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A COMPARISON OF SOME BASIC MONETARY POLICY REGIMES FOR OPEN ECONOMIES: IMPLICATIONS OF DIFFERENT DEGREES OF INSTRUMENT ADJUSTMENT AND WAGE PERSISTENCE

Dale W. Henderson and Warwick J. McKibbin

Abstract

Monetary policy regime combinations are compared for symmetric and asymmetric temporary shocks to money demand, goods demand, and productivity. In every region, the interest-rate instrument is either kept constant or changed to eliminate (full instrument adjustment) or reduce (partial instrument adjustment) the gap between actual and desired values for an intermediate target: the money supply, nominal income, or output plus inflation. Nominal wage persistence may be absent (Contract hypothesis) or present (Phillips hypothesis and Taylor hypothesis). There are analytical and simulation results from a two-region workhorse model and simulation results from the McKibbin-Sachs Global model. The ranking of regime combinations depends not only on the ultimate target and the source of shocks but also on the degrees of instrument adjustment and wage persistence.

A comparison of some basic monetary policy regimes for open economies: implications of different degrees of instrument adjustment and wage persistence

Dale W. Henderson Warwick J. McKibbin*

Introduction

This paper is a comparison of some basic monetary policy regimes for open economies with different degrees of instrument adjustment and wage persistence. It is a unified exposition of old and new results. There are analytical and simulation results from a workhorse, two-region model and simulation results from the fully-specified, multi-region McKibbin-Sachs Global (MSG2) model.[1].

*This paper is an expanded version of Henderson and McKibbin (1993b) which contains some simulation results not reported there. The additional simulation results reported in the text are for the Contract model and the MSG2 model which are discussed in Henderson and McKibbin (1993b), and the additional simulation results presented in Appendix C are for the Taylor model which is not discussed there. We received helpful comments from Robert Rasche, our discussant, and other participants at the Carnegie-Rochester Conference on Public Policy as well as from Joseph Gagnon and other participants in a seminar at the Board of Governors of the Federal Reserve System. Also, we received excellent technical assistance from Tomas Bok. However, no one besides us is responsible for any remaining errors. This paper represents the views of the authors and shoud not be interpreted as reflecting those of the Board of Governors of the Federal Reserve System or other members of its staff or the trustees, officers, or other staff members of the Brookings Institution.

[1]McKibbin and Sachs (1991) spell out the theoretical basis for the essential features of the specification of the MSG2 model. McKibbin (1992)provides the details of the specification of the version used in this paper,version 34C.

Previous comparisons

The prevailing approach to comparing monetary policy regimes is usually attributed to Poole (1970).[2] Poole investigates the effects of temporary money-demand shocks and goods-demand shocks on output under an interest-rate-constant regime and a money-supply-constant regime in a closed economy. He finds that for money-demand shocks, output is more stable under an interest-rate-constant regime because the goods market is insulated from the shocks and that for goods-demand shocks, output is more stable under a money-supply-constant regime because the effects of the induced movements in the interest rate partially offset the effects of the shocks on the goods market.

Roper and Turnovsky (1980) apply the prevailing approach to a single open economy.[3] Like Poole, Roper and Turnovsky conclude that for money-demand shocks, output is more stable under an interest-rate-constant regime, whereas for goods-demand shocks, output is more stable under a money-supply-constant regime. They assume that home (-currency) and foreign (-currency) bonds are perfect substitutes, that exchange-rate expectations are rational, that all shocks are temporary, and that the foreign interest rate is constant. Under their assumptions, the home interest rate must equal the constant foreign interest rate plus the difference between (the logarithms of) the constant expected future exchange rate and the current exchange rate. It follows that the current exchange rate is kept fixed if and only if the home interest rate is kept constant. That is, the interest-rate-constant regime is the same as a fixed-exchange-rate regime, and the money-supply-constant regime is the same as a flexible-exchange-rate regime.

Corden (1981), Meade (1978), and Tobin (1980) suggest that a nominal-income-constant regime might be better than either an interest-rate-constant regime or a money-supply-constant regime. Comparisons of regimes including nominal-income-constant regimes are more difficult to summarize than the Poole and Roper and Turnovsky comparisons.[4] The most important result is that under a basic nominal-income-constant regime, money-demand and goods-demand shocks do not affect output and the output price.

Primarily as a result of the oil shocks of the 1970s, supply shocks such as productivity shocks and oil shocks have been added to the standard list of shocks to consider when comparing monetary policy regimes. For supply shocks, stabilizing

[2]Bailey (1962) appears to be the originator of this approach. Poole's (1970) contribution is the derivation of the optimal"combination" policy.

[3]Other applications of the prevailing approach to one or more open economies include Boyer (1978), Bryant (1980), Henderson (1979 and 1984),Marston (1985), Meltzer (1986), and Parkin (1978).

[4]Comparisons including nominal-income-constant regimes are provided by Bean (1983), Taylor (1985), Aizenman and Frenkel (1986a), Asako and Wagner (1992), and West (1986) for closed economies and by McKibbin and Sachs (1988), Frenkel, Goldstein, and Masson (1989), Frankel (1991), and Frankel and Chinn (1993) for open economies. Argy (1991) surveys the literature on the nominal-income-constant regime.

employment and stabilizing output are usually not the same thing. Also, greater emphasis has been placed on the price level or the inflation rate as an ultimate target of monetary policy. For supply shocks a nominal-income-constant regime may not be superior to interest-rate-constant and money-supply-constant regimes for stabilizing employment and the price level or inflation.

Our comparison

In our comparison we attach an explicit meaning to the term "monetary policy regime." We assume that the policy maker in each country selects an instrument of monetary policy. The instrument may be kept constant, in which case the regime is named for the instrument, or the instrument may be adjusted to reduce or eliminate deviations of an intermediate target from its desired value, in which case the regime is named for the intermediate target.

In comparisons of regimes using small theoretical models, it is usual to assume full instrument adjustment (FIA), but in comparisons of regimes using large econometric models, it is usual to assume partial instrument adjustment (PIA). Under FIA, the instrument is adjusted in each period by the full amount required to eliminate the deviation of the intermediate target from its desired value. Under PIA, the instrument is adjusted in each period by enough to reduce, but not eliminate, the deviation of the intermediate target from its desired value. We consider both FIA and PIA and ask whether under PIA the ranking of regimes depends on the degrees of instrument adjustment under the different regimes.

Most central banks use interest rates as their instruments of monetary policy. Monetary theorists have long debated about whether the price level is determinate when the interest rate is the instrument of monetary policy.[5] Although it is becoming more widely agreed that the price level is determinate under fairly general conditions, there is still considerable confusion about exactly what these conditions are. We want to investigate regimes in which the instrument is the one used by most central banks and to contribute to the clarification of the conditions under which the price level is determinate under such regimes. Therefore, throughout this paper we assume that the nominal interest rate is the instrument of monetary policy in each region.

We consider four combinations of monetary policy regimes, referred to for brevity as the II, MM, YY, and CC regime combinations. All of these regime combinations are matched regime combinations in which the monetary policy regimes in all the regions are the same.[6] Under the II regime combination,

[5] Gagnon and Henderson (1990) summarize this debate and list some recent contributions to the voluminous literature it has spawned.

[6] This paper is an extension of Henderson and McKibbin (1993a) where we consider FIA for the four matched regime combinations considered here and an unmatched regime combination in which the intermediate target variable in the US is the money supply and the intermediate target variable in the ROECD is the nominal exchange rate between the dollar and the ROECD

the nominal interest rate instruments themselves are kept constant. Under the MM, YY, and CC regime combinations the intermediate targets are money supplies, nominal incomes, and unweighted sums of inflation and output, respectively.[7] As explained in more detail below, the II regime combination is a limiting case of both the MM and YY regime combinations in which it is assumed that the responses of interest rates to deviations of the intermediate target variables from their desired values approach zero. Under the CC regime combination, inflations are only a part of the intermediate target variables, but many of the insights gained from the analysis of this regime combination apply to the case in which inflations alone are the intermediate targets. For simplicity, we assume that information on outputs, output prices, interest rates, and money supplies becomes available at the same time. The fact that information on outputs and output prices is received with a longer lag may be an important factor in choosing among the YY or CC regime combinations and the II or MM regime combinations.[8]

In many earlier contributions, the choice among policy regimes in open economies has been viewed as a choice between fixed and flexible exchange rates. In our view, it is not fruitful to view the choice among policy regimes in this way. In some cases, more than one regime combination is consistent with a fixed exchange rate, but the different regime combinations have different implications for other variables. In addition, in many cases more than one regime combination is consistent with a flexible exchange rate, but the different regime combinations have different implications for all variables including the exchange rate.

We spell out the consequences for key variables of six temporary shocks.[9] The shocks are divided into three types: money-demand shocks, goods-demand shocks, and productivity shocks.[10] For each type there are two variants: symmetric shocks and asymmetric shocks.[11] Symmetric shocks have impact effects that are identical in size and sign on markets for corresponding items from each of the regions. Asymmetric shocks have impact effects that are equal in size but opposite in sign on markets for corresponding items from each of two regions. In the analysis of the effects of symmetric shocks and asymmetric shocks in the workhorse model, we construct models for the sums of and differences between corresponding US and ROECD variables by adding and subtracting the equilibrium conditions for

currency.

[7]The pair of lettersCC is chosen because a combination of inflation and output is the intermediate target variable in each region.

[8]However, Gagnon and Tryon (1992) show that in the Federal Reserve staff's MX3 model the performance of a nominal income regime is about the same no matter whether the policy maker uses current nominal income or a forecast of nominal income in his reaction function.

[9]In Henderson and McKibbin (1993a) we compare the effects of temporary and permanent money demand shocks.

[10]In Henderson and McKibbin (1993a) we consider the effects of oil shocks.

[11]In Henderson and McKibbin (1993a) we consider region-specific shocks, shocks that affect markets for items from only one region. There we show that the effects of region-specific shocks can be obtained by adding and subtracting the effects of symmetric and asymmetric shocks.

items from the US and items from the ROECD.[12]

In both the workhorse model and the MSG2 model, wages are sticky but output prices are perfectly flexible and move to clear goods markets in each period, and employments are determined by marginal productivity conditions. In the discussion of the workhorse model in the text, we consider two alternative wage hypotheses: the Contract and Phillips hypotheses.[13] In the Contract model, the workhorse model under the Contract hypothesis, wages in each period depend only on output prices expected to prevail in that period, so there is no wage persistence. In the Phillips model, the workhorse model under the Phillips hypothesis, wages in each period also depend to some extent on wages, prices, and excess demands for labor in the previous period, so there is some degree of wage persistence.[14] In the MSG2 model, wages for most countries, including the United States, are set according to a version of the Phillips hypothesis, but wages for Japan are set according to a version of the Contract hypothesis. In the workhorse model and in the MSG2 model, wage-setters respond to expected changes in the output price and the CPI, respectively.

The rest of the paper is divided into seven sections. The next section is a description of the workhorse model. The following four sections are based on the Contract model: one section on the derivation of the implied models for sums and differences and three sections on the effects of shocks, one each for money-demand shocks, goods-demand shocks, and productivity shocks. The succeeding two sections are based on the MSG2 model and the Phillips model: one section on the structure of the two models and one section on the effects of all six temporary shocks. The last section contains conclusions.

The workhorse model

The workhorse model is in Table 1, and the definitions of variables and parameters are in Table 2. There are two regions, the United States (US) and the rest of the OECD (ROECD) which are mirror images of one another. Variables with no symbol over them are US variables, and variables with asterisks over them are ROECD variables. All variables in the model are logarithms except interest rates. We use the time subscript t only when it is necessary for clarity. All the shocks

[12]As far as we know the technique of using variables representing sums of and differences between individual country variables in the analysis of models with two mirror-image countries was first used by Aoki (1981).

[13]In Appendix C we consider a Taylor (1980) hypothesis with two-period overlapping wage contracts. In Henderson and McKibbin (1993a) we consider two Barro-Grossman (1976) hypotheses, one with wages and the other with both wages and prices adjusting both to close gaps between their actual and flexible-wage-and-price values and to keep up with the expected changes in their flexible-wage-and-price values.

[14]Fukuda and Hamada (1988) and Reinhart(1990) analyze monetary policy regimes in models with price persistence and wage persistence, respectively.

are identically and independently distributed with zero means.

The behavior of private agents

The US specializes in the production of a single final good that is an imperfect substitute for the single final good produced in the ROECD. The production functions [equations (1)] are conventional as are the marginal productivity conditions for labor [equations (2)].[15] In each region, the production function and the marginal product of labor are subject to the same productivity shock. Note that increases in these shocks represent *decreases* in productivity.

As stated above, in the workhorse model we consider two hypotheses about how nominal wages are set. Under both of these hypotheses workers agree to supply whatever amount of labor firms want at the prevailing nominal wage.

Residents of both regions consume both goods. In each region, the average propensity to import out of expenditure is γ ($0 < \gamma \leq \frac{1}{2}$). Consumer price levels (CPIs) are weighted averages of output prices expressed in the same currency [equations (3)]. We refer to the relative price of the ROECD good in terms of the US good as the real exchange rate [equation (4)]. The nominal exchange rate is the dollar price of ROECD currency. We assume that CPIs in the previous period were equal to zero so that CPIs and inflation rates are the same thing in the current period.[16]

There are four kinds of financial assets in the model: dollar bonds, ROECD (-currency) bonds, US money, and ROECD money. The residents of both regions may hold both of the available kinds of bonds. Open-interest parity holds [equation (5)]. A variable with $a + 1|$ subscript represents the value of the variable expected to prevail in the next period based on today's information. (Expected) real interest rates are equal to (nominal) interest rates minus expected rates of CPI inflation [equations (6)]. All US money is held by US residents, and all ROECD money is held by ROECD residents. The money-market equilibrium conditions [equations (7)] are conventional. The demand for each money is subject to a shock.

The excess demand for each good must equal zero [equations (8)].[17] The excess demand for each good falls with the output of that good and rises with the output of the other good. Residents of both regions increase spending by the same fraction ($0 < \epsilon < 1$) of increases in income. In both regions, the marginal propensity to import out of spending is equal to the average propensity, γ. Demands for both

[15] We assume that each country has the same fixed amount of capital or land. Units are chosen so that these fixed amounts are equal to zero, so they do not appear in equations (1)and (2).

[16] More exactly, we assume that $p_{-1} = \overset{*}{p}_{-1} = z_{-1} = 0$, where a variable with the subscript -1 represents the value of the variable in the previous period. This assumption implies that CPIs in period -1 are equal to zero.

[17] Equations (8) are log-linearizations of the goods market equilibrium conditions at expected outputs where expected outputs are defined below.

goods fall with increases in real interest rates. Residents in each region decrease spending by the same amount (ν) for each percentage point increase in the real interest rate available to them. A depreciation of the dollar in real terms (an increase in z) shifts world demand from ROECD goods to US goods.[18] The demand for each good is subject to a shock.

It is useful to define the natural and expected values of employments and outputs in the US and the ROECD. Natural employments and outputs in a given period are the outputs and employments that would result if wages were perfectly flexible given the realized values of shocks. We assume that if wages were perfectly flexible, workers' supply of labor would be nonstochastic and perfectly inelastic at zero in each region. Therefore, in each region, natural employment is constant and equal to zero.[19] As shown below, in each region natural output varies because of productivity shocks. Expected employments and outputs are the employments and outputs that would result if wages were perfectly flexible and the shocks took on their expected values of zero. Under our assumptions, expected output in each region is constant and equal to zero.

The reaction functions of policymakers for the MM, YY, and CC regime pairs

The reaction functions for the US and ROECD policymakers under the MM, YY, and CC regime pairs are displayed in Table 3. Under the MM pair, i and $\overset{*}{i}$ are given by the reaction functions (9) with $\beta \rightarrow \infty$ for FIA. $\hat{m}$ and $\hat{\overset{*}{m}}$ are the desired values of the money supplies under the MM pair, and we assume that $\hat{m} = \hat{\overset{*}{m}} = 0$ for convenience. $\hat{\imath} = \hat{\overset{*}{\imath}} = 0$ are the values of i and $\overset{*}{i}$ that would be consistent with zero inflations if wages were perfectly flexible and the shocks took on their expected values of zero. Under the YY pair, i and $\overset{*}{i}$ are given by the reaction functions (10) with $\rho \rightarrow \infty$ for FIA. The desired values of nominal income are $\hat{p} = \overset{*}{\overline{p+y}} = 0$. Under the CC pair, i and $\overset{*}{i}$ are given by the reaction functions (11) with $\tau \rightarrow \infty$ for FIA. The desired values of the sums of real outputs and inflations are $\hat{\pi} = \overset{*}{\overline{\pi+y}} = 0$. The II pair can be analyzed by letting either β or ρ approach zero.[20]

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[18]It causes residents of both countries to substitute spending on US goods for spending on ROECD goods by the same amount (η), with their incomes measured in US goods held constant, and it increases the US goods value of ROECD output leading to excess demand for US goods and excess supply of ROECD goods of $\gamma\epsilon$, so $\delta = 2\eta + \gamma\epsilon$.

[19]The usual criterion for ranking regimes for employment stabilization is the variance of employment around natural employment. Applying this criterion is much easier if natural employment is constant. Others, including Bean (1983), Marston (1984), and Aizenman and Frenkel (1986b) have considered the case in which the notional supply of labor varies with the real consumption wage.

[20]The model does not have a unique solution under the CC regime for values of $\tau \leq 1$, and the II regime cannot be analyzed by letting $\tau \rightarrow 1$.

Models for sums and differences implied by the Contract model with FIA

In this section we derive models for sums and differences from the Contract model, the workhorse model under the Contract hypothesis, under FIA. We obtain some intermediate results, derive the schedules for the graphical analysis, explain how we obtain the algebraic results, and tell how to read the simulation results in Tables 7 through 9 and Figures 3, 4, 6, 7, 9 and 10. Sums of and differences between US and ROECD variables are represented by variables with s and d subscripts, respectively.

The contract hypothesis

Under the Contract hypothesis, firms and workers set wages for each period so that the expected values of employments based on information available in the previous period are equal to natural employments of zero as shown in equations (12) in Table 4.[21] Under the Contract hypothesis, wages in the current period are independent of wages in the previous period, but, as we explain below, under the Phillips hypothesis, they are not.

Intermediate results

We make use of several intermediate results that are displayed in Table 5. The values of the endogenous variables in period 0 depend on the values of several variables expected to prevail in period +1 and on the wages set in the contracts. Under the assumptions made earlier and two additional assumptions, these values are given by equations (15) and (16).[22] The definition of the real exchange rate [equation (4)], open interest parity [equation (5)], and the expression for $e_{+1|}$ in equation (15) imply equation (17). The definitions of real interest rates [equations (6)] and the expressions for $p_{+1|}, \overset{*}{p}_{+1|}$, and $z_{+1|}$ in equations (15) and z in equation (17), imply equations (18) which in turn imply equations (19) and (20). The definitions of price levels [equations (3)] and the expression for the real exchange rate in equation (17) imply equations (21) which in turn imply equations (22) and (23).

[21]Equations (12) are obtained by taking expectations of equations (2) and setting $n_{t|t-1} = \overset{*}{n}_{t|t-1} = 0$.

[22]The assumptions made earlier are (a) that natural employments are equal to zero and (b) that all shocks are identically and independently distributed with zero means. The two additional assumptions are (c) that agents expect that in every future period the interest rate in each country will be set according to one of the three reaction functions given by equations (9), (10), and (11) and (d) that there are no speculative bubbles. The method of proof is similar to the one used in Appendix A of Canzoneri and Henderson (1991) and in the Appendix to Obstfeld (1985).

The schedules

The schedules for the models of sums and differences have the same qualitative properties. In Figures 1, 2, 5, and 8, the schedules have the subscript h which can take on the values of s for sums and d for differences.

The aggregate-demand schedules. The aggregate-demand schedules for sums (AD_s) and differences (AD_d) show the pairs of p_s and y_s for which the sum of excess demands for goods is zero and the pairs of p_d and y_d for which the difference between excess demands for goods is zero, respectively.[23] They are derived using equations (24) and (29) in Table 6 which are the sums of and differences between equations (8) with r_s and r_d eliminated using equations (19) and (20).

Their slopes are negative and may be greater or less than one in absolute value. For the AD_s schedule with slope $-(1-\epsilon)/\nu$, increases in both p_s and y_s reduce the sum of excess demands: an increase in p_s raises r_s, and an increase in y_s raises the sum of demands by less than the sum of supplies. For the AD_d schedule with slope $-[1-(1-2\gamma)\epsilon]/[(1-2\gamma)^2\nu+2\delta]$, increases in both p_d and y_d reduce the difference between excess demands: an increase in p_d not only increases r_d but also causes the dollar to appreciate in real terms, and an increase in y_d raises the difference between demands by less than the difference between supplies. We emphasize the case shown in Figure 1 in which the slope of AD_h is greater than one in absolute value, but we discuss the other case when the results are different.

An increase in i_s shifts the AD_s schedule down by the same amount, say from $AD_{s,0}$ to $AD_{s,1}$, because unit increases in i_s and p_s reduce the sum of excess demands by the same amount. An increase in i_d shifts the AD_d schedule down by the same amount for an analogous reason.

The money-market equilibrium schedules. The money-market equilibrium schedules for sums (M_s) and differences (M_d) show the pairs of p_s and y_s for which the sum of excess demands for money is zero and the pairs of p_d and y_d for which the difference between excess demands is zero, respectively. They are derived using equations (25) and (30) in Table 6 which are the sum of and difference between equations (7).

Both slopes are negative and equal to $-\phi$ which may be greater than, equal to, or less than one in absolute value. The M_s schedule slopes downward because increases in both p_s and y_s raise the sum of excess demands, and the M_d schedule slopes downward for analogous reasons. We emphasize the case shown in

[23]The assumptions underlying our AD_s and AD_dschedules and the textbook aggregate-demand schedule are different. In deriving our schedules, it is assumed that the nominal interest rate and, therefore, the exchange rate are constant. However, in deriving the textbook aggregate-demand schedule, it is assumed that the nominal interest rate moves in order to keep the money market in equilibrium. In algebraic terms, the nominal interest rate is eliminated from the aggregate-demand equation using the money-market equilibrium condition. Dornbusch (1984) uses two aggregate-demand schedules,one drawn on the assumption that the nominal interest rate and the exchange rate are constant, and one drawn on the assumption that these variables move in order to keep asset markets in equilibrium.

Figure 1 in which M_h has a slope of negative one and is flatter than AD_h but discuss other cases when the results are different.

An increase in i_s shifts the M_s schedule up, say from $M_{s,0}$ to $M_{s,1}$, because it reduces the sum of excess demands for money, so p_s must rise in order to return this sum to its previous value. An increase in i_d shifts the M_d schedule up for analogous reasons.

The aggregate-supply schedules. The aggregate-supply schedules for sums (AS_s) and differences (AS_d) show what y_s will be produced for each p_s and what y_d will be produced for each p_d, respectively. They are derived using equations (26) and (31) in Table 6. These equations are obtained by summing and differencing the production functions [equations (1)] and the marginal productivity conditions for labor [equations (2)] with $w = \overset{*}{w} = \omega$ from equation (16) and using the resulting pairs of equations to eliminate n_s and n_d.

The slopes of both schedules are positive and equal to $(1-\alpha)/\alpha$. The AS_s schedule slopes upward because an increase in p_s causes the sum of real wages to fall, so the sum of employments and, therefore, the sum of outputs increase, and the AS_d schedule slopes upward for analogous reasons.

The nominal-income-constant schedules. The nominal-income-constant schedules for sums (Y_s) and differences (Y_d) show the pairs of p_s and y_s for which $p_s + y_s$ is a constant and the pairs of p_d and y_d for which $p_d + y_d$ is a constant, respectively. They are derived using equations (27) and (32) in Table 6 and have slopes of negative one. The $Y_{h,0}$ schedule coincides with the $M_{h,0}$ schedule in Figure 1 which is drawn under the assumption that $\phi = 1$.

The Y_s and Y_d schedules have another interpretation under the assumptions of this section. Adding and subtracting equations (1), adding and subtracting minus one times equations (2), and adding the sums and differences yield equations (28) and (33) in Table 6. According to these equations, there are one-to-one relationships between $p_s + y_s$ and n_s and between $p_d + y_d$ and n_d.[24] Therefore, the Y_s and Y_d schedules give the pairs of y_s and p_s for which n_s is constant and the pairs of p_d and y_d for which n_d is constant, respectively.

Algebraic results

Algebraic results for the effects of symmetric shocks on y_s, αn_s, and q_s and for the effects of asymmetric shocks on y_d, αn_d, and q_d are reported in Appendix A.

Equations (22) and (24) through (28) are a system of six equations in the seven variables $p_s, y_s, n_s, q_s, i_s, m_s$, and $\overline{p+y}_s$. The algebraic results for sums for the II, MM, or YY regime pairs are obtained by making i_s, m_s, or $\overline{p+y}_s$ exogenous

[24]In Henderson and McKibbin (1993a) we show that there is a one-to-one relationship between nominal incomes and employments no matter whether the elasticity of substitution between labor and the other factor of production is equal to one, as in this paper, or to some other constant.

and solving for the six remaining variables. Equations (23) and (29) through (33) are a system of six equations in the seven variables $p_d, y_d, n_d, q_d, i_d, m_d$, and $\overline{p+y}_d$. The results for differences for the II, MM, or YY regime pairs are obtained by making i_d, m_d, or $\overline{p+y}_d$ exogenous and solving for the six remaining variables.

Simulation results

Each of Tables 7 through 9 contains simulation results for the effects of both symmetric and asymmetric shocks of a given type in the Contract model with FIA. The columns are divided into two groups of four each. In the left-hand group, we report results for the symmetric shock of a given type for the II, MM, YY, and CC regime pairs, and in the right-hand group, results for the asymmetric shock. The rows are divided into three groups that show effects on US variables (top), ROECD variables (bottom), and nominal and real exchange rates (middle).[25] All the numbers are first-period effects and are either actual deviations (D) or percent deviations (%) from baseline. The baseline is a shock-free simulation in which all variables are at steady-state, equilibrium values. The parameter values used in the simulations are in Appendix B.

Each of Figures 3, 4, 6, 7, 9 and 10 contains simulation results for the effects of a single shock in the Contract model for both and PIA and FIA. There are four graphs in each figure, one each for US employment, US CPI inflation, US output, and the US interest-rate instrument. In each graph, on the vertical axis we measure the undiscounted sums of squared deviations (SSDs) of the variable from baseline for the MM, YY, and CC regime pairs, and on the horizontal axis we measure the feedback coefficients β, ρ, and τ.[26] Values of the feedback coefficient equal to 10 yield almost FIA. The SSDs for the II pair is the single value on the vertical axis to which the SSDs for the MM and YY pairs tend as $\beta \rightarrow 0$ and $\rho \rightarrow 0$, respectively. Since the model has no unique solution under the CC pair for $\tau \leq 1$, it is not meaningful to calculate SSDs for this pair for $\tau \leq 1$.

Money-demand shocks in the Contract model

In this and the following two sections we use the models of sums and differences derived in the previous section to discuss the effects of money-demand, goods-demand, and productivity shocks under the II, MM, and YY regime pairs in the Contract model with FIA. In the Contract model with FIA all endogenous variables move in the same way under the YY and CC pairs except for nominal interest rates for productivity shocks, so we do not discuss the CC pair separately

[25] Recall that the nominal exchange rate is the dollar price of ROECD currency, so a rise in the exchange rate is a depreciation of the dollar.

[26] In Henderson and McKibbin (1993a) we present both discounted and undiscounted SSDs under FIA. The rankings of regimes for each variable are not affected by discounting.

with FIA.[27] We also discuss the effects of these shocks under the II, MM, YY, and CC pairs with PIA.

For symmetric or asymmetric money-demand shocks with both FIA and PIA, outcomes are the same under the II, YY, and CC pairs, and any of these pairs is better than the MM pair for all variables. The result for a symmetric shock for FIA is identical to Poole's result for a money-demand shock in a closed economy, and the logic behind the results for both symmetric and asymmetric shocks under FIA is the same as the logic behind Poole's result. Under the II, YY, and CC pairs, the goods markets are insulated from the shocks. We derive the results for a symmetric shock under FIA and then discuss the few differences between these results and those for an asymmetric shock under FIA. We proceed to discuss the results for symmetric and asymmetric shocks under PIA. The results are in Figures 2, 3, and 4 and Table 7.

Symmetric money-demand shocks with FIA

A symmetric increase in money demands in the US and the ROECD, an increase in v_s, causes the M_s schedule to shift down from $M_{s,0}$ to $M_{s,1}$ as shown in Figure 2 with $h = s$. An increase in v_s increases the sum of excess demands, so p_s must be lower for given values of y_s, m_s, and i_s in order to keep this sum equal to zero. The increase in the sum of money demands creates an excess demand for money at the original values of p_s, y_s, m_s, and i_s corresponding to point a, so there is upward pressure on i_s. If i_s is increased, the M_s schedule shifts up and the AD_s schedule shifts down until they meet along the marked part of the $AS_{s,0}$ schedule between points a and b.

The II and YY regime pairs. Under the II and YY regime pairs, i_s is kept unchanged. Under the II pair, i_s must be kept unchanged by definition. Under the YY pair, it must be kept unchanged in order to keep the economy on the $Y_{s,0}$ schedule. If i_s were increased, the new equilibrium would lie on the $AS_{s,0}$ schedule between points a and b below the $Y_{s,0}$ schedule. In order to keep i_s unchanged, the money supply must be allowed to increase by enough to shift the M_s schedule from $M_{s,1}$ back to $M_{s,0}$. So i_s, y_s, and p_s and, therefore, $p_s + y_s, n_s$, and q_s remain unchanged.[28]

The MM regime pair. Under the MM regime pair, i_s must be increased in order to keep m_s constant. The new equilibrium lies somewhere on the marked part of the $AS_{s,0}$ schedule between points a and b and below the $Y_{s,0}$ schedule. In the new equilibrium, i_s is higher and y_s and p_s, and, therefore, $p_s + y_s, n_s$, and q_s are lower. Since y_s is lower, $i_s + p_s$ and, therefore, r_s must be higher in order to

[27]We prove this result in Appendix A of Henderson and McKibbin (1993a).

[28]In the algebraic expressions in Appendix A, $y^{jj}_{s,v_s} = \alpha n^{jj}_{s,v_s} = q^{jj}_{s,v_s} = 0$ where $jj = II, YY$ and where, for example, n^{II}_{s,v_s} represents the effect of a symmetric increase in money demands on the sum of employments under the II regime pair.

keep the sum of excess demands for goods equal to zero. The new equilibrium lies on a new AD_s schedule located below $AD_{s,0}$. $i_s + p_s$ would be unchanged if the new equilibrium lay directly below point a. However, since the new equilibrium lies at the intersection of the new AD_s schedule and $AS_{s,0}$, the fall in p_s must be less than the rise in i_s. For symmetric shocks, the real exchange rate remains unchanged, and corresponding variables in each region move in the same direction with each moving by half as much as their sum.[29]

Asymmetric money-demand shocks with FIA

The analysis of an asymmetric money-demand shock is analogous to the analysis of a symmetric money-demand shock and is conducted using Figure 2 with $h = d$. Under the II and YY regime pairs, i_d is kept constant and y_d and p_d and, therefore, $p_d + y_d, n_d$, and q_d remain unchanged. Under the MM pair, i_d is increased, and y_d and p_d, and, therefore, $p_d + y_d, n_d$, and q_d are lower. Since y_d is lower, $i_d + p_d$ must be higher and, therefore, r_d must be higher and the dollar must appreciate in real terms in order for the difference between excess demands for goods to remain equal to zero. There are two main differences between the results for asymmetric shocks and those for symmetric shocks. For asymmetric shocks, the real exchange rate changes, and corresponding variables in each region move in opposite directions with each moving by half as much as their difference.[30]

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[29]For example, the effects of an increase in v_s onn and $\overset{*}{n}$ under the MM regime($n_{v_s}^{MM}$ and $\overset{*}{n}_{v_s}^{MM}$) can be obtained from the effect of an increase in v_s on n_s:

$$2n_{v_s}^{MM} = 2\overset{*}{n}_{v_s}^{MM} = n_{s,v_s}^{MM} = \frac{1}{2}\left(\left[n_v^{MM} + \overset{*}{n}_v^{MM}\right] + \left[n_{\overset{*}{v}}^{MM} + \overset{*}{n}_{\overset{*}{v}}^{MM}\right]\right),$$

where for example, n_v^{MM} represents the effect of an increase in the demand for US money on US employment and $n_v^{MM} = \overset{*}{n}_{\overset{*}{v}}^{MM}$

and $n_{\overset{*}{v}}^{MM} = \overset{*}{n}_v^{MM}$ because the two countries are mirror images of one another. See the next

footnote.

[30]For example, the effects of an increase in v_d on n and $\overset{*}{n}$ under the MM regime ($n_{v_d}^{MM}$ and $\overset{*}{n}_{v_d}^{MM}$) can be obtained from the effect of an increase in v_d on n_d:

$$2n_{v_d}^{MM} = -2\overset{*}{n}_{v_d}^{MM} = n_{d,v_d}^{MM} = \frac{1}{2}\left(\left[n_v^{MM} - \overset{*}{n}_v^{MM}\right] - \left[n_{\overset{*}{v}}^{MM} - \overset{*}{n}_{\overset{*}{v}}^{MM}\right]\right).$$

See the previous footnote.

Symmetric money-demand shocks with PIA and FIA

One of the simulation results for symmetric and asymmetric shocks with PIA and FIA in Figures 3 and 4 is not at all surprising.[31] The SSDs for all four variables rise with the feedback coefficient under the MM regime pair.

However, another of the results is somewhat surprising. Money-demand shocks have no effect on employments, inflations, and outputs under the YY and CC pairs no matter what the size of the feedback coefficient. We explain the result for sums. The sums p_s+y_s and $\pi_s+y_s = p_s-p_{s,-1}+y_s$ and the individual variables p_s and y_s can all be expressed in terms of n_s alone from the relationship between nominal income and employment, equation (28), and the aggregate-supply schedule, equation (26), since $x_s = 0$. As a result, under the YY and CC regime pairs, i_s can be expressed in terms of n_s alone from the sum of reaction functions under the YY pair, equations (10), and the sum of the reaction functions under the CC pair, equations (11). Therefore, n_s must remain constant in order to satisfy the aggregate-demand schedule for sums, equation (24), since $u_s = 0$.

Goods-demand shocks in the Contract model

For symmetric goods-demand shocks with FIA, the YY regime pair is better than the MM regime pair which is better than the II regime pair for both employments and CPIs. For asymmetric goods-demand shocks with FIA, the ranking is the same for employments, but the ranking for CPIs depends on parameter values.[32]

The result that for symmetric shocks the MM pair is better than the II pair is the same as Poole's result for a goods-demand shock in a closed economy, and the logic behind both this result and the result that for asymmetric shocks the MM pair is better than the II pair for employments is the same as the logic behind Poole's result. Under the MM pair, larger induced movements in real interest rates and, for asymmetric shocks, the real exchange rate offset more of the effects of the shocks on the goods markets.

The result that for asymmetric shocks the ranking for CPIs depends on parameter values deserves special attention because the YY pair unambiguously dominates the II and MM pairs in many other cases.

As for money-demand shocks, we derive the results for a symmetric shock under FIA, discuss the differences between these results and those for an asymmetric shock under FIA, and then discuss results for symmetric and asymmetric shocks

[31] The simulation results for symmetric and asymmetric shocks have identical qualitative properties and analogous explanations. The simulation results for asymmetric shocks are reported in Henderson and McKibbin (1993b).

[32] Melitz (1983) was among the first to point out that the ranking of regimes for measures of real economic activity like employments could be different from the ranking for price levels because of exchange-rate effects.

under PIA. The results for goods-demand shocks are in Figures 5, 6, and 7 and Table 8.

Symmetric goods-demand shocks with FIA

A symmetric increase in the demands for US and ROECD goods, an increase in u_s, causes the AD_s schedule to shift up from $AD_{s,0}$ to $AD_{s,1}$ in Figure 5 with $h = s$. Since an increase in u_s tends to increase the sum of excess demands for goods, for a given value of y_s, p_s must be higher causing r_s to be higher in order to keep this sum equal to zero. At point b where the $AD_{s,1}$ and $AS_{s,0}$ schedules intersect, the sum of excess demands for money is positive, so there is upward pressure on i_s. If i_s is increased, the AD_s schedule shifts down from $AD_{s,1}$ and the M_s schedule shifts up from $M_{s,0}$ until they meet at some point along the marked part of the $AS_{s,0}$ schedule between points a and b.

The II regime pair. Under the II regime pair, i_s is kept constant, so the new equilibrium is at the intersection of the $AD_{s,1}$ and $AS_{s,0}$ schedules at point b which is above the $Y_{s,0}$ schedule. In the new equilibrium, p_s and y_s, and, therefore, $p_s + y_s, n_s$, and q_s are all higher. Since i_s is kept constant, the increase in y_s and the associated increase in p_s must be large enough to fully offset the effect of the disturbance on the goods market. m_s must rise by enough to satisfy money demand at an unchanged i_s and higher p_s and y_s.

The MM regime pair. Under the MM regime pair, i_s is increased in order to prevent an increase in m_s. The new equilibrium lies on the marked part of the $AS_{s,0}$ schedule between points a and b and above the $Y_{s,0}$ schedule. i_s, p_s, and y_s and, therefore, $p_s + y_s, n_s$, and q_s are all higher. p_s and y_s must be higher given that i_s is higher in order for the money market to remain in equilibrium at an unchanged value of m_s. However, the increases in all the variables but i_s are smaller under the MM pair than under the II pair because smaller increases in p_s and y_s are required to reequilibrate the goods markets when i_s is increased.

The YY regime pair. Under the YY regime pair, the new equilibrium is at the same point as the initial equilibrium was, point a on the $Y_{s,0}$ schedule. In order to keep $p_s + y_s$ constant, i_s must be increased by enough to shift the AD_s schedule all the way back to its original position. Not only $p_s + y_s$ and n_s but also p_s and y_s individually remain unchanged under the YY pair. The increase in i_s must be larger under the YY pair than under the MM pair because $p_s + y_s$ rises under the MM pair.

Asymmetric goods-demand shocks with FIA

The analysis of an asymmetric shock is analogous to the analysis of a symmetric shock and is conducted using Figure 5 with $h = d$. y_d, p_d, and, therefore, $p_d + y_d$ and n_d rise more under the II pair than the MM pair and not at all under the

YY pair. i_d is kept constant under the II pair, increased under the MM pair, and increased more under the YY pair.

The results for the difference between CPIs, q_d, depend on the results for p_d and i_d and the value of γ, the average propensity to import according to equation (23). q_d definitely rises under the II pair and definitely falls under the YY pair. However, whether it rises or falls under the MM pair depends on parameter values. For example, it definitely rises if $\gamma = 0$ and definitely falls if $\gamma = \frac{1}{2}$.

The ranking of regime pairs for q_d depends on parameter values. For example, if $\gamma = 0, q_d$ rises more under the II pair than under the MM pair and remains unchanged under the YY pair. However, if $\gamma = \frac{1}{2}, q_d$ falls more under the YY pair than under the MM pair and remains unchanged under the II pair. In the simulation results in Table 8 and Figure 7, γ is high enough that the YY pair is worse than both the II and MM pairs with FIA. This is the first case we have encountered in which the YY pair is worse than both the II and MM pairs.

Symmetric and asymmetric goods-demand shocks with PIA and FIA

Several of the simulation results for symmetric and asymmetric goods-demand shocks with PIA and FIA in Figures 6 and 7 are worth emphasizing. First, the II regime pair is worse than all the other regime pairs for all admissible values of the feedback parameters $(0 < \beta < \infty, 0 < \rho < \infty, 1 < \tau < \infty)$ for both employments and inflations with symmetric goods demand shocks and for employments with asymmetric goods-demand shocks. However, it is better than the YY and CC pairs for a wide range of feedback coefficients for inflations with asymmetric shocks. Recall that the SSDs for the II pair is given by the equal SSDs for the MM or YY pairs as $\beta \to 0$ or $\rho \to 0$, respectively, and that there are no meaningful SSDs for the CC pair for $\tau \leq 1$. Of course, some or all of these rankings might be different with a different set of parameters.

Second, in contrast to the ranking of the regime pairs for money-demand shocks, the ranking of the MM, YY, and CC pairs for goods-demand shocks is sensitive to the choice of feedback coefficients. It is true that for most variables if the feedback coefficients under the various pairs are the same size, then the rankings do not change as the size of the equal feedback coefficients varies. However, there is no reason to restrict attention to the case in which all the feedback coefficients are the same size because the interest rate is responding to percent changes in different variables under the different pairs. Once it is recognized that a policymaker might well choose different feedback coefficients under different pairs, it is clear that ranking reversals are possible. For example, for employments with a symmetric shock, an MM pair with a large feedback coefficient is preferred to a YY or CC pair with a small enough feedback coefficient.

Third, for the MM and YY regime pairs the SSDs for inflations with asymmetric shocks falls from a positive value to zero before rising again as the feedback coefficients increase. Changes in p_d and i_d are of the same sign and have effects of the opposite sign on q_d. The effects of the changes in i_d go from being less than, to being equal to, to being greater than, the effects of the changes in p_d as the feedback coefficients increase.

Productivity shocks in the Contract model

For symmetric and asymmetric productivity shocks with FIA, the YY regime pair is better than the MM and II regime pairs for employments. However, either the MM or II pairs or both may be better than the YY pair for CPIs. Indeed, all other rankings for employments and all rankings for CPIs depend on parameter values. For symmetric shocks, the crucial parameters are the slopes of the AD_s and M_s schedules. For asymmetric shocks, the crucial parameters are γ and the slopes of the AD_d and M_d schedules.

As for the other shocks, we derive the results for a symmetric shock under FIA, discuss the differences between these results and those for an asymmetric shock under FIA, and then discuss the results for symmetric and asymmetric shocks under PIA. The results for productivity shocks are in Figures 8, 9, and 10, and Table 9.

Symmetric productivity shocks with FIA

A symmetric decrease in productivity in the US and the ROECD, an increase in x_s, causes the AS_s schedule to shift up from $AS_{s,0}$ to $AS_{s,1}$ in Figure 8 with $h = s$. In order to keep y_s constant, p_s must be higher so that n_s will rise by enough to offset the effect of the increase in x_s. The pair of y_s and p_s that clears the goods market is given by the intersection of the $AS_{s,1}$ and the $AD_{s,0}$ schedules at either point b or point b'. Whether there is upward or downward pressure on i_s depends on what happens to the sum of excess demands for money at point b or point b'. What happens to the sum of excess demands for money depends on the relative slopes of the AD_s and M_s schedules.

If the AD_s schedule is steeper than the M_s schedule, the intersection of the $AS_{s,1}$ and $AD_{s,0}$ schedules is at point b where the sum of excess demands for money is positive, so there is upward pressure on i_s. If i_s is increased, the AD_s schedule shifts down and the M_s schedule shifts up until they meet somewhere on the marked part of the $AS_{s,1}$ schedule between points b and c. For the parameter values used to generate the simulation results in Table 9, $\phi = 1$ and the AD_s schedule is steeper than the M_s schedule.

