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A re-examination of the impacts of macroeconomic and financial shocks on real exchange rate fluctuation: Evidence from G7 and Asian countries

I Introduction

What are the sources of real exchange rate fluctuations? This question has been a long-standing focus in international economic literature. Extensive evidence shows that macroeconomic shocks play crucial roles in explaining the real exchange rate evolutions. For instance, Clarida and Gali (1994) present a flexible price rational expectation equilibrium model to identify the source of real exchange rate variations since the collapse of Bretton Woods by using a long-run recursive identification scheme proposed by Blanchard and Quah (1989). They find that the demand shocks explain most of the real exchange rate fluctuations in both the short and long term, whereas the nominal shocks explain a substantial amount of the variance of the real exchange rate, and the impact of supply shocks is insignificant. Similar findings can also be found in other works (Webber, 1997; Chadha & Prasad, 1997; Roger, 1999; MacDonald & Swagel, 2000).

On the other hand, it is generally accepted that the monetary policy has also accounted for a sizeable contribution to real exchange rate fluctuations. The seminal works of Dornbusch's (1976) overshooting model indicate that an increase in the domestic interest rate relative to the foreign interest rate would lead to an apparent immediate appreciation followed by a persistent depreciation of the domestic currency toward its long-run equilibrium value. However, a number of research studies (Eichenbaum & Evans, 1995; Grilli & Roubini, 1995, 1996) have empirically tested this model by utilising a recursive identification in an unrestricted vector autoregressive (VAR) framework and found a hump-sharped impulse response of exchange rate, or the so-called delayed overshooting (that is, the domestic currency gradually appreciates for several years followed by a subsequent period of depreciation) in response to a contractionary monetary shock. Although these empirical findings are not consistent with the conventional wisdom, they highlight the importance of monetary shock on the real exchange rate movement.

The identification approach is essential in structural VAR (SVAR) literature. Imposing restrictions on the contemporaneous interactions is often used in short-run identification schemes (Eichenbaum & Evans, 1995). Note that economic theory, to a certain extent, does often not provide sufficient theoretical reason to justify a zero contemporaneous effect on the variables. Imposing zero long-run restrictions is a common alternative in empirical works. However, an exclusive focus on the long-run structure may prove to be misleading when applied to VAR models (Faust & Leeper, 1994).

Similar to Uhlig (2005) and Scholl and Uhlig (2008), this paper tries to investigate the sources of real exchange rate fluctuation by using sign-restricted VAR with agnostic identification[1]. No restrictions are imposed on the signs of the responses of the real exchange rate. I follow the standard identification strategy on the impulse response function to a monetary shock, as in the case of most macroeconomic models in the economic literature. In particular, the price puzzle is avoided by construction in order to verify whether the delayed overshooting can be eliminated. The results show that the delayed overshooting still exists in most cases, particularly in Asian countries. Many of the previous research works focus on how the monetary policy generates the deviation of uncovered interest rate parity (UIP). Different to the existing studies, this paper aims to address a question, namely how does the exchange rate react to a deviation of UIP? Is the dynamic response of the exchange rate consistent with

[1] Although the sign-restricted VAR models with agnostic identification are also criticized in SVAR literature (see Kilian & Murphy, 2012), these models do reasonably well when compared to VAR models that use recursive identification structures.

uncovered interest rate parity or the Dornbusch's overshooting model? Motivated by the works of Malliaropulos (1998), Scholl and Uhlig (2008) and Engel (2016), a deviation of UIP is considered as a surprise change in the foreign interest rate in the sense that the foreign deposit is relatively higher than the domestic deposit held from period t to period $t+1$, and hence causes an excess return in foreign deposit. The empirical results show that all countries experience a significant initial real depreciation, and then gradually decline in response to the shock.

On the other hand, some earlier papers highlight the influence of the relative stock differential to the real exchange rate fluctuation. For instance, Malliaropulos (1998) proposes a theoretical linkage between the transitory components of the real exchange rate and relative stock differential and this relationship is further supported by the empirical works of Wong and Li (2009), who examine the dynamic relationship of the relative stock differential and the real exchange rate of 11 economies during the two financial crises of 1997 and 2008. Other papers such as Eichler and Maltritz (2011) and Wong (2020) also provide empirical evidence to support this relation.

Given that financial markets worldwide have been highly integrated within as well as across boundaries over the past two decades, information technology developments in electronic payment and communication systems have substantially improved the mobility of capital across countries, thus causing international capital funds to become more important in explaining the stock price volatility and exchange rate fluctuation. Including the stock market variable in a VAR system could provide more information to identify the source of real exchange rate fluctuation. According to Malliaropulos (1998), the disturbance of the relative stock prices equation contains the expected depreciation of the real exchange rate and the expected risk premium of domestic stock prices. To additionally take into account investors' expectation on assets markets, I recover the disturbance of relative stock prices by estimating VAR in unrestricted form and term the structural innovations of relative stock price as 'expectation shock'. This allow us to investigate whether international investment opportunities or the shift in stock return expectations are the main factors causing short-terms fluctuations in the real exchange rate.

The rest of this paper is organised as follows. Section II gives a brief review of the theoretical framework. Section III introduces the methodology and discusses the identification schemes. Section IV provides the data description and presents the empirical findings. The final section concludes the paper.

