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Monetary shocks, the exchange rate, and the trade balance

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Abstract

This paper investigates the response of the exchange rate and the trade balance to monetary policy innovations for the US economy during the period 1973:01–1993:12. The empirical findings indicate that contractionary monetary policy shocks lead to transitory appreciations of the real and the nominal exchange rate. Exchange rate appreciations that are caused by a temporary contractionary shock to monetary policy are correlated with a short-lived improvement in the trade balance which is then followed by a deterioration, giving support to the *J*-curve hypothesis. © 1999 Elsevier Science Ltd. All rights reserved.

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1. Introduction

In this paper we address a controversial question in open economy macroeconomics: How do the exchange rate and the trade balance respond to monetary policy innovations? According to exchange rate overshooting models, a contractionary monetary policy shock causes a large initial appreciation followed by a depreciation in nominal and real exchange rates. This view is not supported by the findings of Eichenbaum and Evans (1995) who find that a contractionary shock to US monetary policy leads to persistent appreciations in nominal and real US exchange rates.

Another point of controversy is related to the response of the trade balance to exchange rate movements. It is widely believed that a depreciation (appreciation) of the domestic currency against other currencies improves (deteriorates) the trade bal-

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ance in the long-run, but worsens (improves) it in the short-run, generating a *J*-curve. A common explanation of the *J*-curve is based on the assumption that export contracts are written in domestic currency units and import contracts are written in foreign currency units. Following a depreciation of the domestic currency, prices of import goods rise in domestic currency units while prices of export goods do not change. Therefore, the value of import goods rises significantly while little or no change takes place in the value of exports. This causes the trade balance to deteriorate in the short-run. Export and import quantities adjust over time to changes in relative prices. As the quantity of import goods falls in response to higher import prices and the quantity of export goods increases, the value of exports exceeds the value of imports, leading to an improvement in the trade balance in the long-run.

Empirical evidence on the *J*-curve hypothesis is mixed. The majority of the literature estimates “volume and pass through equations”. Using this approach, Krugman and Baldwin (1987) find that the perverse effect has a duration of four quarters. The estimates of Artus (1975) and Helkie and Hooper (1987) imply *J*-curves lasting only one quarter. Moffett (1989), on the other hand, does not find any evidence for the *J*-curve. This result is also supported by Rose and Yellen (1989) who estimate a “partial” reduced form equation for the net merchandise trade balance.

On a theoretical note, Bacchetta and Gerlach (1994) show that *J*-curves can also arise if import prices adjust slowly to exchange rate changes. The intuition is that in an intertemporal framework, if import prices are sticky, consumers anticipate a rise in future import prices after a devaluation and therefore reallocate their purchases over time. Intertemporal reallocation of purchases leads to the *J*-curve. This result implies that lack of evidence of “pass through” on import prices does not necessarily mean that the *J*-curve does not exist.

In this paper we follow a more direct approach and investigate the response of the trade balance to monetary innovations within the context of a vector autoregression (VAR) model, which is based on a simple open economy model. Analyzing the correlation of the trade balance with exchange rate movements within this context requires an understanding of how monetary policy affects the economy. A broad class of open economy macroeconomic models including Mundell (1968), Calvo and Rodriguez (1977) and Frenkel and Rodriguez (1982), indicate that, following a permanent positive monetary policy shock, output and the price level increase, the interest rate falls, the exchange rate depreciates, and the trade balance improves. Over time, however, output, the interest rate, the exchange rate, and the trade balance are expected to return to their initial values. The price level is expected to be permanently higher if the monetary policy shock is permanent. Recent evidence by Christiano and Eichenbaum (1992), Strongin (1995), Christiano et al. (1996), Eichenbaum and Evans (1995), Pagan and Robertson (1995) and Cushman and Zha (1997) provides support for some of the results predicted by these conventional models. These studies, however, with the exception of Cushman and Zha (1997) who examine the Canadian economy, do not investigate the response of the trade balance to monetary policy innovations. In this paper, we extend these studies to analyze whether the implications of conventional open economy models are supported by evidence for the US economy.

The methodology of the study is presented in Section 2 of the paper, and the empirical results are presented and discussed in Section 3. The results are summarized in the conclusion.

2. Methodology

2.1. Description of the model

To investigate the response of the exchange rate and the trade balance to monetary policy innovations, VARs are employed. Each model comprises the following variables (unless otherwise indicated, all variables are US variables). Output (Y, measured by industrial production), the price level (P, measured by the personal consumption deflator), an index of sensitive commodity prices (CP), a short-term interest rate (R, measured by the federal funds rate), total reserves (TR), nonborrowed reserves (NBR), a foreign output measure (Y^*, measured by foreign industrial production), a foreign price level measure (P^*, measured by the foreign CPI), a foreign short-term interest rate measure (R^*), a nominal exchange rate measure (E), and a real trade balance measure (TB). The results reported below are essentially unchanged when the real exchange rate (RE) replaces the nominal exchange rate (E) with the other variables in the model unchanged.[1] A primary difference between these models and those of Eichenbaum and Evans (1995) is the inclusion of the commodity price and trade balance variables as additional variables.

The model is estimated using multilateral data; trade-weighted measures of foreign output, the foreign price level, the foreign interest rate, the exchange rate, and the total trade balance between the US and the remainder of the G-7 countries are employed in addition to the US variables. This model provides “generic” estimates of the effects of monetary policy shocks on the variables of interest. The response of output, the price level, the interest rate, the exchange rate, and the trade balance to monetary policy shocks are analyzed by computing and plotting impulse response functions (IRFs). The identification of monetary policy shocks is discussed below.