If the AD_s schedule is flatter than the M_s schedule, the intersection of the $AS_{s,1}$ and $AD_{s,0}$ schedules is at point b' where the sum of excess demands for money is negative, so there is downward pressure on i_s. If i_s is decreased, the AD_s schedule shifts up and the M_s schedule shifts down until they meet somewhere on the marked part of the $AS_{s,1}$ schedule between points b' and c.

The II regime pair. Under the II regime pair, i_s is kept constant, so the new equilibrium must be at the intersection of the $AS_{s,1}$ and $AD_{s,0}$ schedules at either point b or point b'. y_s falls, and p_s and, therefore, q_s rise.

If the AD_s schedule is steeper than the M_s schedule, the new equilibrium lies above the $Y_{s,0}$ schedule, so $p_s + y_s$ and, therefore, n_s must rise. The conclusion that symmetric reductions in productivity increase employments may seem counterintuitive, but it can be explained. The pair of y_s and p_s consistent with unchanged factor use following the symmetric productivity shock is given by the intersection of the $AS_{s,1}$ and $Y_{s,0}$ schedules at point c. This pair implies an excess demand for goods. Therefore, y_s must fall by less and p_s must rise by more than the amounts consistent with unchanged factor use, so n_s must rise.

If the AD_s schedule is flatter than the M_s schedule, the new equilibrium lies below the $Y_{s,0}$ schedule, so $p_s + y_s$ and, therefore, n_s must fall. The pair of y_s and p_s consistent with unchanged factor use given by point c implies an excess supply of goods. Therefore, y_s must fall by more and p_s must rise by less than the amounts consistent with unchanged factor use, so n_s must fall.

The MM regime pair. Under the MM regime pair, i_s is changed by enough to keep m_s unchanged, so the new equilibrium lies on the marked part of the $AS_{s,1}$ schedule between points b or b' and c. If the slope of the AD_s schedule is greater than one in absolute value, i_s is increased. y_s falls by more, p_s rises by less, and, therefore, $p_s + y_s, n_s$, and q_s rise by less than under the II pair. If the slope of the AD_s schedule is less than one in absolute value, i_s is decreased. y_s falls by less, p_s rises by more, and, therefore, $p_s + y_s$ and n_s fall by less and q_s rises by more than under the II pair.

The YY regime pair. Under the YY regime pair, $p_s + y_s$ is kept constant, so the new equilibrium must be on the $Y_{s,0}$ schedule just as the initial equilibrium was. i_s is adjusted so that the AD_s schedule passes through the intersection of the $AS_{s,1}$ and $Y_{s,0}$ schedules at point c. Since the new equilibrium is on the original $Y_{s,0}$ schedule, employments are unchanged. Since employments are unchanged, y_s falls and p_s rises by amounts that are equal in absolute value to the increase in x_s. It is important to observe that the equilibrium decrease in y_s is the same as the decrease in y_s that would take place if wages were flexible and all markets cleared.[33]

The ranking of regime pairs for q_s depends on parameter values. If the AD_s schedule is steeper than the M_s schedule, i_s is increased by more, y_s falls by more, and p_s and therefore q_s rise by less than under the MM pair. If instead the AD_s schedule is flatter than the M_s schedule, i_s is decreased by more, y_s falls by less, and p_s and therefore q_s rise by more than under the MM pair. This is another

[33]According to the sum of equations(1), if n_s remains unchanged at zero, the amount by which y_s must change for a given change in x_s is uniquely determined. With perfectly flexible wages, n_s remains unchanged because wages adjust. With one-period wage contracts, n_s remains unchanged under the YY regime because policymakers adjust i_s by enough.

case in which the YY pair is worse than both the II and MM pairs.

Additional results for symmetric productivity shocks with FIA

So far we have been assuming that the slope of the M_s schedule is equal to one in absolute value. The following additional results can be proved for cases in which the slope of the M_s is greater or less than one in absolute value. First, if the slopes of both the M_s and AD_s schedules are greater than one in absolute value, the YY pair is preferred to both other pairs for q_s, and whether the II or MM pair is preferred for both n_s and q_s depends on whether the AD_s schedule is flatter or steeper than the M_s schedule. Second, if the slopes of the M_s and AD_s schedules are less than one in absolute value, then both other pairs are preferred to the YY pair for q_s, and whether the II or MM pair is preferred for n_s while the other is preferred for q_s depends on whether the AD_s schedule is steeper or flatter than the M_s schedule. Third, if the slope of the AD_s schedule is greater than one in absolute value and the slope of the M_s schedule is less than one in absolute value, then the ranking of the MM and II pairs for n_s is ambiguous, the YY pair is preferred to the II pair for q_s, and the ranking of the MM and YY pairs for q_s is ambiguous. Fourth, if the slope of the M_s schedule is greater than one in absolute value and the slope of the AD_s schedule is less than one in absolute value, the ranking of the MM and II pairs for n_s is ambiguous, the II pair is preferred to the YY pair for q_s, and the ranking of the MM and YY pairs for q_s is ambiguous.

Asymmetric productivity shocks with FIA

The analysis of an asymmetric productivity shock with US productivity falling, an increase in x_d, is analogous to the analysis of a symmetric productivity shock and is conducted using Figure 8 with $h = d$. The YY regime pair dominates the II and MM pairs for employments. However, the ranking of pairs for q_d depends on parameter values. In particular, it depends on whether the slope of the AD_d schedule is steeper or flatter than the M_d schedule and, in the case in which the AD_d schedule is steeper, on the value of γ, the average propensity to import.

Suppose the AD_d schedule is steeper than the M_d schedule. y_d falls least under the II pair, more under the MM pair, and most under the YY pair; p_d rises most under the II pair, less under the MM pair, and least under the YY pair. $p_d + y_d$ and n_d rise most under the II pair, less under the MM pair, and not at all under the YY pair. i_d is kept constant under the II pair, is increased under the MM pair, and is increased more under the YY pair.

The results for the difference between CPIs, q_d, depend on the results for p_d and i_d and the value of γ, just as they do in the case of an asymmetric goods-demand shock. q_d definitely rises under the II pair for $\gamma < \frac{1}{2}$. However, whether it rises or falls under the MM and YY pairs depends on parameter values. For example, it definitely rises if $\gamma = 0$ and definitely falls if $\gamma = \frac{1}{2}$.

The ranking of regime pairs depends on the value of γ. For example, if $\gamma = 0$, q_d rises most under the II pair, less under the MM pair, and least under the YY pair. However, if $\gamma = \frac{1}{2}$, q_d falls more under the YY pair than under the MM pair and remains unchanged under the II pair. This is yet another case in which the YY pair is worse than both the II and MM pairs.

Although the signs of the changes under the MM and YY pairs and the ranking of regime pairs for q_d depend on γ for both an asymmetric productivity shock and an asymmetric goods-demand shock, the critical values of γ at which the signs and rankings change are different for the two types of shocks. For productivity shocks, the total effect on p_d is the sum of the increase on impact and the increase induced by the rise in employment, but for goods-demand shocks the total effect on p_d is just the increase induced by the rise in employment.

Suppose the AD_d schedule is flatter than the M_d schedule. y_d falls most under the II pair, less under the MM pair, and least under the YY pair; p_d rises least under the II pair, more under the MM pair, most under the YY pair. $p_d + y_d$ and n_d fall most under the II pair, less under the MM pair, and not at all under the YY pair. i_d is kept constant under the II pair, is decreased under the MM pair, and is decreased more under the YY pair. Therefore, q_d rises least under the II pair, more under the MM pair, and most under the YY pair no matter what the value of γ. This is one more case in which the YY pair is worse than both the MM and II pairs.

It is possible to prove additional results for an asymmetric productivity shock for cases in which the slope of the M_d schedule is greater or less than one in absolute value that are analogous to the additional results for a symmetric productivity shock for cases in which the slope of the M_s is greater or less than one in absolute value. However, we do not report those results here.

Symmetric and asymmetric productivity shocks with PIA and FIA

Several of the simulation results for symmetric and asymmetric productivity shocks with PIA and FIA in Figures 9 and 10 are deserving of comment. First, for a relatively large range of values for τ, the II regime pair is better than the CC regime pair for employments but not for inflations with both symmetric and asymmetric shocks. Although it is not apparent from Figure 10, for employments with an asymmetric shock the SSDs for both the YY and CC pairs converge to zero, but the SSDs for the MM pair does not as the feedback coefficients approach infinity in agreement with the results derived graphically for FIA.

Second, the CC pair is better for inflations than all the other pairs for all admissible values of the feedback parameters with symmetric shocks and for most admissible values of the feedback parameters with asymmetric shocks. This result makes sense because output price inflation is part of the intermediate target variable under the CC pair.

Third, for productivity shocks, just as for goods-demand shocks, the ranking of the MM, YY, and CC pairs is sensitive to the choice of feedback coefficients. For example, for employments with a symmetric shock, an MM pair with a large feedback coefficient is preferred to a YY pair or a CC pair with a small enough feedback coefficient.

The MSG2 model

In this section we provide a brief comparison of the MSG2 model and the workhorse model as preparation for a discussion of results from the MSG2 model in the next section. The MSG2 model is a fully-specified, dynamic, general-equilibrium model of the global economy. Many of the decisions of the agents in the model are made using intertemporal optimization. Most of the decisions are based on rational expectations. A comparison of the MSG2 model with the workhorse model reveals that there are both important similarities and important differences between the two models.

There are at least two important similarities between the MSG2 model and the workhorse model. First, both models embody the same general view of wage and price determination. In both models, wages are sticky, output prices are flexible, and employments are determined using marginal productivity conditions for labor.[34] In the workhorse model we assume that wages in both regions are set either according to the Contract hypothesis or according to the Phillips hypothesis. In the MSG2 model, wages in all regions other than Japan are determined according to a modified version of the Phillips hypothesis where the parameters are allowed to vary among regions, but wages in Japan are determined according to the Contract hypothesis. As shown in equation (14) in Table 4, in the modified version of the Phillips hypothesis, wage-setters respond to the expected change in the CPI, not to the expected change in the output price, and the expected change in the CPI is the sum of forward-looking and backward-looking terms, not just a forward-looking term.

Second, in both models current income variables play an important role in determining spending. According to the findings of several recent empirical studies, current income variables have a larger influence on spending than they would in a model in which all spending was done by "intertemporal optimizers," agents with complete access to financial markets and rational expectations who solve full-blown intertemporal optimization problems. The MSG2 model embodies one set of transparent assumptions that is consistent with these findings. Both consumers and investors are divided into two groups. For both consumers and investors, one group comprises intertemporal optimizers, and the other group comprises "rule of thumbers," agents with incomplete access to financial markets who follow simple

[34]In the MSG2 model, demands for labor and intermediate inputs are determined jointly using the marginal productivity conditions for labor and intermediate inputs.

rules of thumb.[35]

However, there are at least five important differences between the MSG2 model and the workhorse model. We list five features that the MSG2 model has but the workhorse model does not. First, there are intertemporal budget constraints on the behavior of households, firms, and governments and, therefore, countries that can have important implications for the link between the long run and the short run. Second, there is a careful treatment of the relationship between stocks and flows, so it is possible to keep track of the implications of current account deficits for net liabilities to foreigners, the implications of fiscal deficits for the government debt, and the implications of investment for the depreciating capital stock. Third, there are adjustment costs, so there is a rich dynamic structure. For example, both investment and the pass-through of exchange-rate changes into prices take place slowly because of adjustment costs. Fourth, there is a considerable amount of disaggregation. In the version of the MSG2 model used in this paper, there are explicit submodels for the United States, Japan, Germany, Canada, the rest of the EMS, the rest of the OECD, and both oil-producing and non-oil-producing developing countries. Fifth, there are differences in parameters among regions.

This brief comparison of the MSG2 model and the workhorse model suggests two conclusions. For temporary shocks such as the ones considered in this paper, the results from the two models might be somewhat similar qualitatively because important aspects of the specification of short-run behavior are similar in the two models. However, for permanent shocks, the results from the two models might be quite different qualitatively because the MSG2 model incorporates important aspects of the specification of long-run behavior and of the link between the long run and the short run that are absent from the workhorse model.

The effects of shocks in the Phillips model and in the MSG2 model

In this section we discuss the effects of the shocks in the Phillips model and in the MSG2 model. For the Phillips model we present diagrammatic analysis of symmetric shocks and simulation analysis of symmetric and asymmetric shocks using the parameters in Appendix B. For the MSG2 model we present simulation analysis of symmetric and asymmetric shocks. The discussion is organized by regime pair because a separate version of the Phillips model is needed for each of the MM, YY, and CC regime pairs.

Each of Figures 12 through 15, 21 through 24, and 30 through 33 contains graphs of the full paths for eight variables for one shock and four regime pairs

[35]The rules of thumb are designed so that they are equivalent to optimal behavior in certain steady states with no shocks. For example, the rule of thumb for consumers is to consume a fixed proportion of current income. Consuming a fixed proportion of current income is equivalent to the optimal behavior of consuming a fixed-proportion of wealth in a steady state with constant labor income and no shocks.

with FIA. Variables are plotted as deviations from their preshock or baseline levels. Each of Figures 16 through 19, 25 through 28, and 34 through 37 contains SSDs for four variables with PIA and FIA.

The model for sums implied by the Phillips model

Under the "Phillips" hypothesis, wages are set according to expectations-augmented Phillips curves that embody the natural rate hypothesis as shown in equations (13) in Table 4. Wages for period $t+1$ are set in period t and are equal to the wages in period t plus a constant times the gaps between actual employments and natural employments of zero plus expected rates of output price inflation between period t and period $t+1$.[36]

The model for sums implied by the Phillips model is in Table 10. Equations (34), (35), (36), (37), and (38) are the sums of equations (1), (2), (7), (8), and (13), respectively, with r_s eliminated using the sums of equations (3) and (6), and with time subscripts included for clarity. Equation (39) is the sum of equation (34) and minus one times equation (35). The reaction functions for the model for sums, equations (40)–(42), are the sums of equations (9)–(11), respectively. In Table 10, the symbol Δ in front of a variable indicates the difference between that variable and the value of the same variable in the previous period. For simplicity, we assume that there are no shocks after period 0. Under this assumption, the values of all variables after period 0 are equal to their expected values based on information available in period 0. For example, $p_{t|0} = p_t$ for all $t > 0$.

An employment-change equation, equation (43), is used in the analysis of all regime pairs. It is obtained by differencing equation (35) and eliminating $\Delta w_{s,t+1} - \Delta p_{s,t+1}$ using equation (38). A unit increase in $n_{s,t}$ increases the real wage by θ units from equation (38), so $\Delta n_{s,t+1}$ must fall by $\theta/(1-\alpha)$ units from the equation obtained by differencing equation (35).

We assume that $n_{s,t}$ can jump at time t but that $w_{s,t}$ cannot. Therefore, to ensure that there is a unique path to stationary equilibrium, it is necessary to assume that $-1 < 1-\theta/(1-\alpha) < 1$ under all regime pairs. However, we make the still stronger assumption that $0 < 1-\theta/(1-\alpha) < 1$ in order to rule out stable adjustment paths along which $n_{s,t}$ alternates between positive and negative values for two reasons: (a) we do not think such paths are interesting, and (b) we cannot illustrate them using our diagrammatic framework.

[36]Some might prefer a formulation in which wage-setters respond to expected rates of CPI inflation rather than expected rates of output price inflation. We do not explore this alternative formulation in the workhorse model. However, in the formulation of the Phillips hypothesis used for most countries in the MSG2 model, wage-setters respond to expected rates of CPI inflation.

The II and MM regime pairs

First we consider the II and MM regime pairs. We begin by completing the groundwork for the diagrammatic analysis of symmetric shocks under these pairs in the Phillips model. A useful expression for $i_{s,t}$ is equation (44). It is obtained by eliminating $m_{s,t}$ from the reaction function (40) using equation (36) and solving for $i_{s,t}$.

In order to determine the effects of shocks under the II and MM regime pairs, we combine the employment-change equation with a wage-change equation, equation (45). The wage-change equation is obtained by beginning with equation (38), eliminating $p_{s,t+1} - p_{s,t}$ using equation (37), eliminating $i_{s,t}$ using equation (44), and eliminating $y_{s,t}$ and $p_{s,t}$ from the resulting expression using equations (34) and (35), respectively. According to equation (45), a unit increase in $w_{s,t}$ raises $\Delta w_{s,t+1}$ because it raises $p_{s,t}$ by one unit from equation (35), and therefore $i_{s,t}$ from equation (44) and $\Delta p_{s,t+1}$ from equation (37) and $\Delta w_{s,t+1}$ from equation (38) by $\beta/(\beta\lambda+1)$ units. A unit increase in $n_{s,t}$ causes $\Delta w_{s,t+1}$ to rise for three reasons: (a) it raises $\Delta w_{s,t+1}$ directly by θ units; (b) it raises $y_{s,t}$ by α units from equation (34) and therefore $\Delta p_{s,t+1}$ from equation (37) and $\Delta w_{s,t+1}$ from equation (38) by $(1-\epsilon)\alpha/\nu$ units; and (c) it raises $p_{s,t}$ by $1-\alpha$ units from equation (35) and $y_{s,t}$ by α units from equation (34) and, therefore, $i_{s,t}$ from equation (44) and $\Delta p_{s,t+1}$ from equation (37) and $\Delta w_{s,t+1}$ from equation (38) by $\beta(1-\alpha+\phi\alpha)/(\beta\lambda+1)$ units.

We analyze the system made up of the two difference equations (43) and (45) using the phase diagram in Figure 11. An N schedule gives the unique value of $n_{s,t}$ for which $\Delta n_{s,t+1}$ is equal to zero for given values of $x_{s,t+1}$ and $x_{s,t}$. A W schedule shows the pairs of w_s and n_s for which $\Delta w_{s,t+1}$ is equal to zero for given values of $v_{s,t}, u_{s,t}$, and $x_{s,t}$. As explained above, increases in both $w_{s,t}$ and $n_{s,t}$ tend to raise $\Delta w_{s,t+1}$, so an increase in $n_{s,t}$ must be matched by a decrease in $w_{s,t}$ if $\Delta w_{s,t+1}$ is to remain equal to zero. The horizontal arrows show how $n_{s,t}$ changes when the $n_{s,t}, w_{s,t}$ pair is to the right or left of the N_0 schedule. The vertical arrows show how $w_{s,t}$ changes when the $n_{s,t}, w_{s,t}$ pair is above or below the W_1 schedule.

The schedule labeled SP_0 is the unique stable path to the stationary equilibrium at point a. As indicated by the arrows of motion, the unique stable path to a stationary equilibrium must have a negative slope and must be flatter than the corresponding W schedule. The equation for the stable path is equation (47), where $\hat{w}_{s,t}$ and $\hat{n}_{s,t}$ are the stationary-equilibrium values of $w_{s,t}$ and $n_{s,t}$, the values of $w_{s,t}$ and $n_{s,t}$ for which $\Delta w_{s,t+1} = \Delta n_{s,t+1} = 0$, given the values of the exogenous variables in period t. The stable path under the MM regime pair ($\beta \to \infty$) can be steeper or flatter than the stable path under the II regime pair ($\beta \to 0$) as shown in equation (48) where $\left|\frac{w_{s,t}}{n_{s,t}}\right|_{jj}$ is the absolute value of the slope of the stable path under the jj regime pair. The stable path is more likely to be steeper under the MM regime pair, the larger is ϕ, the absolute value of the slope of the M_s

schedule; the larger is $\theta/(1-\alpha)$ the effect of an increase in $p_{s,t}$ on $\Delta n_{s,t+1}$ through its effect on $n_{s,t}$; and the smaller is $(1-\epsilon)/\nu$, the absolute value of the slope of the AD_s schedule.

Money demand shocks. The effects of an increase in money demands, an increase in $v_{s,0}$, are shown in the phase diagram labeled Figure 11. The W schedule shifts down from W_0 to W_1 in period 0 when the shock occurs and then back up to W_0 in period 1. The stationary equilibria for periods -1, 1, and all periods thereafter are at point a. In presenting phase diagram results, it is conventional to refer to the period in which the shock hits as period 0, but in presenting simulation results, it is conventional to refer to the period in which the shock hits as period 1. We follow these different period-labeling conventions in the presentation of our results.

The equilibrium position of the economy in period 0 following the increase in money demands is determined by three requirements. First, if the economy is to reach its steady-state equilibrium at point a, it must be on the SP_0 schedule in period 1. Second, $w_{s,0}$ cannot change from $\hat{w}_{s,-1}$, so the equilibrium must lie on the horizontal line through point a in period 0. Third, the movement of the economy between periods 0 and 1 is determined by the arrows of motion for the W_1 and N_0 schedules as shown in Figure 11. The point that is consistent with these three requirements must lie on the horizontal line through point a between point a and the intersection of that line with the W_1 schedule.

We assume that the economy is at point b in period 0. In period 1 the economy moves to point c on SP_0, and over time it moves down SP_0 to the stationary equilibrium at a. $w_{s,0}$ remains constant at $\hat{w}_{s,-1}$ in period 0, rises above $\hat{w}_{s,1} = \hat{w}_{s,-1}$ in period 1, and falls back to $\hat{w}_{s,1}$ over time. n_s falls below $\hat{n}_{s,-1}$ in period 0, rises to a value that is still below $\hat{n}_{s,1} = \hat{n}_{s,-1}$ in period 1, and continues to rise back to $\hat{n}_{s,1}$ over time.

For a shock to money demands, the qualitative behavior is similar, but the quantitative behavior is quite different under the MM and II regime pairs. Under the II regime pair, $n_{s,t}$ and $w_{s,t}$ are virtually unchanged. As $\beta \to 0$ the slope of the W_1 schedule approaches $-\infty$, but the slope of SP_0 remains finite so the implied movements in $n_{s,t}$ and $w_{s,t}$ approach zero.

We obtain explicit solutions for the effects of temporary shocks on $n_{s,0}$ and $n_{s,1}$ using equations (49) through (51). We begin with three equations: the equation for the stable path, equation (47), and the two difference equations, equations (43) and (45). Then we impose the requirements stated above. The requirement that the economy must be on the stable path in period 1 yields equation (49). The requirement that the wage cannot change in period 0 so that $w_{s,0} = \hat{w}_{s,-1} = 2\omega$ and the requirement that the motion of the system between period 0 and period 1 be governed by the difference equations yields equations (50) and (51). The solutions for $n_{s,0}$ and $n_{s,1}$ are reported in equations (52) and (53).[37] As can be seen from the coefficients on $v_{s,0}$ in these equations, $n_{s,0}$ and $n_{s,1}$ remain negative with $|n_{s,0}| > |n_{s,1}|$ for $\beta \to \infty$ but approach 0 as $\beta \to 0$.

Simulation results for the effects of symmetric money-demand shocks for FIA under all four regime pairs are presented in Figures 12 and 13. Recall that according to the period-labeling convention used in presenting simulation results the shock hits in period 1. First, consider the results for a symmetric increase in money demand for FIA in the Phillips model in Figure 12. The paths for US employment and the US wage under the *MM* and *II* regime pairs conform exactly to what we predict for $w_{s,t}$ and $n_{s,t}$ using the phase diagram analysis. Under the *II* pair there are no perceptible effects on any variable.

Under the *MM* regime pair, the wage and output price paths are striking. We can provide some insight about why these paths arise. We use the equations underlying the phase diagram and switch to the period-labeling convention for phase diagram results. According to equation (50), both $n_{s,0}$ and $n_{s,1}$ must be on the same side of $\hat{n}_{s,1} = \hat{n}_{s,-1}$. They cannot both be above $\hat{n}_{s,1}$ because if they were, $w_{s,1}$ would have to be below $\hat{w}_{s,1}$ to satisfy equation (49) and would have to be above $\hat{w}_{s,1}$ to satisfy equation (51) given that $v_{s,0} > 0$. They can both be below $\hat{n}_{s,1}$ because a value of $w_{s,1}$ above baseline can satisfy both equation (49) and equation (51) given that $v_{s,0} > 0$.

From equation (35), $p_{s,0}$ must be below baseline because $n_{s,0}$ must be below $\hat{n}_{s,1}$ and $w_{s,0}$ is fixed at $\hat{w}_{s,-1}$. $p_{s,1}$ must be above baseline even though $n_{s,1}$ is below $\hat{n}_{s,1}$ because $w_{s,1}$ must be enough above $\hat{w}_{s,1}$. Consider the net effect on $p_{s,1}$ of having $n_{s,1}$ below $\hat{n}_{s,1}$, using equation (35). The direct effect of having $n_{s,1}$ below $\hat{n}_{s,1}$ by one unit is to lower $p_{s,1}$ by $1-\alpha$ units. But if $n_{s,1}$ is below $n_{s,1}$ by one unit, $w_{s,1}$ must be above $\hat{w}_{s,1}$ by $\Omega\left[\frac{\theta}{1-\alpha} + \frac{\beta}{\beta\lambda+1}\right]^{-1} > 1-\alpha$ units from equation (49). Therefore, the net effect of having $n_{s,1}$ below $\hat{n}_{s,1}$ must be to have $p_{s,1}$ above baseline.

In continuing the discussion of the simulation results in Figure 12, we revert to the period-labeling convention for simulation results. The nominal interest rate is above the real interest rate in period 1 reflecting a rate of inflation above baseline in period 2. The high nominal interest rate is consistent with equilibrium in the money market, and the high real interest rate is consistent with equilibrium in the goods market.

After period 2, all variables except inflation adjust monotonically back to their baseline values, and after period 3, inflation does, too. In the Phillips model, there is monotonic adjustment after period 2 for all variables except inflation and after period 3 for inflation following all the temporary shocks because this model has a single stable root. We do not discuss what happens after these periods in what follows.

[37] We do not report a solution for $w_{s,1}$ since the solution for this variable is a simple transformation of the solution for $n_{s,1}$ from equation (49).

Now, compare the results for the MSG2 model in Figure 13 to those for the Phillips model in Figure 12. Under the II regime pair, there are no perceptible effects on any variable in either model. Under the MM pair, in period 1, the movements in all of the variables except the real exchange rate are qualitatively the same in the two models.

There can be movements in the real exchange rate in period 1 and beyond in the MSG2 model even for a symmetric shock because the regions in the model are not completely symmetric. We do not discuss the movements in real exchange rates caused by symmetric shocks in the MSG2 model in what follows.

Under the MM pair, after period 1 the movements in most variables are qualitatively a little different in the Phillips and MSG2 models. In period 2, inflation overshoots its stationary-equilibrium value in the Phillips and MSG2 models. However, output, employment, and the real and nominal interest rates overshoot their stationary-equilibrium values in the MSG2 model but simply move back toward their stationary-equilibrium values in the Phillips model.

In period 2, US wages fall in the MSG2 model and rise in the Phillips model. We explain above why wages must rise in the Phillips model. There is a difference between the Phillips model and the MSG2 model that makes it more likely that US wages will fall in period 2 in the MSG2 model. As shown in Table 4, in the Phillips model, US wage-setters focus on a measure of expected inflation that is entirely forward-looking, but in the MSG2 model they focus on a measure of expected inflation that is the sum of a forward-looking term and a backward-looking term. Because of the backward-looking term, the fall in the output price in period 1 reduces expected inflation, thereby reducing wages in period 2.

After period 2 for all variables except inflation, and after period 3 for inflation, the paths for all variables are cyclical in the MSG2, not monotonic as in the Phillips model. In the MSG2 model, there is cyclical adjustment after these periods because there are some pairs of complex roots among the many stable roots in the MSG2 model. We do not discuss the contrast between monotonic adjustment in the Phillips model and cyclical adjustment in the MSG2 model after these periods in what follows.

The simulation results for an asymmetric shock to money demands with FIA and for symmetric and asymmetric shocks to money demands with PIA are presented in Figures 14 through 19 and can be summarized briefly.[38] With FIA, the results for an asymmetric shock are quite similar to those for a symmetric increase except that the dollar appreciates in real terms under the MM regime pair. With PIA, the results for symmetric and asymmetric shocks are qualitatively identical to those for a symmetric increase and an asymmetric shock in the Contract model in Figures 3 and 4 and illustrate the predictable conclusion that the II regime pair dominates the MM regime pair for all values of the feedback coefficient.

[38]Numerical results for the SSDs for FIA for all the shocks in the Phillips and Taylor models are reported in Henderson and McKibbin (1993a).

Goods demand shocks. The effects of a symmetric increase in goods demands, an increase in $u_{s,0}$, are shown in Figure 20. The W schedule shifts up from W_0 to W_1 in period 0 when the shock occurs and then back down to W_0 in period 1. The stationary equilibrium remains at point a.

From the type of reasoning used in the discussion of money-demand shocks, it follows that the equilibrium in period 0 must lie on the horizontal line through point a between point a and the intersection of that line with the W_1 schedule and that the equilibrium in period 1 must lie on SP_0. We assume that the economy jumps to point b in period 0. It moves to point c on SP_0 in period 1, and it moves up SP_0 to the stationary equilibrium at a over time. $w_{s,0}$ remains constant at $\hat{w}_{s,-1}$ in period 0, falls below $\hat{w}_{s,1} = \hat{w}_{s,-1}$ in period 1, and rises back to $\hat{w}_{s,1}$ over time. n_s rises above $\hat{n}_{s,-1}$ in period 0, falls to a value that is still above $\hat{n}_{s,1} = \hat{n}_{s,-1}$ in period 1, and continues to fall back to $\hat{n}_{s,1}$ over time.

Comparison of the effects of a goods-demand shock under the MM and II regime pairs yields a surprising result. Whether the MM regime pair dominates the II regime pair for employments depends on parameter values. This result contrasts with the finding of Poole and many others and our own finding in the Contract model that for a goods-demand shock the MM regime pair dominates the II regime pair for employments for all parameter values.

The result can be proved using the expressions for $n_{s,0}$ and $n_{s,1}$ in equations (52) and (53). The difference between $n_{s,0}^{II}$ and $n_{s,0}^{MM}$ is in equation (55). This difference can be positive or negative. The sign of the difference depends on the size of θ, the responsiveness of the change in the wage to excess demand for labor. We have assumed that $0 < \theta < 1 - \alpha$. For values of θ close to $1 - \alpha$, the difference is positive; that is, the MM pair dominates the II pair as would be expected from the finding of Poole. However, for values of θ close to zero, the difference is negative; that is, the II pair dominates the MM pair. The difference between $n_{s,1}^{II}$ and $n_{s,1}^{MM}$ is proportional to the difference between $n_{s,0}^{II}$ and $n_{s,0}^{MM}$.

The result can be explained using the requirements for equilibrium in equations (49)–(51). If $u_{s,0}$ rises, $n_{s,0}$ must rise in order to make the wage-change equation, equation (51), hold again. An increase in $u_{s,0}$ reduces the right-hand side of equation (51). The direct effect of an increase in $n_{s,0}$ is to increase the right-hand side of equation (51). The indirect effect of an increase in $n_{s,0}$ is to decrease the left-hand side of equation (51) because it raises $n_{s,1}$ from the employment-change equation, equation (50), thereby lowering $w_{s,1} - 2\omega$ from the stable arm, equation (49). If θ is very close to $1 - \alpha$, the indirect effect of an increase in $n_{s,0}$ is very small under both the II and MM pairs, so the rise in $n_{s,0}$ must make equation (51) hold again almost entirely through its direct effect. The direct effect of an increase in $n_{s,0}, \Omega$, is larger under the MM pair ($\beta \rightarrow \infty$) than under the II pair ($\beta \rightarrow 0$), so $n_{s,0}$ must change by less under the MM pair. However, as θ is reduced toward zero, the indirect effect of an increase in $n_{s,0}$

becomes larger under both the II and MM pairs. Furthermore, for values of θ close enough to zero, the indirect effect under the II pair is enough larger than the indirect effect under the MM pair that $n_{s,0}$ must change by less to make equation (51) hold again under the II pair.

It is possible for employment to rise by less under the II pair because it is possible for the real interest rate to rise by more under this pair. In the Contract model, $p_{s,1}$ is equal to 0 under both the MM and II pairs given our assumptions. However, in the Phillips model, $p_{s,1}$ can be different under the two regime pairs. Under the conditions specified above, $p_{s,1}^{II}$ can be enough lower than $p_{s,1}^{MM}$ that $r_{s,0}^{II} > r_{s,0}^{MM}$ even though $i_{s,0}^{MM} > i_{s,0}^{II} = 0$ and $p_{s,0}^{MM} > p_{s,0}^{II}$.

Simulation results for the effects of symmetric and asymmetric goods-demand shocks are presented in Figures 21 through 28. First, consider the results for a symmetric increase in goods demands with FIA in the Phillips model in Figure 21. The paths for US employment and the US wage under the MM and II regime pairs conform exactly to what we predict for w_s and n_s using the phase diagram analysis. The explanations of the wage and price paths are analogous to the explanations of the wage and price paths following a symmetric money-demand disturbance.

Above we obtain the surprising analytical result that the II pair may dominate the MM pair for employments. However, for the parameters used in the simulations, including $\theta = .2$, the MMpair dominates the II pair for both employments and inflations. In supplementary simulations (not reported) with $\theta = .1$ but all the other parameters unchanged, the II pair dominates the MM pair for both employments and inflations. Whether the result that the II pair may dominate the MM pair is empirically relevant is not yet clear. At a minimum, this result suggests that it is important to study the effects of shocks in models with wage persistence like the Phillips model.

Real interest rates are above nominal interest rates in period 1 reflecting rates of inflation below baseline in period 2. Real interest rates above baseline are consistent with equilibrium in the goods market, and a nominal interest rate above baseline under the MM regime pair is consistent with equilibrium in the money market. Real interest rates are below nominal interest rates in period 2 reflecting rates of inflation above baseline in period 3. Real interest rates below baseline are consistent with equilibrium in goods markets, and nominal interest rates below baseline under the MM regime pair are consistent with equilibrium in money markets because outputs are above baseline but output prices are below baseline in period 2.

Now, compare the results for the MSG2 model in Figure 22 to those for the Phillips model in Figure 21. Under both the II and MM pairs, in period 1, the movements in all of the variables except the real exchange rate are qualitatively the same in the two models.

After period 1 the movements in most variables are qualitatively a little different in the two models. In period 2, inflation overshoots its stationary-equilibrium value in both models. However, output and employment overshoot their stationary-equilibrium values in the MSG2 model but simply move back toward their stationary-equilibrium values in the Phillips model. In addition, nominal interest rates under the MM pair and real interest rates under both the II and MM pairs overshoot their stationary-equilibrium values in the Phillips model but either fall back toward or move farther away from their stationary-equilibrium values in the MSG2 model.

In period 2, US wages fall in the MSG2 model and rise in the Phillips model just as they did in the case of a symmetric money-demand shock. As we explain above in the discussion of a symmetric money-demand shock, there is a difference between the specifications of the Phillips curves in the Phillips model and the MSG2 model that makes it more likely that wages will move in opposite directions in the two models.

Next, consider the results for an asymmetric goods-demand shock with FIA in the Phillips model and in the MSG2 model in Figures 23 and 24, respectively. For each model, the qualitative behavior for most variables after an asymmetric shock is the same as after a symmetric shock, but there are some differences. As should be expected, the most important difference is that the real exchange rate changes more with an asymmetric shock. As a result the movement of real interest rates is less with an asymmetric shock. With an asymmetric shock, the qualitative behavior of US inflation is different under the II and MM pairs in the Phillips model because the movement in the real exchange rate is enough larger under the MM regime pair, but the qualitative behavior of inflation is the same under the II and MM pairs in the MSG2 model.

Finally, consider the results for symmetric and asymmetric goods-demand shocks with PIA in the Phillips and MSG2 models in Figures 25 through 28. For the parameter values in the simulations, the MM regime pair dominates the II regime pair no matter what the value of the feedback coefficient in both the Phillips and MSG2 models just as it does in the Contract model.

Productivity shocks. The effects of a symmetric decrease in productivity, an increase in $x_{s,0}$, are shown in Figure 29. The N schedule shifts from N_0 to N_1 in period 0 and then back to N_0 in period 1. In the phase diagram and simulation analysis, we assume that $\phi = 1$, but the general case is presented in Table 11. With $\phi = 1$, the W schedule shifts up from W_0 to W_1 in period 0 and then back to W_0 in period 1. The point of intersection between the W_1 and N_1 schedules, point d, may lie above the horizontal line through point a or below it. For the parameters used in the simulations, point d lies below this line as in Figure 29. The stationary equilibrium remains at point a.

The equilibrium in period 0 must lie on the horizontal line through point a to the left of the intersection of that line with the W_1 schedule, and the equilibrium in period 1 must lie on SP_0. In the case of productivity shocks, in contrast to the cases of money-demand shocks and goods-demand shocks, these restrictions do not imply a path with unique qualitative properties for $n_{s,0}$. By experimenting with the phase diagram, it can be confirmed that $n_{s,1}$ must always be above $\hat{n}_{s,-1} = \hat{n}_{s,1}$, that $n_{s,0}$ may be above or below $\hat{n}_{s,-1}$, and that if $n_{s,0}$ is above $\hat{n}_{s,-1}$, it may be above or below $n_{s,1}$. That all of these configurations are possible can be verified by comparing the coefficients on $x_{s,0}$ in equations (52) and (53).

The case in which $n_{s,0}$ is below $\hat{n}_{s,-1}$ is illustrated in Figure 29. In this case, the economy jumps to a point like point b in period 0. It moves to point c on SP_0 in period 1, and it moves up SP_0 to the stationary equilibrium at a over time. $w_{s,t}$ remains constant at $\hat{w}_{s,-1}$ in period 0, falls below $\hat{w}_{s,-1} = \hat{w}_{s,1}$ in period 1, and rises back to $\hat{w}_{s,1}$ over time. $n_{s,t}$ falls below $\hat{n}_{s,-1}$ in period 0, rises above $\hat{n}_{s,-1} = \hat{n}_{s,1}$ in period 1, and falls back to $\hat{n}_{s,1}$ over time.

Comparison of the effects of a productivity shock under the MM and II regime pairs yields no surprises. As we show above in the Contract model, whether the MM or II regime pair is better for both employments and inflations depends on parameter values. Under the Phillips hypothesis, the same result is obtained. This conclusion can be verified using the expressions for $n_{s,0}$ and $n_{s,1}$ in equations (52) and (53).

Simulation results for the effects of symmetric and asymmetric productivity shocks in the Phillips and MSG2 models are presented in Figures 30 through 37. The results for a symmetric decrease in productivity with FIA in the Phillips model are shown in Figure 30. The paths for US employment and US wages under the MM and II regime pairs are qualitatively the same as the paths for $w_{s,t}$ and $n_{s,t}$ in Figure 29. The explanations of the wage and price paths are analogous to the explanations of the wage and price paths following a symmetric money-demand disturbance. The MM regime pair dominates the II regime pair for both employments and inflations. The results for an asymmetric productivity shock with FIA in the Phillips model in Figure 32 are similar to those for a symmetric shock except that for an asymmetric shock the real exchange rate is affected.

There are several differences between the results for a symmetric decrease in productivity with FIA for the MSG2 model shown in Figure 31 and those for the Phillips model. Employment in period 1 and wages in period 2 under both pairs and the nominal interest rate in period 1 under the MM pair rise in the MSG2 model as in the Contract model instead of falling as in the Phillips model. However, the qualitative behavior of real interest rates is the same in the MSG2 and Phillips models. The results for an asymmetric productivity shock with FIA in the MSG2 model in Figure 33 are similar to those for a symmetric productivity shock, except that for an asymmetric shock the real exchange rate is affected.

For a symmetric decrease in productivity with PIA in the Phillips and MSG2 models, the MM pair dominates the II pair for employments and inflations no matter what the value of the feedback coefficient just as it does in the Contract model as shown in Figures 34 and 35.

For asymmetric productivity shocks with PIA, the results for the Phillips and MSG2 models are strikingly different. In the results for the Phillips model shown in Figure 36, the II pair dominates the MM pair for employments, but the MM pair dominates the II pair for inflations no matter what the value of the feedback coefficient. However, in the results for the MSG2 model in Figure 37, the MM pair dominates the II pair for both employments and inflations no matter what the value of the feedback coefficient. The ranking in the MSG2 model is the same as the ranking in the Contract model and in the Phillips and MSG2 models for symmetric productivity shocks.

The YY regime pair

In order to analyze the effects of shocks under the YY regime pair, we combine the employment-change equation with a wage-change equation, equation (56), which is different from the wage-change equation for the MM and II regime pairs. The wage-change equation for the YY regime pair is obtained by beginning with equation (38), eliminating $p_{s,t+1} - p_{s,t}$ using equation (37), eliminating $i_{s,t}$ using equation (41), and eliminating $y_{s,t}$ and $p_{s,t} + y_{s,t}$ from the resulting expression using equations (34) and (39), respectively. A unit increase in $w_{s,t}$ raises $\Delta w_{s,t+1}$ because it raises $p_{s,t}$ by one unit from equation (35), and therefore $i_{s,t}$ from equation (41) and $\Delta p_{s,t+1}$ from equation (37) and $\Delta w_{s,t+1}$ from equation (38) by ρ units. A unit increase in $n_{s,t}$ causes $\Delta w_{s,t+1}$ to rise for three reasons: (a) it raises $\Delta w_{s,t+1}$ directly by θ units; (b) it raises $y_{s,t}$ by α units from equation (34) and therefore $\Delta p_{s,t+1}$ from equation (37) and $\Delta w_{s,t+1}$ from equation (38) by $(1-\epsilon)\alpha/\nu$ units; and (c) it raises $p_{s,t} + y_{s,t}$ by one unit from equation (39) and therefore $i_{s,t}$ from equation (41) and $\Delta p_{s,t+1}$ from equation (37) and $\Delta w_{s,t+1}$ from equation (38) by ρ units.

We analyze the system made up of the two difference equations (43) and (56) using the same phase diagrams that we used to analyze the MM and II regime pairs beginning with Figure 11. The N schedule has the same interpretation as it does under the MM and II regime pairs. A W schedule shows the pairs of $w_{s,t}$ and $n_{s,t}$ for which $\Delta w_{s,t+1}$ is equal to zero in equation (56) for given values of $v_{s,t}, u_{s,t}$, and $x_{s,t}$. As explained above, increases in both $w_{s,t}$ and $n_{s,t}$ tend to raise $\Delta w_{s,t+1}$ so an increase in $n_{s,t}$ must be matched by a decrease in $w_{s,t}$ if $\Delta w_{s,t+1}$ is to remain equal to zero. The horizontal arrows show how $n_{s,t}$ changes when the $n_{s,t}, w_{s,t}$ pair is to the right or left of the N_0 schedule. The vertical arrows show how $w_{s,t}$ changes when the $n_{s,t}, w_{s,t}$ pair is above or below the W_1 schedule.

The SP_0 schedule is the unique stable path to the stationary equilibrium at point a. As indicated by the arrows of motion, the unique stable path to a stationary equilibrium must have a negative slope and must be flatter than the corresponding W schedule. The equation for the stable path is equation (58). $\hat{w}_{s,t}$

and $\hat{n}_{s,t}$ are the values of $w_{s,t}$ and $n_{s,t}$ for which $\Delta w_{s,t+1} = \Delta n_{s,t+1} = 0$, given the values of the exogenous variables in period t.

