0.744
	1.05	27.14	10.71
Italy	735.57	0.937	0.871
	0.72	22.31	11.02
Japan	-6827.21	1.066	0.494
	-4.18	60.09	9.01
UK	12.08	0.756	0.283
	2.23	7.87	3.59
<i>Flexible exchange rates</i>			
US	40.43	0.924	0.709
	1.01	19.42	14.37
Canada	1.61	0.967	0.697
	0.60	43.01	17.05
France	34.92	0.877	0.274
	1.63	13.76	7.54
Germany	54.46	0.840	0.726
	2.07	12.75	9.44
Italy	1105.39	0.922	0.863
	0.93	16.70	9.35
Japan	-1270.23	1.009	0.370
	-0.84	43.26	5.17
UK	10.64	0.780	0.329
	2.07	8.33	4.71

Real investment  $I$  is regressed on lagged investment  $I(-1)$  and on the change in real income  $Y - Y(-1)$ . Average coefficients and  $t$ -statistics across 10 simulations.

on the short rate increases with flexible exchange rates despite the greater variance of short rates. Only in Germany and Japan does it decrease. Once again, however, the size of these changes is less than I would have expected.<sup>4</sup>

### Some Possible Explanations

What are the reasons that the parameter shifts are fairly small? One possible explanation is that the model that I am using is not structural enough. Perhaps the model does not adequately describe how the reduced form parameters would change. For example, the consumption and investment equations in this model look forward, but for computational reasons not very far, only eight quarters. Or perhaps the wage equations should look forward to future prices as well

<sup>4</sup> I have not computed reduced forms for other relationships. For example, Christopher Murphy suggested that reduced form exchange rate relationships might reveal evidence of a policy regime shift.

Table VI. Shifts in term structure correlation

Country	Const.	<i>RS</i>
<i>Fixed exchange rates</i>		
US	0·03	0·725
	2·80	3·86
Canada	0·02	0·899
	1·35	5·71
France	0·02	0·778
	0·93	2·73
Germany	0·01	0·938
	1·56	6·22
Italy	0·01	0·918
	0·34	5·34
Japan	0·01	0·826
	1·18	4·06
UK	0·04	0·594
	1·38	2·17
<i>Flexible exchange rates</i>		
US	0·02	0·834
	2·17	4·70
Canada	0·02	0·933
	3·36	18·17
France	0·03	0·829
	1·47	6·28
Germany	0·01	0·880
	1·86	7·82
Italy	0·00	0·935
	0·45	11·52
Japan	0·01	0·780
	1·72	7·29
UK	0·04	0·732
	2·26	5·69

The long rate *RL* is regressed on the short rate *RS*. The average coefficient and *t*-statistic across 10 simulations is reported in each entry. The interest rate is measured as a fraction.

as to the future wages of other workers. On the other hand, the model has expectations of future variables in a large number of equations, and it is difficult to explain why they would not have a large effect on the reduced form for policy shifts in general.

Perhaps a more satisfactory explanation is that the regime shift considered here is not as large as one might think, at least for the types of reduced form equations that I chose to estimate. In terms of the time-series properties of some of the variables, and how they impact on the decision rules, the change may not be so big. In both the fixed exchange rate and the flexible exchange rate regimes (see equations (15) and (16)) the central banks are committed to price stability. They do not let the price level, and certainly not the inflation rate, drift permanently from the target path. There are no shifts in the long-run average rate of inflation in either regime. Hence, there is no reason for the expectations term in the expectations-augmented Phillips curve to shift by a large amount. Wage inflation is far from a random walk for either policy rule.

Similarly, while the change in the variance and the persistence of income may be large when one compares the fixed and the flexible exchange rate regime, these changes may not be large enough to affect the estimates of how a change in income affects permanent income. The changes in the size of the business cycle are significant when viewed as an effect of macroeconomic policy, but evidently these changes do not affect very much how agents adjust their estimates of permanent income when actual income changes.

More research is necessary to determine whether larger parameter shifts would occur for other types of regime shifts. In addition, it is important to determine whether the shifts observed to be small by looking at individual equations actually have large effects on the whole model and thereby on the policy evaluation results. If so, then the practical importance of the Lucas critique would remain, even for this regime shift, despite the small effect on individual reduced form parameters. One way to test for this effect would be to substitute the estimated reduced forms from Table II to VI into the model in place of the forward-looking equations.