The data used to estimate the model consist of monthly observations for the G-7 countries for the period 1973:01–1993:12. All data except the interest rates and exchange rates are seasonally-adjusted. A complete description of and sources of the data are given in the Appendix A. The calculation of trade weights and the construction of the multilateral data are also described in the Appendix A.

Following Eichenbaum and Evans (1995), the model was estimated using log lev-

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[1] We have also estimated a system in which RE replaces E, P, and P^*. The effects of a monetary policy shock on domestic and foreign output, commodity prices, total reserves, nonborrowed reserves, the federal funds rate, the real exchange rate, and the trade balance are qualitatively similar to those in Fig. 1. Although the pattern of effects is very similar in both systems, the specific magnitudes and timing differ somewhat, especially for domestic and foreign output, commodity prices, and total reserves. The differences in magnitudes and timing likely reflect the omission of domestic and foreign prices which certainly play an important role in the adjustment of the macroeconomy to a monetary policy shock in theoretical models of the open economy.

els for all data except the interest rate variables. The levels of the interest rate variables were used, and the trade balance was measured as the log of the ratio of nominal exports to nominal imports. The lag length for the VARs was determined by examining the serial correlation properties for the VAR residuals for alternative lag lengths of 3, 6, 9, 12, and 13 months. The shortest lag length that generated white noise residuals (as measured by *Q*-statistics) for all equations in the model was selected as the optimal lag length.[2] The optimal lag was found to be 12.

2.2. Identification of policy shocks

Structural shocks to monetary policy are identified from a Choleski decomposition of the variance–covariance matrix. Two alternative monetary policy variables are considered: nonborrowed reserves and the federal funds rate. These two variables have been the focus of attention in recent studies that examine the effects of monetary policy shocks on macroeconomic activity. Although Bernanke and Blinder (1992) contend that the federal funds rate is a good monetary policy measure, Eichenbaum (1992) argues that nonborrowed reserves are a preferred measure. Christiano et al. (1996) consider both nonborrowed reserves and the federal funds rate as alternative monetary policy variables. We follow that strategy here.

2.2.1. Nonborrowed reserves as the policy variable

When nonborrowed reserves are the policy variable, the Wold causal ordering for the decomposition is *Y*, *P*, *CP*, *Y**, *P**, *TR*, *NBR*, *R*, *R**, *TB*, and *E*. It is assumed that monetary policy innovations affect the output and price variables only with a lag and that the Fed alters the setting of its policy variable in response to current period shocks to output and price. These assumptions are reflected in the ordering of *Y*, *P*, *CP*, *Y**, and *P** prior to the monetary policy variable and are similar to assumptions made in Christiano et al. (1996) and Eichenbaum and Evans (1995). Variables higher in the ordering are assigned “credit” for any contemporaneous correlation between these variables and those lower in the ordering. It is further assumed that monetary policy actions have contemporaneous effects on *R*, *R**, *TB*, and *E*, but that monetary policymakers respond only with a lag to movements in these variables. Consequently, *R*, *R**, *TB*, and *E* are placed after the monetary policy variable in the ordering. We note that Eichenbaum and Evans (1995) place *R** before the monetary policy variable; this ordering implies that US monetary actions affect foreign interest rates only with a lag. This assumption is questionable in light of the degree of integration of financial markets for the countries under examination. Furthermore, it seems reasonable that the Fed will respond only to sustained developments in foreign financial markets and that contemporaneous shocks to foreign interest rates will typically have little impact on contemporaneous policy actions. For these reasons, we

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[2] An alternative way to choose lag lengths would be to use a criterion like the AIC. However, when this criterion was employed, the lag lengths selected yielded serial correlation in at least some of the equations in the model. Consequently, we employed the technique described in the text.

place R^* after the monetary policy variable. Because it might be argued that monetary policy actions affect the trade balance only with a lag, we also considered the effects of this assumption by placing *TB* just prior to *TR*. The results were essentially unchanged from those reported for our primary ordering.

CP is included in light of the "price puzzle" that has emerged in VAR models that do not include a variable that contains information about future inflation. The "price puzzle" refers to the prolonged increase in the price level following a contractionary shock to monetary policy found in these VARs. Ordering *CP* before the monetary policy variable allows a contemporaneous response by the monetary authority to an indicator of future inflation. Earlier studies (see, for example, Christiano et al., 1996) have found that this eliminates the price puzzle.

We note that the model contains both *TR* and *NBR*. The inclusion of both these variables reflects the argument of Strongin (1995) that *NBR* shocks are mixtures of policy shocks and reserve demand shocks. He argues that under the policy procedures followed over our sample, the level of *TR* was primarily determined by Federal Reserve accommodation of the demand for reserves. In this view, shocks to *TR* reflect reserve demand shocks, and ordering *TR* before *NBR* purges *NBR* shocks of effects due to reserve demand shocks. In the ordering above, *TR* precedes *NBR*; consequently, we interpret *NBR* shocks as monetary policy shocks. Placing *R* after *NBR* allows monetary policy shocks to contemporaneously alter domestic interest rates. We note that Strongin (1995) focuses upon the mix of reserves as measured by the ratio of current period *NBR* to *TR* lagged one period. In his closed economy model, this variable is ordered after a total reserves measure—the ratio of total reserves in the current period to total reserves lagged one period—and the shocks to the *NBR* ratio are interpreted as monetary policy shocks. We follow the more common use of the log levels of *TR* and *NBR*. Thus, the ordering we use is in the spirit of Strongin, although we do not use the exact variable he suggests.[3]

The rationale for ordering the exchange rate after the monetary policy variable is similar to that for ordering the foreign interest rate after the policy variable. It is assumed that the Fed responds only to sustained developments in foreign exchange markets and that contemporaneous shocks to the exchange rate typically have little effect on current policy actions. Placement of the exchange rate after the interest rate variables allows current period developments in financial markets to alter the exchange rate, and placement of the exchange rate after the trade balance allows shocks to exports and imports, the components of the trade balance, to have contemporaneous effects on the exchange rate.