We obtain explicit solutions for $n_{s,0}$ and $n_{s,1}$ using equations (59)–(61). We begin with three equations: the equation for the stable path, equation (58), and the two difference equations, equations (43) and (56). Then we impose requirements analogous to those imposed above in the analysis of the MM regime pair. The requirement that the economy must be on the stable path in period 1 yields equation (59). The requirement that the wage cannot change in period 0 so that $w_{s,0} = \hat{w}_{s,-1} = 2\omega$ and the requirement that the motion of the system between period 0 and period 1 be governed by the difference equations yields equations (60) and (61). The solutions for $n_{s,0}$ and $n_{s,1}$ are reported in equations (62) and (63).

Money-demand shocks. Under the Phillips hypothesis just as under the Contract hypothesis, a symmetric increase in money demands, an increase in $v_{s,0}$, has no effect on any variable except m_s under the YY regime pair for any value of the feedback coefficient. An increase in $v_{s,0}$ does not affect the wage-change equation under the YY regime pair and does not affect the employment-change equation under any regime pair.

The result can be proved by contradiction. Suppose that $i_{s,0}$ rose in response to the excess demand for money, then $p_{s,0}+y_{s,0}$ would rise from the reaction function, equation (41); $n_{s,0}$ would rise from the nominal-income equation, equation (39), and $y_{s,0}$ would rise from the production function, equation (34). If $n_{s,0}$ rises, then $n_{s,1}$ rises from the employment-change equation, equation (43). If $i_{s,0}$ and $y_{s,0}$ rise, then $p_{s,1} - p_{s,0}$ must rise in order to satisfy the goods-market-equilibrium condition, equation (37). If $n_{s,0}$ and $p_{s,1} - p_{s,0}$ rise, then $w_{s,1}$ must rise from the Phillips curve, equation (38). However, having both $n_{s,1}$ and $w_{s,1}$ higher is inconsistent with convergence to stationary equilibrium according to the equation for the stable path, equation (58), so having $i_{s,0}$ rise is impossible.

The simulation results for the effects of symmetric and asymmetric money-demand shocks in Figures 12 through 19 confirm that these shocks have no effects on any variables except money supplies under the YY regime pair, no matter what the value of ρ in both the Phillips model and the MSG2 model just as in the Contract model. Therefore, the YY and II pairs are equivalent in all the models.

Goods-demand shocks. The effects of a symmetric increase in goods demands, an increase in $u_{s,0}$, are shown in Figure 20; the W schedule shifts up from W_0 to W_1 in period 0 when the shock occurs and then back down to W_0 in period 1. The stationary equilibrium remains at point a.

The equilibrium in period 0 must lie on the horizontal line through point a between point a and the intersection of that line with the W_1 schedule, and the equilibrium in period 1 must lie on SP_0. We assume that the economy jumps to point b in period 0. In period 1 it moves to point c on SP_0, and over time it moves up SP_0 to the stationary equilibrium at a. $w_{s,t}$ remains constant at

$\hat{w}_{s,-1}$ in period 0, falls below $\hat{w}_{s,1} = \hat{w}_{s,-1}$ in period 1, and rises back to $\hat{w}_{s,1}$ over time. $n_{s,t}$ rises above $\hat{n}_{s,-1}$ in period 0, falls to a value still above $\hat{n}_{s,1} = \hat{n}_{s,-1}$ in period 1, and continues to fall back to $\hat{n}_{s,1}$ over time.

The larger is ρ the smaller is the shift in the W schedule in period 0 and the smaller the effects on employments in all periods and on wages in period 1 and beyond. If $\rho \to \infty$, the W schedule does not shift at all, and employments are stabilized perfectly in the Phillips model just as they were in the Contract model.

Simulation results for the effects of symmetric and asymmetric goods-demand shocks under the YY pair are presented in Figures 21 through 28. First, consider the effects of a symmetric increase in goods demand with FIA. As shown in Figure 21, in the Phillips model this shock has no effects on any variables except nominal and real interest rates which rise by enough to offset the effect of the shock on the goods markets in period 0. As shown in Figure 22, in the MSG2 model this shock does have some effects because the regions are not completely symmetric, but these effects are much smaller than under the II and MM pairs.

Now, consider the effects of an asymmetric shock to goods demands with FIA. In the Phillips model, this shock has no effect on employments, but it does have effects on inflations that are larger than those under the MM pair by a big margin and larger than those under the II pair by a small margin as shown in Figure 23. In the MSG2 model, this shock has noticeable effects on employments as well as on inflations because the regions are not completely symmetric as shown in Figure 24. For US employments the effects under the YY pair are much smaller than under the II and MM pairs. For US inflation, the MM pair dominates the YY pair, but the YY pair dominates the II pair.

For a symmetric increase in goods demands with PIA, for both the Phillips model and the MSG2 model and for both employments and inflations, the YY regime pair dominates the II regime pair no matter what the value of the feedback coefficient ρ, but the ranking of the YY and MM regime pairs depends on feedback coefficients as shown in Figures 25 and 26.

For asymmetric goods demand shocks with PIA in the MSG2 model for both employments and inflations, the YY pair dominates the II pair but the ranking of the YY and MM pairs depends on feedback coefficients as shown in Figure 28. For inflation, the SSDs first falls and then rises as the feedback coefficient is increased, in large part because the dollar appreciates more in real terms. The results for an asymmetric goods-demand shock with PIA in the Phillips model in Figure 27 are qualitatively the same as those in the MSG2 model, except that for inflations not only the ranking of the YY and MM pairs but also the ranking of the YY and II pairs depends on feedback coefficients.

Productivity shocks. The effects of a symmetric reduction in productivity, an increase in $x_{s,0}$, are shown in Figure 29. The N and W schedules shift from N_0 to N_1 and W_0 to W_1 in period 0 and then back to N_0 and W_0. The point of intersection between the W_1 and N_1 schedules, point d, may lie above the horizontal line through point a or below it. For the parameters used in the simulations, point d lies below this line as in Figure 29. The stationary equilibrium remains at point a.

The equilibrium in period 0 must lie on the horizontal line through point a between point a and the intersection of that line with the W_1 schedule, and the equilibrium in period 1 must lie on SP_0. In the case of productivity shocks under the YY regime pair just as under the MM and II regime pairs, these restrictions do not imply a path with unique qualitative properties for $n_{s,0}$.

By experimenting with the phase diagram, it can be confirmed that $n_{s,1}$ must always be above $\hat{n}_{s,1} = \hat{n}_{s,-1}$, that $n_{s,0}$ may be above or below $\hat{n}_{s,-1}$, and that if $n_{s,0}$ is above $\hat{n}_{s,-1}$, it may be above or below $n_{s,1}$. That all of these configurations are possible can be verified by comparing the coefficients on $x_{s,0}$ in equations (62) and (63).

The case in which $n_{s,0}$ is below $\hat{n}_{s,-1}$ is illustrated in Figure 29. In this case, the economy jumps to a point like point b in period 0. It moves to point c on SP_0 in period 1, and it moves up SP_0 to the long-run equilibrium at a over time. $w_{s,0}$ remains constant at $\hat{w}_{s,-1}$ in period 0, falls below $\hat{w}_{s,1} = \hat{w}_{s,-1}$ in period 1, and rises back to $\hat{w}_{s,1}$ over time. n_s falls below $\hat{n}_{s,-1}$ in period 0, rises above $\hat{n}_{s,1} = \hat{n}_{s,-1}$ in period 1, and falls back to $\hat{n}_{s,1}$ over time.

In the limit with full instrument adjustment ($\rho \rightarrow \infty$), the W schedule and the stable path both approach a line with a slope of negative one, and the effect of the productivity shock on these schedules approaches zero as can be confirmed by inspection of equations (56) and (58). In this case, the economy remains at point a in period 0, jumps down along the equivalent W schedule and stable path to a point to the southeast of point a in period 1, and then moves back along the equivalent W schedule and stable path to point a over time.

As for the other shocks, since $w_{s,0} = \hat{w}_{s,-1} = 2\omega, n_{s,0}$ remains equal to zero from the nominal income equals the wage bill minus 2ω condition, equation (39). Since $n_{s,0}$ remains equal to zero, $n_{s,1}$ must rise above baseline. Since $w_{s,0}$ is predetermined, $p_{s,0}$ must rise by the amount of the productivity shock from the marginal productivity condition, equation (35). Since $n_{s,1}$ rises, $y_{s,1}$ rises, and, therefore, $p_{s,1}$ falls by the same amount because nominal income remains constant. Since $w_{s,0} = 2\omega, n_{s,0} = 0, p_{s,1}$ falls, and $p_{s,0}$ rises, $w_{s,1}$ must fall from the Phillips curve, equation (38).

Now consider what happens from period 1 on. $n_{s,t}$ falls back toward $\hat{n}_{s,1}$ according to equation (43). It follows immediately that y_{st} falls back to baseline and $w_{s,t} - p_{s,t}$ rises back to baseline. $w_{s,t}$ rises back toward $\hat{w}_{s,1}$ as can be confirmed by differencing equation (39) and noting that $p_{s,t} + y_{s,t}$ is constant. $p_{s,t}$ rises back toward baseline as can be confirmed by noting that $y_{s,t}$ falls back toward baseline and that $p_{s,t} + y_{s,t}$ is constant.

For the YY regime pair with FIA, there are two important differences between the results in the Contract model and those in the Phillips model. In the Contract model, employments remain unchanged at their full employment values in all periods, and the YY regime pair dominates the MM and II regime pairs for employments for all parameter values. The first difference between results is that in the Phillips model, although employments remain unchanged at their full employment values in period 0, they rise above these values in period 1 and remain above them throughout the adjustment period. The second difference is that in the Phillips model the YY regime pair may be worse than either the MM or II pair for employments.

Simulation results for the effects of symmetric and asymmetric productivity shocks are presented in Figures 30 through 37. The results for a symmetric decrease in productivity with FIA in the Phillips model are shown in Figure 30. The paths for US employment and the US wage under the YY pair are qualitatively the same as the paths for $w_{s,t}$ and $n_{s,t}$ in Figure 29 in the limiting case in which $\rho \rightarrow \infty$. The explanations of the wage and price paths are analogous to the explanations of the wage and price paths following a symmetric money-demand shock. For employments, the MM pair dominates the YY pair which dominates the II pair. For inflations, the YY pair dominates the MM pair which dominates the II pair. The results for an asymmetric productivity shock with FIA in the Phillips model in Figure 32 are similar to those for a symmetric shock except that for an asymmetric shock the real exchange rate is affected.

There are several differences between the results for a symmetric decrease in productivity with FIA for the MSG2 model shown in Figure 31 and those for the Phillips model. Employment and wages in period 2 and nominal interest rates in period 1 move in opposite directions in the two models. However, real interest rates rise in period 1 in both models. The results for an asymmetric productivity shock with FIA in the MSG2 model in Figure 33 are similar to those for a symmetric productivity shock except that for an asymmetric shock the real exchange rate is affected.

The results for the effects of symmetric decreases in productivity with PIA in the Phillips model and in the MSG2 model are shown in Figures 34 and 35, respectively. The results for the two models are similar in some respects. The YY regime pair dominates the II regime pair for both employments and inflations no matter what the value of the feedback coefficient, but the ranking of the YY and MM pairs depends on parameter values. However, the results are different in other respects. The range of feedback coefficients for which the MM pair dominates the YY pair for employments is much larger in the Phillips model. Also, as the feedback coefficient is increased, the SSDs for employment first falls and then rises in the Phillips model but falls monotonically in the MSG2 model.[39]

As before, the results for the effects of asymmetric productivity shocks with PIA in the Phillips and MSG2 models are strikingly different. As shown in Figure 36 in the results for the Phillips model, no matter what the value of

[39]We have not yet arrived at an explanation for this difference in results.

the feedback coefficient, the II pair dominates the YY pair for employments, but the YY pair dominates the II pair for inflations. In contrast, as shown in Figure 37 in the results for the MSG2 model, no matter what the value of the feedback coefficient, the YY pair dominates the II pair for both employments and inflations.

The CC regime pair

In order to analyze the effects of shocks under the CC regime pair, we combine the employment-change equation, equation (43), with an inflation-change equation, equation (65). The inflation-change equation is obtained by beginning with equation (37), eliminating $i_{s,t}$ using equation (42), and eliminating $y_{s,t}$ from the resulting expression using equation (34). According to equation (65), a unit increase in $\pi_{s,t}$ raises $\Delta\pi_{s,t+1}$ by $\tau - 1$ units because it raises $i_{s,t}$ from equation (42) and $\Delta\pi_{s,t+1}$ from equation (37) by τ units and lowers $\Delta\pi_{s,t+1}$ directly from equation (37) by one unit. We assume that $\tau > 1$ so that $\tau - 1$ is positive. As we explain below, if $\tau \leq 1$, the model is not well-behaved. Also, according to equation (65), a unit increase in $n_{s,t}$ causes $\Delta\pi_{s,t+1}$ to rise because it raises $y_{s,t}$ by α units from equation (34) and therefore $i_{s,t}$ from equation (42) and $\Delta\pi_{s,t+1}$ from equation (37) by $\tau\alpha$ units and $\Delta\pi_{s,t+1}$ from equation (37) by $(1-\epsilon)\alpha/\nu$ units.

We analyze the system made up of the two difference equations (43) and (65) using the phase diagram in Figure 38. The N schedule has the same interpretation as it does under the other regime pairs. A Π schedule shows the pairs of $\pi_{s,t}$ and $n_{s,t}$ for which $\Delta\pi_{s,t+1}$ is equal to zero for given values of $u_{s,t}$ and $x_{s,t}$. As explained above, increases in both $\pi_{s,t}$ and $n_{s,t}$ tend to raise $\Delta\pi_{s,t+1}$, so an increase in $n_{s,t}$ must be matched by a decrease in $\pi_{s,t}$ if $\Delta\pi_{s,t+1}$ is to remain equal to zero. The horizontal arrows show how $n_{s,t}$ changes when the $n_{s,t}, \pi_{s,t}$ pair is to the right or left of the N_0 schedule. The vertical arrows show how $\pi_{s,t}$ changes when the $n_{s,t}, \pi_{s,t}$ pair is above or below the Π_1 schedule.

The economy must satisfy one initial condition, equation (73), which is represented by the IC_0 schedule. This initial condition is obtained by beginning with the marginal productivity condition for period 0, equation (71), and eliminating the price level in period 0 using the definition of $\pi_{s,0}$, equation (72), and rearranging. The IC_0 schedule has a positive slope. An increase in $n_{s,0}$ must be associated with a fall in the real wage. With $w_{s,0}$ fixed at $\hat{w}_{s,-1} = 2\omega$, the fall in the real wage must be associated with a rise in $p_{s,0}$. With $p_{s,-1}$ given, a rise in $p_{s,0}$ must be associated with a rise in $\pi_{s,0}$.

Under our assumption that $\tau > 1$, the economy is saddle-path stable. Stationary equilibria are represented by intersections of N and Π schedules. From the arrows of motion in Figure 38, it is clear that there is a unique stable path to each stationary equilibrium and that this stable path must have a negative slope and be flatter than the associated Π schedule.[40] The schedule labeled SP_0 is the unique stable path to the equilibrium at point a. The equation for the stable path is equation (66). $\hat{\pi}_{s,t}$ and $\hat{n}_{s,t}$ are the values of $\pi_{s,t}$ and $n_{s,t}$ for which $\Delta\pi_{s,t+1} = \Delta n_{s,t+1} = 0$ given the values of the exogenous variables in period t.

If $\tau < 1$, the economy is stable, and initial emloyments and initial inflation rates and, therefore, initial price levels are indeterminate. It can be confirmed that the economy is stable by drawing the relevant phase diagram.[41] The single initial condition for the economy can be satisfied by an infinite number of pairs of $n_{s,0}$ and $\pi_{s,0}$. If the economy is stable, any pair that satisfies the initial condition is an equilibrium pair.

If $\tau = 1$, the economy is neither saddle-path stable nor stable. It can be shown that initial employments and initial inflation rates and, therefore, initial price levels are also indeterminate in this case, but we do not do so here.

We can analyze the economy when $\tau > 1$ but not when $\tau \leq 1$ because we can determine unique values for the variables in the former case but not in the latter. That is, when $\tau \leq 1$, shocks have indeterminate effects, not well-defined bad effects.

We also obtain explicit solutions for $n_{s,0}$ and $n_{s,1}$ using equations (68) through (70) and equation (73). The requirement that the economy must satisfy the equation for the stable path, equation (66), in period 1 yields equation (68); the requirement that the initial condition must be satisfied in period 0 yields equation (73); and the requirement that the motion of the system between period 0 and period 1 must be governed by the difference equations of the system, equations (43) and (65), yields equations (69) and (70). The solutions for $n_{s,0}$ and $n_{s,1}$ are reported in equations (75) and (76).[42]

Money-demand shocks. Under the Phillips hypothesis just as under the Contract hypothesis, a symmetric increase in money demands, an increase in $v_{s,0}$, has no effect on any variable except m_s under the CC regime pair no matter what the value of the feedback coefficient. The results under the CC and YY regime pairs are identical, and the explanations for the results under these two regime pairs are similar.

The simulation results for the effects of symmetric and asymmetric money-demand shocks in Figures 12 through 19 confirm that these shocks have no effects on any variables except money supplies under the CC regime pair no matter

[40] It can be determined by inspection that the roots of the system are τ and $1 - \frac{\theta}{1-\alpha}$. We have assumed that $\frac{\theta}{1-\alpha} < 1$, so $1 - \frac{\theta}{1-\alpha} < 1$. The economy is saddle-path stable if and only if one root lies outside the unit circle and the other root lies inside the unit circle. This condition is satisfied under our assumption that $\tau > 1$. The economy is stable if both roots lie inside the unit circle, as they do if $\tau < 1$.

[41] See the previous footnote.

[42] We do not report solutions for $\pi_{s,1}$ or $w_{s,1}$. The solution for $\pi_{s,1}$ is a simple transformation of the solution for $n_{s,1}$ from equation (68). The solution for $w_{s,1}$ depends on the solution for both $n_{s,0}$ and $\pi_{s,1}$ from equation (74) which follows from equation (38) with $w_{s,0} = 2\omega$.

what the value of τ in both the Phillips model and the MSG2 model, just as in the Contract model. Therefore, the CC, YY, and II pairs are equivalent in all the models.

Goods-demand shocks. The effects of a symmetric increase in goods demands, an increase in $u_{s,0}$, are shown in Figure 38. The Π schedule shifts up from Π_0 to Π_1 in period 0 when the shock occurs and then back down to Π_0 in period 1. The stationary equilibrium remains at point a. The IC_0 schedule must pass through point a both before and after the goods-demand shock.

In period 0, the equilibrium must lie on the IC_0 schedule between point a and the intersection with the Π_1 schedule, say at point b. In period 1, the equilibrium must lie on SP_0 to the southwest of point b as indicated by the arrows of motion and to the southeast of point a, say at point c. Over time, the equilibrium moves up SP_0 back to the unchanged stationary equilibrium at point a. $\pi_{s,t}$ rises above $\pi_{s,-1}$ in period 0, falls below $\hat{\pi}_{s,1} = \hat{\pi}_{s,-1}$ in period 1, and rises back to $\pi_{s,1}$ over time. n_s rises above $n_{s,-1}$ in period 0, falls back toward $\hat{n}_{s,1} = \hat{n}_{s,-1}$ in period 1, and continues to fall back to $\hat{n}_{s,1}$ over time. The conclusions regarding $n_{s,0}$ and $n_{s,1}$ can be confirmed from equations (75) and (76).

The larger is τ, the smaller is the shift in the Π schedule in period 0 and the smaller the effects on employments in all periods and on wages in period 1 and beyond. If $\tau \to \infty$, the Π schedule does not shift at all, and employments are stabilized perfectly in the Phillips model just as they were in the Contract model.

Simulation results for the effects of symmetric and asymmetric goods-demand shocks under the CC pair are presented in Figures 21 through 28. First, consider the effects of a symmetric increase in goods demands with FIA. In the Phillips model under the equivalent CC and YY pairs, this shock has no effects on any variables except nominal and real interest rates as shown in Figure 21. In the MSG2 model, since the regions are not completely symmetric, there are some effects on both employments and inflations under both the CC pair and the YY pair, and the CC and YY pairs are no longer exactly equivalent as shown in Figure 22. However, the effects under these two pairs are similar and are much smaller than under the II and MM pairs.

Now, consider the effects of an asymmetric shock to goods demands with FIA. In the Phillips model under the equivalent CC and YY regime pairs this shock has no effects on employments, but it does have effects on inflations that are larger than the effects under the II and MM regime pairs as shown in Figure 23. In the MSG2 model, since the regions are not completely symmetric, the CC and YY pairs are no longer exactly equivalent as shown in Figure 24. However, the effects under the CC and YY pairs are similar. For employments, both the CC and YY pairs dominate the II and MM pairs, but for inflations the MM pair dominates the CC and YY pairs and the CC and YY pairs dominate the II pair.

Next, consider the effects of a symmetric increase in goods demands with PIA for the Phillips model and the MSG2 model shown in Figures 25 and 26, respectively. For employments, the CC pair dominates the II pair in both models and the MM pair in the Phillips model for all admissible values of the feedback coefficient, τ, but the ranking of the CC and YY pairs in both models and the ranking of the CC and MM pairs in the MSG2 model depend on feedback coefficients. For inflations in both models, the CC regime pair dominates the II regime pair for all admissible values of the feedback coefficient, but the ranking of the CC, YY, and MM regime pairs depends on feedback coefficients.

Finally, for asymmetric goods-demand shocks with PIA in the MSG2 model, the CC pair dominates the II pair for employments, but the ranking of the CC pair relative to the MM and YY pairs for employments and the ranking of the CC pair relative to all the other pairs for inflations depend on feedback coefficients as shown in Figure 28. The SSDs for inflation first falls and then rises as the feedback coefficient is increased, in large part because the dollar appreciates more in real terms. The results for an asymmetric goods-demand shock with PIA in the Phillips model in Figure 27 are qualitatively the same as those in the MSG2 model.

Productivity shocks. The effects of a symmetric reduction in productivity, an increase in $x_{s,0}$, are shown in Figure 39. The Π and N schedules shift from Π_0 to Π_1 and N_0 to N_1, in period 0 and then back to Π_0 and N_0 in period 1. The IC schedule shifts from IC_0 to IC_0'. The point of intersection between the Π_1 and N_1 schedules, point d, may lie above the horizontal line through point a or below it. For the parameters used in the simulations, point d lies below this line as shown in Figure 39. The stationary equilibrium remains at point a.

The equilibrium in period 0 must lie on the IC'_0 schedule below the intersection with the Π_1 schedule, and the equilibrium in period 1 must lie on SP_0. In the case of productivity shocks under the CC regime pair, these restrictions do not imply a path with unique qualitative properties for $\pi_{s,0}$ and $n_{s,0}$.

By experimenting with the phase diagram, it can be confirmed that $n_{s,1}$ must always be above $\hat{n}_{s,1} = \hat{n}_{s,-1}$, that $n_{s,0}$ may be above or below $\hat{n}_{s,1}$, and that if $n_{s,0}$ is above $\hat{n}_{s,1}$, it may be above or below $n_{s,1}$. That all of these configurations are possible can be verified by comparing the coefficients on $x_{s,0}$ in equations (75) and (76).

The case in which $n_{s,0}$ is below $\hat{n}_{s,-1}$ is illustrated in Figure 39. In this case, the economy jumps to a point like point b in period 0. In period 1 it moves to point c on SP_0, and over time it moves up SP_0 to the stationary equilibrium at a. $\pi_{s,t}$ falls below $\hat{\pi}_{s,-1}$ in period 0, falls farther below $\hat{\pi}_{s,1} = \hat{\pi}_{s,-1}$ in period 1, and rises back to $\hat{\pi}_{s,1}$ over time. $n_{s,t}$ falls below $\hat{n}_{s,-1}$ in period 0, rises above $\hat{n}_{s,1} = \hat{n}_{s,-1}$ in period 1, and falls back to $\hat{n}_{s,1}$ over time.

In the limit with full instrument adjustment ($\tau \rightarrow \infty$), the Π schedule and the stable path both approach a line with a slope of negative one as can be confirmed by inspection of equations (65) and (66). In this case, in period 0 the economy jumps to a point on the IC_0' schedule directly above the intersection of the equivalent Π_0 and SP_0 schedules with the N_0 schedule, jumps to a point on the equivalent Π_0 and SP_0 schedule to the southeast of point a in period 1, and then moves back up along the equivalent Π_0 and SP_0 schedules to point a over time.

As for the other shocks, since $w_{s,0} = \hat{w}_{s,-1} = 2\omega, n_{s,0}$ remains equal to zero from the nominal income equals the wage bill minus 2ω condition, equation (39). Since $n_{s,0}$ remains equal to zero, $n_{s,1}$ must rise above baseline. Since $w_{s,0}$ is predetermined, $p_{s,0}$ must rise by the amount of the productivity shock from the marginal productivity condition, equation (35). Since $n_{s,1}$ rises, $y_{s,1}$ rises and $p_{s,1}$ falls by the same amount. Since $w_{s,0} = \hat{w}_{s,-1} = 2\omega, n_{s,0} = 0, p_{s,1}$ falls, and $p_{s,0}$ rises, $w_{s,1}$ must fall from the Phillips curve, equation (38).

Now consider what happens from period 1 on. $n_{s,t}$ falls back toward $\hat{n}_{s,1}$ according to equation (43). It follows immediately that $y_{s,t}$ falls back to baseline and that $w_{s,t} - p_{s,t}$ and $\pi_{s,t}$ rise back to baseline.

With FIA the employment paths under the CC and YY regime pairs are identical, so there are the same two important differences between the results for employments in the Contract model and those in the Phillips model for the CC regime pair as there are for the YY pair.

There is an important difference between the results for symmetric productivity decreases under the CC regime pair and the results under all other regime pairs. Under the CC pair wages and output prices are permanently affected by the productivity decreases. For example, according to equation (67), the output price in period $T, p_{s,T}$, is given by the output price in the period before the shock, $p_{s,-1}$ and the sum of all the inflations between period 0 when the shock occurs and period T. We assume that $p_{s,-1}$ is equal to zero for convenience, but in general the sum of inflations is not equal to zero for productivity decreases under the CC regime pair.

Simulation results for the effects of symmetric and asymmetric productivity shocks are presented in Figures 30 through 37. The results for a symmetric decrease in productivity with FIA in the Phillips model are shown in Figure 30. The paths for US employment and US inflation under the CC pair are qualitatively the same as the paths for $n_{s,t}$ and $\pi_{s,t}$ in Figure 39. As we explain above, in contrast to what happens under the other regime pairs, under the CC regime pair US wages and the US output price are permanently changed by temporary productivity decreases. For employments, the MM pair dominates the equivalent CC and YY pairs which dominate the II pair. For inflations, the CC pair dominates all other pairs. The results for an asymmetric productivity shock with FIA in the Phillips model in Figure 32 are similar to those for a symmetric shock except that for an asymmetric shock the real exchange rate is affected.

There are several differences between the results for a symmetric decrease in productivity with FIA for the MSG2 model shown in Figure 31 and those for the

Phillips model. Wages in period 2 and nominal interest rates in period 1 move in opposite directions in the two models. For both employments and inflations, the CC pair dominates all other pairs. The results for an asymmetric productivity shock with FIA in the MSG2 model in Figure 33 are similar to those for a symmetric productivity shock except that for an asymmetric shock the real exchange rate is affected.

The results for the effects of symmetric decreases in productivity with PIA in the Phillips model and in the MSG2 model are shown in Figures 34 and 35, respectively. The results for the two models are different in many respects. For employments, in the Phillips model the rankings of the CC pair relative to the II, MM, and YY pairs depend on feedback coefficients, but in the MSG2 model the CC pair dominates the II, MM, and YY pairs for all values of the feedback coefficients. For inflations, in both the Phillips and MSG2 models the ranking of the CC pair relative to the MM and YY pairs and in the Phillips model the ranking of the CC pair relative to the II pair depend on feedback coefficients, but in the MSG2 model the CC pair dominates the II pair for all values of the feedback coefficient τ. Also, for the CC pair just as for the YY pair, as the feedback coefficient is increased, the SSDs for employment first falls and then rises in the Phillips model but falls monotonically in the MSG2 model.

Once again, the results for the effects of an asymmetric productivity shock with PIA in the Phillips and MSG2 models are strikingly different. In the results for the Phillips model, not only the II pair but also the MM and YY pairs dominate the CC pair for employments and inflations for a wide range of feedback coefficients as shown in Figure 36. In contrast, in the results for the MSG2 model in Figure 37, the CC pair dominates the II pair for employments and inflations no matter what the value of the feedback coefficient and dominates the MM and YY pairs for a wide range of feedback coefficients. In the Phillips model the results for symmetric and asymmetric productivity shocks are also strikingly different. For an asymmetric shock the ranking of the CC pair for both employments and inflations depends on feedback coefficients just as it does for a symmetric shock, but for employments the CC pair is best instead of worst for low feedback coefficients.

Conclusions

In this paper we compare four basic monetary policy regimes for open economies. We consider matched regime combinations that comprise identical regimes in all regions. Under each regime, each region uses the interest rate as the instrument of monetary policy. Either the interest rate is kept constant (II regime), or it is adjusted in response to deviations between the desired and actual values for one of three intermediate targets: the money supply (MM regime), nominal income (YY regime), or the sum of inflation and output (CC regime). We rank the outcomes under the four regime combinations for three types of temporary shocks

– money-demand shocks, goods-demand shocks, and productivity shocks – with each type having two variants – symmetric shocks and asymmetric shocks.

We focus on two factors that affect the ranking of regimes and that have received less attention than they deserve. The first is the degree of instrument adjustment: the interest rate may be adjusted to eliminate – full instrument adjustment (FIA) – or only to reduce – partial instrument adjustment (PIA) – deviations between desired and actual values for intermediate targets. The second is the degree of wage persistence: wages in a period may depend only on the output prices expected to prevail in that period (no wage persistence), or they may also depend to some extent on wages and excess demands for labor in the previous period (some degree of wage persistence).

We present results from three models: the Contract model, the Phillips model, and the MSG2 model. The Contract model and the Phillips model are versions of a single workhorse model of two symmetric regions obtained by imposing two different wage hypotheses: the Contract hypothesis (no wage persistence) and the Phillips hypothesis (some degree of wage persistence). We obtain some analytical results for the Contract and Phillips models, and we illustrate and extend these results with simulation analysis.

The MSG2 model is a fully-specified, dynamic, general-equilibrium model that incorporates intertemporal optimization and rational expectations. The MSG2 model and the workhorse model embody the same general view of wage and price determination, and in both models current income variables play an important role in determining spending. However, the MSG2 model has intertemporal budget constraints, careful treatment of stocks and flows, rich dynamics based on adjustment costs, considerable disaggregation, and different parameters among regions.

We obtain one result that is very general and, in part, predictable. For all money-demand shocks the II, YY, and CC regime combinations dominate the MM regime combination no matter what the degree of instrument adjustment and wage persistence. Under the II, YY, and CC combinations, employments, outputs, and inflations remain unaffected in all the models with both FIA and PIA, but under the MM combination they do not.

For shocks other than money-demand shocks, the results are more ambiguous. However, a few generalizations can be made. The rankings often depend on the source of shocks to the economy and the ultimate target of policy as well as on the degrees of instrument adjustment and wage persistence. Definite rankings can be found more often for employments than for inflations. The rankings for outputs are frequently different from those for employments with productivity shocks.

As a base case, we compare regime combinations with FIA and no wage persistence. We use the Contract model in which wages are set each period so that expected employments are equal to their full employment values. In this base case, we obtain a number of clear-cut results. The equivalent YY and CC regimes are best for employments for both variants of goods-demand and productivity shocks and for inflations for symmetric goods-demand shocks. Employments and inflations are unaffected under these regime pairs for these shocks. In the analytical results for inflations, the rankings for asymmetric goods-demand shocks and for both variants of productivity shocks depend on parameter values.

As a first departure from the base case, we relax the assumption of FIA. With PIA in the Contract model, all the rankings of regime pairs for both variants of goods-demand and productivity shocks depend on the size of the feedback coefficients that govern the size of the interest-rate response to deviations of the intermediate target variables from their desired values.

As a second departure from the base case, we relax the assumption of no wage persistence. We use the Phillips and MSG2 models in which wages are determined according to expectations-augmented Phillips curves that embody the natural rate hypothesis.

With FIA, some of the results with wage persistence are the same as those without it, but others are different. In both models, the YY and CC regimes are best for employments for both variants of goods-demand shocks and for inflations for symmetric goods-demand shocks. In the Phillips model, employments and inflations are completely unaffected under these regime pairs for these shocks.

We obtain a surprising analytical and simulation result in the Phillips model with FIA. In contrast to the familiar result of Poole (1970), for symmetric goods-demand shocks the II pair dominates the MM pair for some parameter values. It is not yet clear whether this result is empirically relevant. One indication that it may not be is that in the simulation results from the MSG2 model, the MM pair dominates the II pair.

It can be shown analytically that for the Phillips model, the rankings for inflations for asymmetric goods-demand shocks and for both employments and inflations for both variants of productivity shocks depend on parameter values.

With PIA and wage persistence, as is logical given our other results, most of the rankings of regimes for goods-demand and productivity shocks for both the Phillips model and the MSG2 model depend on the size of the feedback coefficients.

The MSG2 model reflects the added complication that results when recent advances in intertemporal macroeconomics are incorporated into an empirically-based model. In many cases the results from the MSG2 model are similar to those from either the Contract model or the Phillips model or both in qualitative terms. However, there are some important qualitative differences. Furthermore, even when the results of the MSG2 model are similar to those from one or both of the other models in qualitative terms, the results from the MSG2 model are of particular interest because it is empirically based.

The main contribution of our analysis is the demonstration that the ranking of monetary policy regimes frequently depends on two often neglected factors: the degree of instrument adjustment and the degree of wage persistence. Two byproducts are especially important. The first is the confirmation that the ranking of regime pairs depends on two familiar factors: the source of shocks to the economy and the ultimate target of policy. The second is the additional support provided for the increasingly widely-shared view that the price level is determinate under fairly general conditions when the interest rate is the instrument of monetary policy.

We have demonstrated that it is not useful to view the choice among policy regimes in open economies as a choice between fixed and flexible exchange rates. A requirement that the exchange rate must remain fixed or must be allowed to change is not by itself a complete specification of a monetary policy-regime combination. For all the asymmetric shocks all of the regime combinations lead to movements in the exchange rate, but different regime combinations have different implications for all variables including the exchange rate. To have a complete specification of a regime combination, it is necessary to specify a regime for each region as we have done in this paper.

Our results have an important implication for future research. In comparisons of monetary policy regimes based on econometric models, it is common practice to postulate a small number of PIA regimes each with a different intermediate target and an arbitrarily-chosen adjustment coefficient. Our result that the ranking of regimes frequently depends on the degree of instrument adjustment suggests that the results of such comparisons may depend on the particular adjustment coefficients chosen. We believe that it is better to compare regimes in which the adjustment coefficient for each intermediate target is chosen optimally as in McKibbin (1993). Proceeding in this way guarantees that the best version of each regime is ranked against the best version of every other regime, at least for the econometric model in which the study is being conducted.

Table 1:
The Workhorse Model

Production functions

$$y = \alpha n - x, \qquad \overset{*}{y} = \alpha \overset{*}{n} - \overset{*}{x}, \tag{1}$$

Real-product wage equals marginal product of labor conditions

$$w - p = \omega - (1-\alpha)n - x, \qquad \overset{*}{w} - \overset{*}{p} = \omega - (1-\alpha)\overset{*}{n} - \overset{*}{x}, \qquad \omega = ln\alpha \tag{2}$$

Consumer price indices

$$q = (1-\gamma)p + \gamma(e + \overset{*}{p}) = p + \gamma z, \qquad \overset{*}{q} = \gamma(p - e) + (1-\gamma)\overset{*}{p} = \overset{*}{p} - \gamma z, \tag{3}$$

Real exchange rate

$$z = e + \overset{*}{p} - p, \tag{4}$$

Open interest parity

$$i = \overset{*}{\imath} + e_{+1|} - e, \tag{5}$$

Real interest rates

$$r = i - q_{+1|} + q, \qquad \overset{*}{r} = \overset{*}{\imath} - \overset{*}{q}_{+1|} + \overset{*}{q}, \tag{6}$$

Money-market equilibrium conditions

$$m = p + \phi y - \lambda i + v, \qquad \overset{*}{m} = \overset{*}{p} + \phi \overset{*}{y} - \lambda \overset{*}{\imath} + \overset{*}{v}, \tag{7}$$

Goods-market equilibrium conditions

$$- \quad [1 - (1-\gamma)\epsilon]y + \gamma\epsilon\overset{*}{y} - (1-\gamma)\nu r - \gamma\nu\overset{*}{r} + \delta z + u = 0,$$

$$\gamma\epsilon y - [1 - (1-\gamma)\epsilon]\overset{*}{y} - \gamma\nu r - (1-\gamma)\nu\overset{*}{r} - \delta z + \overset{*}{u} = 0. \tag{8}$$

Table 2:
Definitions of Variables and Parameters

$y, \overset{*}{y}$	outputs	z	real exchange rate
$n, \overset{*}{n}$	employments	e	nominal exchange rate
$x, \overset{*}{x}$	productivity shocks	$i, \overset{*}{i}$	nominal interest rates
$w, \overset{*}{w}$	nominal wages	$r, \overset{*}{r}$	real interest rates
$p, \overset{*}{p}$	output prices	$v, \overset{*}{v}$	money demand shocks
$q, \overset{*}{q}$	consumer price levels (CPIs)	$u, \overset{*}{u}$	goods demand shocks
$\hat{i}, \hat{\overset{*}{i}}$	unconditional means of i and $\overset{*}{i}$	$\hat{m}, \hat{\overset{*}{m}}$	desired money supplies
$\widehat{\overline{p+y}}, \widehat{\overline{\overset{*}{p}+\overset{*}{y}}}$	desired nominal incomes	$\widehat{\overline{\pi+y}}, \widehat{\overline{\overset{*}{\pi}+\overset{*}{y}}}$	desired sums $\pi + y$ and $\overset{*}{\pi} + \overset{*}{y}$

$\pi, \overset{*}{\pi}$ output price inflations $(p - p_{-1}, \overset{*}{p} - \overset{*}{p}_{-1}, p_{-1} = \overset{*}{p}_{-1} = 0)$

α	elasticity of output with respect to labor
γ	marginal and average propensities to import out of spendings
δ	absolute value of elasticity of output demands with respect to the real exchange rate with incomes measured in US good changing (c.f. η)
ϵ	marginal propensity to consume out of incomes
η	absolute value of elasticity of output demands with respect to the real exchange rate with incomes measured in US good constant (c.f. δ)
ν	semi-elasticity of spending with respect to the real interest rate
ϕ	elasticity of demand for money with respect to income
λ	semi-elasticity of demand for money with respect to the interest rate
θ	increase in wages induced by increase in gap between actual and natural employments under the Phillips hypothesis
β	increase in interest rate induced by increase in gap between current and target money supplies
ρ	increase in interest rate induced by increase in gap between current and target nominal incomes
τ	increase in interest rate induced by increase in gap between current and target sums of real output and inflation

Table 3:
Monetary Policy Reaction Functions for Regime Pairs

<u>MM Regime Pair</u>

$$i - \hat{i} = \beta(m - \hat{m}), \qquad \hat{i} = \hat{m} = 0, \qquad \overset{*}{i} - \hat{\overset{*}{i}} = \beta(\overset{*}{m} - \hat{\overset{*}{m}}), \qquad \hat{\overset{*}{i}} = \hat{\overset{*}{m}} = 0, \tag{9}$$

<u>YY Regime Pair</u>

$$\begin{aligned} i - \hat{i} &= \rho(p + y - \widehat{\overline{p+y}}), \qquad &\widehat{\overline{p+y}} &= 0, \\ \overset{*}{i} - \hat{\overset{*}{i}} &= \rho(\overset{*}{p} + \overset{*}{y} - \hat{\overset{*}{\overline{p+y}}}), \qquad &\hat{\overset{*}{\overline{p+y}}} &= 0, \end{aligned} \tag{10}$$

<u>CC Regime Pair</u>

$$\begin{aligned} i - \hat{i} &= \tau(\pi + y - \widehat{\overline{\pi+y}}), \qquad &\widehat{\overline{\pi+y}} &= 0, \\ \overset{*}{i} - \hat{\overset{*}{i}} &= \tau(\overset{*}{\pi} + \overset{*}{y} - \hat{\overset{*}{\overline{\pi+y}}}), \qquad &\hat{\overset{*}{\overline{\pi+y}}} &= 0, \end{aligned} \tag{11}$$

Table 4:
Alternative Wage Hypotheses

<u>The Contract Hypothesis</u>

$$w_t - p_{t|t-1} = \omega, \qquad \overset{*}{w}_t - \overset{*}{p}_{t|t-1} = \omega, \tag{12}$$

<u>The Phillips Hypothesis</u>

$$w_{t+1} - w_t = \theta n_t + p_{t+1|t} - p_t, \qquad \overset{*}{w}_{t+1} - \overset{*}{w}_t = \theta \overset{*}{n}_t + \overset{*}{p}_{t+1|t} - \overset{*}{p}_t, \tag{13}$$

<u>Wage Hypothesis for US in MSG2 Model</u>

$$w_{t+1} - w_t = .25n_t + .4(q_{t+1|t} - q_t) + .6(q_t - q_{t-1}). \tag{14}$$

Table 5:
Intermediate Results

$$z_{+1|} = p_{+1|} = q_{+1|} = \overset{*}{p}_{+1|} = \overset{*}{q}_{+1|} = e_{+1|} = 0, \tag{15}$$

$$w = \overset{*}{w} = \omega, \tag{16}$$

$$z = -(i_d + p_d), \tag{17}$$

$$r = (1-\gamma)(i+p) + \gamma(\overset{*}{i} + \overset{*}{p}), \quad \overset{*}{r} = \gamma(i+p) + (1-\gamma)(\overset{*}{i} + \overset{*}{p}), \tag{18}$$

$$r_s = i_s + p_s, \tag{19}$$

$$r_d = (1-2\gamma)(i_d + p_d), \tag{20}$$

$$q = p - \gamma(i_d + p_d), \qquad \overset{*}{q} = \overset{*}{p} + \gamma(i_d + p_d), \tag{21}$$

$$q_s = p_s, \tag{22}$$

$$q_d = (1-2\gamma)p_d - 2\gamma i_d. \tag{23}$$

Table 6:
The Models for Sums and Differences under the Contract Hypothesis

The Model for Sums

$$-(1-\epsilon)y_s - \nu(i_s + p_s) + u_s = 0, \qquad (AD_s \text{ schedule}) \qquad (24)$$

$$p_s + \phi y_s - \lambda i_s + v_s - m_s = 0, \qquad (M_s \text{ schedule}) \qquad (25)$$

$$-(1-\alpha)y_s + \alpha p_s - x_s = 0, \qquad (AS_s \text{ schedule}) \qquad (26)$$

$$p_s + y_s = \overline{p+y}_s, \qquad (Y_s \text{ schedule}) \qquad (27)$$

$$p_s + y_s = n_s, \qquad (28)$$

The Model for Differences

$$-[1-(1-2\gamma)\epsilon]y_d - [(1-2\gamma)^2\nu + 2\delta](i_d + p_d) + u_d = 0, \qquad (AD_d \text{ schedule}) \qquad (29)$$

$$p_d + \phi y_d - \lambda i_d + v_d - m_d = 0, \qquad (M_d \text{ schedule}) \qquad (30)$$

$$-(1-\alpha)y_d + \alpha\sigma p_d - x_d = 0, \qquad (AS_d \text{ schedule}) \qquad (31)$$

$$p_d + y_d = \overline{p+y}_d, \qquad (Y_d \text{ schedule}) \qquad (32)$$

$$p_d + y_d = n_d. \qquad (33)$$

Table 7: First Period Impact of Symmetric and Asymmetric Money Demand Shocks - Contracts Hypothesis (FIA)