II Theoretical Framework

This section provides a brief review of Clarida and Gali's (1994) stochastic rational expectations open macro model, which explains the relationship between real exchange rate to aggregate supply, aggregate demand, and monetary shocks, respectively. Most of the restrictions in the identification scheme rely on this model. In addition, I also show how the deviation from UIP or namely currency risk premium (CRP) and expectation shocks affect the variables in the system. Consider the following elements of the model:

IS Equation: (1)

Price Adjustment Equation: (2)

LM Equation: (3)

Uncovered Interest Parity: (4)

Equation (1) gives the IS equation in which the aggregate demand for home output relative to the foreign output ( ) is positive in relation to the real exchange rate ( ) and negative in relation to the real interest rate ( ). Equation (2) is a price-setting equation, which captures the sluggish adjustment of the price level to its flexible price equilibrium. Equation (3) is a standard LM equation, which gives the money market equilibrium condition, while Equation (4) is a statement of the uncovered interest parity condition.

Clarida and Gali (1994) specify the stochastic processes that govern the relative supply ( ), the relative demand ( ) and the relative money ( ) shocks as the following three equations:

(5)

(6)

(7)

It is assumed that the relative supply and the relative money represent simple random walk processes while the relative demand contains permanent and transitory components. and are assumed to be a serial and mutually uncorrelated innovation. The flexible-price rational expectations equilibrium for the relative output, real exchange rate and relative price levels is represented below:

(8)

(9)

. (10)

The three equations above provide the long-run solution for the flexible-price model. In the flexible-price equilibrium, the supply shock affects the levels of relative output, relative price and the real exchange rate. The demand shock influences the long-run real exchange rate and relative price, while the nominal shock does not affect the relative outputs and the real exchange rate.

Under sluggish price adjustment, the short-run solution for the flexible price model can be expressed as:

(11)

(12)

(13)

where and . It is clear that the relative output, relative price and real exchange rate are affected by the supply, demand and monetary shocks.

To additionally take into account investors' expectation on assets markets, I consider the relationship between the real exchange rate and relative stock differential formulated by Malliaropulos (1998):

(14)

Equation (14) describes the relationship between the ex-post risk premium of a k-period investment in the domestic stock market relative to an equivalent investment in the foreign stock market, and the k-period change in the real exchange rate. In which ; is the forward difference operator; represents the relative stock prices between the domestic economy and the US. Earlier studies (Fama & French, 1988; Malliaropulos, 1998) indicate that the relative stock prices contain both permanent and temporary components: . The permanent and temporary components of the relative stock price are respectively specified as:

, (15))

. (16)

Huizinga (1987) and Baxter (1994) suggest that the real exchange rate contains both permanent and transitory components: . The permanent and temporary components of the real exchange rate are equal to:

, (17)

. (18)

Note that both the permanent components of the relative stock price as well as the real exchange rate are specified as a random walk with drift. The error term in the permanent components (and) is a serial uncorrelated innovation; the transitory components are assumed to follow a stationary first-order autoregressive process with , and the error term in the transitory components (and) is a serial uncorrelated innovation.

Once more, consider equation (14), which suggests a negative forward difference relationship between the ex-post risk premium of a k-period investment in the home stock market relative to an equivalent investment in the foreign stock market, and the k-period changes of the real exchange rate and the disturbance in equation (14) can be expressed as:

, (19)

which not only includes the cumulated innovations of the relative stock price and the real exchange rate permanent components: and , but also the revision in the expected real return differential between the home and the foreign market. Note that represents the revision of the conditional risk premium of domestic shares relative to the foreign shares and is the revision of the expected real exchange rate, respectively. So that, can be considered as the expectation shock, as it captures the expected depreciation of the real exchange rate and the expected risk premium of domestic stock prices.

On the other hand, the deviation from the UIP condition can be considered as an excess return on the foreign deposit (see for example: Scholl & Uhlig, 2008; Engel, 2016) held from period t to period t+1, or namely currency risk premium (CRP):

(20)

Equation (20) shows that the interest rate differential is negatively related to the excess return. By substituting equation (20) in real terms into equation (14), we get:

(21)

Equation (21) suggests that the relative stock differential decreases (increases) in response to CRP (expectation) shock.

III Methodology and Identification Scheme

a) Methodology:

In this section, I first describe the SVAR model, and then give an overview of the identification strategies. To examine how real exchange rate response to the structural shocks, I impose sign restrictions directly on the shape of the impulse response. Consider the following SVAR equation:

(22)

where Y_t is a *5 x 1* vector of endogenous variables that includes relative real output differential, , relative price differential, , real interest rate differential, , real exchange rate and relative stock differential, ; c is a vector of constants; captures the contemporaneous relationship while is the matrix of structural parameters. *L* is the number of lags in the system. The number of lagged variables is based on the AIC and Schwarz information criterion. e_t is a *5 x 1* vector of structural stocks. To estimate equation (22), it is necessary to dispense with the contemporaneous endogenous variables by multiplying to the structural form equation:

(23)