2.2.2. Federal funds rate as an alternative policy variable

When the federal funds rate is the monetary policy variable, the Wold causal ordering for the Choleski decomposition is *Y*, *P*, *CP*, Y^*, P^*, *R*, *TR*, *NBR*, R^*, *TB*,

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[3] The use of log levels is not strictly compatible with the linear identification scheme outlined by Strongin. However, Strongin indicates that his results are not sensitive to the use of log levels in place of the ratio variables.

and *E*. Following Christiano et al. (1996), *R* is ordered before the reserves measures. The other identifying assumptions are unchanged. We note that one might argue that if *TR* shocks are interpreted as reserve demand shocks, a more appropriate ordering would be to place *TR* before *R*. This would purge shocks to *R* of any effect of reserve demand shocks. However, if the reserve supply curve is horizontal at the policy-determined level of *R*, reserve demand shocks would have no effect on *R*. Since, over our sample, a target range for the federal funds rate was typically specified by the Federal Reserve, there is some limited scope for reserve demand shocks to alter *R*. Accordingly, we consider the effects of ordering *TR* before *R*. The results are essentially identical to those for the case where *R* is ordered before the reserve variables. Hence we report only results for ordering *R* before the reserves measures.

3. Empirical results

3.1. Nonborrowed reserves as the policy variable

We initially assume that the monetary policy variable is nonborrowed reserves. The responses of *Y*, *P*, *CP*, *Y**, *P**, *R*, *R**, *TR*, *NBR*, *E*, *RE*, and *TB* to a one standard deviation negative shock to *NBR* are presented in Fig. 1. Although the real exchange rate (*RE*) is not included as a variable in the model, the effects of the monetary policy shock on *RE* can be derived from the effects of policy on *E*, *P*, and *P**. The solid line is the point estimate while the dotted lines represent a one-standard error confidence bound around this point estimate. The standard errors are generated from a Monte Carlo simulation of 1000 draws. A contractionary shock is considered for consistency with the case where the federal funds rate is the monetary policy variable. A positive one standard deviation shock to the federal funds rate represents a contractionary impulse.

A close examination of the response of *NBR* to a negative (contractionary) *NBR* shock indicates that the shock can be interpreted as a temporary shock. The immediate effect is a sharp and significant decline in *NBR*, followed by a rebound to the initial value within seven months.

A negative shock to *NBR* is followed by a decline in *Y* and *P*. The confidence band for *Y* becomes negative about four months after the shock, reaches its trough after nine months and remains below zero for about one and a half years. Following a shock to *NBR*, it takes roughly 10 months for the confidence band for *P* to fall below zero, where it remains for the entire horizon. (When the horizon is extended beyond 48 months, the confidence band spans zero after 53 months.) The point estimate for *P* is always negative over the horizon reported, and the decline in *P* is persistent and reaches its trough after 5 months. The initial effect of a negative *NBR* shock to *Y** is negative, and output returns to its initial level in less than a year. The effect of an *NBR* shock on *Y** is not as strong as it is for *Y*. However, it is clear from the evidence that both *Y* and *Y** respond to *NBR* innovations in a qualitatively similar manner. The response of *P** to a negative *NBR* shock is also very similar to that of *P*.

The initial response of *R* to a negative *NBR* shock is strongly positive, consistent