		Symmetric				Asymmetric			
		MM	II	YY	CC	MM	II	YY	CC
U.S. Economy									
Output	%	-2.93	0	0	0	-3.68	0	0	0
CPI Inflation	D	-1.26	0	0	0	-2.88	0	0	0
Output Price	%	-1.26	0	0	0	-1.58	0	0	0
Nominal Interest Rate	D	7.27	0	0	0	5.92	0	0	0
Real Interest Rate	D	6.01	0	0	0	3.04	0	0	0
Nominal Wage	%	0	0	0	0	0	0	0	0
Employment	%	-4.19	0	0	0	-5.26	0	0	0
Money	%	0	10	10	10	0	10	10	10
Nominal Exchange Rate ($/R)	%	0	0	0	0	-11.84	0	0	0
Real Exchange Rate ($/R)	%	0	0	0	0	-8.68	0	0	0
ROECD Economy									
Output	%	-2.93	0	0	0	3.68	0	0	0
CPI Inflation	D	-1.26	0	0	0	2.88	0	0	0
Output Price	%	-1.26	0	0	0	1.58	0	0	0
Nominal Interest Rate	D	7.27	0	0	0	-5.92	0	0	0
Real Interest Rate	D	6.01	0	0	0	-3.04	0	0	0
Nominal Wage	%	0	0	0	0	0	0	0	0
Employment	%	-4.19	0	0	0	5.26	0	0	0
Money	%	0	10	10	10	0	-10	-10	-10

key: % is percent deviation from unchanged baseline;
D is change from unchanged baseline (in percentage points)

Table 8: First Period Impact of Symmetric and Asymmetric Goods Demand Shocks - Contracts Hypothesis (FIA)

		Symmetric				Asymmetric			
		MM	II	YY	CC	MM	II	YY	CC
U.S. Economy									
Output	%	11.73	20.17	0	0	5.92	12.49	0	0
CPI Inflation	D	5.03	8.65	0	0	-1.39	3.75	-6.02	-6.02
Output Price	%	5.03	8.65	0	0	2.54	5.35	0	0
Nominal Interest Rate	D	20.94	0	50	50	10.57	0	20.08	20.08
Real Interest Rate	D	25.96	8.65	50	50	9.17	3.75	14.06	14.06
Nominal Wage	%	0	0	0	0	0	0	0	0
Employment	%	16.75	28.82	0	0	8.45	17.85	0	0
Money	%	0	28.82	-40	-40	0	17.85	-16.06	-16.06
Nominal Exchange Rate ($/R)	%	0	0	0	0	-21.14	0	-40.16	-40.16
Real Exchange Rate ($/R)	%	0	0	0	0	-26.21	-10.71	-40.16	-40.16
ROECD Economy									
Output	%	11.73	20.17	0	0	-5.92	-12.49	0	0
CPI Inflation	D	5.03	8.65	0	0	1.39	-3.75	6.02	6.02
Output Price	%	5.03	8.65	0	0	-2.54	-5.35	0	0
Nominal Interest Rate	D	20.94	0	50	50	-10.57	0	-20.08	-20.08
Real Interest Rate	D	25.96	8.65	50	50	-9.17	-3.75	-14.06	-14.06
Nominal Wage	%	0	0	0	0	0	0	0	0
Employment	%	16.75	28.82	0	0	-8.45	-17.85	0	0
Money	%	0	28.82	-40	-40	0	-17.85	16.06	16.06

key: % is percent deviation from unchanged baseline;
D is change from unchanged baseline (in percentage points)

Table 9: First Period Impact of Symmetric and Asymmetric Productivity Shocks - Contracts Hypothesis (FIA)

		Symmetric				Asymmetric			
		MM	II	YY	CC	MM	II	YY	CC
U.S. Economy									
Output	%	-7.54	-5.76	-10	-10	-9.47	-8.89	-10	-10
CPI Inflation	D	11.06	11.82	10	10	6.88	7.33	6.46	6.46
Output Price	%	11.06	11.82	10	10	10.23	10.48	10	10
Nominal Interest Rate	D	4.4	0	10.5	20.5	0.94	0	1.79	11.79
Real Interest Rate	D	15.45	11.82	20.5	20.5	7.82	7.33	8.25	8.25
Nominal Wage	%	0	0	0	0	0	0	0	0
Employment	%	3.52	6.05	0	0	0.75	1.59	0	0
Money	%	0	6.05	-8.4	-16.4	0	1.59	-1.43	-9.43
Nominal Exchange Rate ($/R)	%	0	0	0	0	-1.88	0	-3.57	-3.57
Real Exchange Rate ($/R)	%	0	0	0	0	-22.33	-20.95	-23.57	-23.57
ROECD Economy									
Output	%	-7.54	-5.76	-10	-10	9.47	8.89	10	10
CPI Inflation	D	11.06	11.82	10	10	-6.88	-7.33	-6.46	-6.46
Output Price	%	11.06	11.82	10	10	-10.23	-10.48	-10	-10
Nominal Interest Rate	D	4.4	0	10.5	20.5	-0.94	0	-1.79	-11.79
Real Interest Rate	D	15.45	11.82	20.5	20.5	-7.82	-7.33	-8.25	-8.25
Nominal Wage	%	0	0	0	0	0	0	0	0
Employment	%	3.52	6.05	0	0	-0.75	-1.59	0	0
Money	%	0	6.05	-8.4	-16.4	0	-1.59	1.43	9.43

key: % is percent deviation from unchanged baseline;
D is change from unchanged baseline (in percentage points)

Table 10:
The Model for Sums under the Phillips Hypothesis

The Full Model

$$y_{s,t} = \alpha n_{s,t} - x_{s,t}, \tag{34}$$

$$w_{s,t} - p_{s,t} = 2\omega - (1-\alpha) n_{s,t} - x_{s,t}, \tag{35}$$

$$p_{s,t} + \phi y_{s,t} - \lambda i_{s,t} + v_{s,t} - m_{s,t} = 0, \tag{36}$$

$$-(1-\epsilon) y_{s,t} - \nu[i_{s,t} - (p_{s,t+1} - p_{s,t})] + u_{s,t} = 0, \tag{37}$$

$$w_{s,t+1} - w_{s,t} = \theta n_{s,t} + p_{s,t+1} - p_{s,t}, \tag{38}$$

The Nominal Income Equation

$$p_{s,t} + y_{s,t} = n_{s,t} + w_{s,t} - 2\omega, \tag{39}$$

The *MM* Regime Pair

$$i_{s,t} - \hat{i}_s = \beta(m_{s,t} - \hat{m}_s), \qquad \hat{i}_s = \hat{m}_s = 0, \tag{40}$$

The *YY* Regime Pair

$$i_{s,t} - \hat{i}_s = \rho(p_{s,t} + y_{s,t} - \widehat{\overline{p+y}}_s), \qquad \widehat{\overline{p+y}}_s = 0, \tag{41}$$

The *CC* Regime Pair

$$i_{s,t} - \hat{i}_s = \tau(\pi_{s,t} + y_{s,t} - \widehat{\overline{\pi+y}}_s), \qquad \widehat{\overline{\pi+y}}_s = 0,$$

$$\pi_{s,t} = p_{s,t} - p_{s,t-1}, \qquad p_{s,-1} = 0, \tag{42}$$

The Employment Change Equation

$$\Delta n_{s,t+1} = n_{s,t+1} - n_{s,t} = -\left[\frac{\theta}{1-\alpha}\right] n_{s,t} - \left[\frac{1}{1-\alpha}\right](x_{s,t+1} - x_{s,t}). \tag{43}$$

Table 11:
The II and MM Regime Pairs

Intermediate Interest Rate Equation

$$i_{s,t} = \left[\frac{\beta}{\beta\lambda+1}\right] p_{s,t} + \left[\frac{\beta\phi}{\beta\lambda+1}\right] y_{s,t} + \left[\frac{\beta}{\beta\lambda+1}\right] v_{s,t}, \tag{44}$$

Wage Change Equation

$$\begin{aligned}\Delta w_{s,t+1} &= w_{s,t+1} - w_{s,t} = \left[\frac{\beta}{\beta\lambda+1}\right] w_{s,t} + \Omega n_{s,t} + \left[\frac{\beta}{\beta\lambda+1}\right] v_{s,t} \\ &- \left[\frac{1}{\nu}\right] u_{s,t} - \left[\frac{1-\epsilon}{\nu} - \frac{\beta(1-\phi)}{\beta\lambda+1}\right] x_{s,t} - \left[\frac{\beta 2\omega}{\beta\lambda+1}\right],\end{aligned} \tag{45}$$

$$\Omega = \theta + \frac{(1-\epsilon)\alpha}{\nu} + \frac{\beta(1-\alpha+\phi\alpha)}{\beta\lambda+1}, \qquad \begin{aligned}&\Omega = \Omega^{MM} \text{ if } \beta \to \infty, \\ &\Omega = \Omega^{II} \text{ if } \beta \to 0,\end{aligned} \tag{46}$$

Stable Path

$$\left[\frac{\theta}{1-\alpha} + \frac{\beta}{\beta\lambda+1}\right](w_{s,t} - \hat{w}_{s,t}) = -\Omega(n_{s,t} - \hat{n}_{s,t}), \quad \hat{w}_{s,1} = 2\omega, \quad \hat{n}_{s,1} = 0, \tag{47}$$

$$\left|\frac{w_{s,t}}{n_{s,t}}\right|_{MM} - \left|\frac{w_{s,t}}{n_{s,t}}\right|_{II} = \left[\frac{1}{\Omega^{MM}\Omega^{II}}\right]\left[\frac{\alpha}{\lambda}\right]\left(\phi\left[\frac{\theta}{1-\alpha}\right] - \left[\frac{1-\epsilon}{\nu}\right]\right). \tag{48}$$

Requirements for Equilibrium

$$\left[\frac{\theta}{1-\alpha} + \frac{\beta}{\beta\lambda+1}\right](w_{s,1} - 2\omega) = -\Omega n_{s,1}, \tag{49}$$

$$n_{s,1} = \left[1 - \frac{\theta}{1-\alpha}\right] n_{s,0} + \left[\frac{1}{1-\alpha}\right] x_{s,0}, \tag{50}$$

$$w_{s,1} - 2\omega = \Omega n_{s,0} + \left[\frac{\beta}{\beta\lambda+1}\right] v_{s,0} - \left[\frac{1}{\nu}\right] u_{s,0} - \left[\frac{1-\epsilon}{\nu} - \frac{\beta(1-\phi)}{\beta\lambda+1}\right] x_{s,0}, \tag{51}$$

Table 11: continued

Solutions for the Effects of Temporary Shocks

$$\Omega\Delta n_{s,0} = -\left[\frac{\beta}{\beta\lambda+1}\right] v_{s,0} + \left[\frac{1}{\nu}\right] u_{s,0}$$

$$+ \left(\left[\frac{1-\epsilon}{\nu} - \frac{\beta(1-\phi)}{\beta\lambda+1}\right] - \Omega\left[\frac{\theta}{1-\alpha} + \frac{\beta}{\beta\lambda+1}\right]^{-1}\left[\frac{1}{1-\alpha}\right]\right) x_{s,0}, \qquad (52)$$

$$\Omega\Delta n_{s,1} = -\left[1-\frac{\theta}{1-\alpha}\right]\left[\frac{\beta}{\beta\lambda+1}\right] v_{s,0} + \left[1-\frac{\theta}{1-\alpha}\right]\left[\frac{1}{\nu}\right] u_{s,0}$$

$$+ \left(\left[1-\frac{\theta}{1-\alpha}\right]\left[\frac{1-\epsilon}{\nu} - \frac{\beta(1-\phi)}{\beta\lambda+1}\right] + \Omega\left[\frac{1}{1-\alpha}\right]\right) x_{s,0}, \qquad (53)$$

$$\Delta = \left[1+\frac{\beta}{\beta\lambda+1}\right]\left[\frac{\theta}{1-\alpha} + \frac{\beta}{\beta\lambda+1}\right]^{-1},$$

$$\Delta = \Delta^{MM} \text{ if } \beta \to \infty, \qquad \Delta = \Delta^{II} \text{ if } \beta \to 0, \qquad (54)$$

$$\nu\Omega^{MM}\Omega^{II}(n_{s,0}^{II} - n_{s,0}^{MM}) =$$

$$\left(\left[\frac{\theta}{1-\alpha} - 1\right]\left[\frac{1}{1+\lambda}\right]\left[\theta + \frac{(1-\epsilon)\alpha}{\nu}\right] + \left[\frac{\theta}{1-\alpha}\right]\left[\frac{1-\alpha+\phi\alpha}{\lambda}\right]\right) u_{s,0}. \qquad (55)$$

Table 12:
The YY Regime Piar

Wage Change Equation

$$\Delta w_{s,t+1} = \rho w_{s,t} + \Phi n_{s,t} - \left[\frac{1}{\nu}\right] u_{s,t} - \left[\frac{1-\epsilon}{\nu}\right] x_{s,t} - \rho 2\omega, \tag{56}$$

$$\Phi = \theta + \rho + \frac{(1-\epsilon)\alpha}{\nu}, \tag{57}$$

Stable Path

$$\left[\frac{\theta}{1-\alpha} + \rho\right] (w_{s,t} - \hat{w}_{s,t}) = -\ \Phi(n_{s,t} - \hat{n}_{s,t}), \quad \hat{w}_{s,1} = 2\omega, \quad \hat{n}_{s,1} = 0, \tag{58}$$

Requirements for Equilibrium

$$\left[\frac{\theta}{1-\alpha} + \rho\right] (w_{s,1} - 2\omega) = -\ \Phi n_{s,1}, \tag{59}$$

$$n_{s,1} = \left[1 - \frac{\theta}{1-\alpha}\right] n_{s,0} + \left[\frac{1}{1-\alpha}\right] x_{s,0}, \tag{60}$$

$$w_{s,1} - 2\omega = \Phi n_{s,0} - \left[\frac{1}{\nu}\right] u_{s,0} - \left[\frac{1-\epsilon}{\nu}\right] x_{s,0}, \tag{61}$$

Solutions for the Effects of Temporary Shocks

$$\Phi \Delta^{YY} n_{s,0} = \left[\frac{1}{\nu}\right] u_{s,0} + \left(\frac{1-\epsilon}{\nu} - \Phi \left[\frac{\theta}{1-\alpha} + \rho\right]^{-1} \left[\frac{1}{1-\alpha}\right]\right) x_{s,0}, \tag{62}$$

$$\begin{aligned} \Phi \Delta^{YY} n_{s,1} = & \left[1 - \frac{\theta}{1-\alpha}\right] \left[\frac{1}{\nu}\right] u_{s,0} \\ & + \left(\left[1 - \frac{\theta}{1-\alpha}\right] \left[\frac{1-\epsilon}{\nu}\right] + \Phi \left[\frac{1}{1-\alpha}\right]\right) x_{s,0}, \end{aligned} \tag{63}$$

$$\Delta^{YY} = (1+\rho) \left[\frac{\theta}{1-\alpha} + \rho\right]^{-1}. \tag{64}$$

Table 13:
The CC Regime Pair

Inflation Change Equation

$$\Delta\pi_{s,t+1} = (\tau - 1)\pi_{s,t} + \left[\tau + \frac{1-\epsilon}{\nu}\right] \alpha n_{s,t} - \left[\frac{1}{\nu}\right] u_{s,t} - \left[\tau + \frac{1-\epsilon}{\nu}\right] x_{s,t}, \quad (65)$$

Stable Path

$$\left[\frac{\theta}{1-\alpha} + \tau - 1\right] (\pi_{s,t} - \hat{\pi}_{s,t}) = -\left[\tau + \frac{1-\epsilon}{\nu}\right] \alpha (n_{s,t} - \hat{n}_{s,t}),$$
$$\hat{\pi}_{s,1} = \hat{n}_{s,1} = 0, \quad (66)$$

$$p_{s,T} = p_{s,-1} + \sum_{t=0}^{T} \pi_{s,t}, \quad (67)$$

Requirements for Equilibrium

$$\left[\frac{\theta}{1-\alpha} + \tau - 1\right] \pi_{s,1} = -\left[\tau + \frac{1-\epsilon}{\nu}\right] \alpha n_{s,1}, \quad (68)$$

$$n_{s,1} = \left[1 - \frac{\theta}{1-\alpha}\right] n_{s,0} + \left[\frac{1}{1-\alpha}\right] x_{s,0}, \quad (69)$$

$$\pi_{s,1} = \tau \pi_{s,0} + \left[\tau + \frac{1-\epsilon}{\nu}\right] \alpha n_{s,0} - \left[\frac{1}{\nu}\right] u_{s,0} - \left[\tau + \frac{1-\epsilon}{\nu}\right] x_{s,0}, \quad (70)$$

$$w_{s,0} - p_{s,0} = 2\omega - (1-\alpha) n_{s,0} - x_{s,0}, \qquad w_{s,0} = 2\omega, \quad (71)$$

$$\pi_{s,0} = p_{s,0} - p_{s,-1}, \qquad p_{s,-1} = 0, \quad (72)$$

$$\pi_{s,0} = (1-\alpha) n_{s,0} + x_{s,0}, \quad (73)$$

$$w_{s,1} = 2\omega + \theta n_{s,0} + \pi_{s,1}, \quad (74)$$

Solutions for the Effects of Temporary Shocks

$$\Delta^{CC} n_{s,0} = \left[\frac{1}{\nu}\right] u_{s,0}$$

$$+ \left(\frac{1-\epsilon}{\nu} - \left[\tau + \frac{1-\epsilon}{\nu}\right] \alpha \left[\frac{\theta}{1-\alpha} + \tau - 1\right]^{-1} \left[\frac{1}{1-\alpha}\right]\right) x_{s,0}, \tag{75}$$

$$\Delta^{CC} n_{s,1} = \left[1 - \frac{\theta}{1-\alpha}\right] \left[\frac{1}{\nu}\right] u_{s,0}$$

$$+ \left(\left[1 - \frac{\theta}{1-\alpha}\right] \left[\frac{1-\epsilon}{\nu}\right] + \left[\tau + \frac{(1-\epsilon)\alpha}{\nu}\right] \left[\frac{1}{1-\alpha}\right]\right) x_{s,0}, \tag{76}$$

$$\Delta^{CC} = \left[\tau + \frac{(1-\epsilon)\alpha}{\nu}\right]$$

$$+ \left[1 - \frac{\theta}{1-\alpha}\right] \left[\tau + \frac{1-\epsilon}{\nu}\right] \alpha \left[\frac{\theta}{1-\alpha} + \tau - 1\right]^{-1}. \tag{77}$$

Figure 1: Explanation of Schedules (Contract)

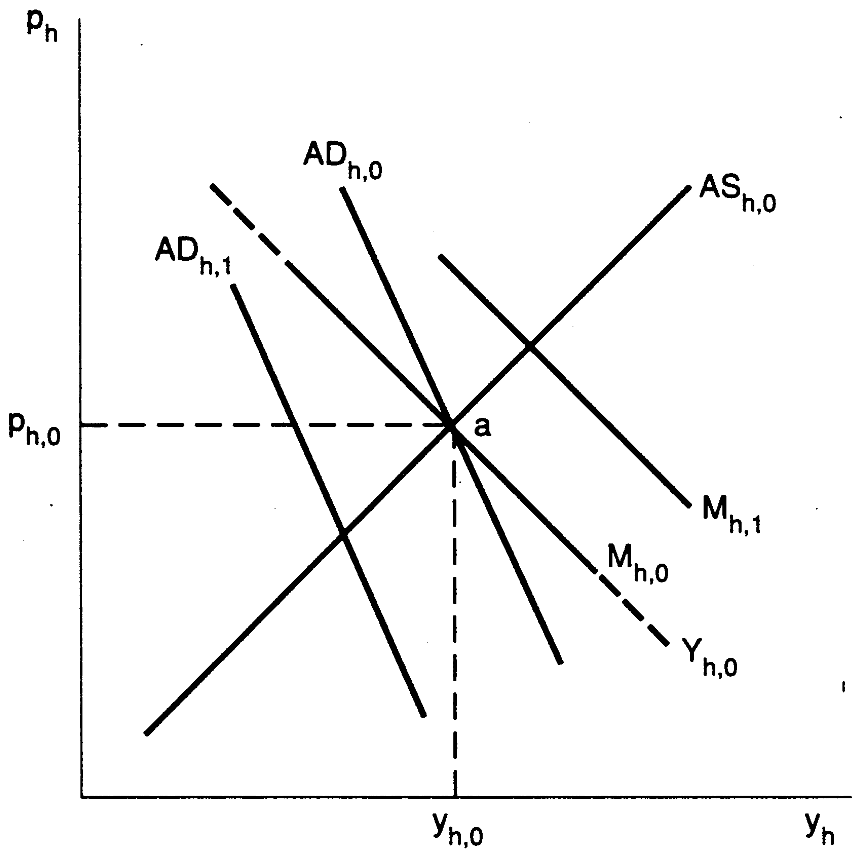


Figure 2: Money-Demand Shock (Contract)

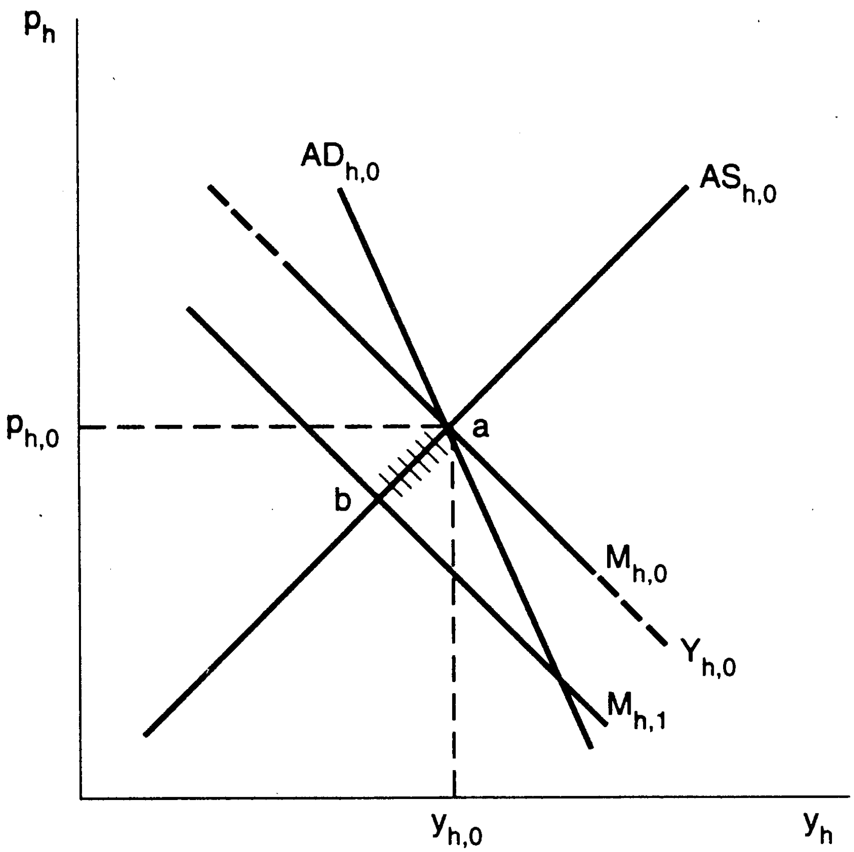


Figure 3. Symmetric Increase in Money Demand - Contract Hypothesis (PIA and FIA)

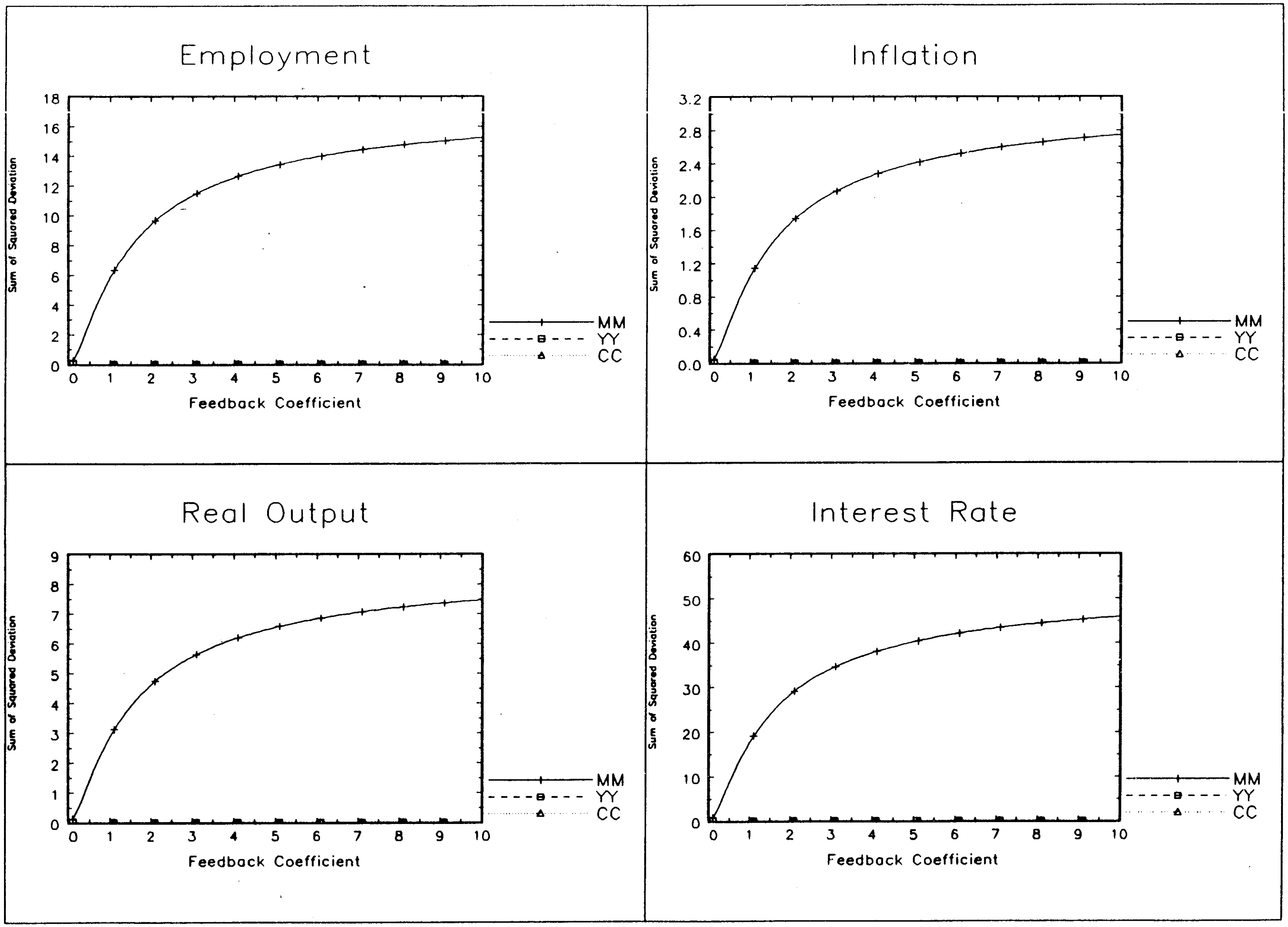


Figure 4. Asymmetric Money-Demand Shock (US Demand Increasing) - Contract Hypothesis (PIA and FIA)

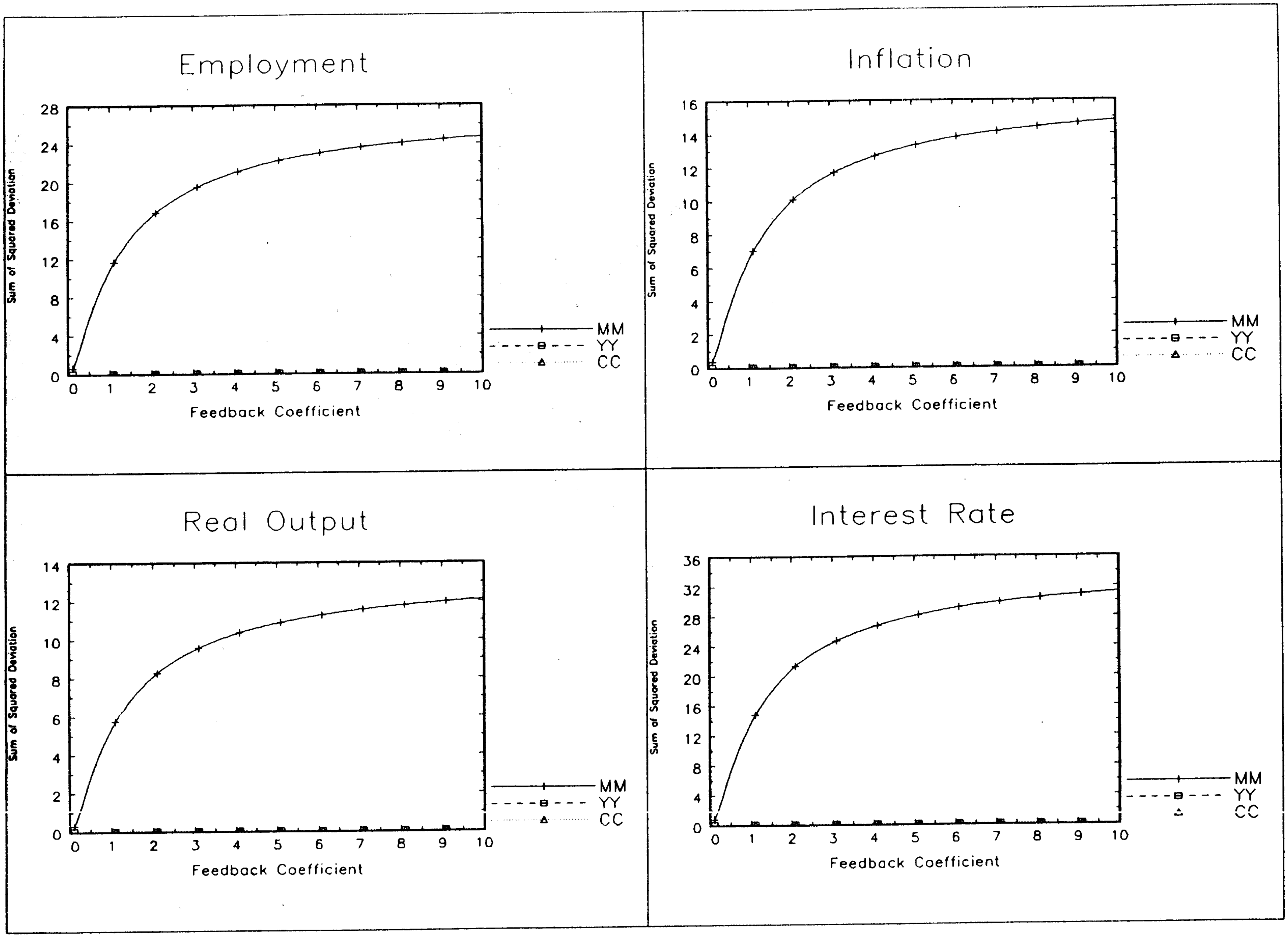


Figure 5: Goods-Demand Shock (Contract)

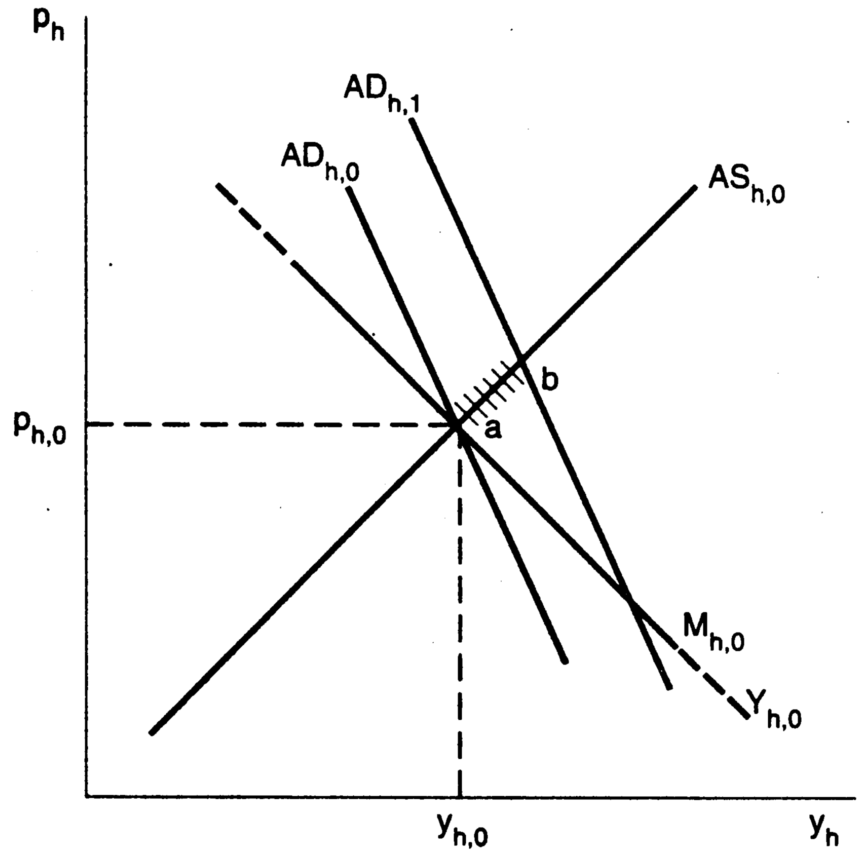


Figure 6. Symmetric Increase in Goods Demand - Contract Hypothesis (PIA and FIA)

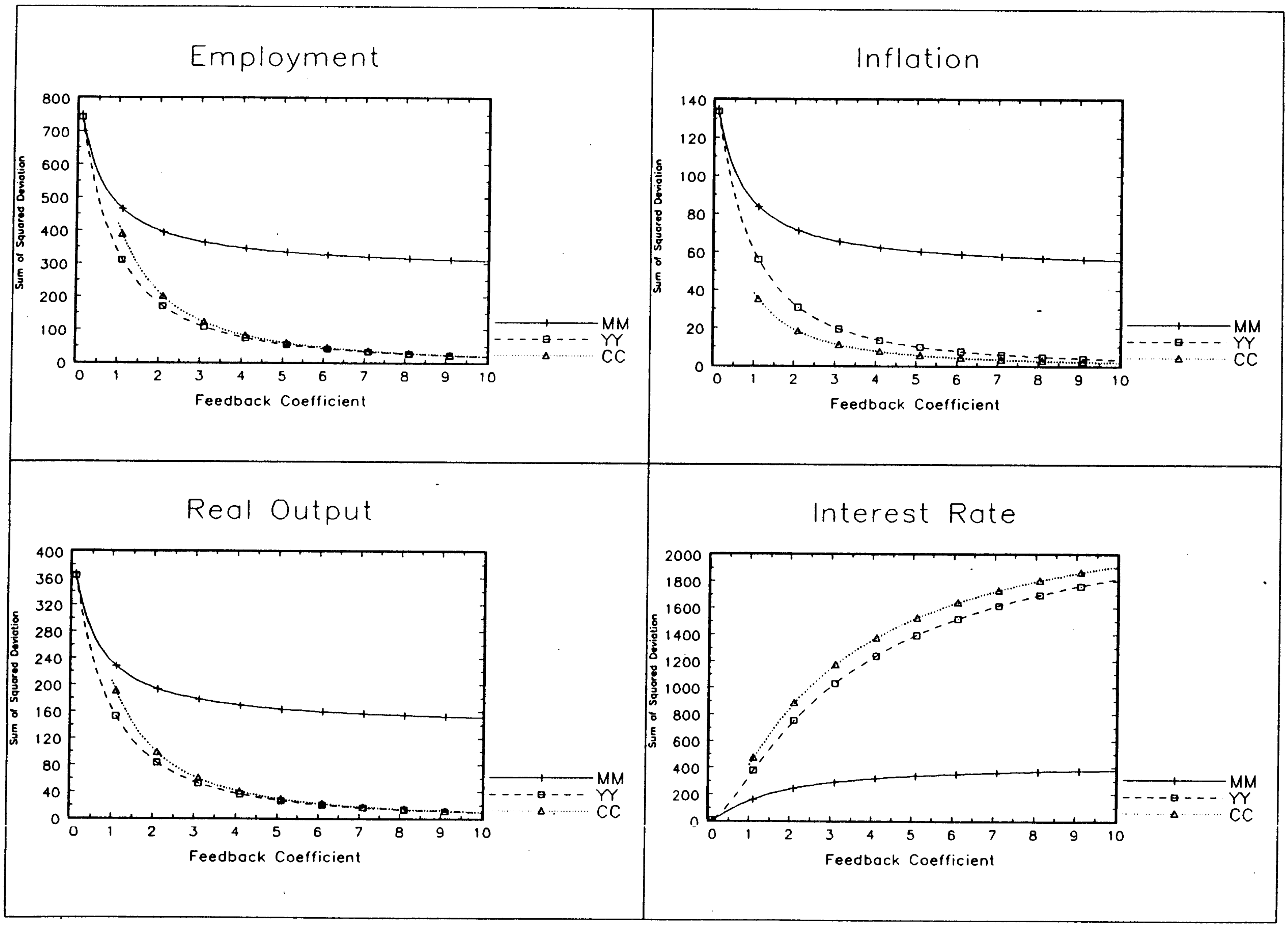


Figure 7. Asymmetric Goods-Demand Shock (US Demand Increasing) - Contract Hypothesis (PIA and FIA)

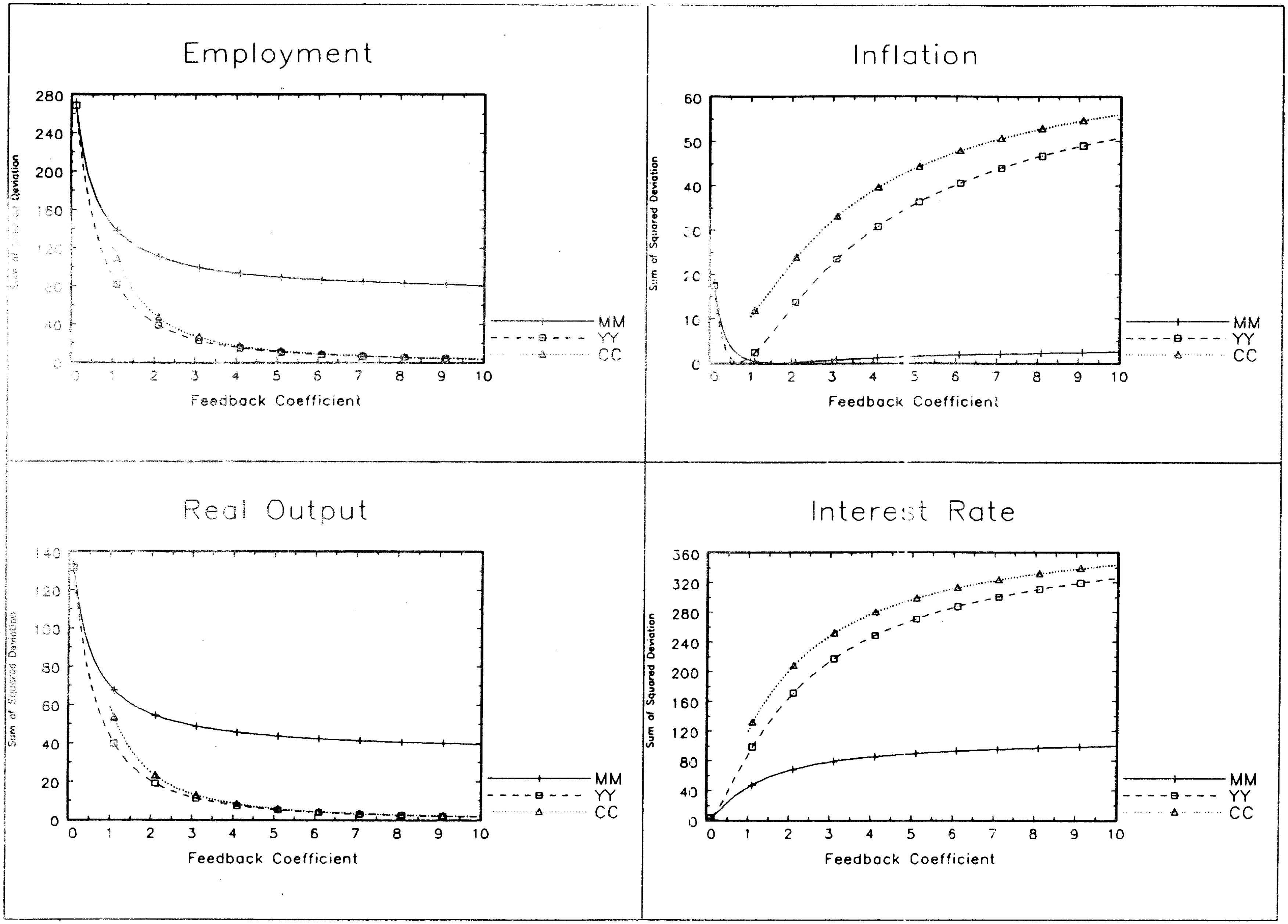


Figure 8: Productivity Shock (Contract)