Equation (23) is a reduced form VAR, where , and . The reduced form residuals are related to the structural disturbances: , and its covariance matrix is: . In order to recover the structural shocks, some identifications restrictions are needed. Note that, as discussed in Rubio-Ramirez, Waggoner and Zha (2010), the SVAR is set identified regardless of the number of restrictions are imposed. All structural shocks are identified by imposing sign restrictions on the impulse responses of a set of variables in the data. Particularly, I utilize the sign and zero restriction method, proposed by Arias, Rubio-Ramirez, and Waggoner (2018), in the specification and estimation of the SVAR model to identify the effect of expectation shocks.

b) Identification Schemes:

Two identification schemes are used in the analysis. An overview of the identifying sign restriction on the impulse responses for the two identification methods is presented in Tables 1 and 2. In the first identification scheme, following Uhlig (2005) and Scholl and Uhlig (2008), I apply an agnostic identification procedure by leaving the response of the real exchange rate unrestricted. The restrictions rely on the stochastic flexible model of Gali and Clarida (1994), the empirical work of Farrant and Peersman (2006) and the linkage between the real exchange rate and the two financial shocks (CRP and expectation shocks) constructed in the previous section. All restrictions are imposed on the contemporaneous reaction

First, the relative supply shock is defined as a shock which can cause an increase (decrease) in the relative real output differential (relative price). Second, the demand shock is defined as a shock, which jointly moves the relative output, relative price and real interest rate differential in the same positive direction. Third, I define an expansionary monetary shock by imposing a positive reaction of the relative real output differential and relative price[2], and by requiring that the shock decreases the real interest rate differential in response to a positive monetary shock. Forth, one ought to bear in mind that a positive CRP shock is to be considered as a surprise

[2] This restriction can avoid the price puzzle.

change in the foreign interest rate in the sense that the foreign deposit is relatively higher than the domestic deposit held from period *t* to period *t*+1, and hence causes an excess return in foreign deposit. An alternative explanation for the CRP shock can be interpreted as an increase in the preference for holding foreign-currency assets relative to domestic assets. For instance, as Burnstein et al. (2004) indicate, higher global uncertainty typically induces a relative increase in foreign investors' perception of risk, which in turn increases preference for US assets. Based on equations (20) and (21), it is reasonable to identify a CRP shock by imposing a negative reaction on the impulse response of the real interest rate differential and relative stock differential for 1 horizon in which the shock occurs. Finally, I identify the expectation shock by imposing zero restrictions on the contemporaneous reactions of relative output and relative price, and positive reaction of the impulse response of the relative stock differential for the month in which the shock occurs.

In the second identification scheme (Table 2), all restrictions are replicated from the first identification scheme. However, additional restrictions are imposed on the responses of the real exchange rate in order to conduct a robustness check and provide an alternative supplement to examine how those shocks affect the real exchange rate. The real exchange rate is restricted to increase in response to supply shock. To assure comparability, the following restrictions are based on Farrant and Peersman (2006). The real exchange rate is restricted to depreciate (appreciate) in response to monetary and CRP (demand) shocks. Finally, according to equation (21), a real appreciation is assumed in response to expectation shocks.

IV Data and Empirical Results:

In this paper, all monthly data are obtained from the International Financial Statistics and DataStream. The sample countries include G7 countries: Canada, France, Germany, Italy Japan, the United Kingdom (UK) and the United States (US), while the Asian countries include Korea, Singapore and Thailand. The sample covers the period from January 1993 to December 2019[3]. All variables are expressed in logarithmic form, with the exception of the real interest rates, and in a relative manner, with the exception of the real exchange rate. The US is considered as the foreign country.

The relative stock price between the home and the foreign economy expressed in the domestic currency is calculated by:

where is the domestic (foreign) stock price and is the nominal exchange rate, expressing the domestic currency per unit of US dollar.

The real exchange rate is defined as:

,

where is the domestic (foreign) price index. The real interest rate is constructed by the equation:

,

where is the nominal interest rate, and is the expected inflation rate obtained from one period forecast by a third-order autoregressive model, AR(3). The real interest rate differential is measured by subtracting the real interest rate for the US from the real interest rate of each economy. The relative output differential

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[3] The sample period may be different in some countries due to the availability of data.

is measured by the domestic GDP minus the foreign GDP . The monthly GDP is constructed from the quarterly real GDP using the state space approach with the monthly industrial production data serving as the related interpolator variable.

Empirical Results:

Figures 1a to 1c plot the monthly evolution of all structural shocks identified according to the first identification scheme as shown in Table 1. The highlighted area represents the 97 Asian financial crisis (AFC), 07/08 global financial crisis (GFC) and the 11/12 European sovereign debt crisis (EDC), respectively.

In Figures 1a and 1b, sharp changes in structural shocks can be found in most economies during financial crises. Demand and supply shocks are highly volatile in Asian countries but not in the G7 during the AFC. The impact of the GFC affected most countries on a global scale, while the EDC only affected European countries. In Figure 1c, one may note that the CRP shock is clearly higher than the expectation shock in Asian countries during the AFC, particularly in Thailand and Korea. This might result from the collapse of the fixed exchange rate of Thailand's currency, and the unexpected subsequent shift of the exchange rate regime to independently floating in Korea, which caused significant changes in their exchange rates. In contrast, there are no significant changes in CRP and expectation shocks in Canada and the European countries. The impacts of the GFC are more substantial in most cases. Compared to the AFC, the magnitude of the changes in the CRP shock in EDC is relatively low. One important observation from this figure is that these two shocks often appear to move in an opposite direction, particularly during financial crises. This interesting pattern might imply that international capital funds play an important role in the international stock market performance.