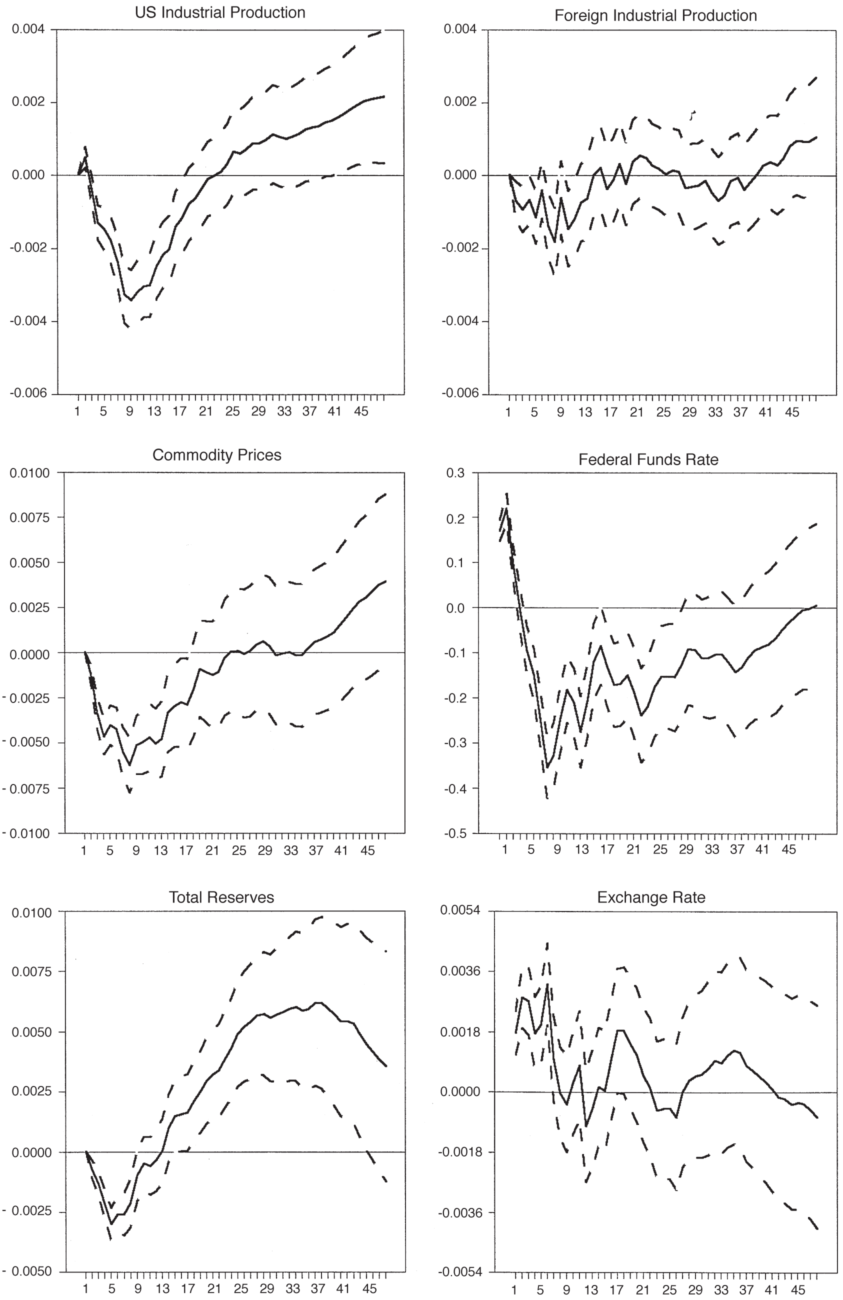
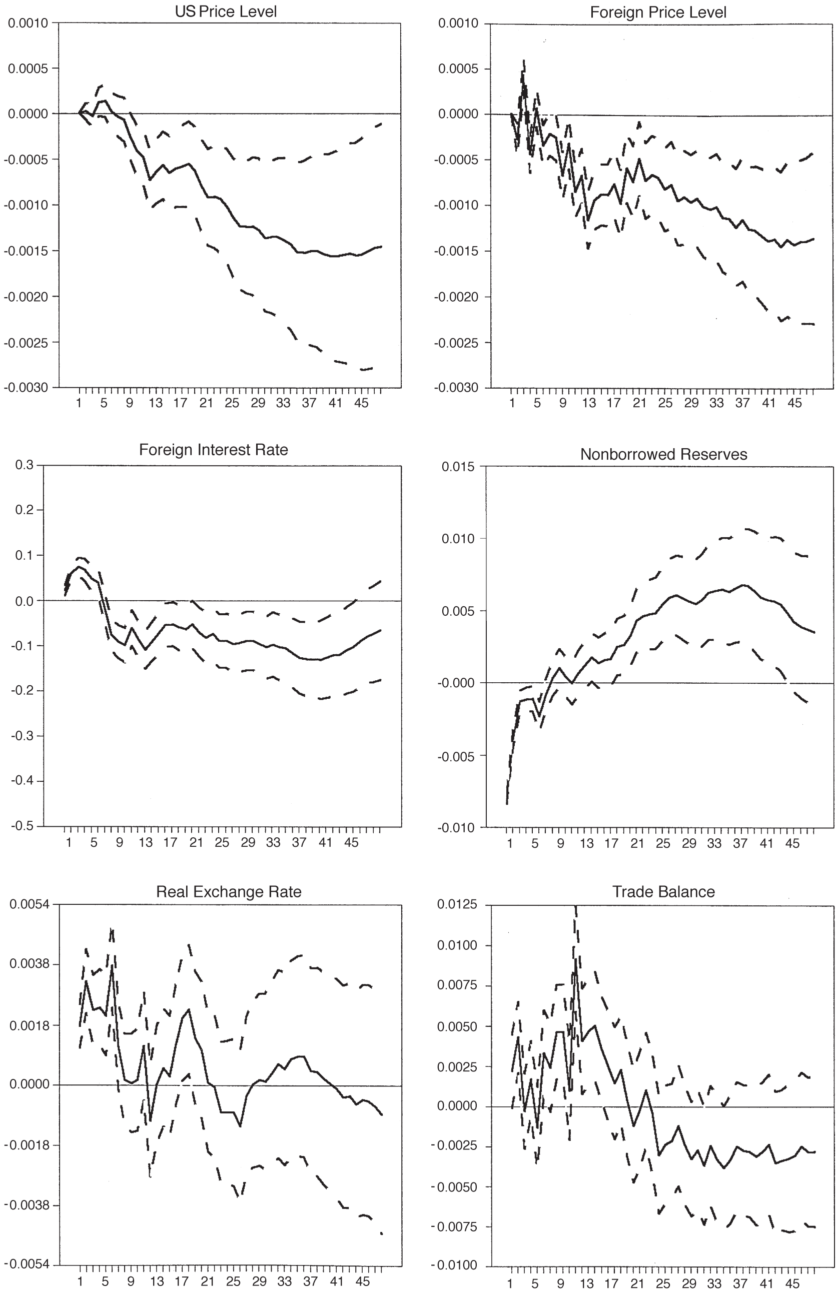


Fig. 1. Shock to *NBR*.