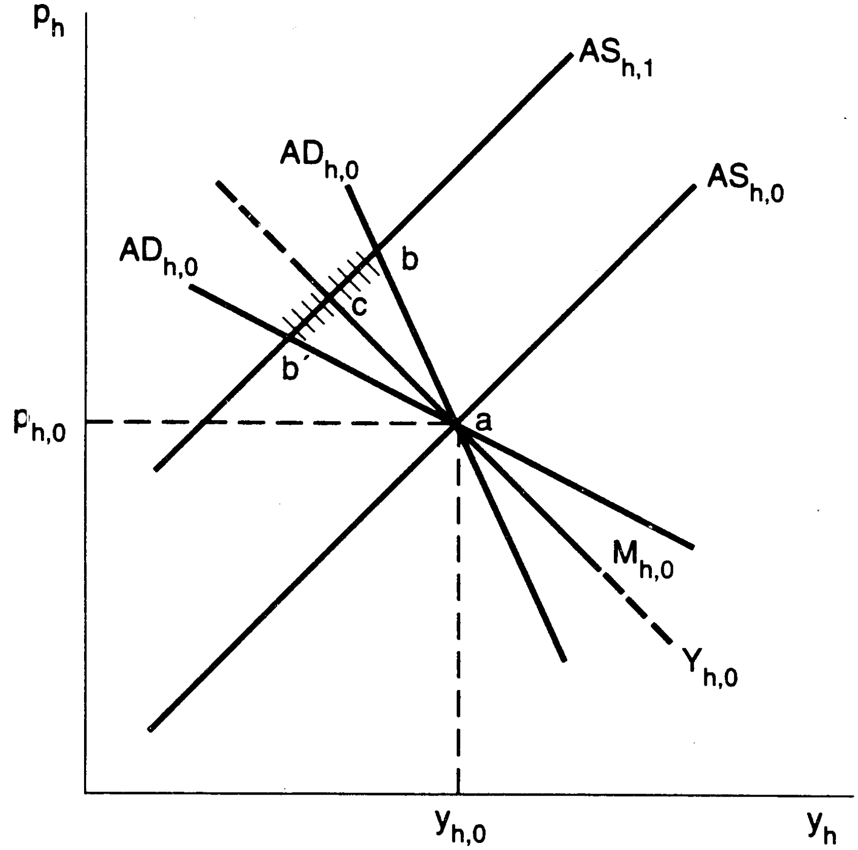


Figure 9. Symmetric Decrease in Productivity - Contract Hypothesis (PIA and FIA)

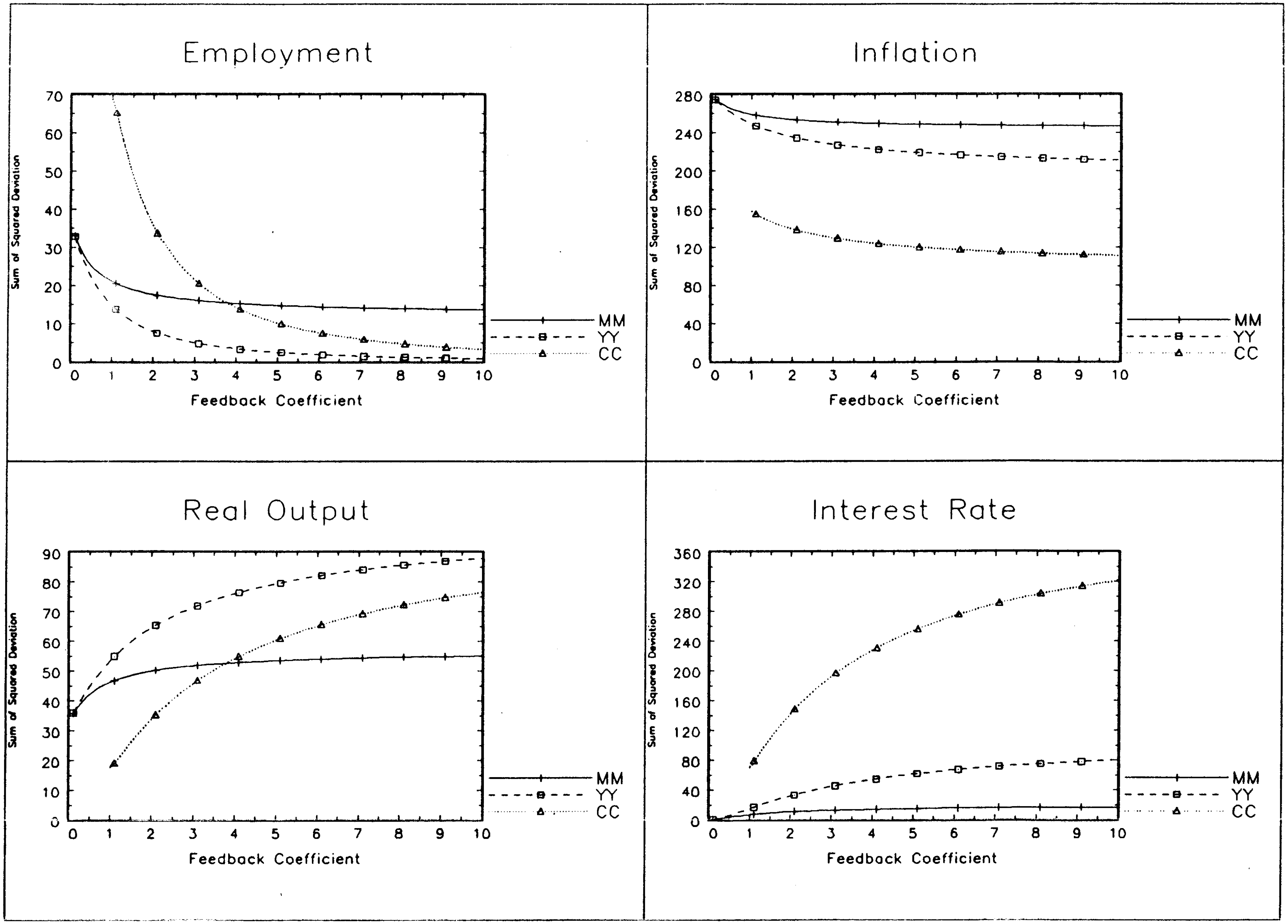


Figure 10. Asymmetric Productivity Shock (US Productivity Decreasing) - Contract Hypothesis (PIA and FIA)

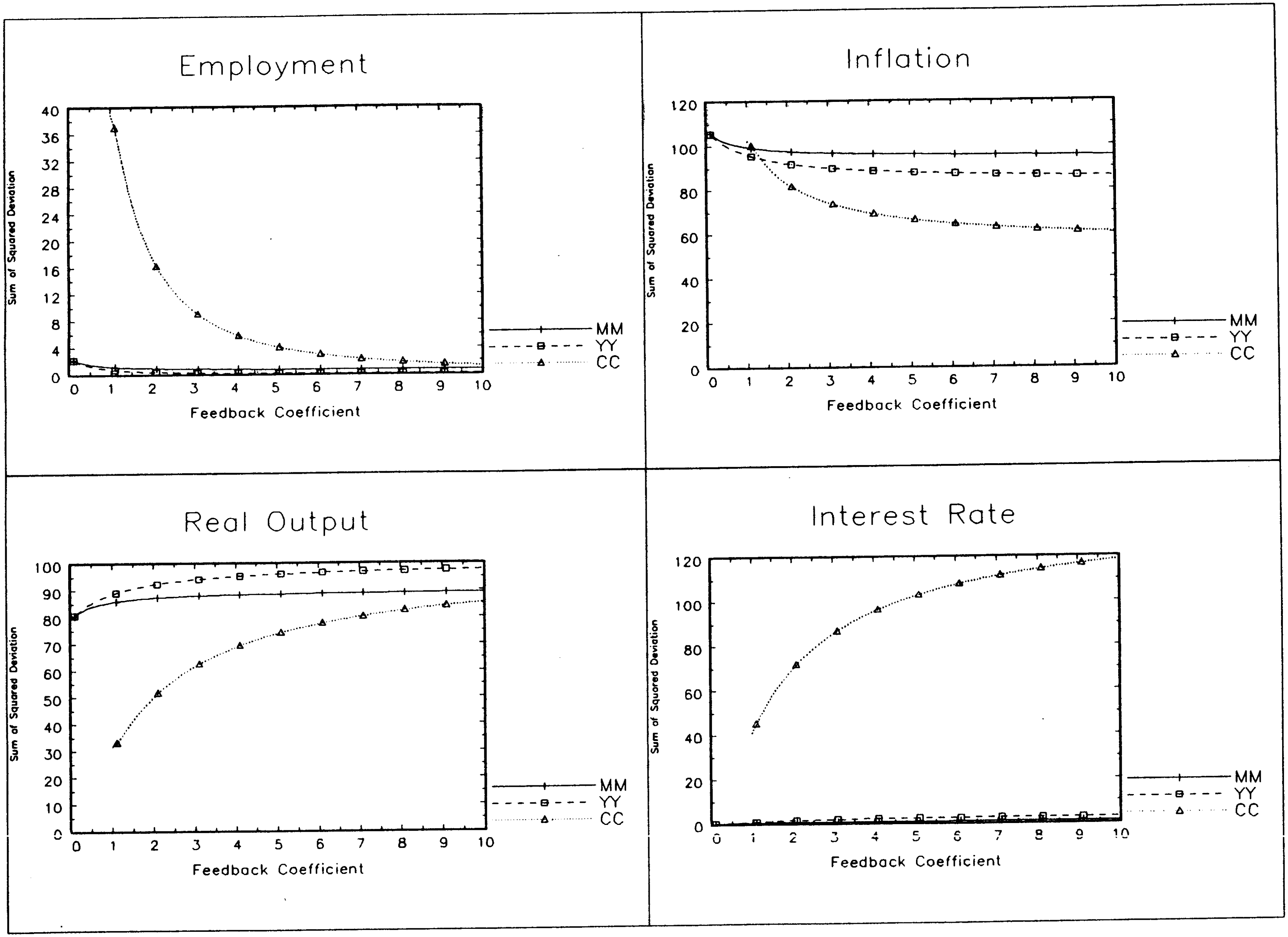


Figure 11: Money-Demand Shock (Phillips: II, MM, YY)

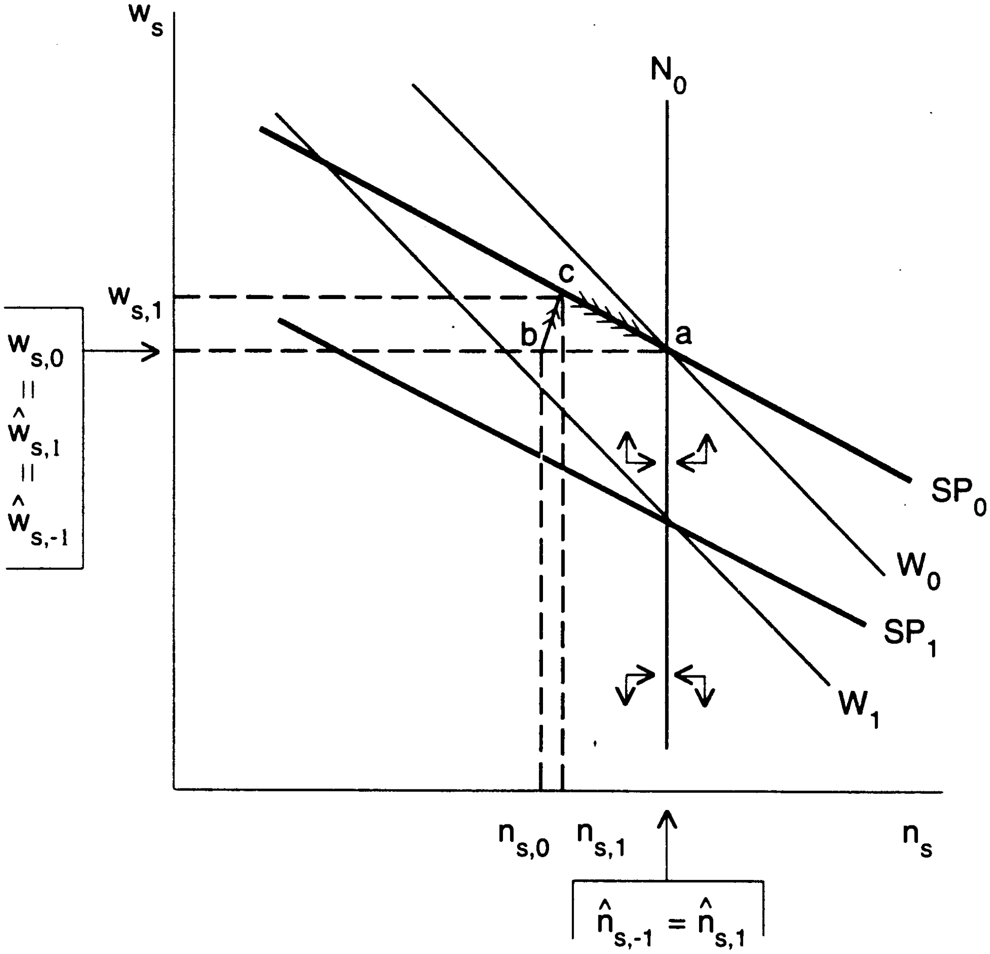


Figure 12. Symmetric Increase in Money Demand - Phillips Hypothesis (FIA)

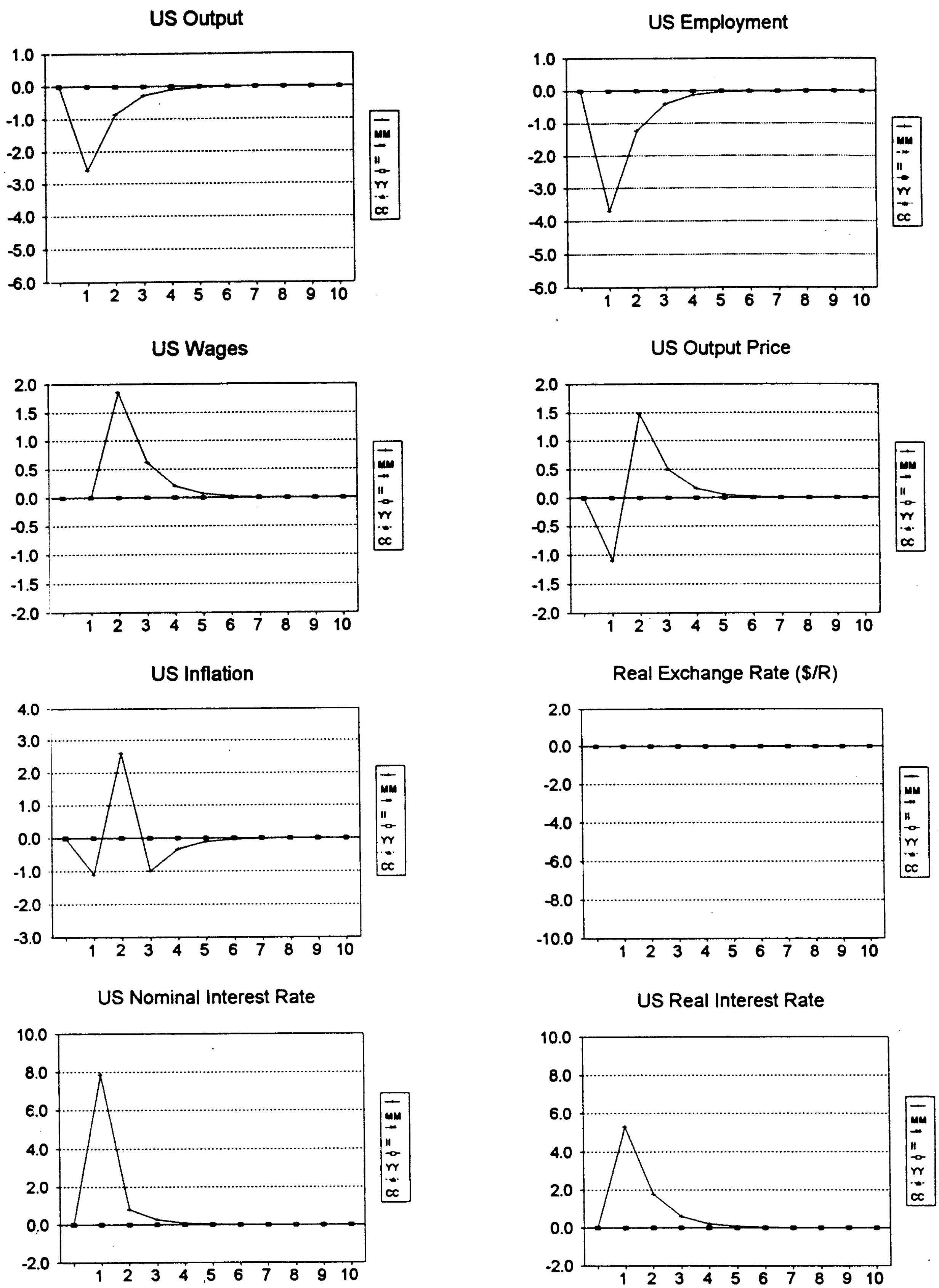


Figure 13. Symmetric Increase in Money Demand - MSG2 Model (FIA)

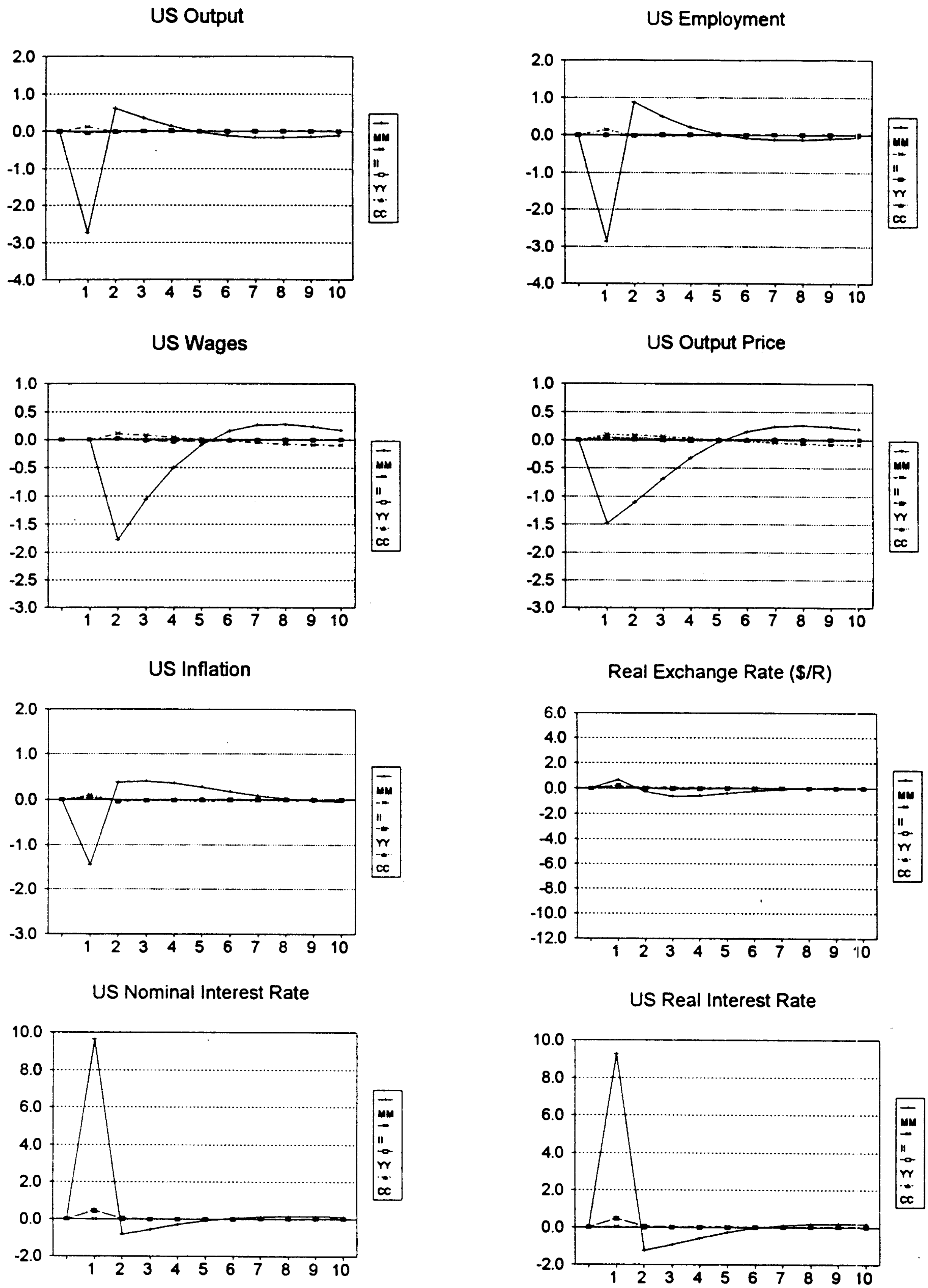


Figure 14. Asymmetric Money-Demand Shock (US Demand Increasing) - Phillips Hypothesis (FIA)

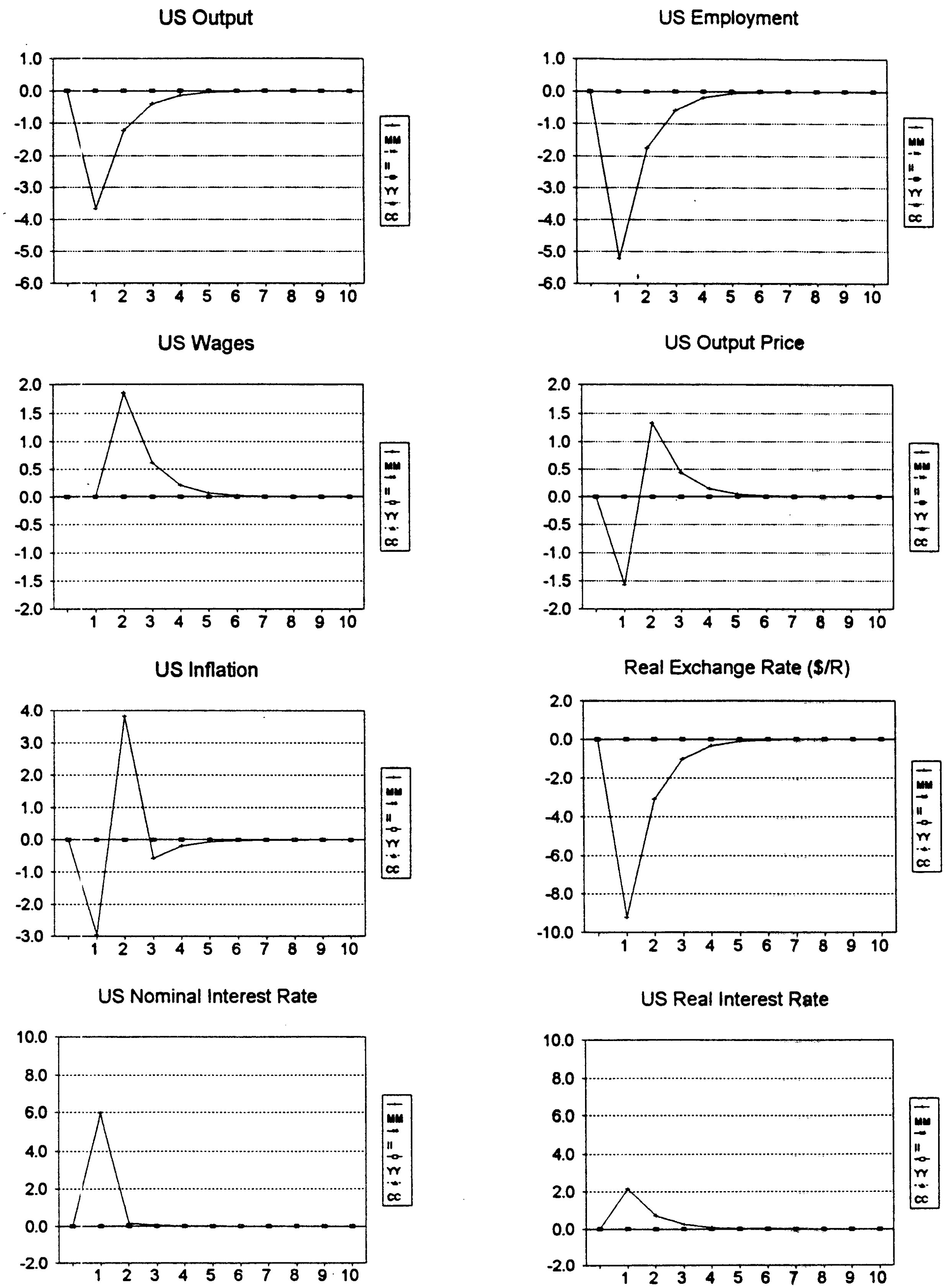


Figure 15. Asymmetric Money-Demand Shock (US Demand Increasing) - MSG2 Model (FIA)

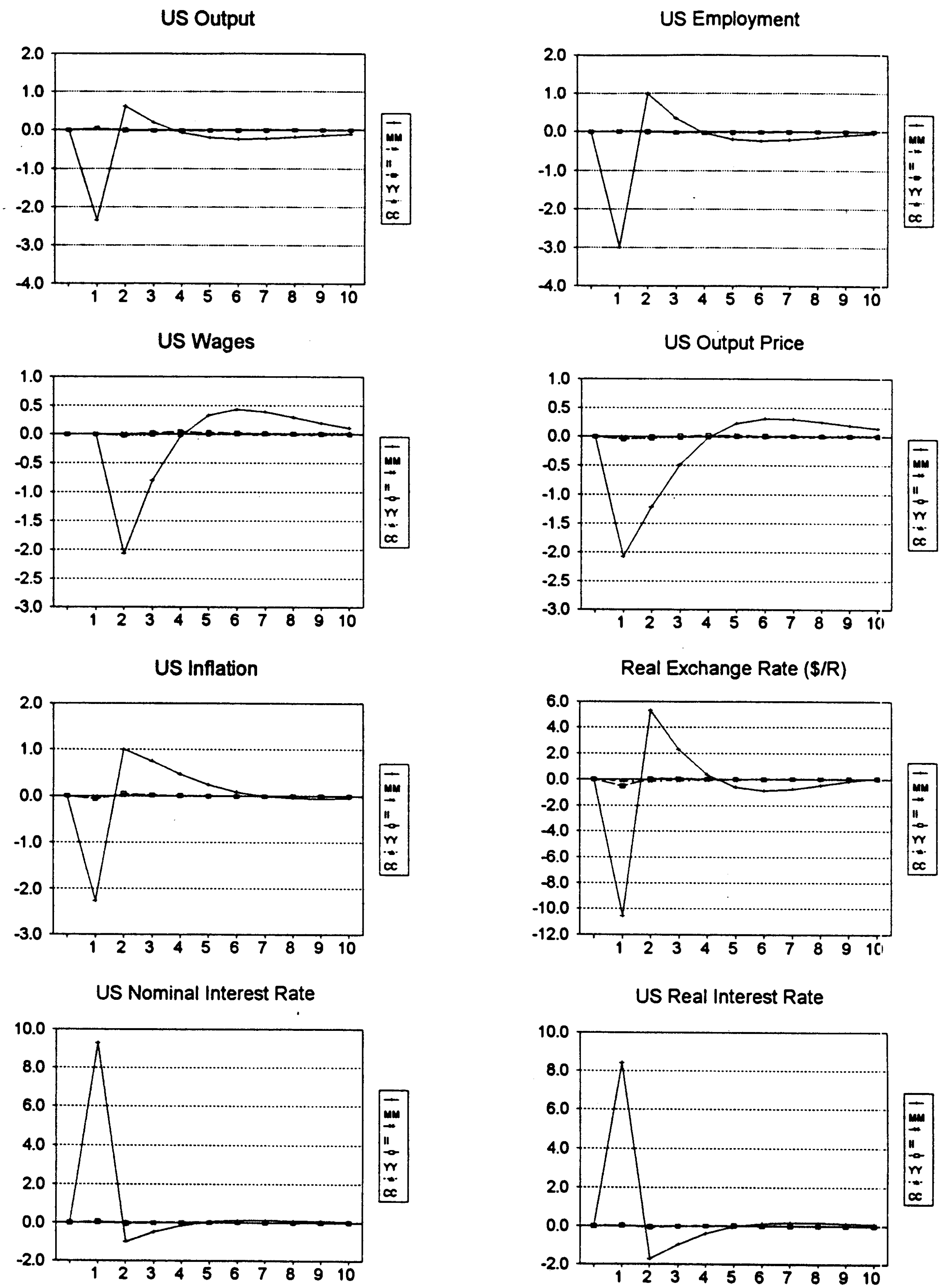


Figure 16. Symmetric Increase in Money Demand - Phillips Hypothesis (PIA and FIA)

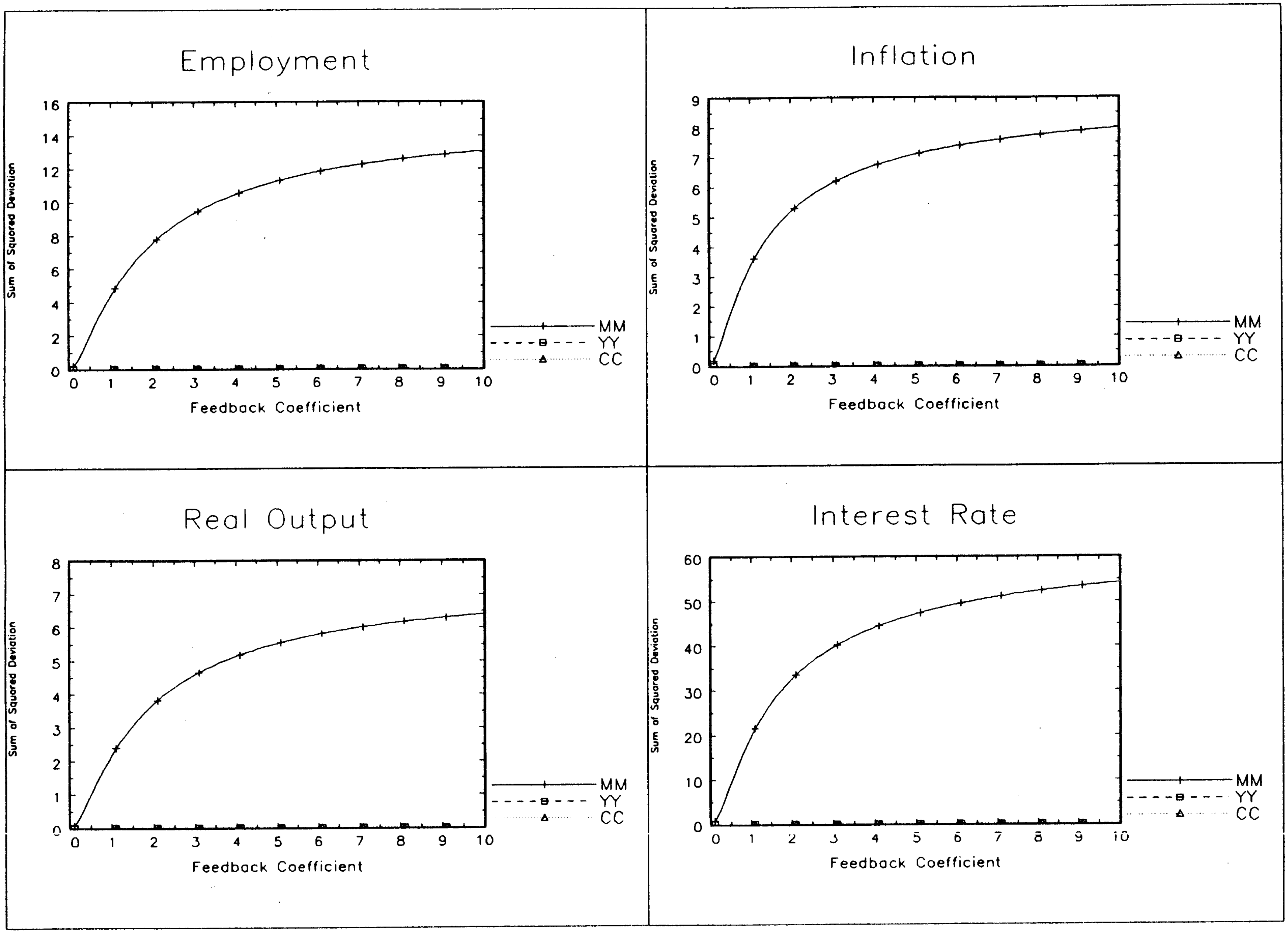


Figure 17. Symmetric Increase in Money Demand - MSG2 Model (PIA and FIA)

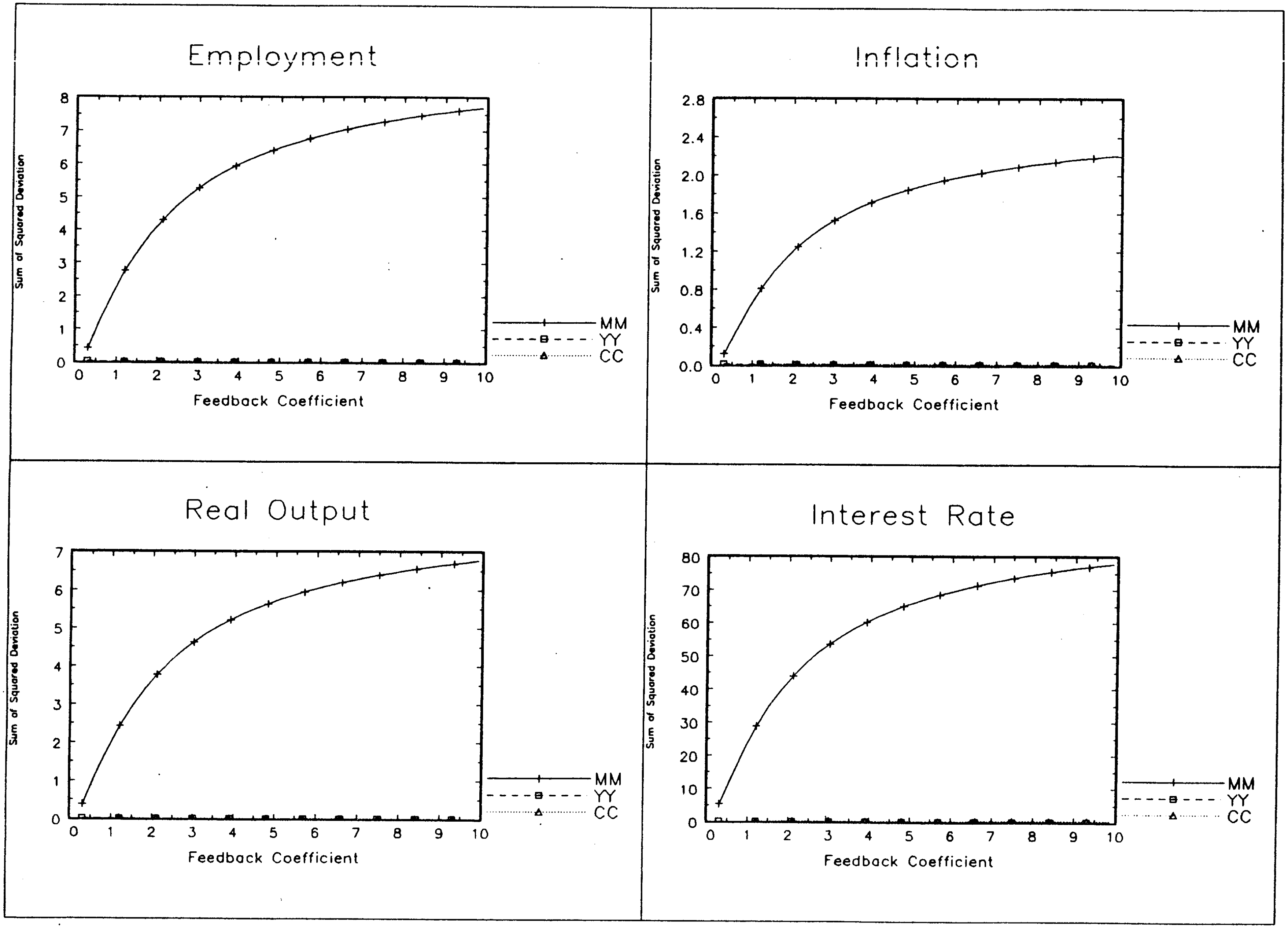


Figure 18. Asymmetric Money-Demand Shock (US Demand Increasing) - Phillips Hypothesis (PIA and FIA)

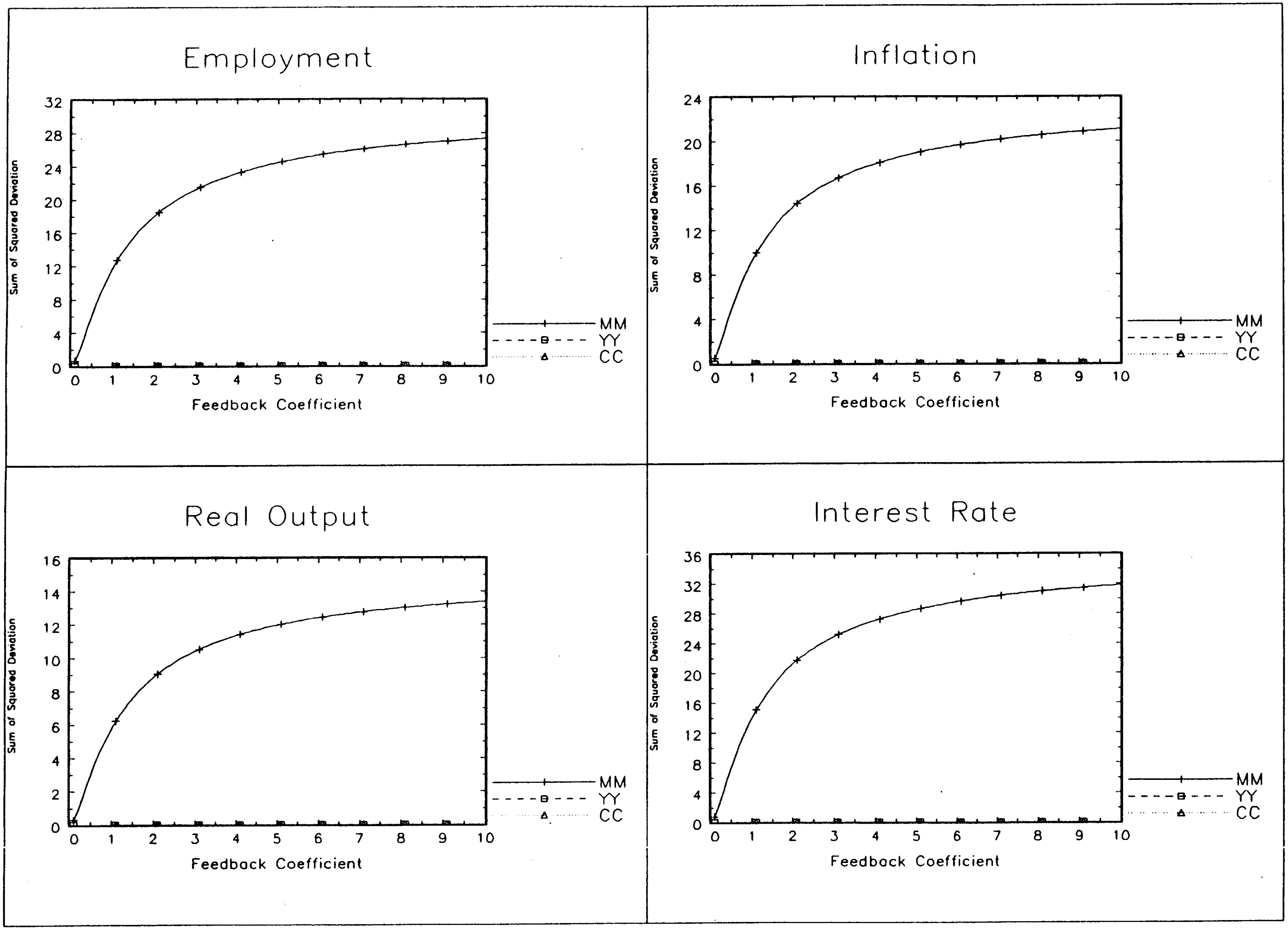


Figure 19. Asymmetric Money-Demand Shock (US Demand Increasing) - MSG2 Model (PIA and FIA)

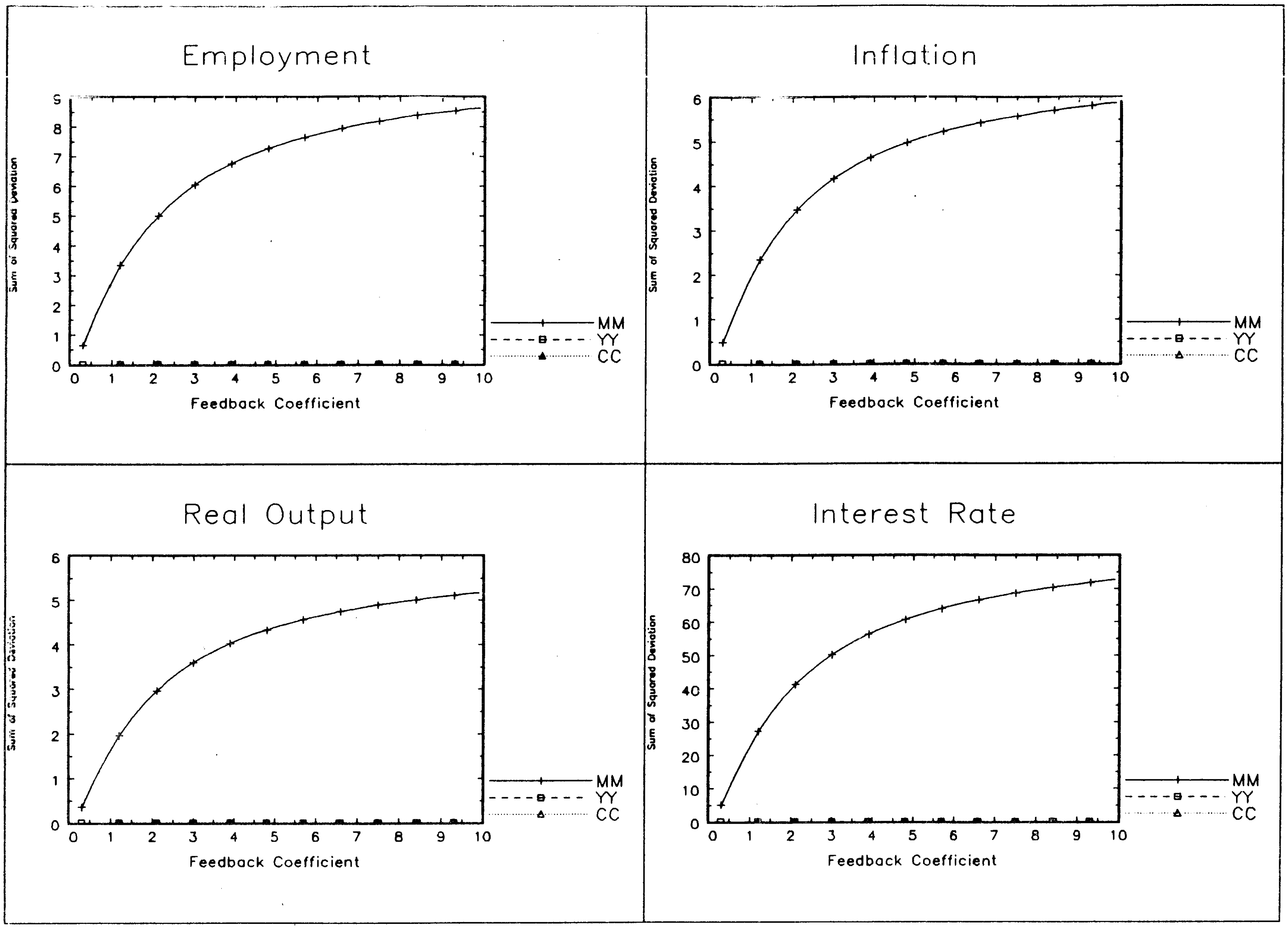


Figure 20: Goods-Demand Shock (Phillips: II, MM, YY)