Impulse Response Analysis

Figures 2 to 6 report the impulse responses to the supply, demand, monetary, CRP and expectation shocks, respectively. Each figure gives the impulse responses to a positive structural innovation over a horizon of 24 months. The horizontal axis measures the time horizon in terms of months after the shock, while the vertical axis represents the response of the variables. The solid line denotes the pointwise-median responses, whereas the upper and lower dotted lines represent the 16th and 84th percentiles of the posterior distribution of the impulse response obtained from the agnostic identification scheme. For a clearer comparison, the pointwise-median responses (long-dashed line) obtained from the second identification strategy are also reported in the figures.

Supply Shocks

Figures 2A to 2E illustrate the dynamic responses of relative real output differential, relative price, real interest rate differential, real exchange rate and relative stock differential to a relative supply shock. In Figures 2A and 2B, there is no significant difference between the results from the two identification strategies. Since the response of the relative output (relative price) has been restricted to increase (decrease) following the supply shock, their immediate response is by construction. In Figure 2C, it is obvious that the supply shock leads to an immediate increase in the interest rate differential in all economies except Korea. In Figure 2D, under the agnostic identification scheme, the impulse response analysis indicates that an initial real depreciation can be confirmed in all G7 and Asian countries (except Korea), which is consistent with the results of Clarida and Gali (1994), who applied a SVAR model with long-run restrictions, and those of Farrant and Peersman (2006), who used a sign-restricted SVAR model to examine the real exchange rate fluctuation.

Note that if the real exchange rate is restricted to depreciate after the supply shock (dashed line), the effect is much greater by approximately 3 times the first identification. The perverse supply-side effect as suggested in MacDonald (1998) cannot be found in the European countries. This is probably due to the introduction of the Euro Dollar in 1999. However, this effect may be useful in explaining the appreciation in Korea. The supply shock is accompanied by an increase in relative demand as a result of the real wealth effect and home bias in consumption. Similar findings can also be found in previous studies (Detken et al., 2002; MacDonald, 1998). Following a positive supply shock, the relative stock differential declines in all countries under the estimation of the second identification scheme (Figure 2E). This finding is at odds with the empirical results of Fraser and Groenewold (2006). In contrast, under the agnostic identification scheme, the relative stock differential increases initially in most countries, particularly in Asian countries.

Demand Shocks:

Figure 3 shows the five variables in response to a demand shock. Due to the model restrictions, it is no surprise that the relative output, relative price and real interest rate differential respond positively to a demand shock. In Figure 3D, under the agnostic restriction, the impact of relative demand shock on the real exchange rate is negative in most cases, particularly in the G7 countries, which is in line with the expected sign of the Mundell-Fleming-Dornbusch model and the empirical findings of the previous research studies. This suggests that an upward shift in the relative demand curve would cause a real appreciation in the domestic currency. Again, the impact is substantially smaller in all countries compared to the results obtained in the second identification scheme. In general, the real exchange rate declines by more than 0.1 percent initially. As for the relative stock differential (Figure 3E), there is a clear difference between the results of the two identification strategies. Under the agnostic identification procedure, the relative stock declines in most countries initially. In particular, the response in Korea is more significant (greater than 2%) after the shock. However, an apparent positive reaction can be found in all cases when the impact of the real exchange rate is restricted to positive.

Monetary Shocks

Figure 4 reports the impulse responses to an expansionary monetary shock. Again, no significant difference is found between the results of the two identification schemes: an expansionary monetary shock has a positive effect on the relative output differential (Figure 4A) and relative price (Figure 4B), and a long-lasting negative impact on the real interest rate differential (Figure 4C).

Figure 4D provides the impulse response functions of the real exchange rate. Although the price puzzle is ruled out in the estimation, the delayed overshooting as discovered in Eichenbaum and Evans (1995) still exists in the case of Canada, Italy, Korea, Singapore and Thailand, respectively[4]. These results are in contrast with the findings of Farrant and Peersman (2006), who restricted that the real exchange rate does not decline following a monetary shock. In particular, the monetary shock generates a long-lasting impact (more than one year) on the real exchange rate in most cases, and the real exchange rate will eventually return to its pre-shock level. In the case of the UK, France and Germany, the real exchange rates depreciate after a monetary shock, and the effects experience an opposing trend after the second month. This is in line with the Dornbusch's overshooting model, which suggests that, under the assumption of price rigidity, an unanticipated increase in money supply will lead to a significant initial depreciation of the exchange rate. The initial depreciation must

[4] The estimation result with no restrictions on the relative price is reported in Appendix 1. In general, the result is similar to Figure 4D. However, no delayed overshooting can be found in Japan.

be proportionately larger than the long-term appreciation. The excess exchange rate depreciation ensures the appreciation needed in order to simultaneously clear the money and bonds markets in each case.

In Figure 4E, the relative shock differential increases in response to an expansionary shock in most cases. The reason for this positive impact might be explained by the present-value valuation model, which suggests that a decrease in the interest rate would decrease the rates at which future cash flows are discounted and hence the relative stock differential increases. One might also note that the response is persistent and will eventually return to its pre-shock level in some economies. This result is consistent with Fama and French (1988) and Poterba and Summers (1988), who argue that the stock prices contain a mean-reverting property.