#### 4. CONCLUDING REMARKS

In this paper I have shown how monetary policy can be evaluated within a quantitative rational expectations econometric framework that incorporates international factors and uncertainty about the direction of future variables. The approach was illustrated with a policy evaluation in which I added a derivative term to a proportional price rule for interest rates. The results indicate that such derivative terms in a price rule would not be desirable. While output variability is reduced, price instability is increased slightly and, more importantly, interest rate volatility increases by a large amount.

Perhaps the most surprising finding is that there is not a great amount of reduced form parameter instability across apparently largely different regimes. Fixed exchange rates and flexible exchange rates are usually viewed as significantly different policy regimes, and the econometric model used here indicates that the two regimes have big effects on the size of the variance of real GNP and the GNP deflator. Yet the effect of these different policy regimes on conventional 'reduced form' equations, such as the Phillips curve and the Keynesian conception function, is small. In this sense the Lucas critique is not quantitatively important for this type of regime shift. I discussed several possible reasons for this finding in the paper, but further research will be necessary to determine which of these reasons is correct and whether similar results hold for other models or other regime shifts. Given the great methodological importance of the Lucas critique,<sup>5</sup> such research should be given high priority on any macroeconomic research agenda.

#### ACKNOWLEDGEMENTS

It is appropriate that I begin the acknowledgements for this paper by emphasizing—with no exaggeration for the occasion—the great influence that A. W. Phillips' research has had on my own research programme in macroeconomics, starting with my undergraduate thesis at Princeton 20 years ago and lasting through the general approach I use today in this paper. My undergraduate thesis (Taylor, 1968) used Phillips's (1954) approach to policy evaluation by applying feedback control rules from the engineering literature to a dynamic macroeconomic model, and even the model used was a cyclical growth model designed by Phillips (1961). My

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<sup>5</sup> For recent discussion of the methodological importance of the Lucas critique, see Sims (1982), Sargent (1984), and Taylor (1988a).

research today can be viewed as a stochastic, rational expectations, empirical generalization of Phillips's work, but this research has yet to go as far in synthesizing growth and fluctuations as Phillips did in his 1961 article. I would also like to acknowledge a grant from the National Science Foundation at the National Bureau of Economic Research and the helpful comments and assistance from Peter Klenow, Paul Lau, Michael McAleer, Christopher Murphy and Adrian Pagan.

## REFERENCES

- Fair, R. C., and J. B. Taylor (1983), 'Solution and maximum likelihood estimation of nonlinear rational expectations models', *Econometrica*, **51**, 1169–1185.
- Lucas, R. E. Jr (1976), 'Econometric policy evaluation: a critique', *The Phillips Curve and Labor Markets*, Vol. 1 of Carnegie Rochester Conference Series on Public Policy, North-Holland, pp. 19–46.
- Phillips, A. W. (1954), 'Stabilization policies in a closed economy', *Economic Journal*, June, **LXIV**, 290–323.
- Phillips, A. W. (1961), 'A simple model of employment, money, and prices in a growing economy', *Economica*, November, **XXVIII**, 360–370.
- Sargent, T. J. (1984), 'Autoregressions, expectations, and advice', *American Economic Review*, 408–415.
- Sims, C. (1982), 'Policy analysis with econometric models', *Brookings Papers on Economic Activity*, pp. 107–164.
- Taylor, J. B. (1968), 'Fiscal and monetary stabilization policies in a model of endogenous cyclical growth', undergraduate thesis, Princeton University (abridged version distributed as Econometric Research Program Research Memorandum, No. 104, October 1968).
- Taylor, J. B. (1980), 'Aggregate dynamics and staggered contracts', *Journal of Political Economy*, **88**, 1–23.
- Taylor, J. B. (1988a), 'The treatment of expectations in large multicountry models', in R. Bryant, D. Henderson, G. Holtham, P. Hooper, and S. Symansky (eds) *Empirical Macroeconomics for Interdependent Economies*, Brookings Institution, Washington, DC.
- Taylor, J. B. (1988b), 'Japanese macroeconomic policy and the current account under alternative international monetary policy regimes', *Monetary and Economic Studies, Bank of Japan*, **6**, 1–36.
- Taylor, J. B. (1989), 'Policy analysis with a multicountry model', in R. Bryant, D. Currie, J. Frenkel, P. Masson, and R. Portes (eds), *Macroeconomic Policies in an Interdependent World*, International Monetary Fund.