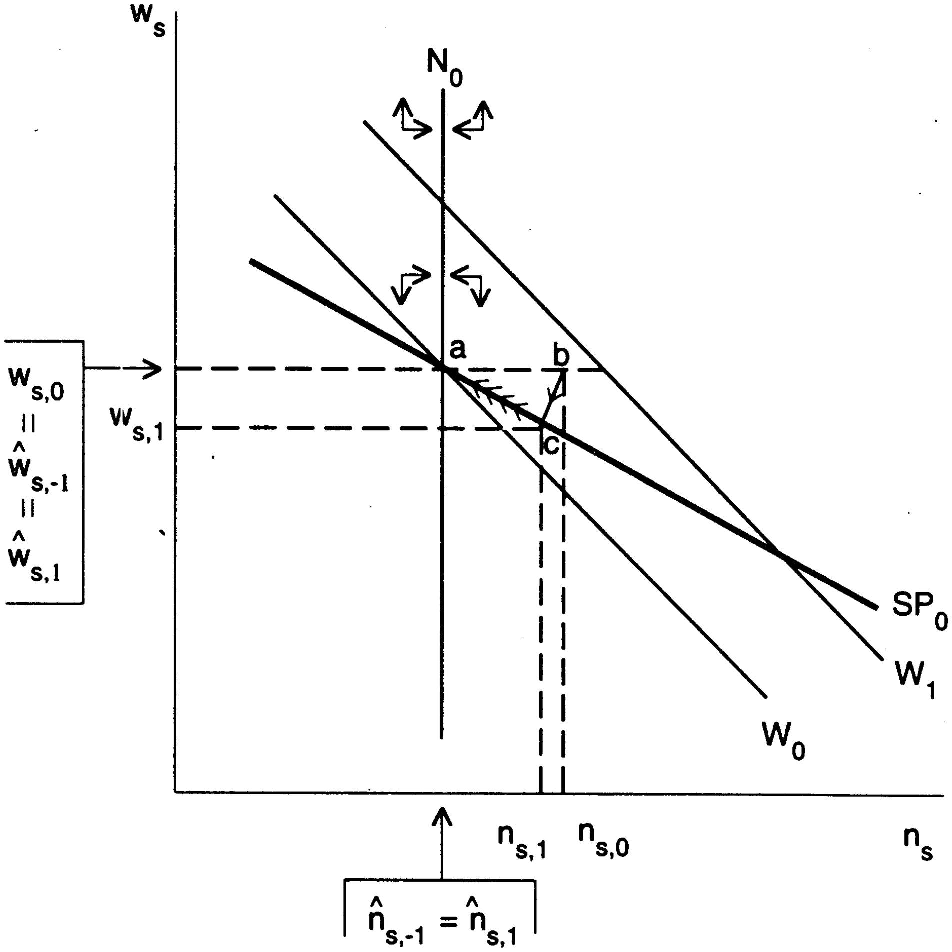


Figure 21. Symmetric Increase in Goods Demand - Phillips Hypothesis (FIA)

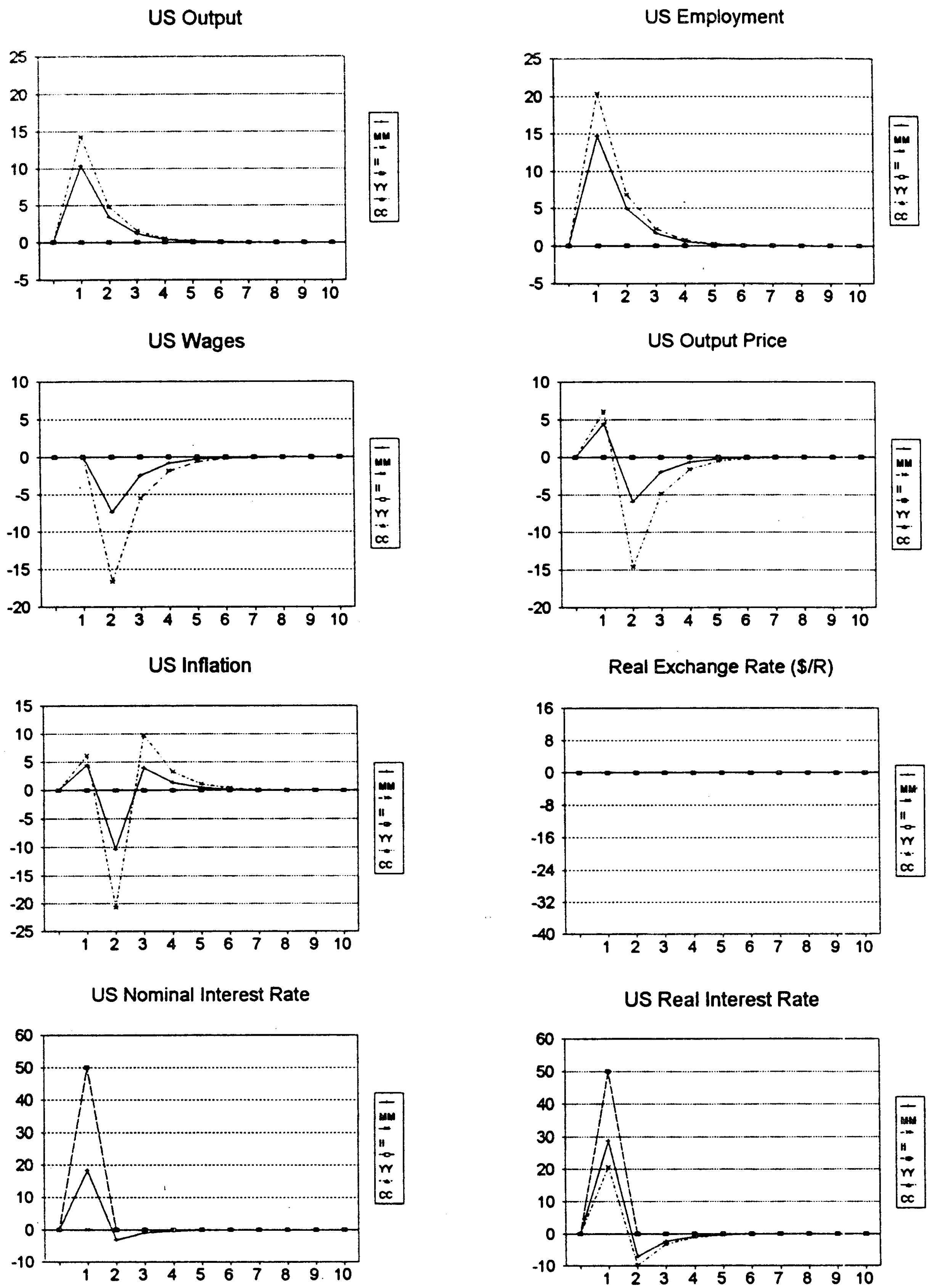


Figure 22. Symmetric Increase in Goods Demand - MSG2 Model (FIA)

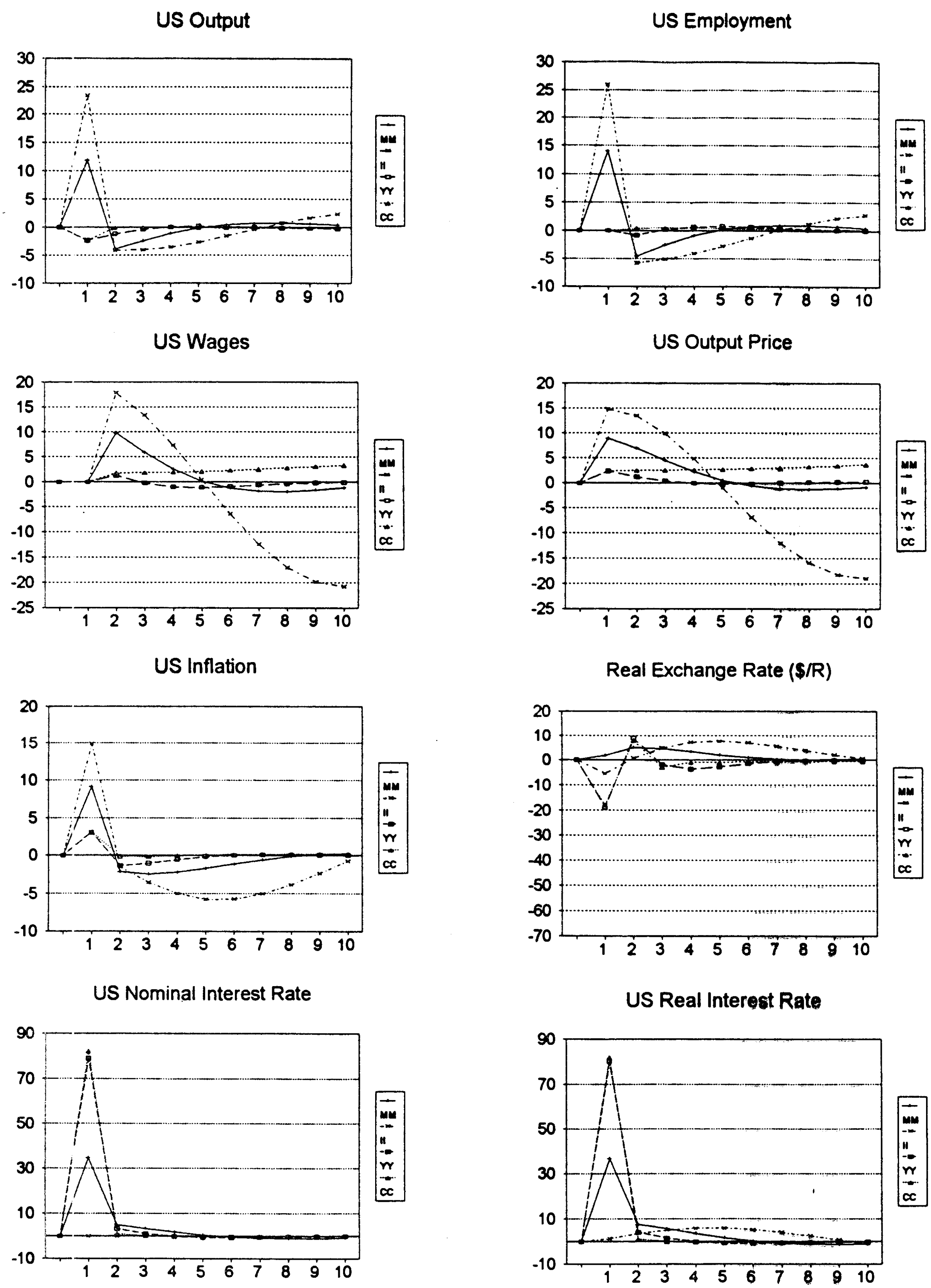


Figure 23. Asymmetric Goods-Demand Shock (US Demand Increasing) - Phillips Hypothesis (FIA)

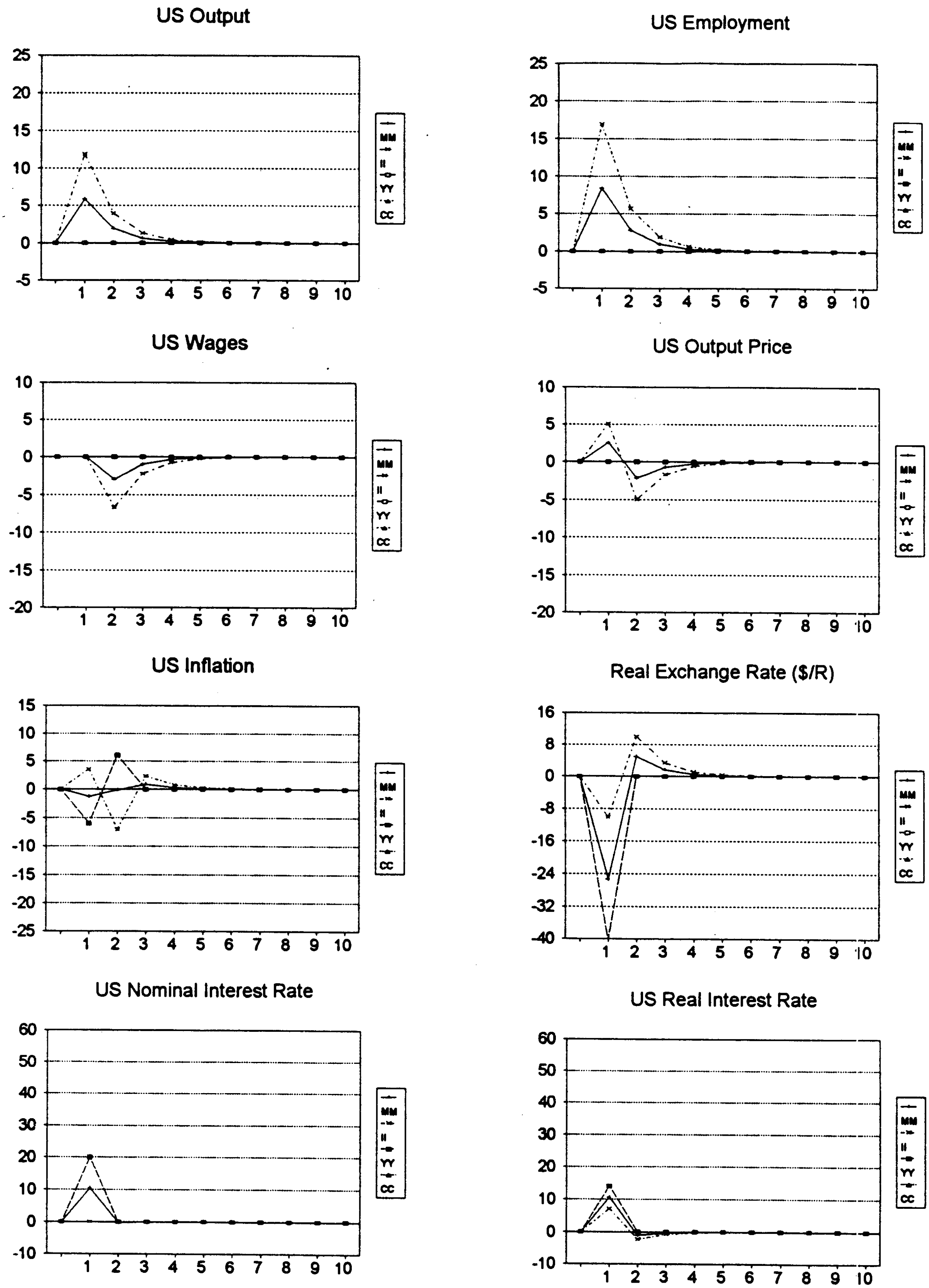


Figure 24. Asymmetric Goods-Demand Shock (US Demand Increasing) - MSG2 Model (FIA)

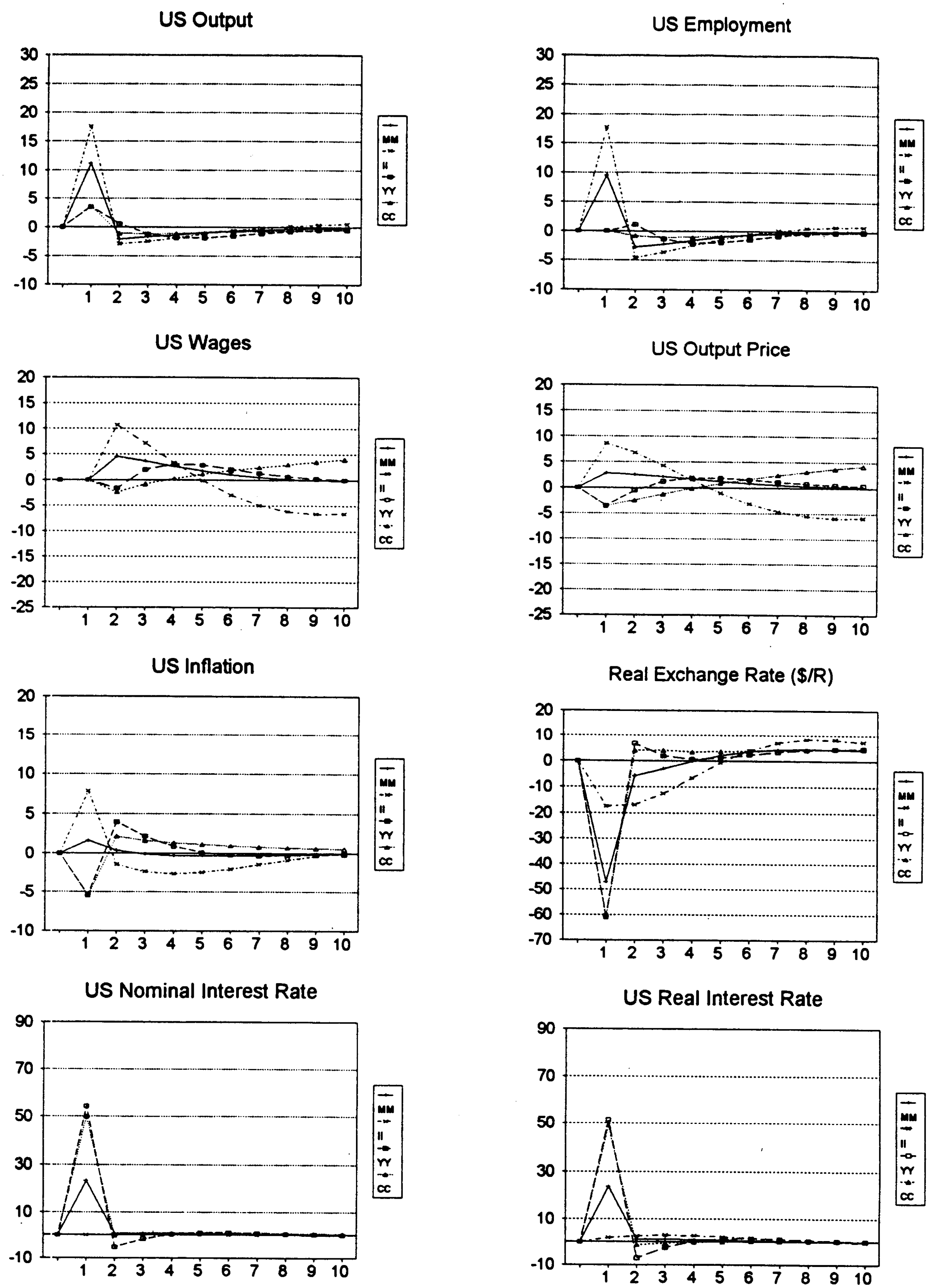


Figure 25. Symmetric Increase in Goods Demand - Phillips Hypothesis (PIA and FIA)

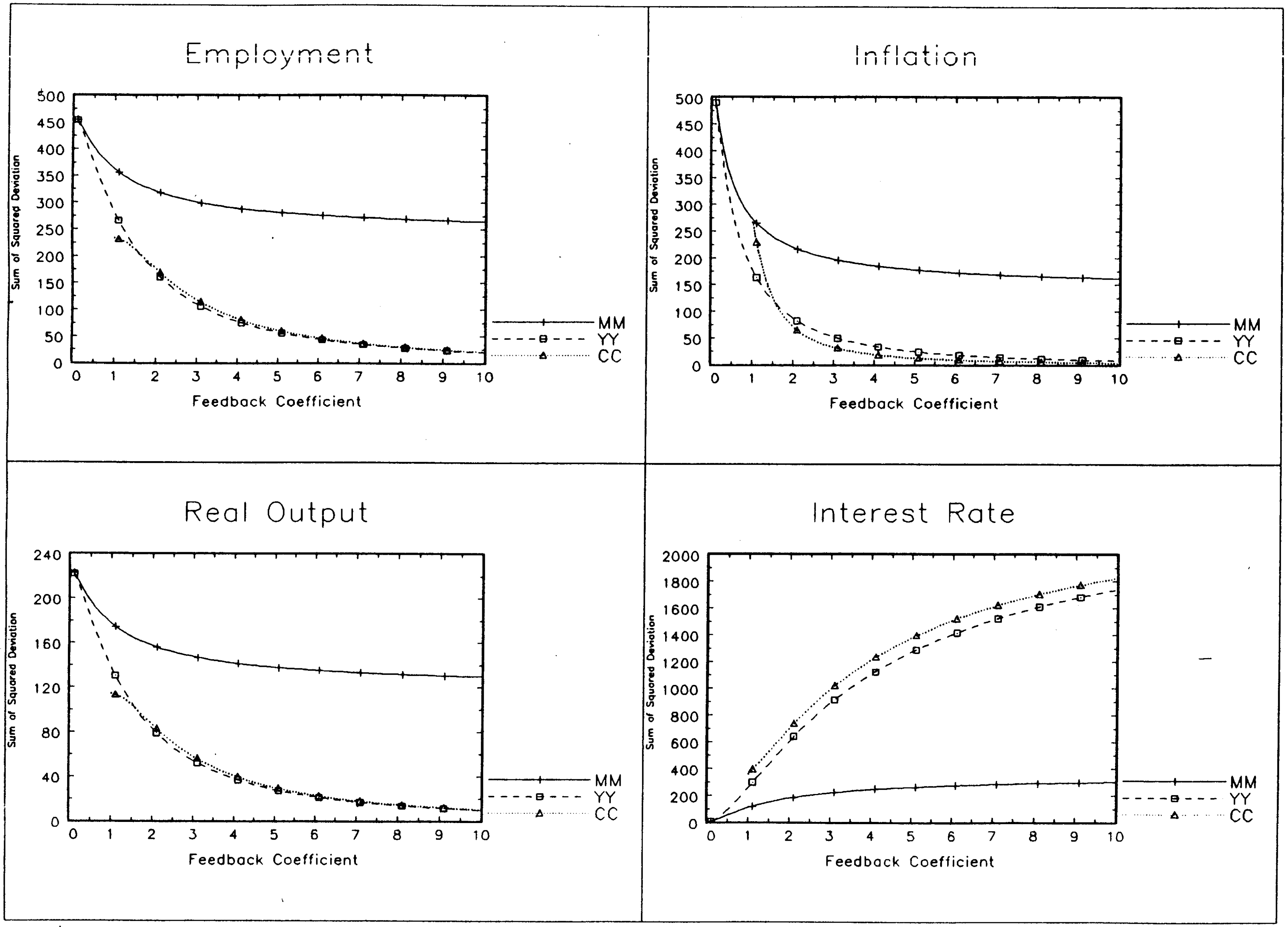


Figure 26. Symmetric Increase in Goods Demand - MSG2 Model (PIA and FIA)

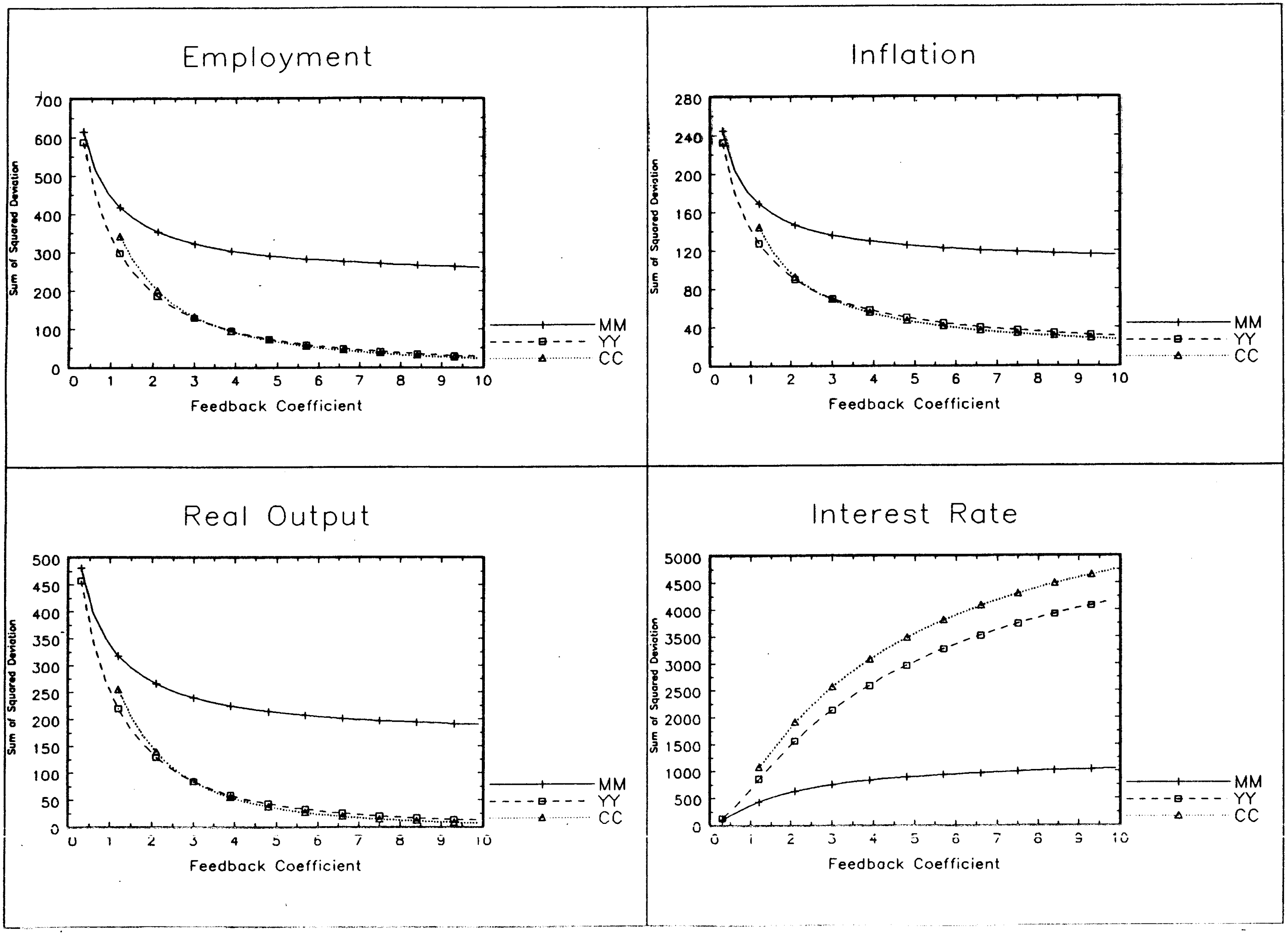


Figure 27. Asymmetric Goods-Demand Shock (US Demand Increasing) - Phillips Hypothesis (PIA and FIA)

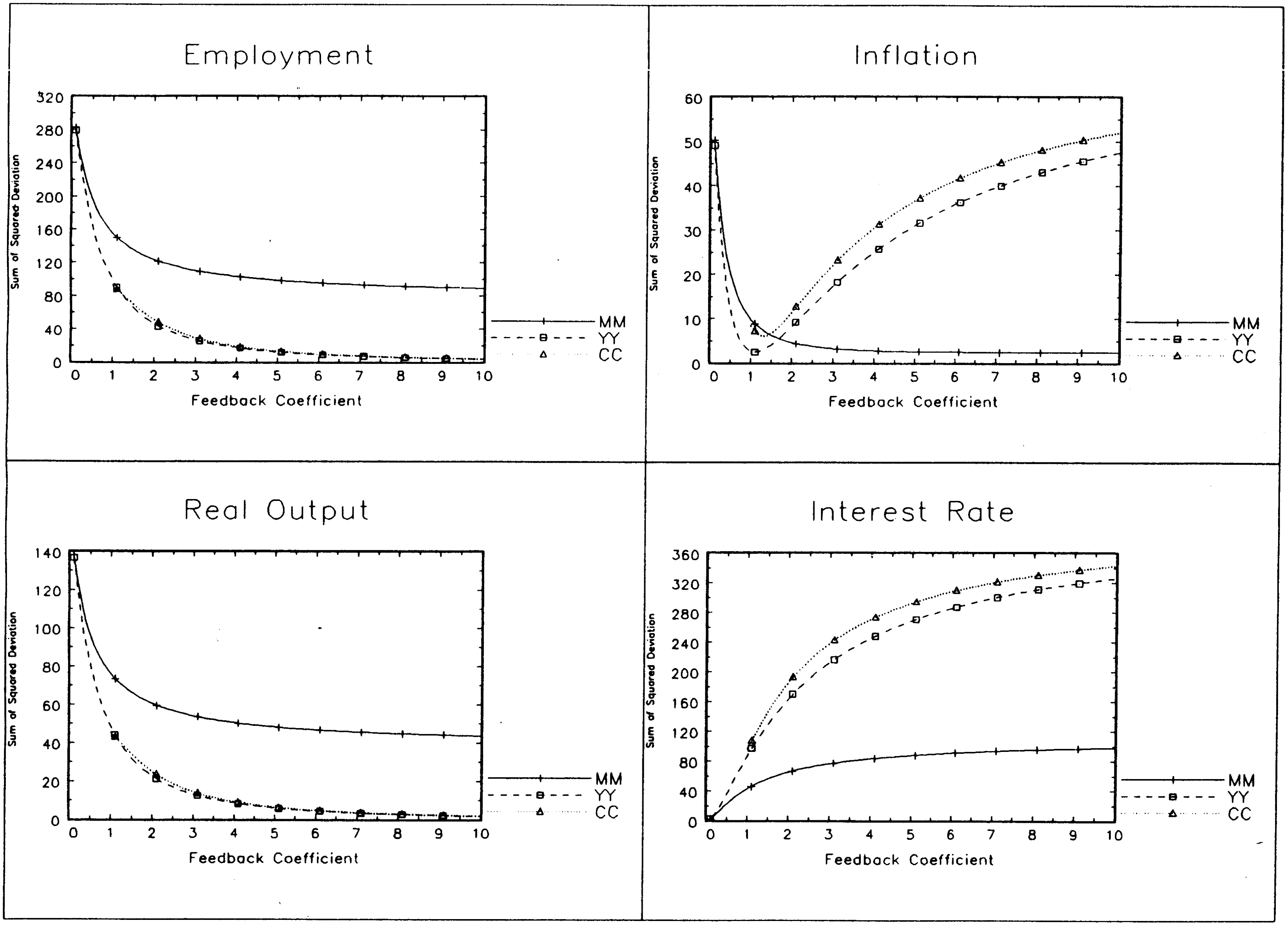


Figure 28. Asymmetric Goods-Demand Shock (US Demand Increasing) - MSG2 Model (PIA and FIA)

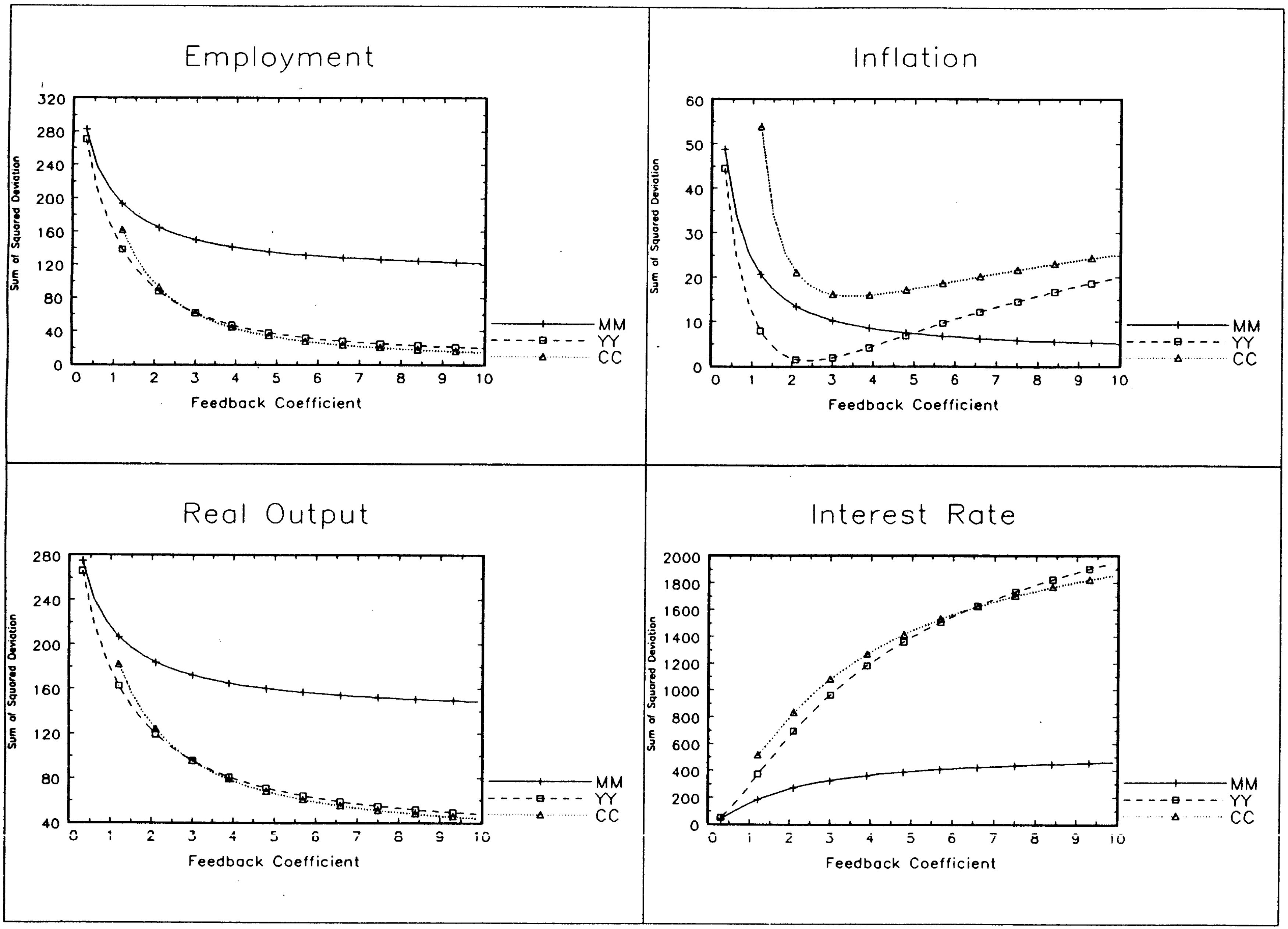


Figure 29: Productivity Shock (Phillips: II, MM, YY)

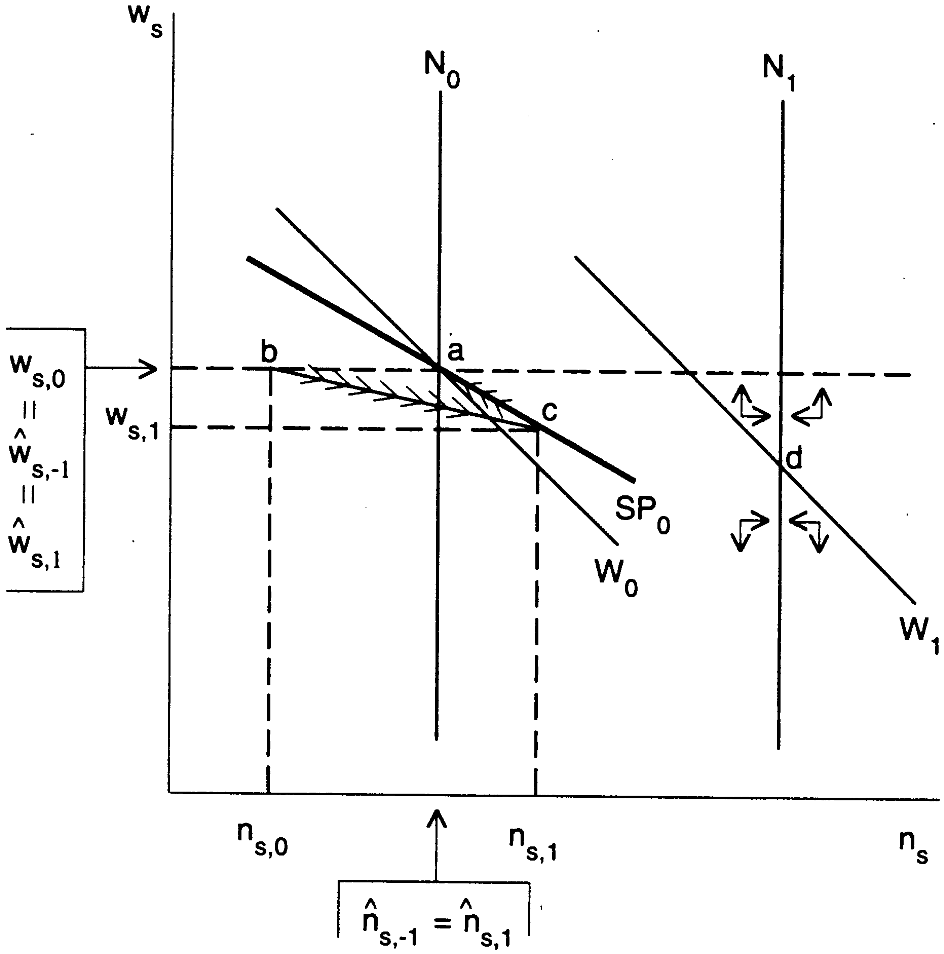


Figure 30. Symmetric Decrease in Productivity - Phillips Hypothesis (FIA)

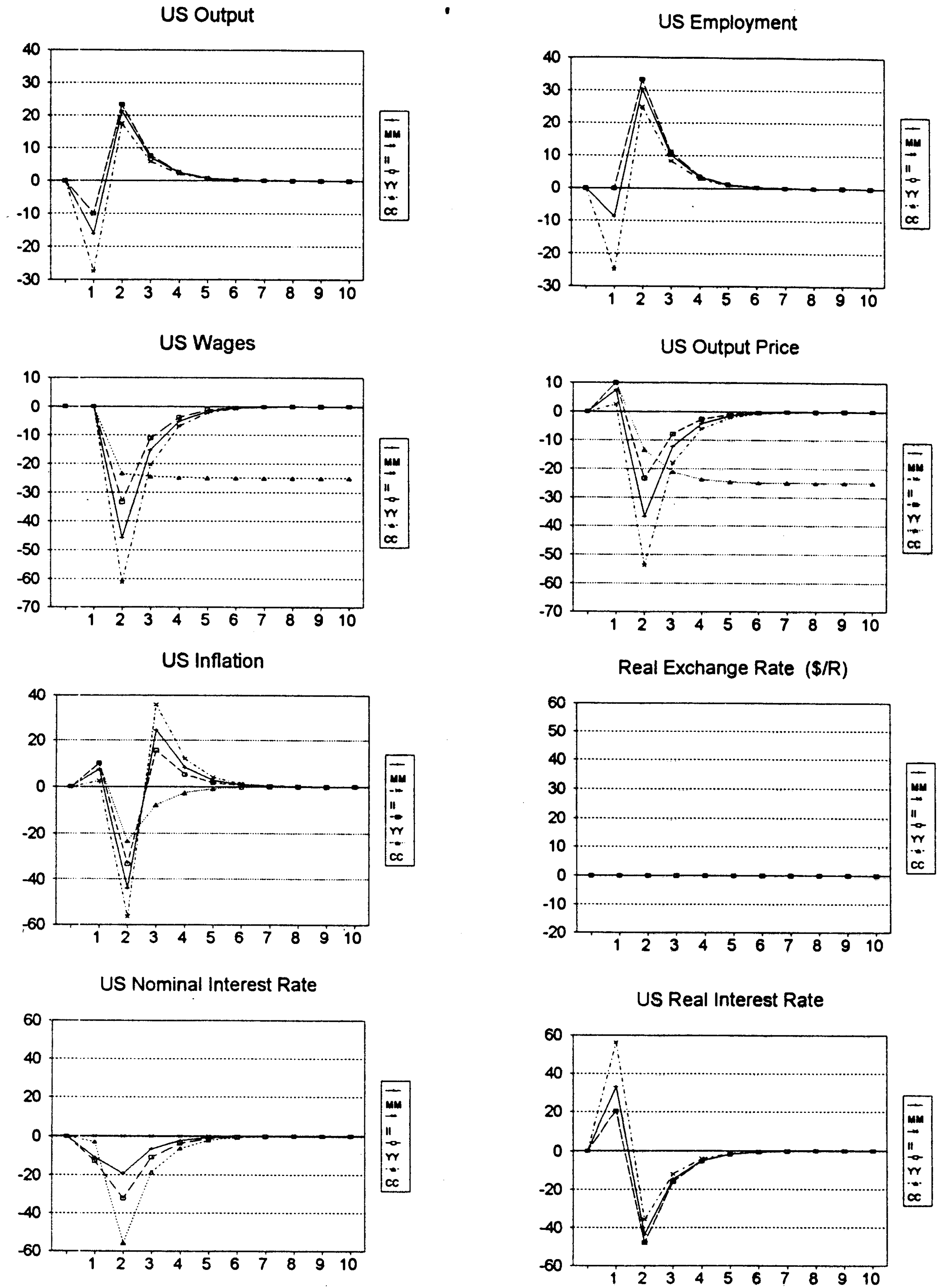


Figure 31. Symmetric Decrease in Productivity - MSG2 Model (FIA)

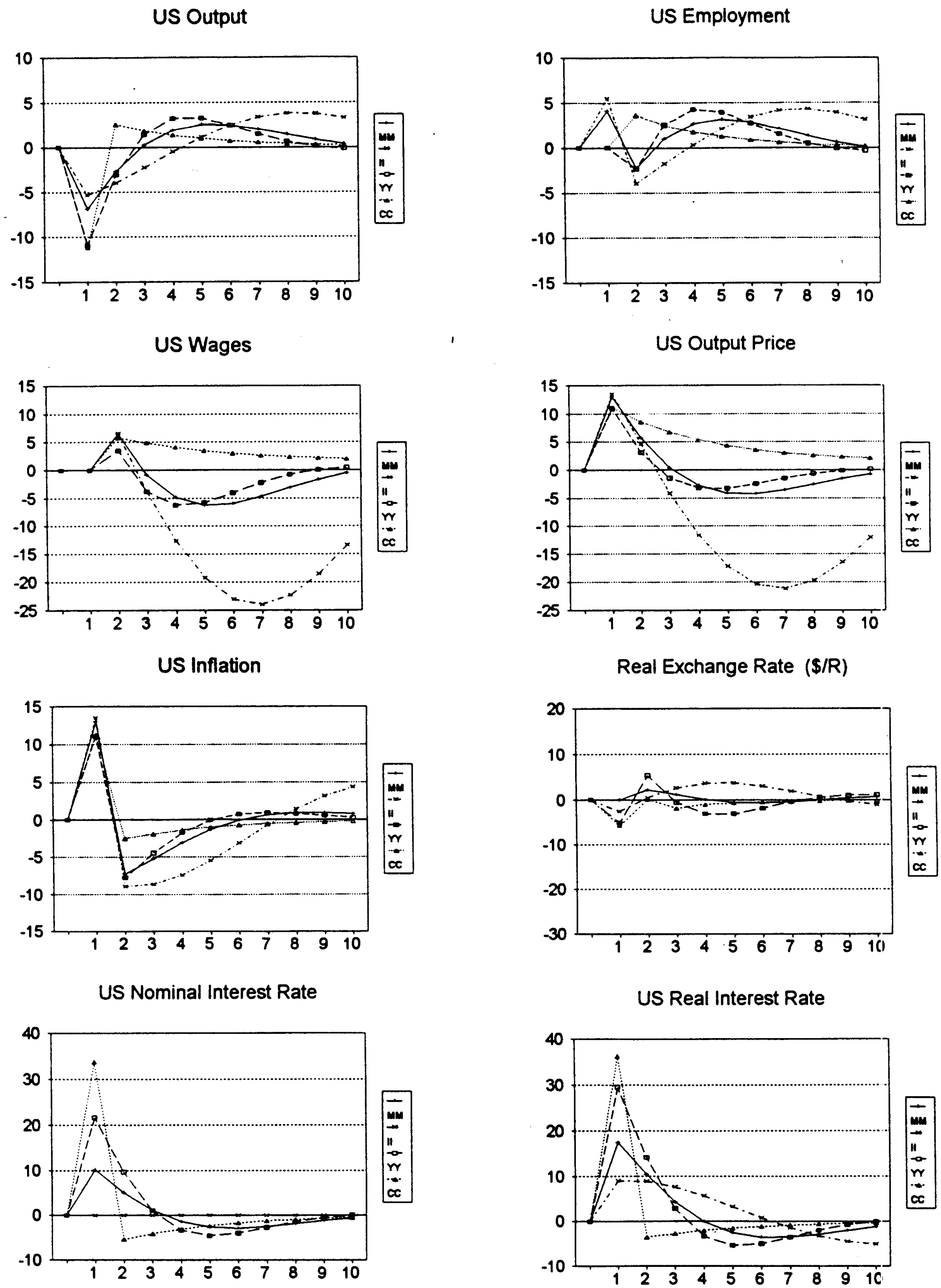


Figure 32. Asymmetric Productivity Shock (US Productivity Decreasing) - Phillips Hypothesis (FIA)