Currency Risk Premium (CRP) Shocks

Figure 5 reports the impulse response analysis to the CRP shock. In Figure 5A, the relative output differential declines in most countries following a positive CRP shock, as the capital outflow would limit the growth of the economy, particularly in some Asian countries. In response to the CRP shock, the relative price rises while the real interest rate differential declines in most countries. Since the capital outflow could influence the expected inflation due to the exchange rate pass-through effect on prices, it could in turn influence nominal interest rates through the uncovered interest parity channel or due to monetary policy reaction rule. As for the real exchange rate (Figure 5D), two identification schemes provide similar results. All countries experience a significant initial real depreciation, and then gradually decline in response to a positive CRP shock. This finding is in line with Dornbusch (1976) in the sense that if the foreign interest rate is unexpected to rise relative to the domestic interest rate, the no-arbitrage UIP condition requires an immediate depreciation of the domestic currency so that it can appreciate over the period of relatively low home returns. The corresponding capital movement would eliminate all future excess returns. In addition, a persistent impact can also be found in Singapore, Thailand and the European countries. In line with the expected sign in Equation (21), all relative stock differential declines in response to CRP shocks (Figure 5E).

Expectation Shocks

Figures 6A to 6E report the impulse response functions to expectation shocks. It is worth reviewing the equation of the relationship between the relative stock price and the real exchange rate as shown in equation (5). In the equation, the error term contains two components, the expected change in the real exchange rate: and the expected change in the relative stock prices: . Since the zero restriction is imposed on the contemporaneous impulse response of the relative real output differential and relative price, no initial reaction of these two variables can be seen in Figure 6A and 6B, but the relative real output differential (relative price) sharply increases (decreases) thereafter in most cases. In Figure 6C, the real interest rate differential declines in all countries, with the exception of Germany, Italy and the UK. Since the interest rate is negatively related to the stock return, these results might reveal that the investors anticipate the future interest rate movement.

In Figure 6D, two identification schemes provide similar results. The real exchange rate appreciates instantaneously in response to a positive expectation shock in all countries. The impact is short-lasting in that the real exchange rate appreciates initially and then the response quickly reverts to its pre-shock level. This finding is consistent with Blanchard (1981), who indicates that if an asset has a higher expected level of future profitability, the international capital funds would move towards the assets, even across countries. Such capital movement would initially reflect on the changes in the exchange rate. This provide empirical evidence that international capital funds not only play an important role for the stock price volatility, but also for the exchange rate fluctuation. In Figure 6E, the relative stock differential initially increases following a positive expectation shock.

Variance Decomposition

Having identified the supply, demand, monetary, CRP and expectation shocks, I then examine what fraction of the variance in the real exchange rate is accounted for these shocks. Table 3 shows the median contribution of all shocks at selected horizons together with the 16th and 84th percentiles from the first identified strategy. It can be noted that the contribution of the supply shock is the smallest among the structural shocks (below 5%) while the impact of the demand and monetary shock is also small (below 7%) in all countries. These findings are not consistent with the previous works (Webber, 1997; Chadha & Prasad, 1997; Roger, 1999). However, their proportion has increased over the course of 5 months in most cases. Different to the other shocks, the impact of CRP and expectation shocks on real exchange rate variance has rapidly reached its peak after the second horizons.

Compared to other shocks, the expectation shock obviously outperformed the other shocks in terms of explaining the variance of the real exchange rate. Consider that the expectation shock consists of the revision of the expected real exchange rate, and the conditional risk premium of domestic shares relative to the foreign shares, , the significance of the expectation shock might reflect the expected change in the relative stock differential, which induces capital movement between countries. Indeed, financial markets all over the world have been highly integrated in recent decades. International capital funds play an important role in stock market performance, which in turn generate significant impact on the exchange rate volatility. This result strongly confirms that the expectation shock is one of the main factors causing a real exchange rate fluctuation.

Table 4 provides the variance decomposition obtained from the second identification scheme. The CRP shocks play a dominate role, ranging between 37% and 62% in short horizon. Compared to Table 3, the proportion of relative supply, relative demand and monetary shocks has apparently increased after imposing restrictions on the impact of the real exchange rate to each structural shock. In European countries, the relative demand and supply account for 22 – 40% variations in real exchange rates at all horizons. Note that the expectation shock is the second largest fraction explained for real exchange rates in most countries (Canada, Korea, Singapore and the United Kingdom); it highlights the importance of expectation shock on real exchange rate fluctuations.

V Conclusion

This paper re-examines the sources of the real exchange rate fluctuation by utilizing an agnostic identification method proposed by Uhlig (2005). I impose a minimum set of restrictions that are needed to uniquely identify the structural shocks in order to investigate the actual sign of the real exchange rate from the data. In response to a monetary shock, the delayed overshooting still exists in most countries even if price puzzle is avoided by construction. One possible reason for the delayed appreciation might be the herd behaviour in the financial markets, since some currencies are dominated by a few big players as evidenced in The Federal Reserve Bank of New York (1998). Capital will inflow to the country if those big players become aware that the asset markets of the country is profitable. Their actions would initially cause changes in real exchange rate, and the real exchange rate would further appreciate as a result when the other investors become aware of current trends and follow those big players' actions. In contrast, it is interesting that all countries experience a significant initial real depreciation, and then gradually appreciate in response to currency risk premium shock. This finding is consistent with Dornbusch's overshooting model. In addition, the CRP and expectation shocks obviously outperformed the demand, supply and monetary shocks in terms of explaining the real exchange rate fluctuation.