US Price Level

Foreign Price Level

Foreign Interest Rate

Nonborrowed Reserves

Real Exchange Rate

Trade Balance

Fig. 1. (*continued*)

with a strong liquidity effect. After approximately 3 months, *R* declines sharply and actually falls below zero for a while, possibly due to expected deflation, output, and price level effects, and finally returns to its initial level.[4]

Following a negative shock to *NBR*, *E* appreciates. This result is in line with Eichenbaum and Evans (1995). However, unlike Eichenbaum and Evans (1995) who find a persistent appreciation of the exchange rate, we find that approximately after 7 months, the confidence band for *E* spans zero. Also, unlike Eichenbaum and Evans (1995), we find that the maximal impact of the *NBR* shock on *E* occurs in 6 months rather than taking 2 to 3 years. Our results are consistent with the predictions of the asset market approach to exchange rate determination. We find that the immediate effect of a negative *NBR* shock is to raise both *R* and *R**. This implies an increase in the expected rate of return on foreign assets in domestic currency units as well as an increase in domestic rates of return. Since the immediate increase in *R* is more than that in *R**, the result is an appreciation of the exchange rate. Due to the temporary nature of the *NBR* shock, however, once the effects of the shock are over, the exchange rate returns to its initial level. The response of the real exchange rate to a negative *NBR* shock is very similar to that of the nominal exchange rate. This is not very surprising, given the close correlation between real and nominal exchange rates.

The response of *TB* to the negative *NBR* shock is positive for the first 20 months and negative after 2 years, although the confidence band spans zero for almost the entire period. The initial effect of a negative *NBR* shock on the trade balance is positive. After the impact period, *Y*, *Y**, *E* (*RE*), and *TB* all interact simultaneously.

In order to infer the relationship between the trade balance and the exchange rate resulting from a negative *NBR* shock, we use the VAR previously estimated but set the coefficients on the lagged effects of *Y* and *Y** to zero in the trade balance equation. All other coefficients are the same as those used in generating the IRFs in Fig. 1. This exercise eliminates the direct effects of *Y* and *Y**. (Indirect effects continue to occur through the effects of *Y* and *Y** on other variables in the system and then through the effects of these other variables on *TB*.)

In Fig. 2, IRFs of *E*, *RE*, *TB*, *P*, and *P** to a negative *NBR* shock for the regular system are presented with a solid black line and analogous IRFs for the system which sets the lagged effects of *Y* and *Y** to zero in the *TB* equation are illustrated with a dotted line. We can infer from Fig. 2 the typical textbook *J*-curve effect. After eliminating the direct effects of *Y* and *Y** on *TB*, we can see that the trade balance initially improves in response to a negative *NBR* shock and then deteriorates strongly after a year while the exchange rate appreciates. This evidence is consistent with that of Krugman and Baldwin (1987) who find that the perverse effect has a duration of four quarters. Cushman and Zha (1997) examine the effects of Canadian monetary policy shocks on Canadian variables including the trade balance using a VAR model of the Canadian economy and find similar *J*-curve effects where the perverse effect lasts for 6 months.

An analysis of Fig. 2 indicates that the deterioration of the trade balance ends

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[4] The response of the real interest rate (real federal funds rate) to a negative *NBR* shock is similar to the response of the nominal interest rate, but is not as smooth as is the response of the nominal interest rate.

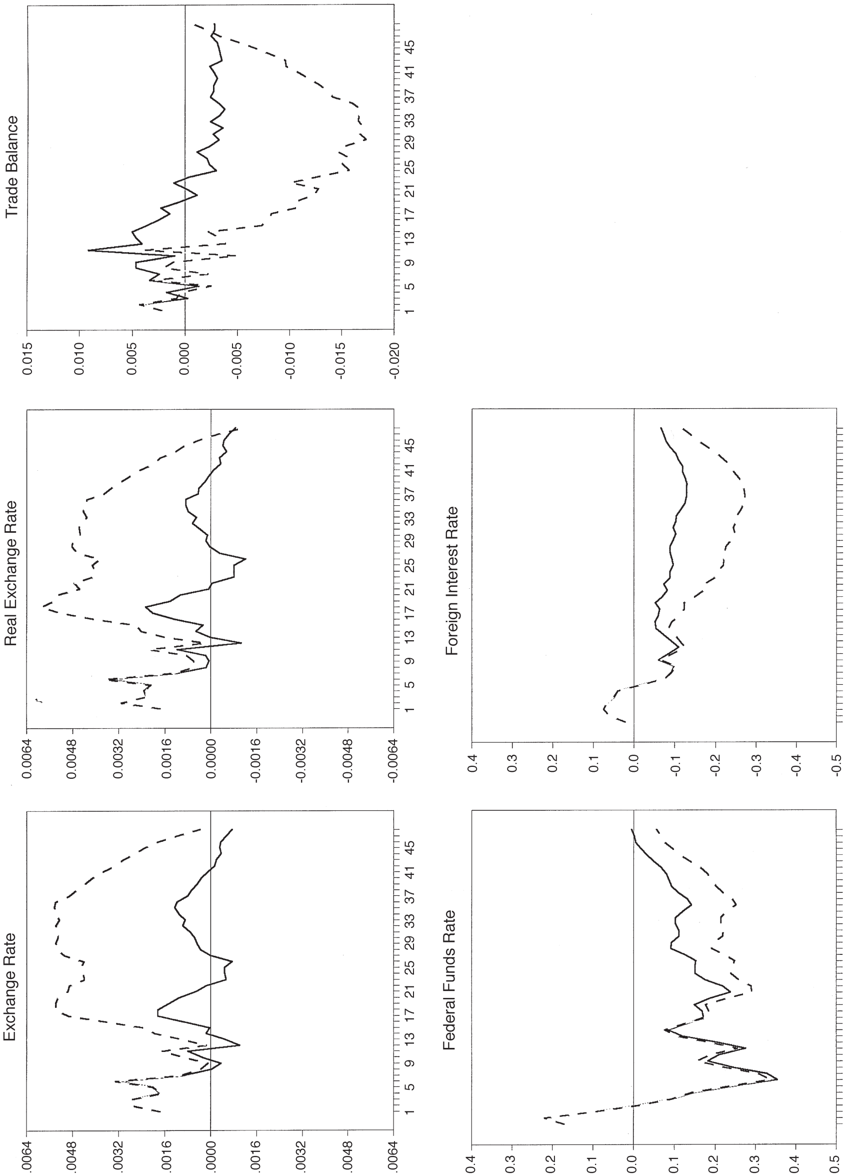

Fig. 2. Shock to *NBR*. Regular system and system omitting domestic and foreign output in *TB* equation.