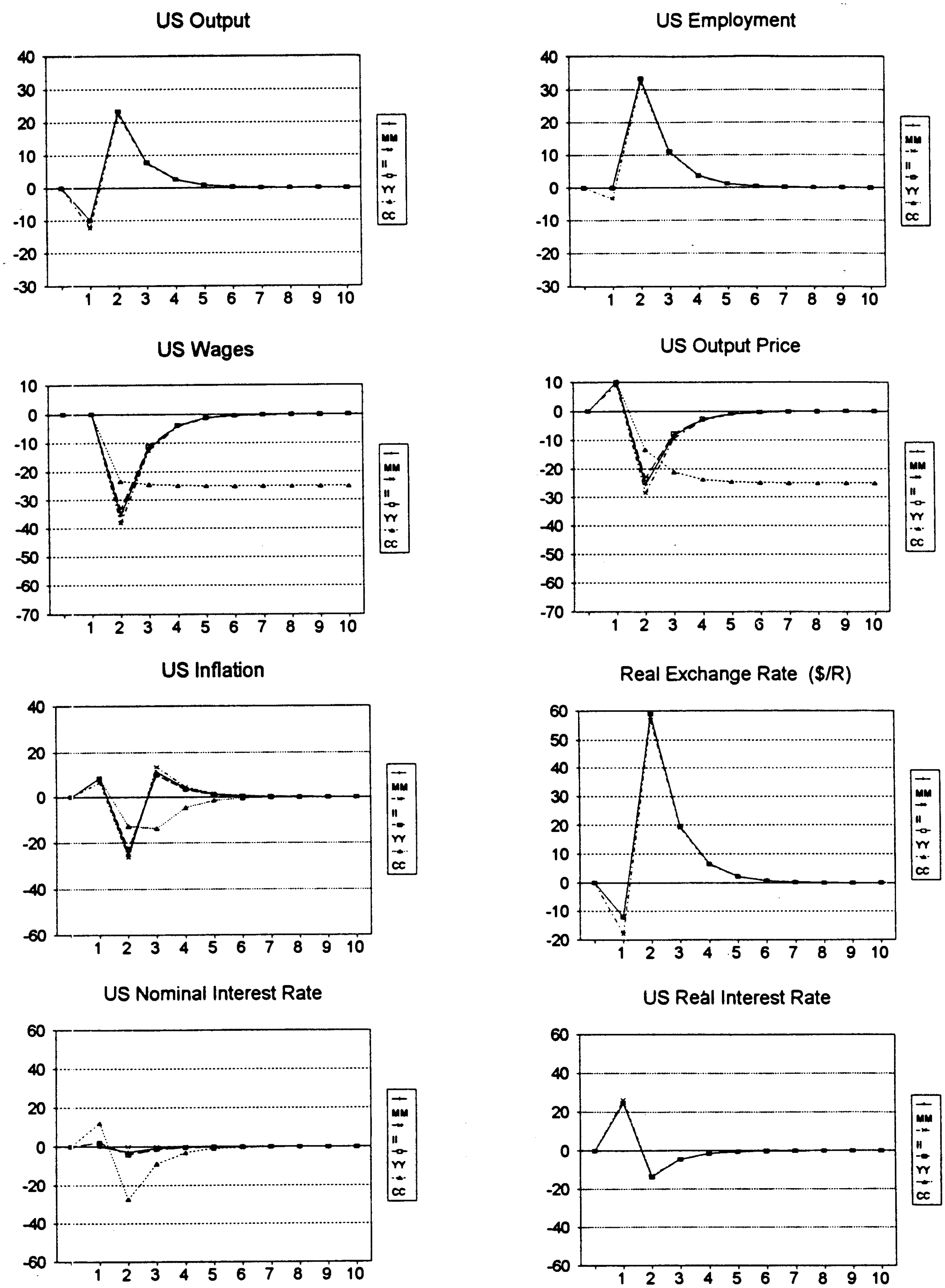


Figure 33. Asymmetric Productivity Shock (US Productivity Decreasing) - MSG2 Model (FIA)

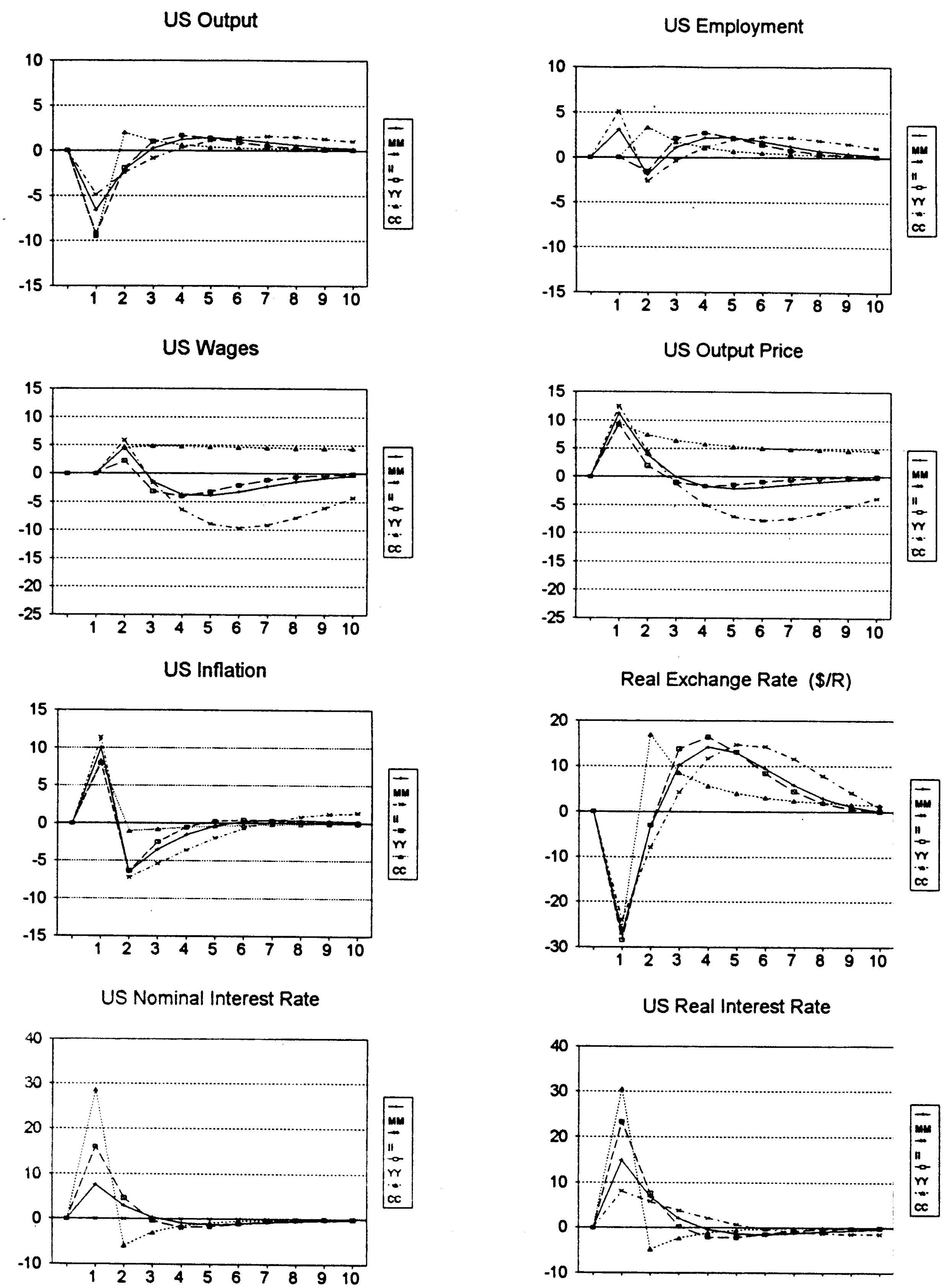


Figure 34. Symmetric Decrease in Productivity - Phillips Hypothesis (PIA and FIA)

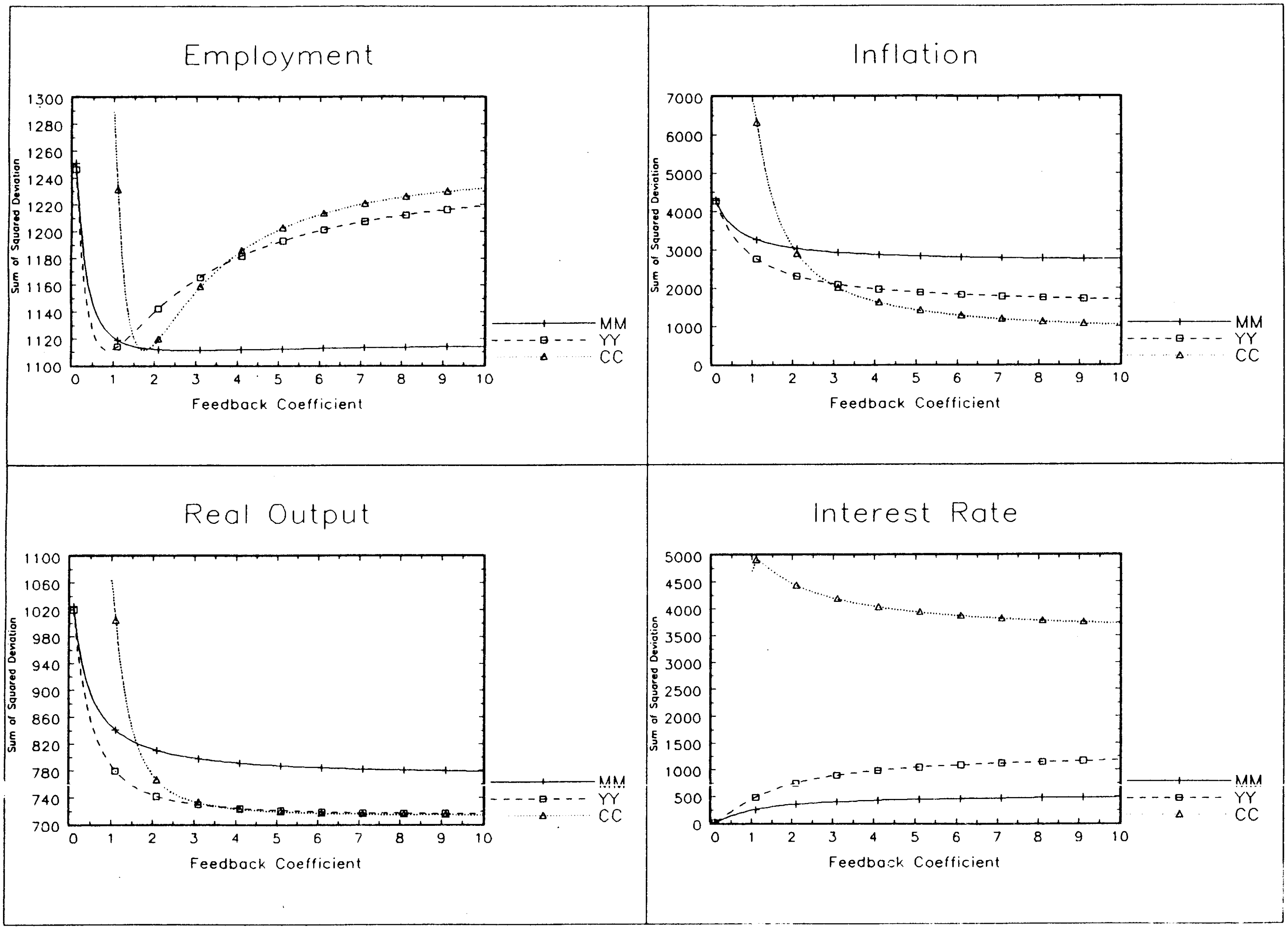


Figure 35. Symmetric Decrease in Productivity - MSG2 Model (PIA and FIA)

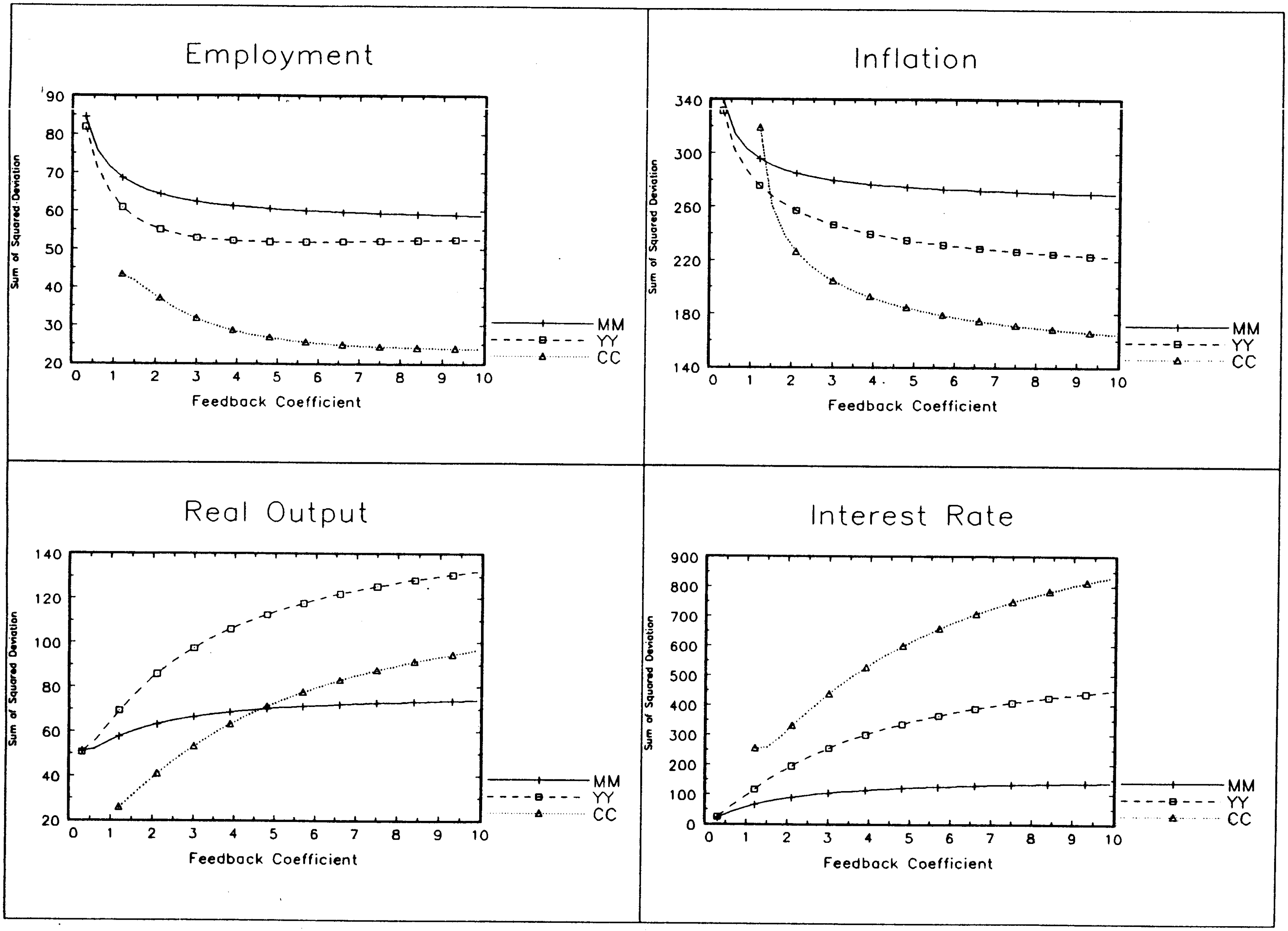


Figure 36. Asymmetric Productivity Shock (US Productivity Decreasing) - Phillips Hypothesis (PIA and FIA)

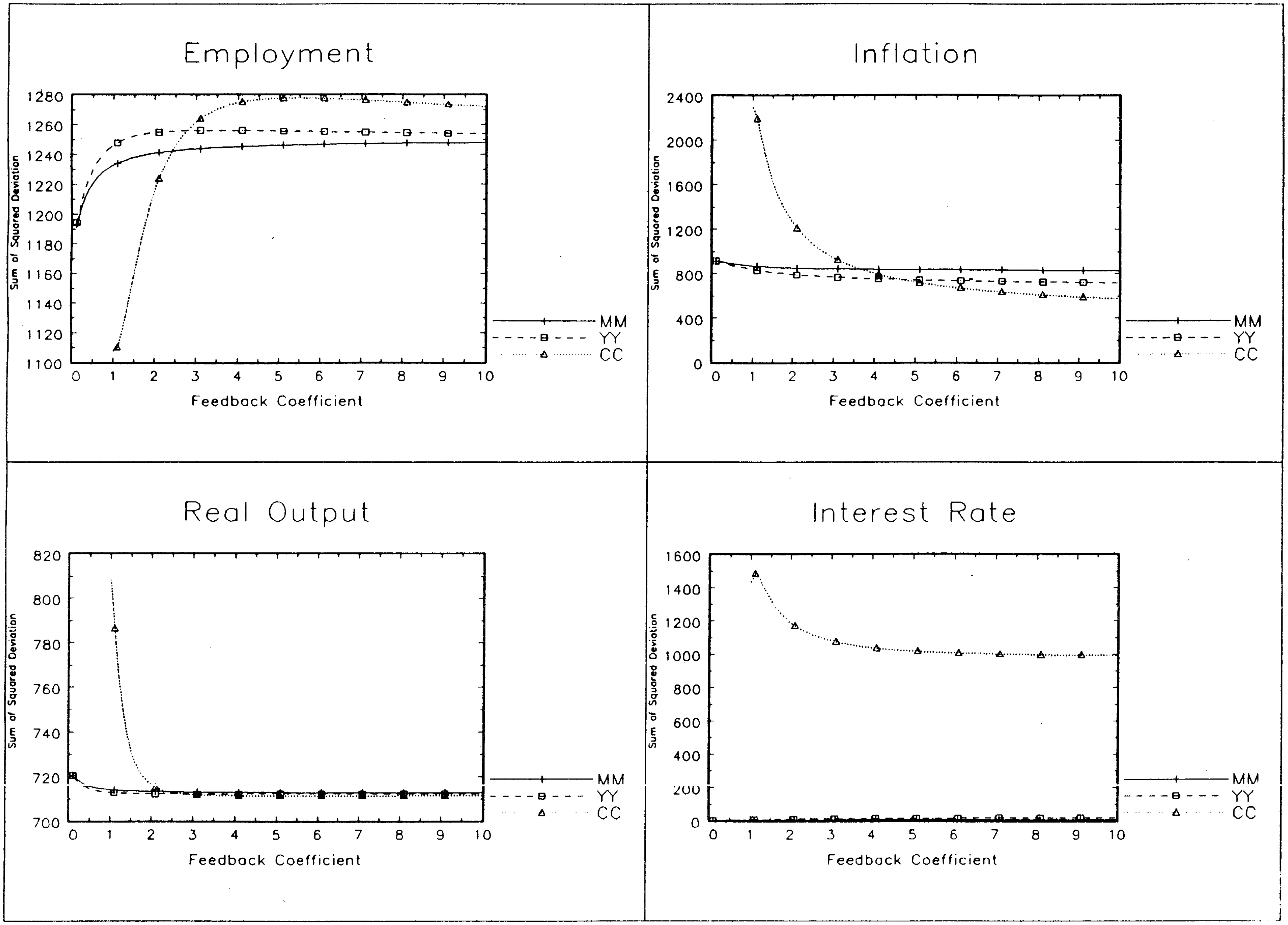


Figure 37. Asymmetric Productivity Shock (US Productivity Decreasing) - MSG2 Model (PIA and FIA)

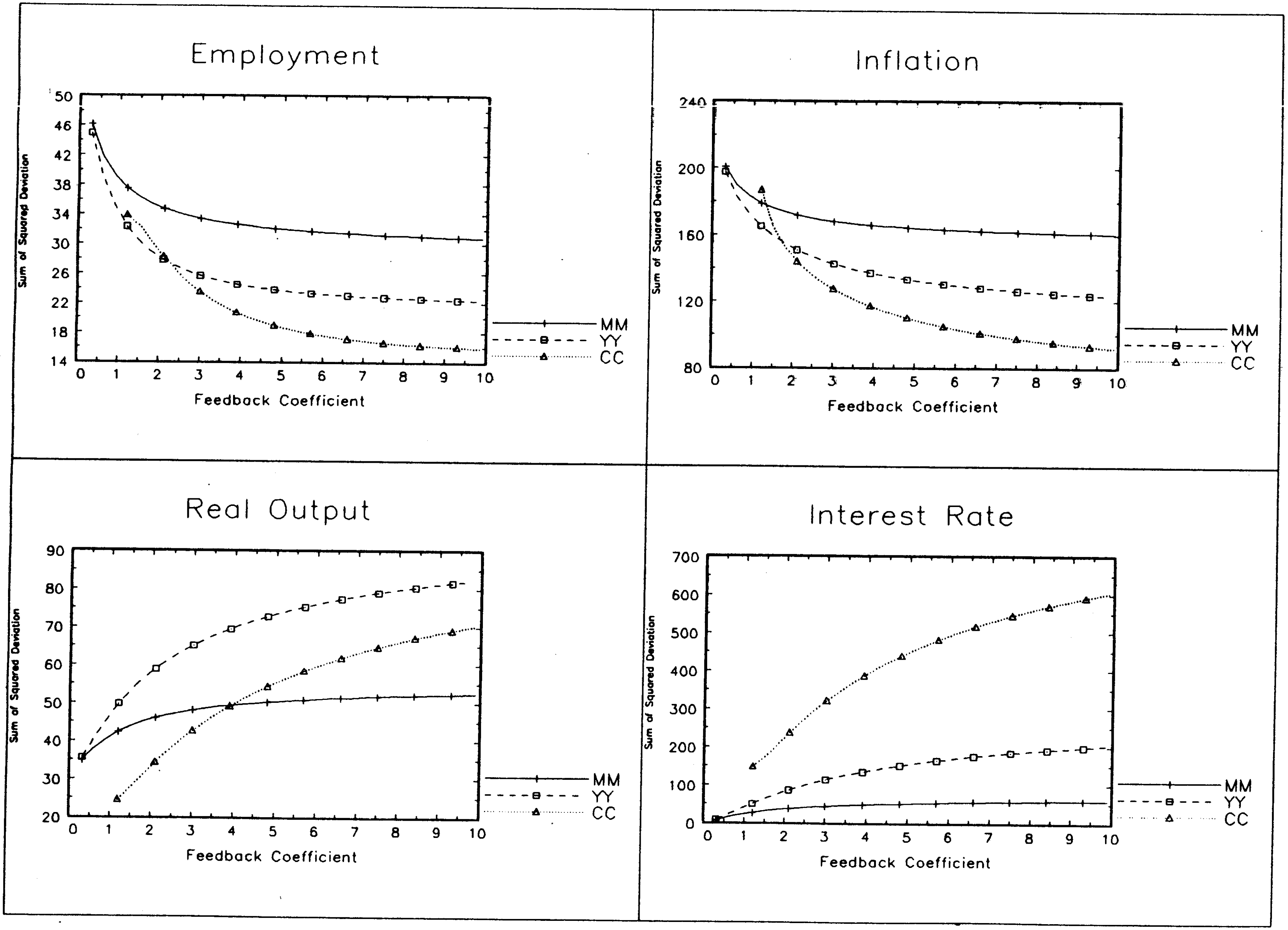


Figure 38: Goods-Demand Shock (Phillips: CC)

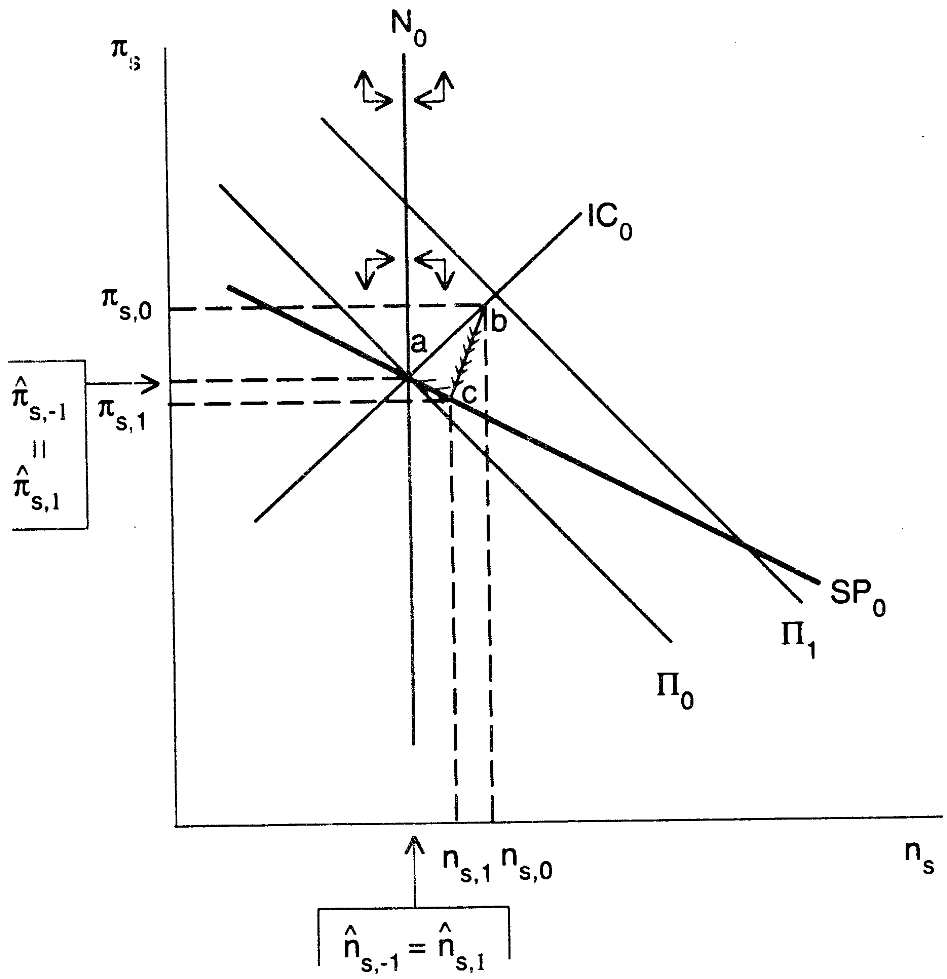


Figure 39: Productivity Shock (Phillips: CC)

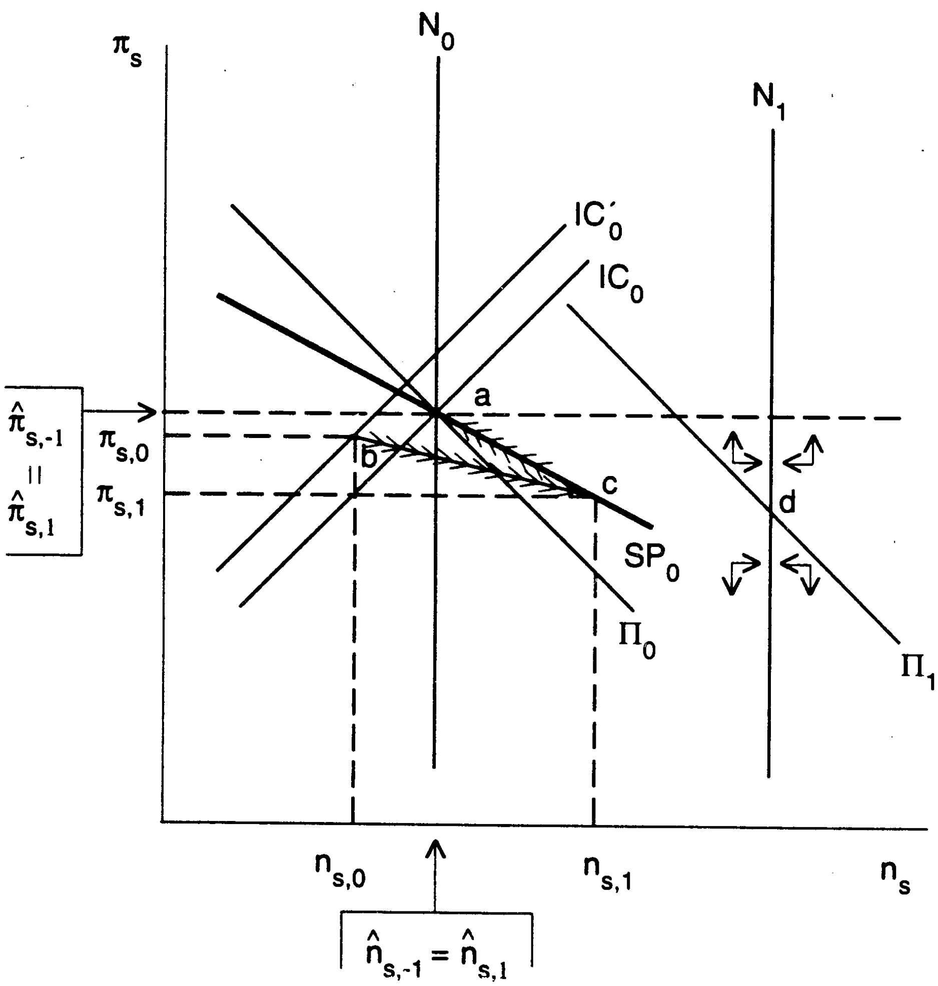


Figure 40. Symmetric Increase in Money Demand - Taylor Hypothesis (FIA)

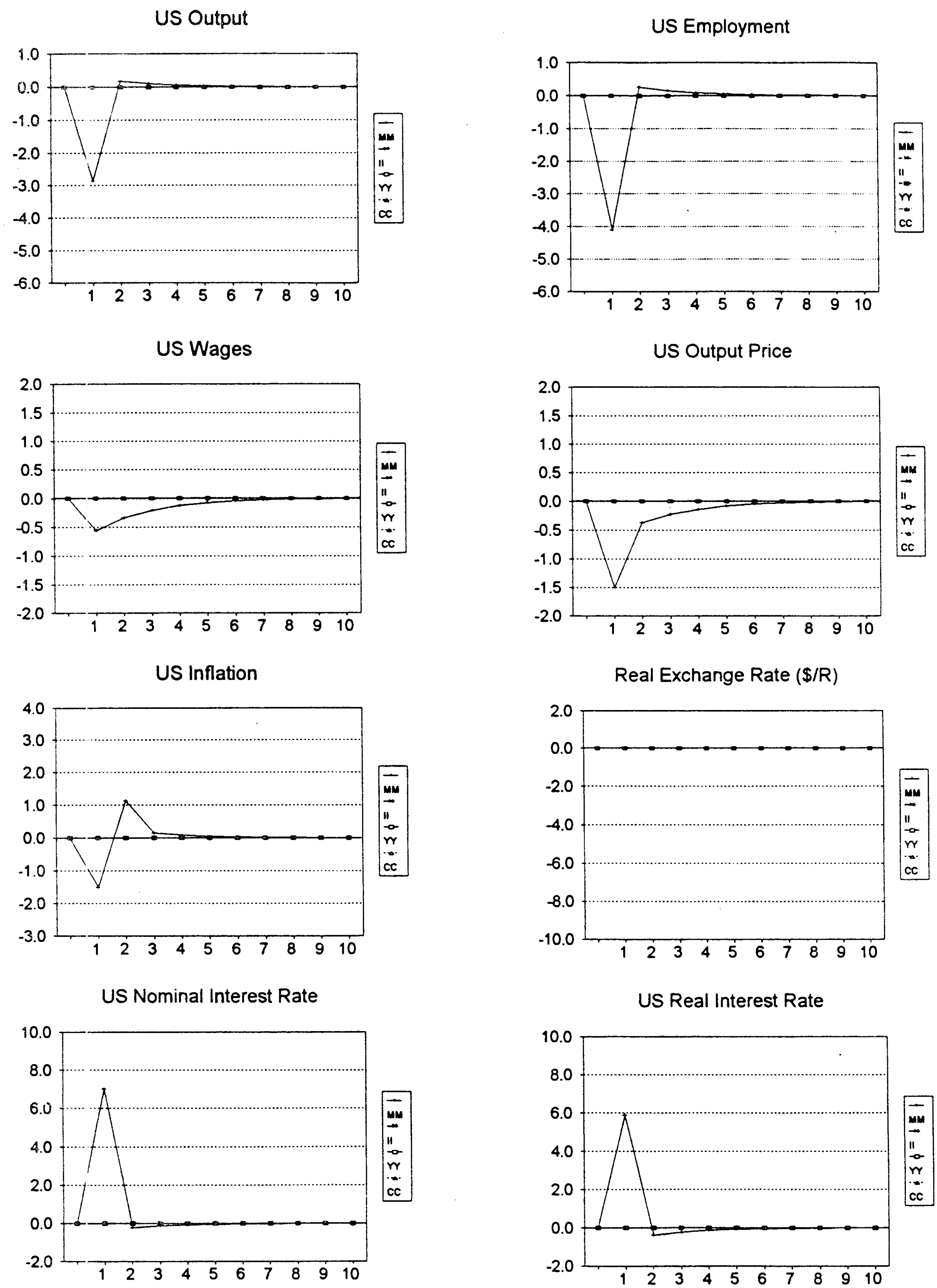


Figure 41. Asymmetric Money-Demand Shock (US Demand Increasing) - Taylor Hypothesis (FIA)

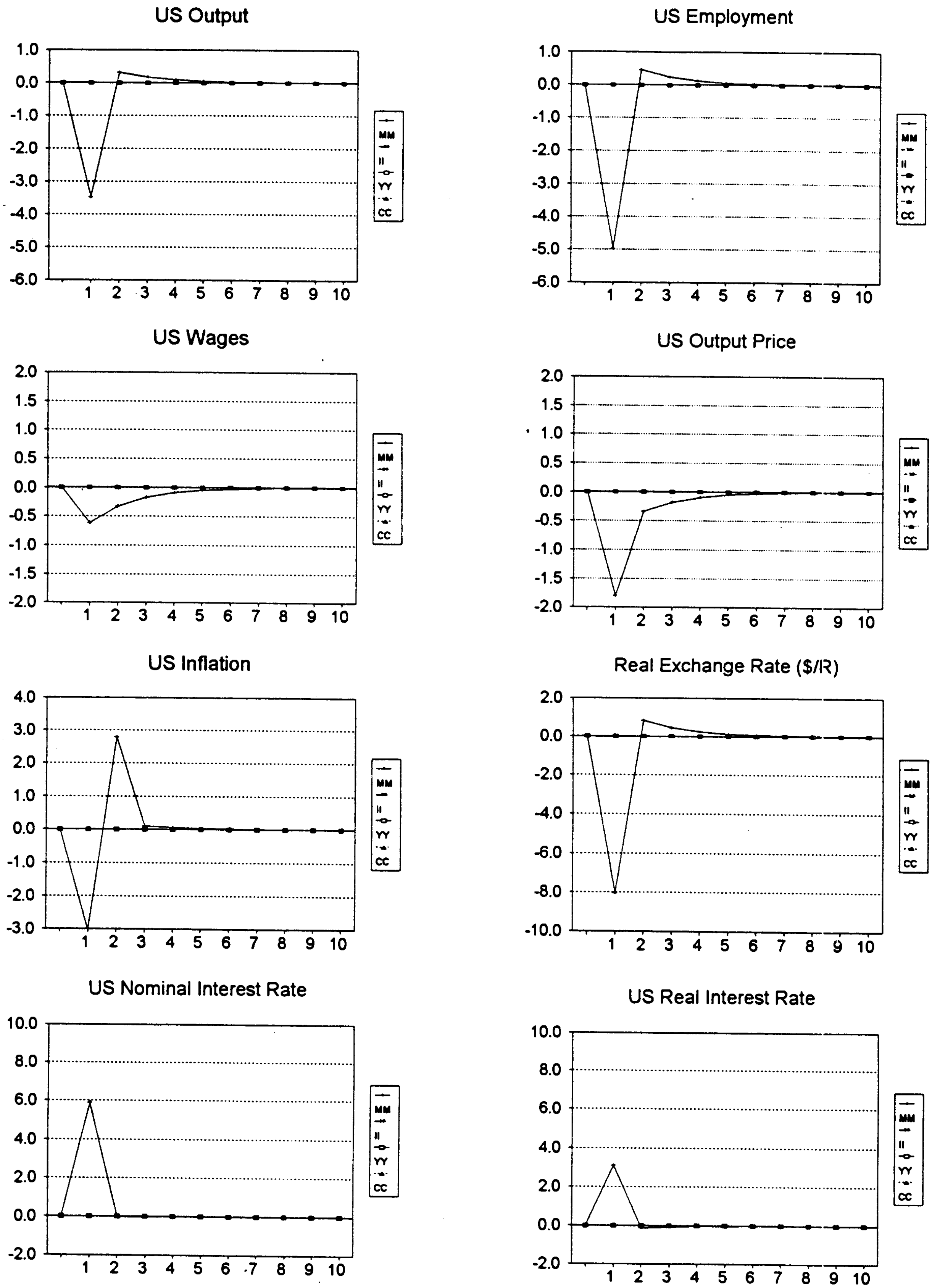


Figure 42. Symmetric Increase in Money Demand - Taylor Hypothesis (PIA and FIA)

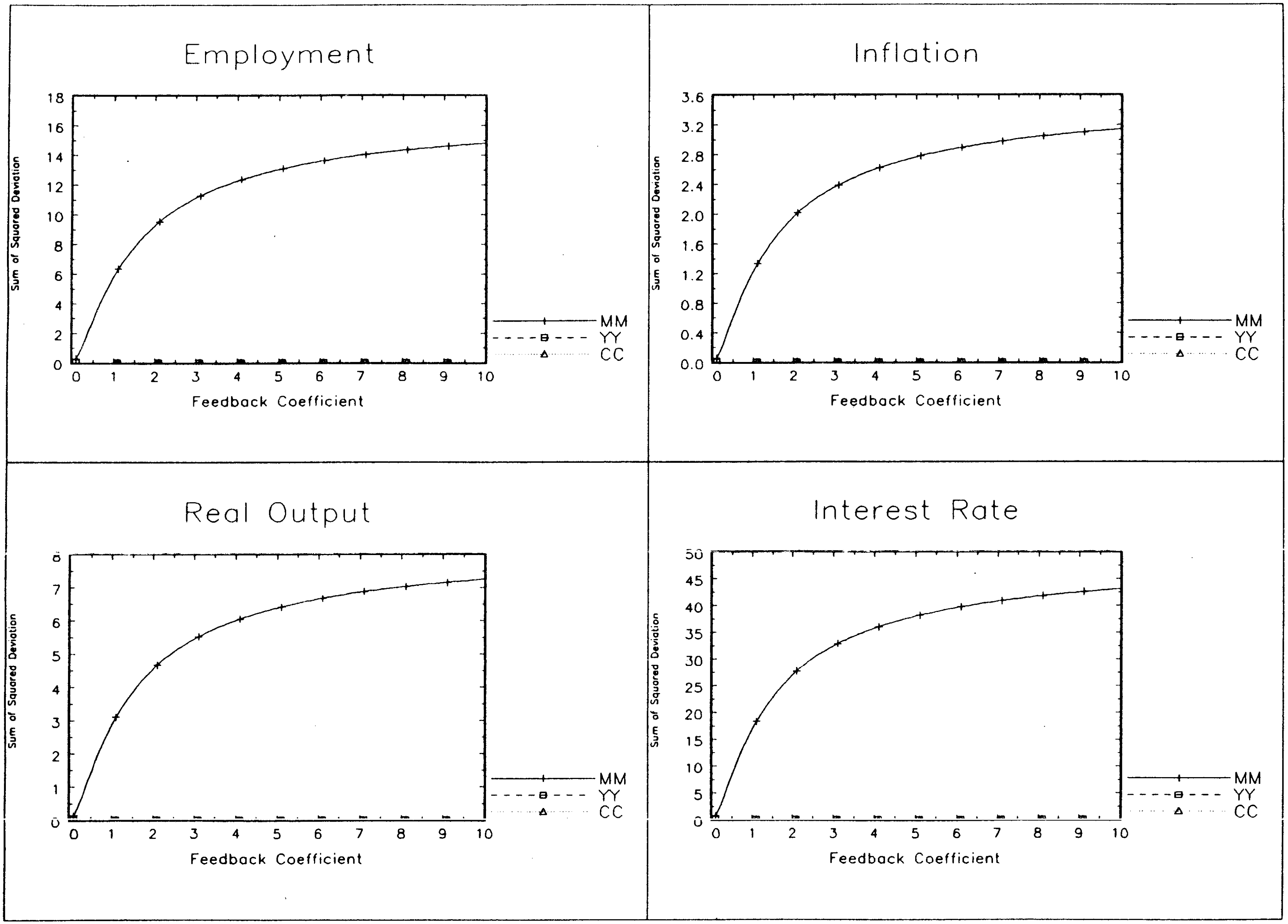


Figure 43. Asymmetric Money-Demand Shock (US Demand Increasing) - Taylor Hypothesis (PIA and FIA)