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Table 1: First identification scheme

	Supply	Demand	Monetary	CRP	Expectation
Relative output differential	+	+	+		0
Relative price	-	+	+		0
Real interest rate		+	-	-	
Real exchange rate					
Relative stock differential				-	+

Note: '+', (-) means that the contemporaneous impact of impulse response is restricted to positive (negative). '0' means zero restriction.

Table 2: Second identification scheme

	Supply	Demand	Monetary	CRP	Expectation
Relative output differential	+	+	+		0
Relative price	-	+	+		0
Real interest rate		+	-	-	
Real exchange rate	+	-	+	+	-
Relative stock differential				-	+

Note: '+', (-) means that the contemporaneous impact of impulse response is restricted to positive (negative). '0' means zero restriction.

Table 3: Variance decomposition of real exchange rates (first identification scheme)

CANADA		Supply			Demand			Monetary			CRP			Expectation	
2	0.55	**1.15**	2.10	0.85	**1.55**	2.41	0.93	**1.57**	2.51	15.42	**17.96**	20.93	6.00	**51.30**	77.96
5	1.15	**1.90**	3.05	1.54	**2.43**	3.80	1.61	**2.42**	3.47	15.99	**18.26**	21.11	9.21	**58.72**	76.96
12	1.15	**1.90**	3.05	1.21	**2.05**	3.11	1.75	**2.68**	3.94	15.98	**18.30**	21.26	10.74	**38.79**	71.91
24	1.38	**2.10**	3.11	1.73	**2.77**	3.83	1.75	**2.63**	3.74	15.89	**18.30**	20.92	6.14	**19.47**	55.91
FRANCE		Supply			Demand			Monetary			CRP			Expectation	
2	0.28	**0.65**	1.54	0.48	**1.14**	2.16	0.53	**0.97**	1.72	4.32	**5.96**	8.11	5.78	**52.15**	71.99
5	0.88	**1.54**	2.61	1.16	**1.83**	2.93	1.08	**1.69**	2.53	5.36	**6.81**	8.51	6.97	**28.86**	75.29
12	1.20	**2.04**	3.10	1.10	**2.02**	3.22	1.34	**2.15**	2.99	5.37	**6.94**	8.71	4.57	**27.50**	69.87
24	1.11	**1.94**	3.21	1.48	**2.41**	3.84	1.38	**2.18**	3.17	5.47	**7.06**	8.91	3.58	**26.87**	67.79
GERMANY		Supply			Demand			Monetary			CRP			Expectation	
2	0.70	**1.59**	2.93	1.13	**2.02**	3.25	1.02	**1.69**	2.83	3.24	**4.79**	6.24	3.66	**22.55**	73.75
5	1.22	**2.14**	3.41	1.59	**2.53**	3.57	1.26	**2.24**	3.42	3.83	**5.22**	6.88	6.97	**37.52**	66.17
12	1.11	**1.96**	3.27	1.71	**2.83**	4.00	1.62	**2.46**	3.67	4.01	**5.49**	7.34	3.83	**23.38**	55.48
24	1.17	**2.08**	3.27	1.86	**2.90**	4.32	1.67	**2.68**	4.07	3.97	**5.57**	7.24	4.36	**25.76**	69.22
ITALY		Supply			Demand			Monetary			CRP			Expectation	
2	0.48	**1.07**	2.20	0.52	**1.04**	1.92	0.53	**1.03**	1.77	0.84	**1.57**	2.66	5.85	**13.09**	33.97
5	0.99	**1.81**	3.06	0.92	**1.63**	2.59	0.98	**1.62**	2.64	1.09	**1.86**	2.74	1.74	**14.11**	50.76
12	1.00	**1.94**	3.36	1.15	**1.99**	2.93	1.13	**1.74**	2.67	1.43	**2.18**	3.04	1.45	**10.37**	36.10
24	1.08	**2.00**	3.49	1.18	**1.99**	3.10	1.16	**1.93**	2.81	1.44	**2.32**	3.41	2.11	**9.41**	39.82
JAPAN		Supply			Demand			Monetary			Currency risk premium			Expectation	
2	1.94	**3.11**	4.77	2.37	**3.36**	4.46	2.48	**3.46**	4.74	4.75	**6.70**	8.33	4.32	**22.60**	64.20
5	3.17	**4.63**	6.27	3.06	**4.18**	5.41	3.37	**4.42**	5.82	5.06	**6.75**	8.50	6.32	**31.27**	63.96
12	3.25	**4.64**	6.13	3.37	**4.46**	5.83	3.45	**4.49**	5.64	4.89	**6.51**	8.33	5.92	**26.21**	60.56
24	3.52	**4.82**	6.46	3.94	**5.18**	6.58	4.17	**5.34**	6.72	5.04	**6.59**	8.49	2.80	**26.47**	65.15

Table 3: Variance decomposition of real exchange rates (first identification scheme) - continued