when the exchange rate returns to its initial value. The deterioration of the trade balance and the length of time required for the adjustment of the trade balance are quite consistent with the way the exchange rate responds to the negative *NBR* shock. Eliminating the direct effects of Y and Y^* on *TB* prolongs the adjustment of the trade balance as well as the exchange rate. It should be noted that when the direct effects of Y and Y^* are eliminated, the appreciation of the exchange rate is much stronger. An explanation of why E (or *RE*) appreciates more in the absence of lagged direct effects of Y and Y^* on *TB*, at horizons greater than 9 months, is that R^* decreases relatively more, in comparison to the full model path, than does R. When R^* decreases relatively more than R, the resulting capital inflows lead to appreciation of the exchange rate.

3.2. Federal funds rate as the policy variable

The results discussed thus far are for nonborrowed reserves as the monetary policy variable. As noted earlier, an alternative monetary policy measure is the federal funds rate (R). The IRFs for R as the monetary policy variable are presented in Fig. 3. The IRFs in Fig. 3 are very similar to those of Fig. 1 with only very minor differences. The response of R to a positive R shock indicates the temporary nature of this shock. After a sharp and significant rise, the confidence band for R spans zero. A positive shock to R is followed by a decrease in Y with a rebound to the initial level in the long run. The confidence band for P indicates a price puzzle which lasts more than 2 quarters but falls below zero after a while, although with a much longer lag than when monetary policy is measured by shocks to *NBR*. The response of R is similar to that in Fig. 1, except we do not observe the sharp undershooting of R that occurs when monetary policy is measured as a shock to *NBR*. However, in both Figs. 1 and 3, there is no lasting long-run effect on R. The response of R^* is quite similar to that of R even though it is not as strong as that of R. E responds immediately, quickly appreciating and then returning to its initial value. The confidence band for *TB* spans zero over most of the horizon, similar to Fig. 1.

We infer from Fig. 4 that, after eliminating the direct effects of Y and Y^* on *TB*, the trade balance initially improves in response to an appreciation of the exchange rate and then deteriorates after a year, confirming the *J*-curve effect.[5] One striking difference between a negative *NBR* shock and a negative R shock is that, in the absence of direct income effects, the *TB*, *E*, and *RE* return to their initial values much slower for a shock to R than for a shock to *NBR*.

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[5] It should be noted that initially both IRFs in each diagram in Figs. 2 and 4 are essentially identical for about 8 months; consequently the package used to graph displays only the dotted line for the periods in which the IRFs are the same. The IRFs are initially the same for the following reason. Each equation in the VAR contains 12 lagged values of the trade balance. It takes some time before the trade balance equation that zeroes out the coefficients on lagged Y and Y^* to work through the system. Thus initially the IRFs for the regular and modified systems will be essentially the same. The IRFs for the modified system will begin to diverge from the regular system IRFs as the lagged values of the trade balance generated by the system with the modified trade balance equation “take over”.