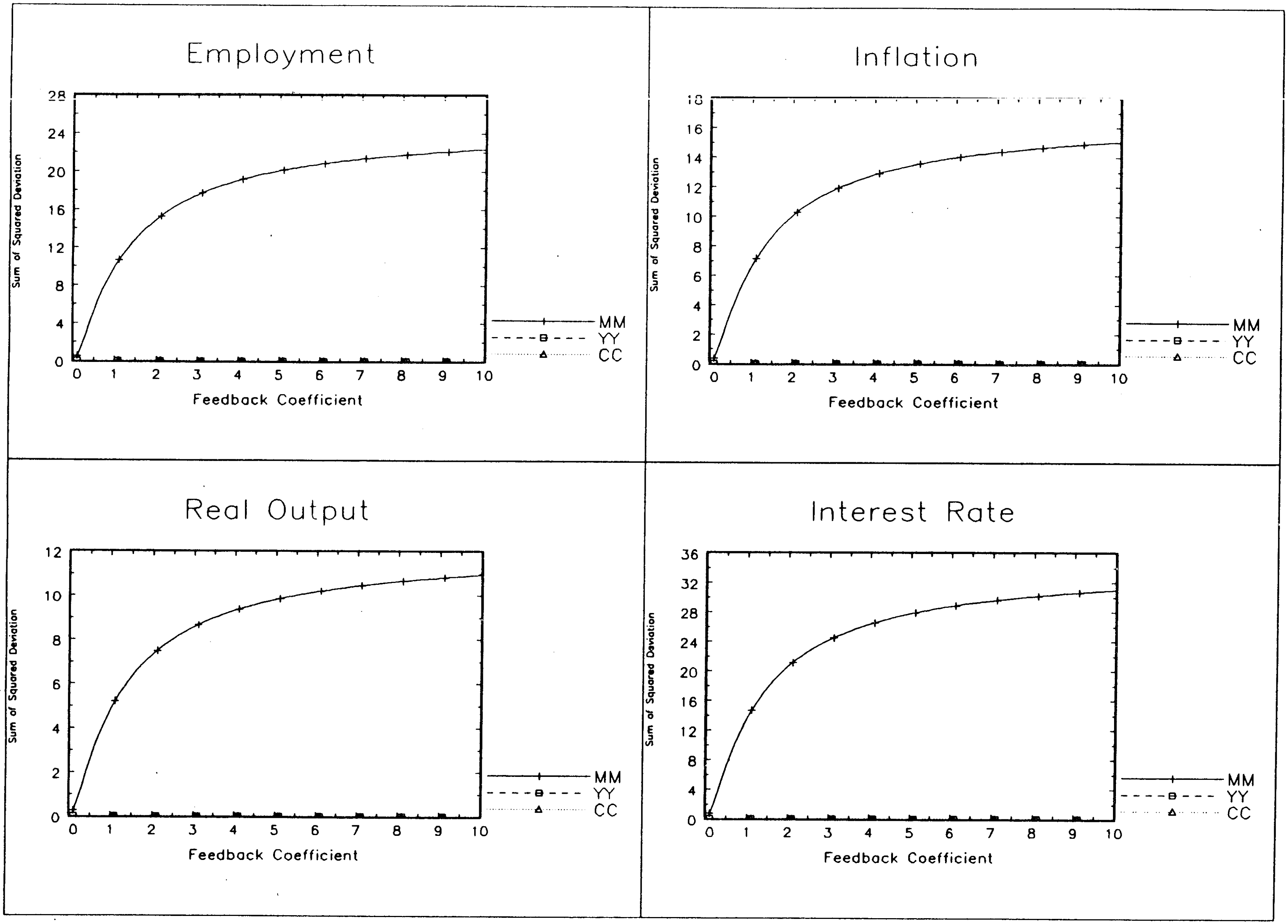


Figure 44. Symmetric Increase in Goods Demand - Taylor Hypothesis (FIA)

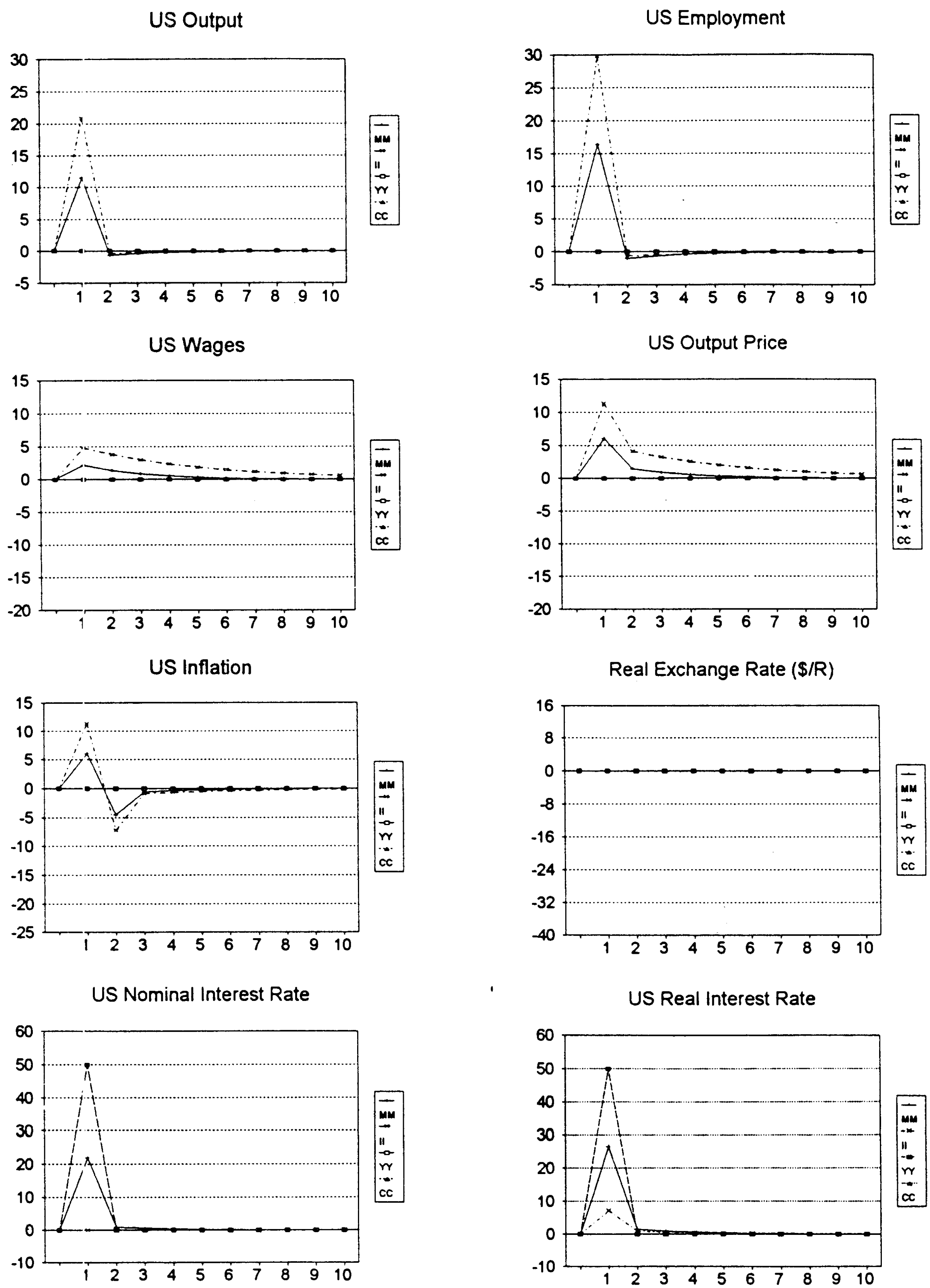


Figure 45. Asymmetric Goods-Demand Shock (US Demand Increasing) - Taylor Hypothesis (FIA)

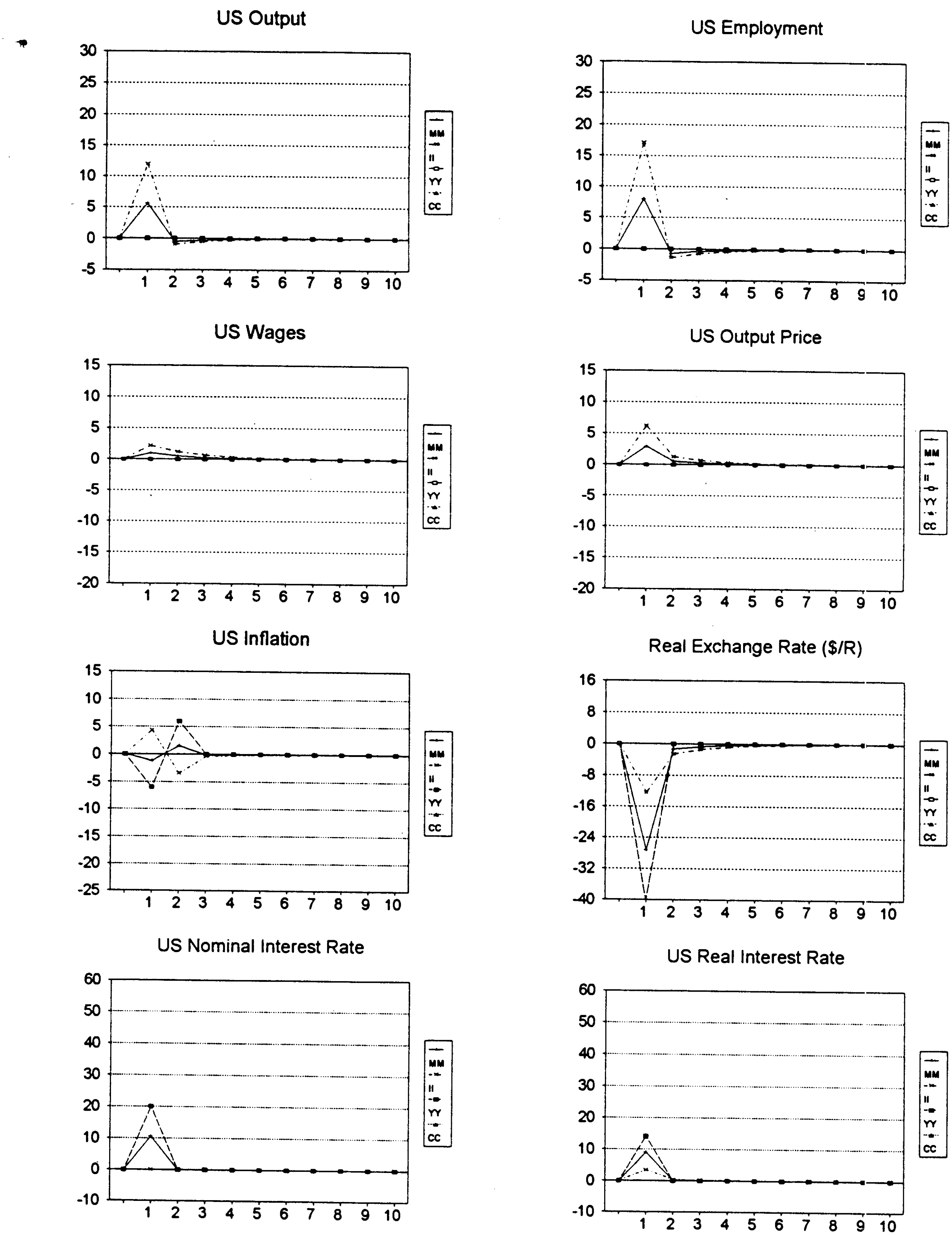


Figure 46. Symmetric Increase in Goods Demand - Taylor Hypothesis (PIA and FIA)

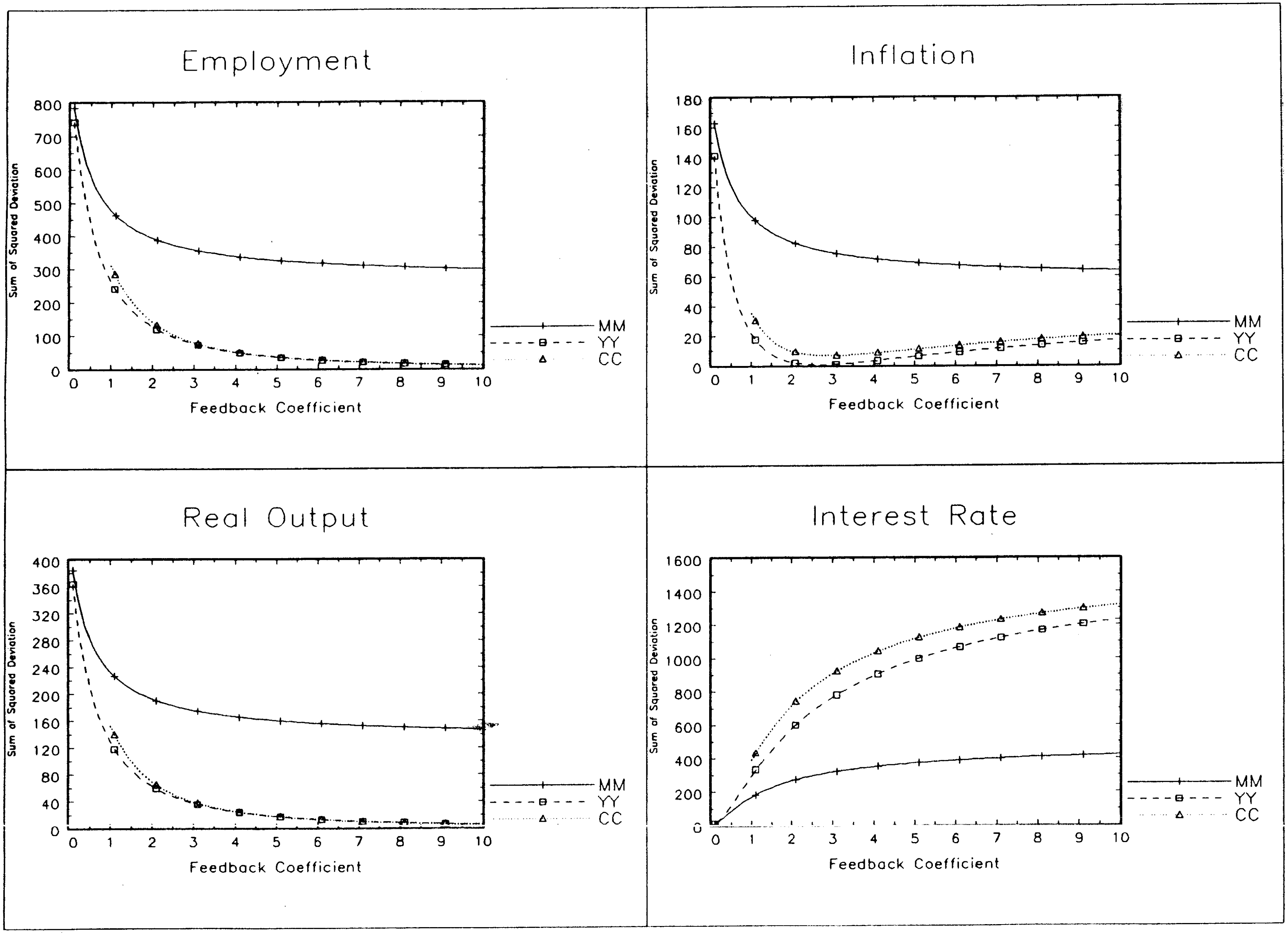


Figure 47. Asymmetric Goods-Demand Shock (US Demand Increasing) - Taylor Hypothesis (PIA and FIA)

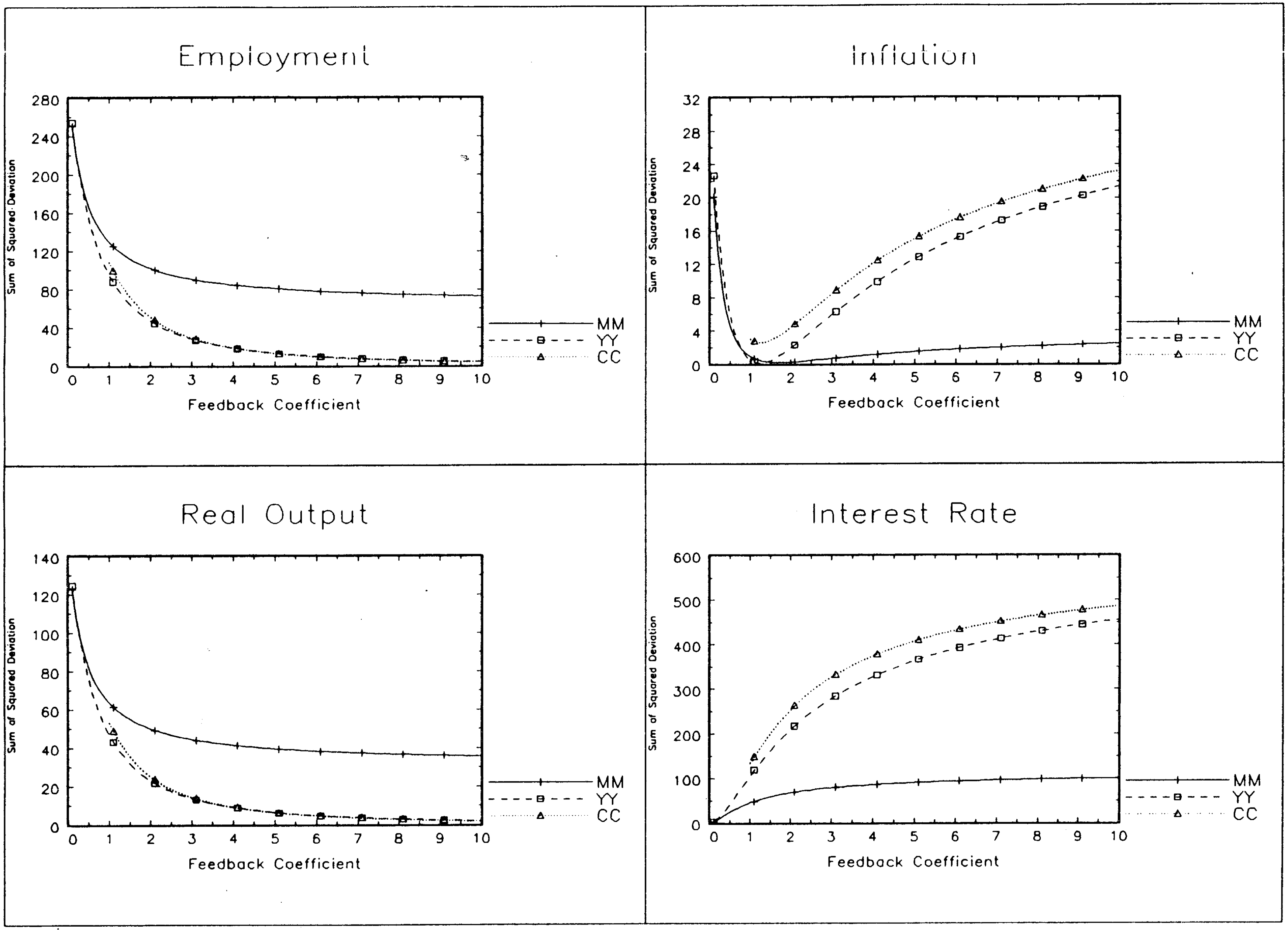


Figure 48. Symmetric Decrease in Productivity - Taylor Hypothesis (FIA)

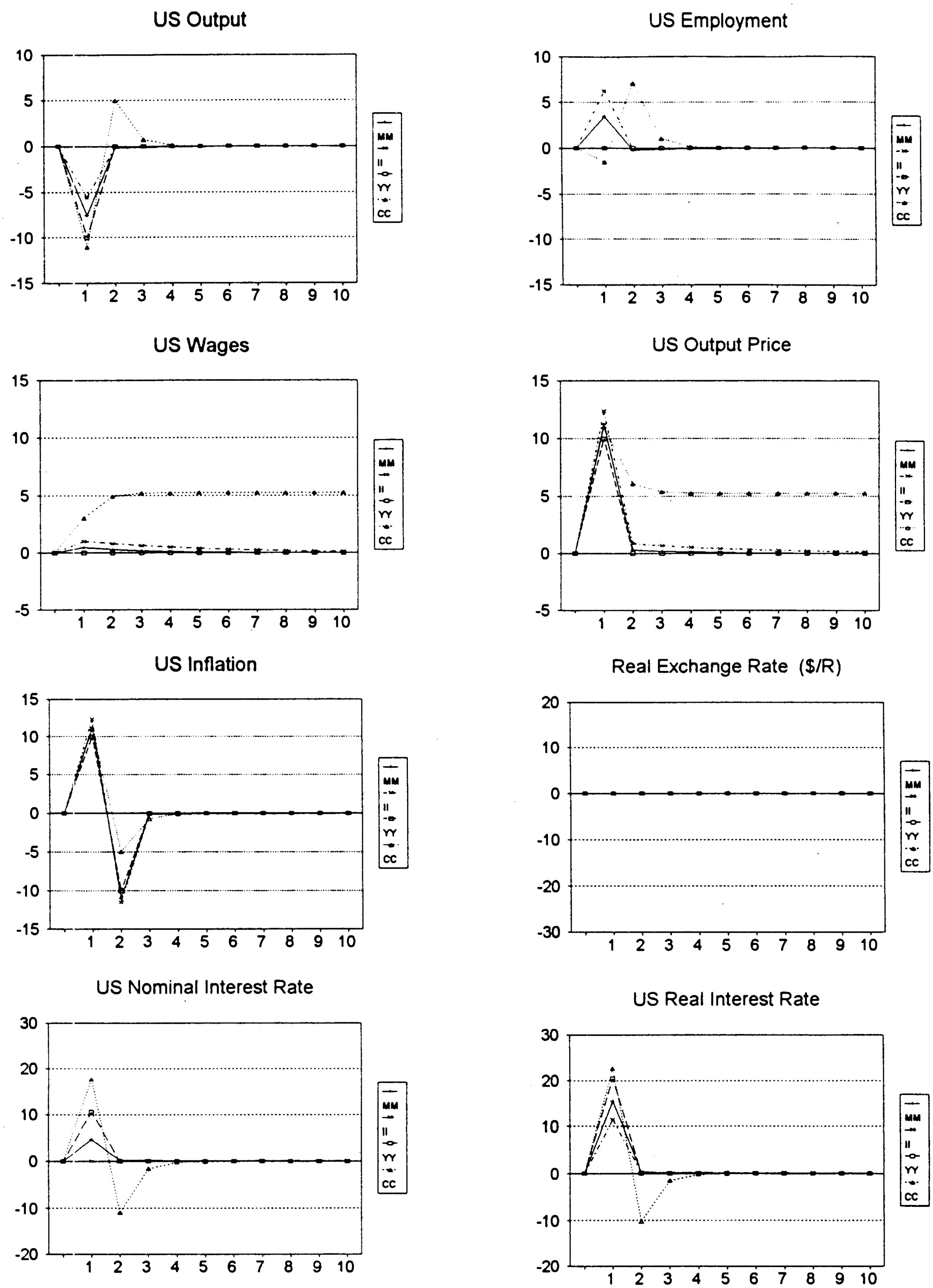


Figure 49. Asymmetric Productivity Shock (US Productivity Decreasing) - Taylor Hypothesis (FIA)

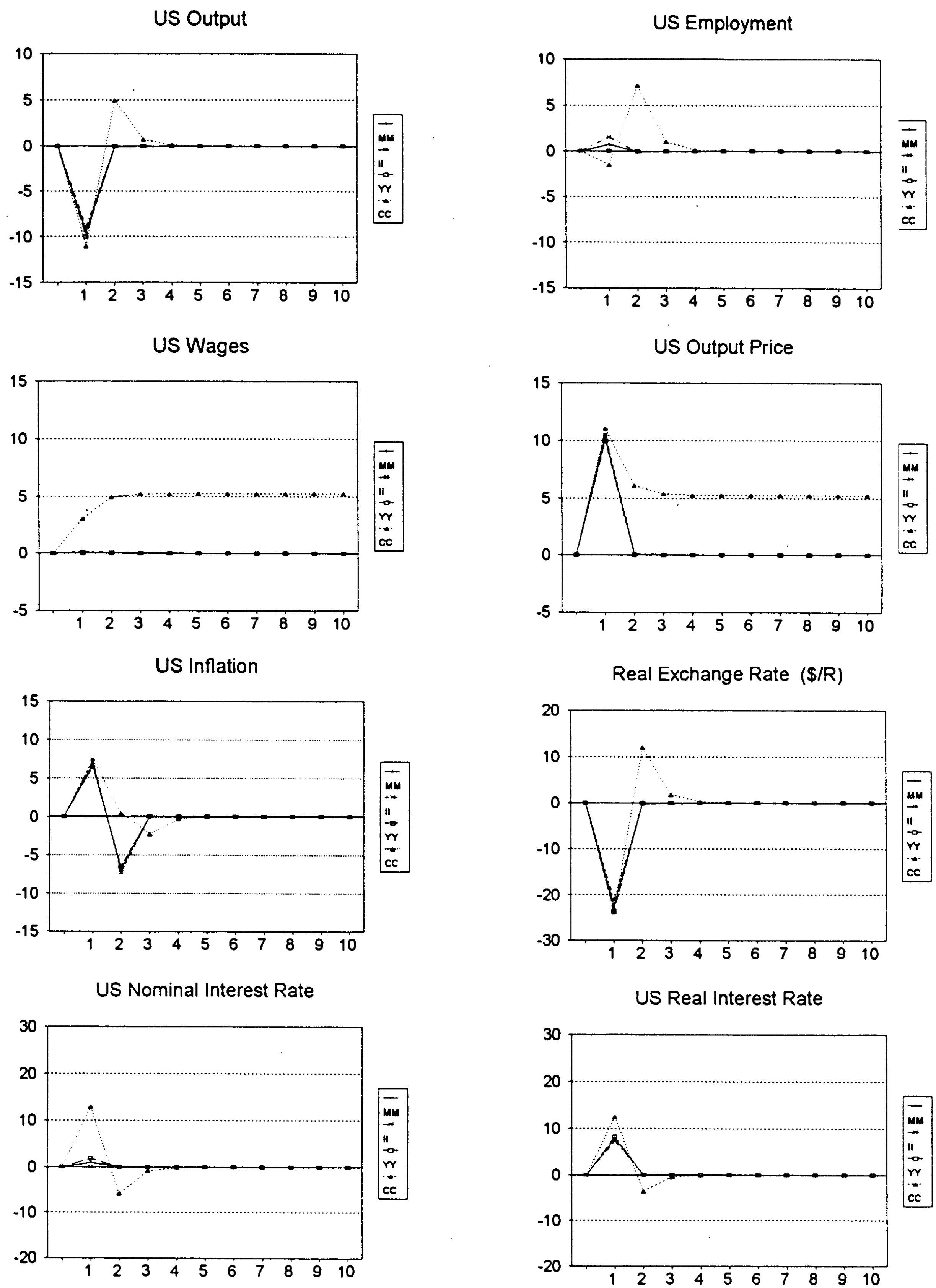


Figure 50. Symmetric Decrease in Productivity - Taylor Hypothesis (PIA and FIA)

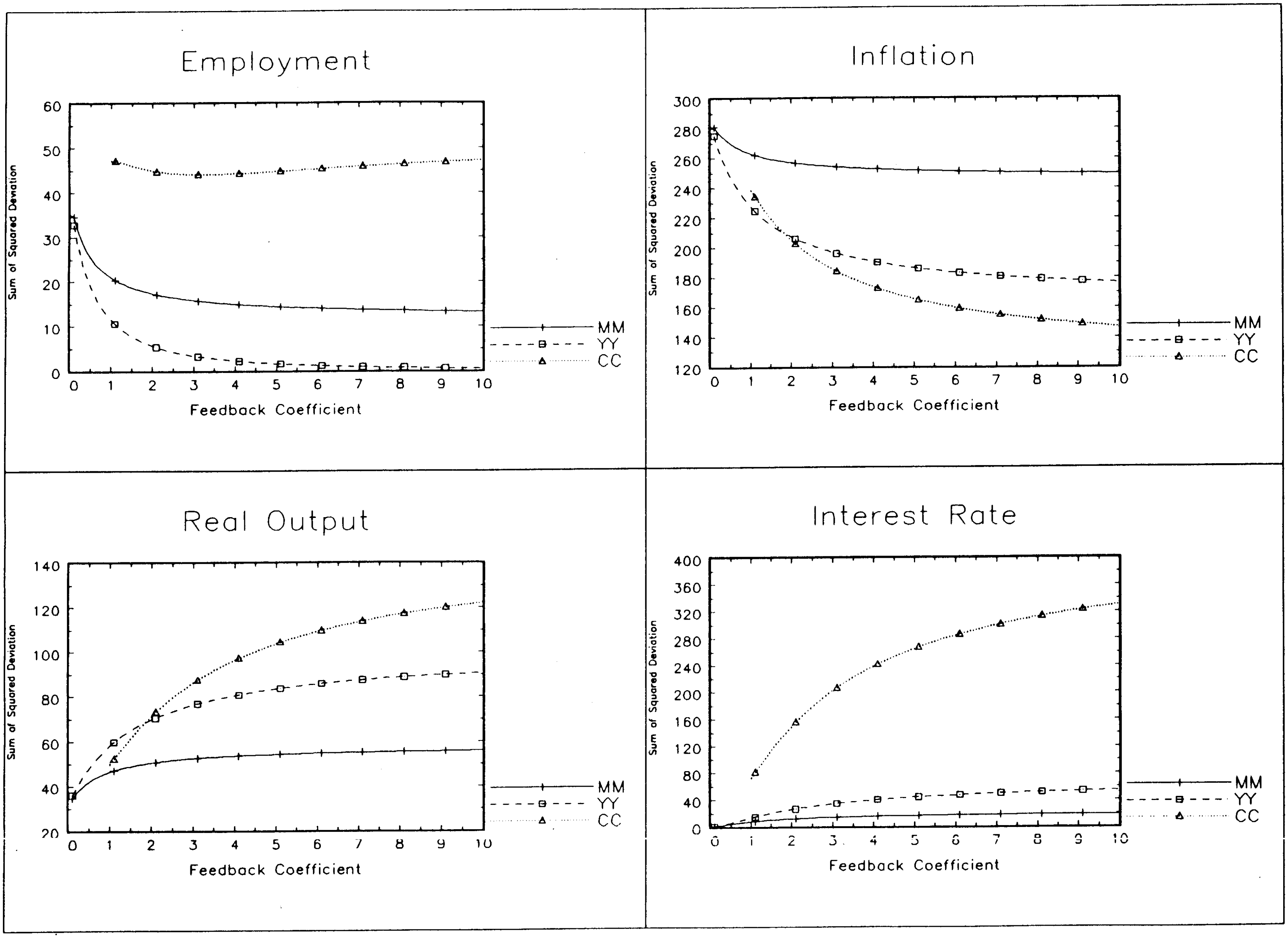
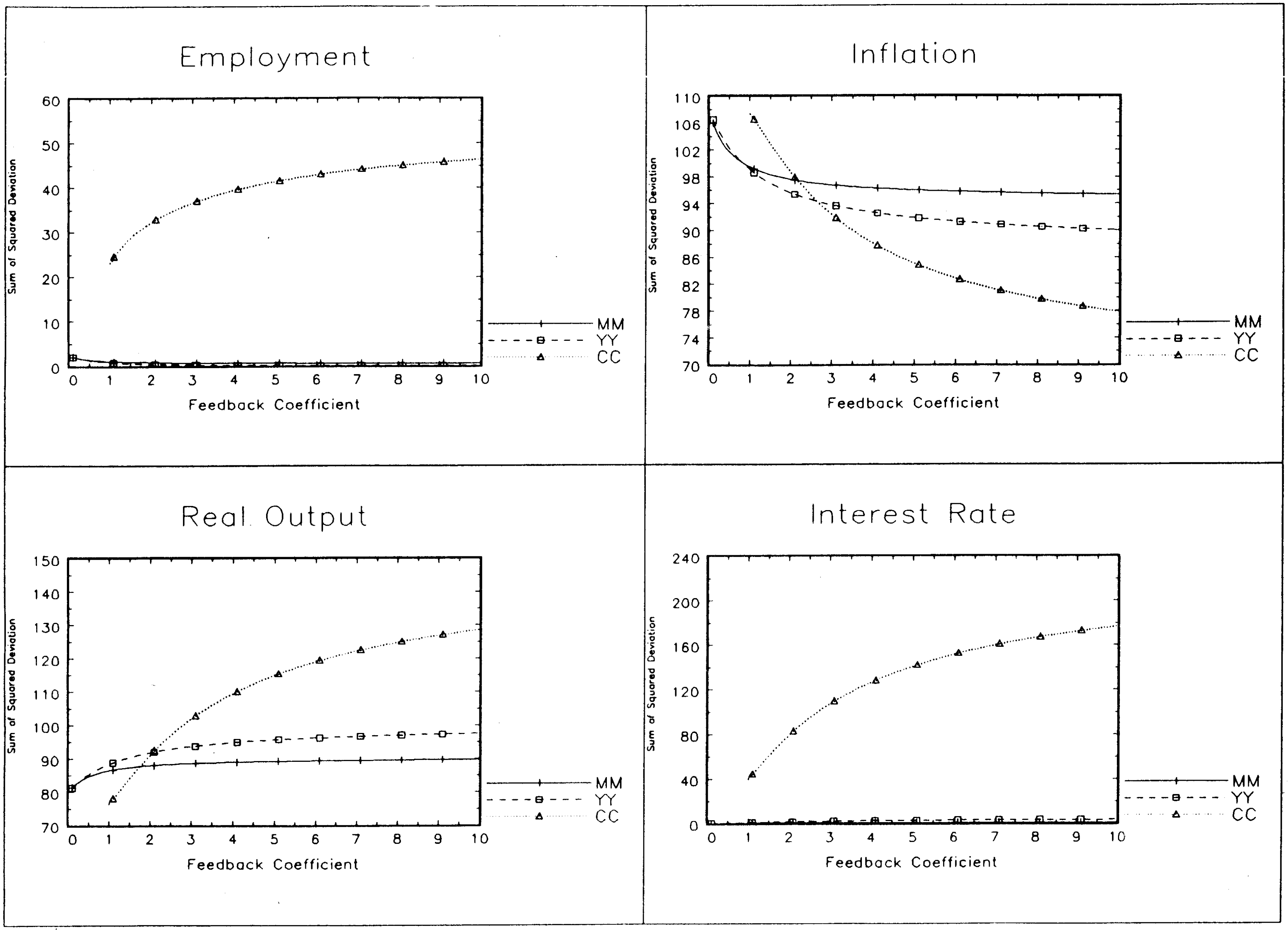


Figure 51. Asymmetric Productivity Shock (US Productivity Decreasing) - Taylor Hypothesis (PIA and FIA)



Appendix A:
Reduced Forms for Sums and Differences

Table A-1:
Sums: Reduced Forms for $\mathbf{y_s}, \alpha\mathbf{n_s}$, and $\mathbf{q_s}$

$\underline{II}$ Regime

$$By_s^{II} = u_s - \nu(A+1)x_s - \nu\bar{i}_s \qquad (A-1)$$

$$B\alpha n_s^{II} = u_s + Cx_s - \nu\bar{i}_s \qquad (A-2)$$

$$Bq_s^{II} = Au_s + (B+AC)x_s - A\nu\bar{i}_s \qquad (A-3)$$

$\underline{MM}$ Regime

$$\lambda E y_s^{MM} = -\nu v_s + \lambda u_s - \nu(1+\lambda)(A+1)x_s + \nu\overline{m}_s \qquad (A-4)$$

$$\lambda E\alpha n_s^{MM} = -\nu v_s + \lambda u_s + [\lambda C + \nu(\phi - 1)]x_s + \nu\overline{m}_s \qquad (A-5)$$

$$\lambda E q_s^{MM} = -\nu A v_s + \lambda A u_s + [\lambda E + \lambda CA + \nu(\phi - 1)A]x_s + \nu A\overline{m}_s \qquad (A-6)$$

$\underline{YY}$ Regime

$$(A+1)y_s^{YY} = -\ (A+1)x_s + \overline{p+y}_s \qquad (A-7)$$

$$(A+1)\alpha n_s^{YY} = \overline{p+y}_s \qquad (A-8)$$

$$(A+1)q_s^{YY} = (A+1)x_s + A(\overline{p+y}_s) \qquad (A-9)$$

Definitions of Combinations of Parameters

$A = (1-\alpha)/\alpha > 0$
$B = 1 - \epsilon + \nu A > 0$
$C = 1 - \epsilon - \nu \gtrless 0$
$D = A + \phi$
$E = 1 - \epsilon + \nu(A + D/\lambda) > 0$

Table A-2:
Differences: Reduced Forms for $\mathbf{y_d}, \alpha\mathbf{n_d}$, and $\mathbf{q_d}$

<u>II Regime</u>

$$Gy_d^{II} = u_d - (A+1)Fx_d - F\bar{i}_d \qquad (A-10)$$

$$G\alpha n_d^{II} = u_d + Hx_d - F\bar{i}_d \qquad (A-11)$$

$$Gq_d^{II} = (1-2\gamma)Au_d + (1-2\gamma)(G+AH)x_d - [(1-2\gamma)AF + 2\gamma G]\bar{i}_d \quad (A-12)$$

<u>MM Regime</u>

$$\lambda J y_d^{MM} = -\ Fv_d + \lambda u_d - F(1+\lambda)(A+1)x_d + F\overline{m}_d \qquad (A-13)$$

$$\lambda J \alpha n_d^{MM} = -\ Fv_d + \lambda u_d + [\lambda H + F(\phi - 1)]x_d + F\overline{m}_d \qquad (A-14)$$

$$\lambda J q_d^{MM} = -\ Kv_d + Lu_d + [(1-2\gamma)\lambda J - (\phi - 1)K + HL]x_d + K\overline{m}_d \quad (A-15)$$

<u>YY Regime</u>

$$(A+1)y_d^{YY} = -\ (A+1)x_d + \overline{p+y}_d \qquad (A-16)$$

$$(A+1)\alpha n_d^{YY} = \overline{p+y}_d \qquad (A-17)$$

$$(A+1)Fq_d^{YY} = -2\gamma(A+1)u_d$$
$$+[(1-2\gamma)F - 2\gamma H](A+1)x_d^{YY} + K(\overline{p+y}_d) \qquad (A-18)$$

<u>Definitions of Combinations of Parameters</u>

$A = (1-\alpha)/\alpha > 0$
$D = A + \phi$
$F = (1-2\gamma)^2\nu + 2\delta > 0$
$G = 1 - (1-2\gamma)\epsilon + FA > 0$

$H = 1 - (1-2\gamma)\epsilon - F \gtrless 0$
$J = 1 - (1-2\gamma)\epsilon + F(A + D/\lambda) > 0$
$K = (1-2\gamma)AF + 2\gamma G > 0$
$L = (1-2\gamma)\lambda A - 2\gamma D \gtrless 0$

Appendix B:
Values of Parameters and Combinations Used in Simulations

α	0.7
γ	0.15
δ	0.2
ϵ	0.59
η	0.05575
ν	0.2
ϕ	1.0
λ	0.8
θ	0.2
$A := (1-\alpha)/\alpha$	0.4286
$B := 1-\epsilon+\nu A$	0.4957
$C := 1-\epsilon-\nu$	0.21
$D := A+\phi$	1.4286
$E := 1-\epsilon+\nu(A+D/\lambda)$	0.8529
$F := (1-2\gamma)^2\nu+2\delta$	0.498
$G := 1-(1-2\gamma)\epsilon+FA$	0.8004
$H = 1-(1-2\gamma)\epsilon-F$	0.089
$J := 1-(1-2\gamma)\epsilon+F(A+D/\lambda)$	1.69
$K = (1-2\gamma)FA+2\gamma G$	0.3895
$L := (1-2\gamma)\lambda A-2\gamma D$	-0.1878

Appendix C:
Simulation Results for the Taylor Model

The purpose of this appendix is to present some simulation results for the Taylor model, the workhorse model under a "Taylor" hypothesis based on Taylor (1980).[1] The Taylor model, like the Phillips model, has some degree of wage persistence, but the results for the two models are sometimes quite different.

Under the Taylor hypothesis, there are overlapping wage contracts. Half the workers and firms in each region enter into two-period contracts in each period. The workers and firms negotiating contracts in period t agree on a single contract nominal wage $(\tilde{w}_t, \overset{*}{\tilde{w}}_t)$ that workers will receive in both period t and period t+1, and the workers agree to supply whatever amount of labor the firms want in those periods at the agreed on contract wage. $\tilde{w}_t$ and $\overset{*}{\tilde{w}}_t$ are set according to equations (C.1):

$$
\begin{aligned}
\tilde{w}_t &= .25(n_{t+1|t} + n_t) + .5(\tilde{w}_{t+1|t} + \tilde{w}_{t-1}), \\
\overset{*}{\tilde{w}}_t &= .25(\overset{*}{n}_{t+1|t} + \overset{*}{n}_t) + .5(\overset{*}{\tilde{w}}_{t+1|t} + \overset{*}{\tilde{w}}_{t-1}).
\end{aligned}
\qquad \text{(C.1)}
$$

The sums $n_{t+1|t} + n_t$ and $\overset{*}{n}_{t+1|t} + \overset{*}{n}_t$ are the sums of excess demand for labor in period t and expected excess demand for labor in period t+1 in the US and the ROECD, respectively. If these sums are equal to zero, $\tilde{w}_t$ and $\overset{*}{\tilde{w}}_t$ are set so as to maintain the relative wage of the contracting workers over the life of the contract. $\tilde{w}_t$ and $\overset{*}{\tilde{w}}_t$ are set equal to the average of the wage being received in period t by workers who negotiated contracts in period t-1 $(\tilde{w}_{t-1}, \overset{*}{\tilde{w}}_{t-1})$ and the wage it is expected that these same workers will receive when they negotiate new contracts in period t+1 $(\tilde{w}_{t+1|t}, \overset{*}{\tilde{w}}_{t+1|t})$. If the sums of current and expected future excess demands for labor are positive or negative, $\tilde{w}_t$ and $\overset{*}{\tilde{w}}_t$ are set so as to raise or lower the relative wage of the contracting workers.

According to equations(C.2), (average) wages $(w_t, \overset{*}{w}_t)$ are the averages of the contract wages negotiated in periods t and t-1:

$$
w_t = .5(\tilde{w}_t + \tilde{w}_{t-1}), \qquad \overset{*}{w}_t = .5(\overset{*}{\tilde{w}}_t + \overset{*}{\tilde{w}}_{t-1}). \qquad \text{(C.2)}
$$

[1] Our specification of the "Taylor" hypothesis is discussed in more detail in Henderson and McKibbin (1993a), and the relationship between our specification and Taylor's own formulation is spelled out in Appendix J of that chapter.

The values of w_t and $\overset{*}{w}_t$ generated by the Taylor hypothesis are used in the marginal productivity conditions for labor in the same way as the values of w_t and $\overset{*}{w}_t$ generated by the Contract and Phillips hypotheses.

The Taylor model comprises equations (C.1), (C.2), and equations (1) through (8) in Table 1. Results for simulations of the Taylor model using the parameters in Appendix B for all six shocks considered in the other models under both FIA and PIA appear in Figures 40 through 51. Although we do not discuss these results here, we do discuss the results under FIA in Henderson and McKibbin (1993a). It would be useful to obtain a better understanding of the reasons for the differences in results between the Taylor model and the Phillips model since both of them have some degree of wage persistence.

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