KOREA		Supply			Demand			Monetary			CRP			Expectation	
2	0.63	**1.23**	2.15	4.66	**6.34**	8.11	4.77	**6.79**	8.48	19.30	**21.44**	24.23	4.70	**34.00**	72.47
5	1.66	**2.63**	3.93	4.98	**6.43**	8.33	5.50	**7.05**	8.76	19.88	**22.33**	24.51	9.44	**30.17**	64.11
12	2.06	**3.31**	4.67	5.22	**6.87**	8.44	5.42	**6.99**	8.98	19.51	**21.85**	23.93	6.17	**24.06**	62.74
24	2.08	**3.23**	4.65	5.31	**6.79**	8.60	5.62	**7.08**	9.19	19.54	**21.76**	24.16	9.07	**29.47**	66.37
SINGAPORE		Supply			Demand			Monetary			CRP			Expectation	
2	2.66	**3.81**	5.34	3.11	**4.51**	5.97	3.88	**5.45**	7.20	12.17	**14.81**	17.29	4.08	**20.42**	68.96
5	3.31	**4.76**	6.28	3.60	**4.88**	6.31	4.39	**5.87**	7.75	12.86	**15.48**	18.21	7.99	**33.93**	65.21
12	3.45	**4.71**	6.66	4.02	**5.37**	7.22	4.84	**6.58**	8.24	13.15	**15.25**	18.13	3.66	**25.17**	60.01
24	3.57	**4.88**	6.40	4.29	**5.74**	7.46	5.07	**6.69**	8.58	12.71	**14.98**	17.83	4.19	**24.74**	53.44
THAILAND		Supply			Demand			Monetary			CRP			Expectation	
2	0.89	**1.82**	3.11	0.87	**1.51**	2.68	0.74	**1.34**	2.17	7.29	**9.19**	11.55	9.20	**14.97**	44.82
5	2.35	**3.61**	5.26	1.80	**2.78**	3.90	1.58	**2.53**	3.68	8.18	**9.92**	11.69	5.88	**26.04**	56.26
12	2.79	**4.34**	6.42	2.44	**3.62**	5.15	2.07	**3.02**	4.49	8.68	**10.25**	12.18	8.52	**26.08**	59.69
24	2.96	**4.51**	6.62	2.45	**3.74**	5.44	2.18	**3.36**	4.66	8.77	**10.58**	12.42	7.31	**22.81**	61.00
UNITED KINGDOM		Supply			Demand			Monetary			CRP			Expectation	
2	0.95	**1.81**	2.97	1.49	**2.35**	3.49	1.44	**2.19**	3.34	11.27	**13.32**	15.50	5.37	**40.35**	75.11
5	1.31	**2.34**	3.65	1.82	**2.79**	3.88	1.69	**2.54**	3.84	11.26	**13.19**	15.74	9.43	**36.31**	68.27
12	1.40	**2.37**	4.03	2.04	**2.89**	4.08	1.67	**2.78**	3.98	11.33	**13.07**	15.68	9.79	**36.64**	81.54
24	1.44	**2.37**	3.67	1.93	**2.92**	4.27	1.96	**2.85**	4.10	11.29	**13.50**	15.57	5.41	**38.61**	80.55

Note: This table gives the median contribution (bold) together with the 16th and 84th percentiles for each shock.

Table 4: Variance decomposition of real exchange rates (second identification scheme)

CANADA	Supply			Demand			Monetary			Currency risk premium			Expectation		
2	27.43	**30.14**	33.69	20.44	**22.83**	25.03	19.17	**21.20**	23.40	48.88	**52.87**	56.79	4.02	**35.74**	70.48
5	26.91	**29.29**	32.32	20.50	**22.42**	24.20	18.95	**20.69**	22.68	47.94	**51.66**	55.60	12.97	**41.99**	69.06
12	26.98	**29.68**	32.43	20.45	**22.49**	24.74	18.93	**20.78**	22.74	47.11	**51.30**	55.35	12.10	**46.13**	78.99
24	26.91	**29.48**	32.83	20.45	**22.29**	24.53	18.93	**20.85**	22.80	47.69	**51.48**	56.00	14.95	**41.78**	74.32
FRANCE	Supply			Demand			Monetary			Currency risk premium			Expectation		
2	30.59	**34.00**	38.13	33.11	**36.27**	39.88	12.59	**14.42**	16.71	48.07	**51.92**	56.19	2.00	**23.46**	63.45
5	30.52	**33.35**	36.45	31.91	**35.35**	38.86	25.07	**27.68**	30.43	46.24	**50.02**	54.47	7.04	**24.14**	67.96
12	30.49	**33.13**	36.77	32.22	**35.35**	38.52	24.98	**27.77**	30.46	47.56	**51.17**	55.44	8.63	**28.64**	61.04
24	30.10	**32.81**	36.49	32.03	**35.31**	38.26	13.22	**15.02**	16.91	45.51	**49.67**	54.00	6.79	**33.25**	61.05
GERMANY	Supply			Demand			Monetary			Currency risk premium			Expectation		
2	25.12	**27.24**	29.70	28.37	**31.23**	34.21	14.44	**16.66**	18.70	38.53	**42.26**	45.82	2.45	**17.63**	69.74
5	24.39	**26.96**	29.40	28.21	**31.02**	34.15	26.87	**29.25**	31.88	37.65	**41.24**	45.29	3.43	**16.59**	60.40
12	24.39	**26.80**	29.58	28.20	**30.61**	33.40	26.64	**29.32**	32.29	37.18	**41.03**	45.29	3.18	**26.03**	52.44
24	24.49	**26.67**	29.80	28.31	**31.08**	33.72	14.87	**16.79**	19.17	37.44	**41.27**	44.78	3.90	**25.17**	62.96
ITALY	Supply			Demand			Monetary			Currency risk premium			Expectation		
2	37.32	**40.66**	44.77	24.84	**27.26**	29.95	28.31	**31.48**	34.70	34.92	**39.08**	42.96	2.58	**14.07**	59.72
5	36.49	**40.05**	43.91	24.72	**27.17**	30.32	28.39	**31.14**	34.08	35.28	**38.54**	42.59	2.66	**11.66**	50.61
12	37.07	**40.01**	43.68	24.78	**27.05**	29.58	27.86	**30.86**	33.91	34.59	**38.71**	42.24	1.52	**12.25**	49.52
24	36.31	**39.64**	43.59	24.69	**27.03**	30.17	27.88	**31.14**	33.99	34.54	**38.29**	42.04	3.74	**11.78**	35.75
JAPAN	Supply			Demand			Monetary			Currency risk premium			Expectation		
2	23.85	**26.19**	28.70	16.78	**18.20**	19.72	21.98	**24.02**	26.11	35.89	**39.86**	43.54	5.04	**17.25**	63.90
5	24.03	**26.38**	28.68	17.16	**18.62**	20.06	21.90	**24.05**	26.12	34.27	**37.73**	41.33	2.17	**18.36**	48.91
12	24.12	**26.14**	28.48	17.14	**18.46**	20.09	21.73	**23.61**	25.92	33.84	**37.75**	41.50	3.73	**20.61**	58.58