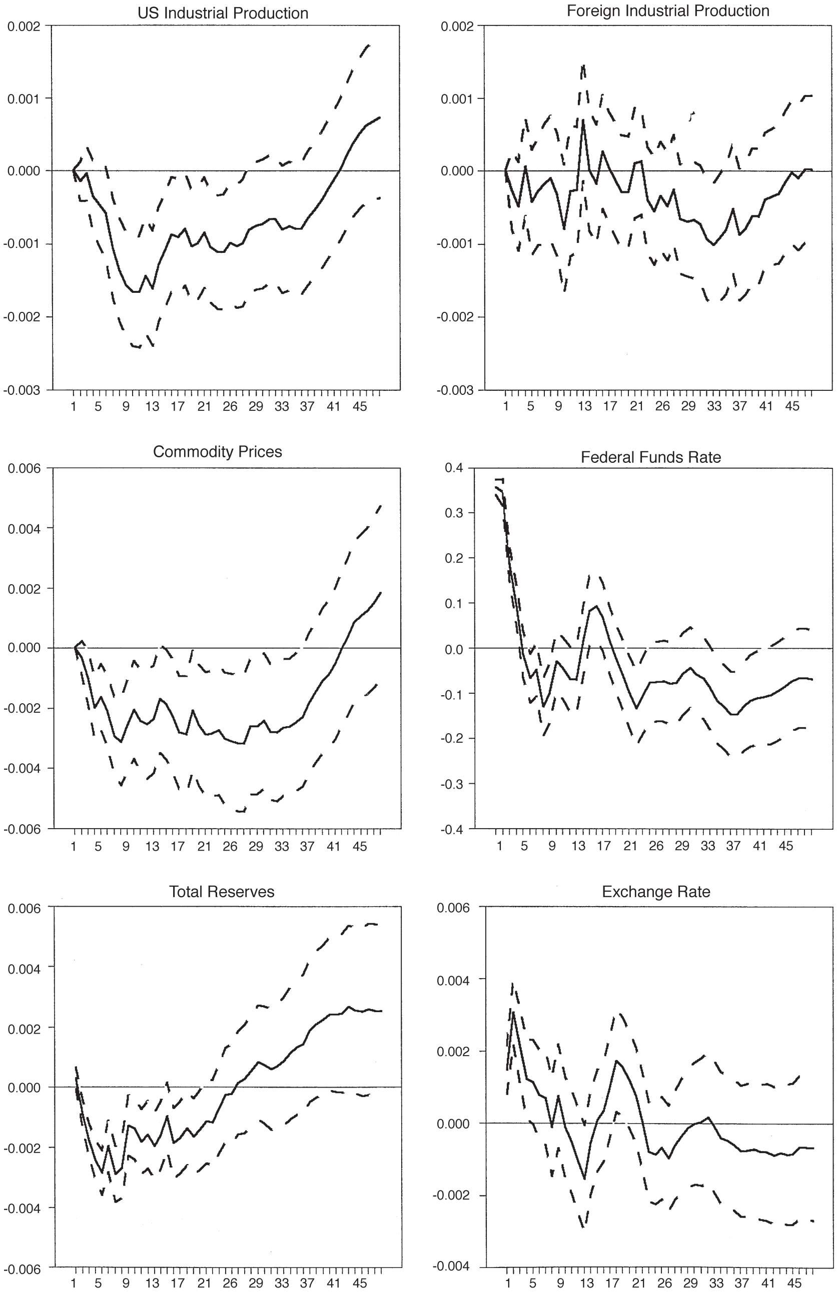
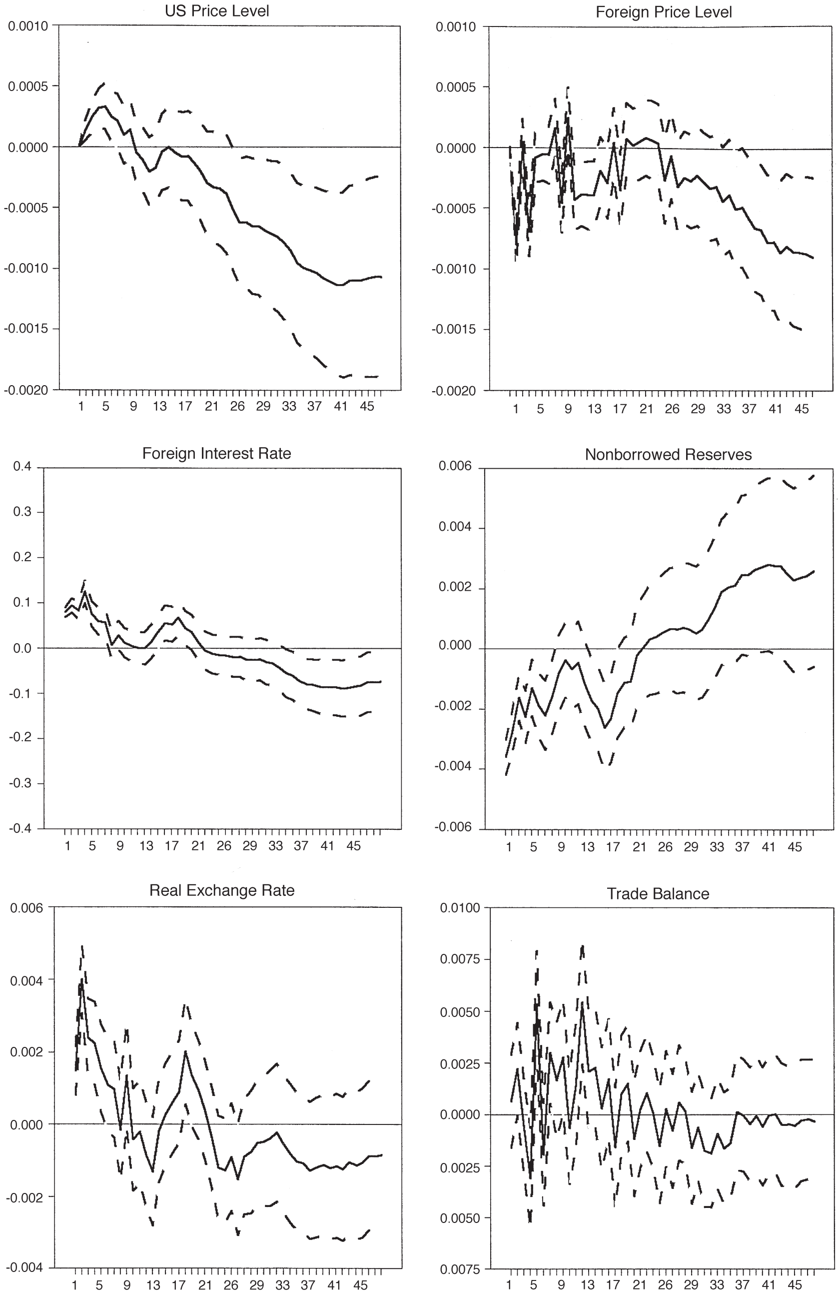


Fig. 3. Shock to *R*.


US Price Level

Foreign Price Level

Foreign Interest Rate

Nonborrowed Reserves

Real Exchange Rate

Trade Balance

Fig. 3. (*continued*)

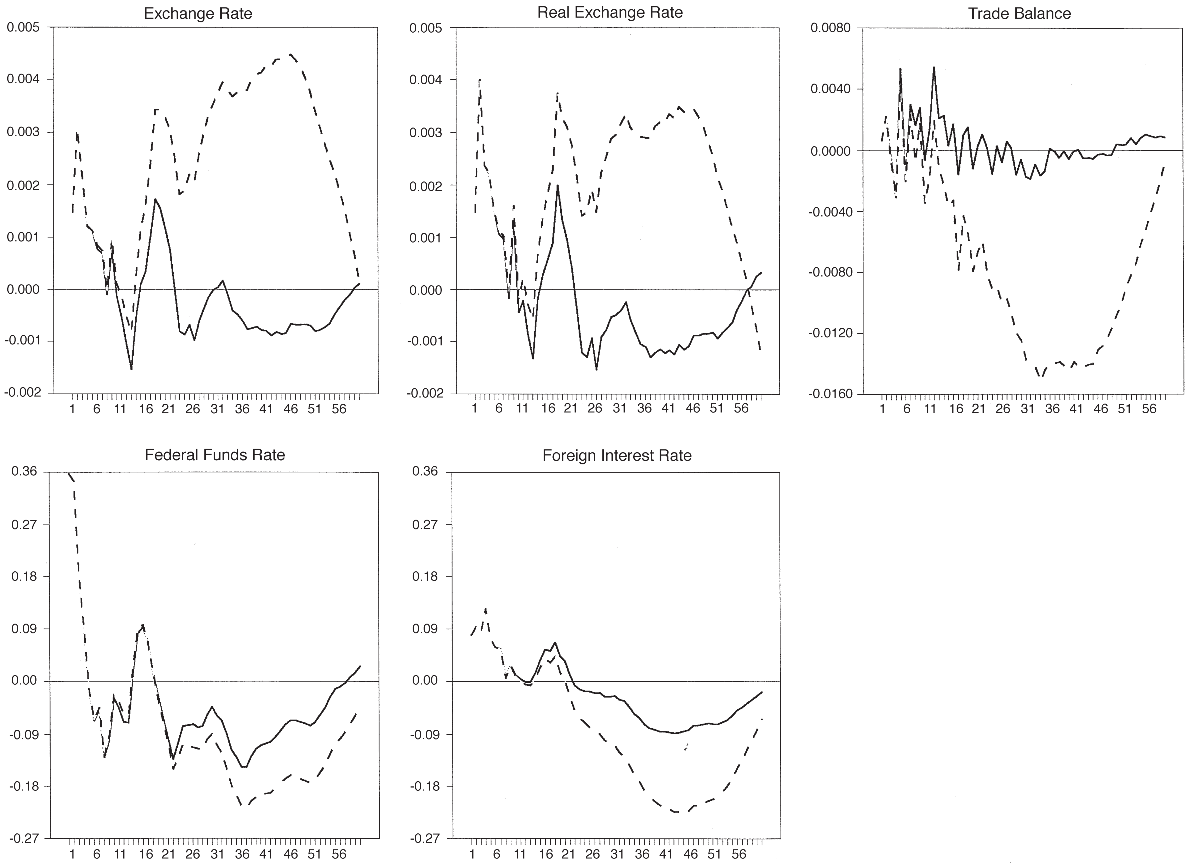


Fig. 4. Shock to R. Regular system and system omitting domestic foreign output in *TB* equation.

4. Conclusion

Our findings indicate that US output, foreign output, the US price level, and the foreign price level respond negatively to a contractionary monetary policy shock. The immediate appreciation of the exchange rate in response to a contractionary monetary policy shock and the ensuing return to its initial level is consistent with the predictions of the asset market approach to exchange rate determination, given the temporary nature of the monetary policy shock. The initial improvement in the trade balance, which is correlated with an appreciation of the exchange rate, and the following deterioration provide support for the *J*-curve hypothesis.

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Appendix A

This appendix provides a complete description and sources of the data employed in this paper. The following US data are obtained from Citibase: industrial production index, personal consumption expenditures price deflator, producer price index for sensitive crude and intermediate materials, total reserves, nonborrowed reserves, and the federal funds rate.

The industrial production index, consumer price index, and call money rate for Canada, France, Germany, Japan, Italy, and the United Kingdom are obtained from the *International Financial Statistics* CD-ROM as are the bilateral monthly average exchange rates expressed as foreign currency units per US dollar.

The consumer price index and the producer price index for sensitive crude and intermediate materials were seasonally adjusted using the X-11 procedure. Exchange rates and interest rates were not seasonally adjusted since they do not show seasonal variation. All the other data were seasonally adjusted at the source.

Bilateral real exchange rates were calculated using the definition where $RE=ExP/P^*$. E is the bilateral nominal exchange rate, P is the US price index, and P^* is the foreign country's price index.

The trade-weighted exchange rate was calculated as follows:

$$E_w=s_m\sum_{i=1}^{i=6}\left(IM_i\div\sum_{i=1}^{i=6}IM_i\right)(E_{it}\div E_{i0})+s_x\sum_{i=1}^{i=6}\left(EX_i\div\sum_{i=1}^{i=6}EX_i\right)(E_{it}\div E_{i0}),$$

where E_w is the trade-weighted nominal exchange rate, s_m is the share of US imports in total trade with the G-6, s_x is the share of US exports in total trade with the G-6, IM_i is imports from country i, EX_i, is exports to country i, E_{it} is the bilateral exchange rate at time t, and E_{i0} is the bilateral exchange rate at base period 0.

The trade-weighted industrial production index was calculated as follows:

$$IP_w = s_m \sum_{i=1}^{i=6} \left(IM_i \div \sum_{i=1}^{i=6} IM_i \right)(IP_i) + s_x \sum_{i=1}^{i=6} \left(EX_i \div \sum_{i=1}^{i=6} EX_i \right)(IP_i),$$

where IP_w is the trade-weighted industrial production index and IP_i is the industrial production index for country i. The trade-weighted interest rate and the trade weighted price index were also calculated in a similar manner.

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