24	24.48	**26.44**	28.99	17.19	**18.46**	19.90	21.93	**23.87**	25.88	33.94	**37.72**	42.00	3.47	**21.34**	62.62

Table 4: Variance decomposition of real exchange rates (second identification scheme) - continued

KOREA		Supply			Demand			Monetary			CRP			Expectation	
2	18.66	**21.00**	23.61	26.31	**28.91**	31.75	26.67	**29.19**	31.87	57.91	**61.19**	63.87	2.58	**37.93**	79.47
5	18.35	**20.22**	22.65	24.76	**26.87**	29.25	25.12	**27.24**	29.64	53.88	**56.74**	59.98	9.61	**29.43**	57.20
12	18.67	**20.60**	22.67	24.60	**27.11**	29.34	24.89	**27.20**	29.83	52.11	**55.94**	59.06	7.31	**27.55**	76.38
24	18.62	**20.56**	22.83	24.43	**26.75**	29.28	25.17	**27.22**	29.66	52.65	**56.21**	59.47	9.94	**28.83**	65.59
SINGAPORE		Supply			Demand			Monetary			CRP			Expectation	
2	17.20	**18.71**	20.47	23.10	**25.24**	27.34	22.89	**25.50**	27.48	43.77	**48.51**	53.24	2.12	**26.49**	69.89
5	17.36	**18.53**	20.19	22.49	**24.74**	26.87	22.09	**24.68**	27.23	42.67	**46.55**	51.36	8.52	**25.66**	56.82
12	17.27	**18.82**	20.44	22.46	**24.66**	26.77	22.57	**25.09**	27.60	42.04	**46.59**	51.15	4.87	**27.86**	48.05
24	17.24	**18.73**	20.38	22.91	**24.83**	26.96	22.42	**24.77**	27.47	42.01	**46.00**	50.63	5.99	**29.59**	69.71
THAILAND		Supply			Demand			Monetary			CRP			Expectation	
2	23.39	**25.79**	28.95	31.28	**35.20**	39.51	17.85	**20.22**	22.70	41.24	**45.29**	49.09	5.22	**18.66**	69.21
5	22.99	**25.21**	28.12	29.86	**33.34**	37.09	17.89	**19.86**	22.10	38.52	**42.56**	46.56	10.91	**24.05**	60.95
12	23.03	**25.59**	28.36	29.11	**32.67**	36.75	17.72	**19.80**	22.53	37.93	**42.19**	46.15	17.12	**37.27**	69.71
24	23.18	**25.43**	27.97	29.12	**32.80**	36.97	17.68	**19.69**	22.01	37.65	**41.95**	46.18	11.04	**53.54**	74.12
UNITED KINGDOM		Supply			Demand			Monetary			CRP			Expectation	
2	19.99	**21.49**	23.39	29.41	**31.96**	34.93	24.50	**26.82**	29.31	44.84	**48.25**	52.47	5.51	**54.23**	77.47
5	19.74	**21.53**	23.33	29.42	**31.72**	34.69	24.53	**26.85**	29.22	43.64	**47.88**	51.85	14.05	**42.54**	87.00
12	19.79	**21.69**	23.46	29.39	**31.66**	34.33	24.33	**26.62**	29.11	43.23	**47.05**	51.34	8.76	**42.91**	78.53
24	19.90	**21.64**	23.75	29.37	**31.96**	34.50	24.81	**26.80**	29.20	43.81	**47.47**	51.87	16.51	**41.13**	87.65

Note: This table gives the median contribution (bold) together with the 16th and 84th percentiles for each shock.

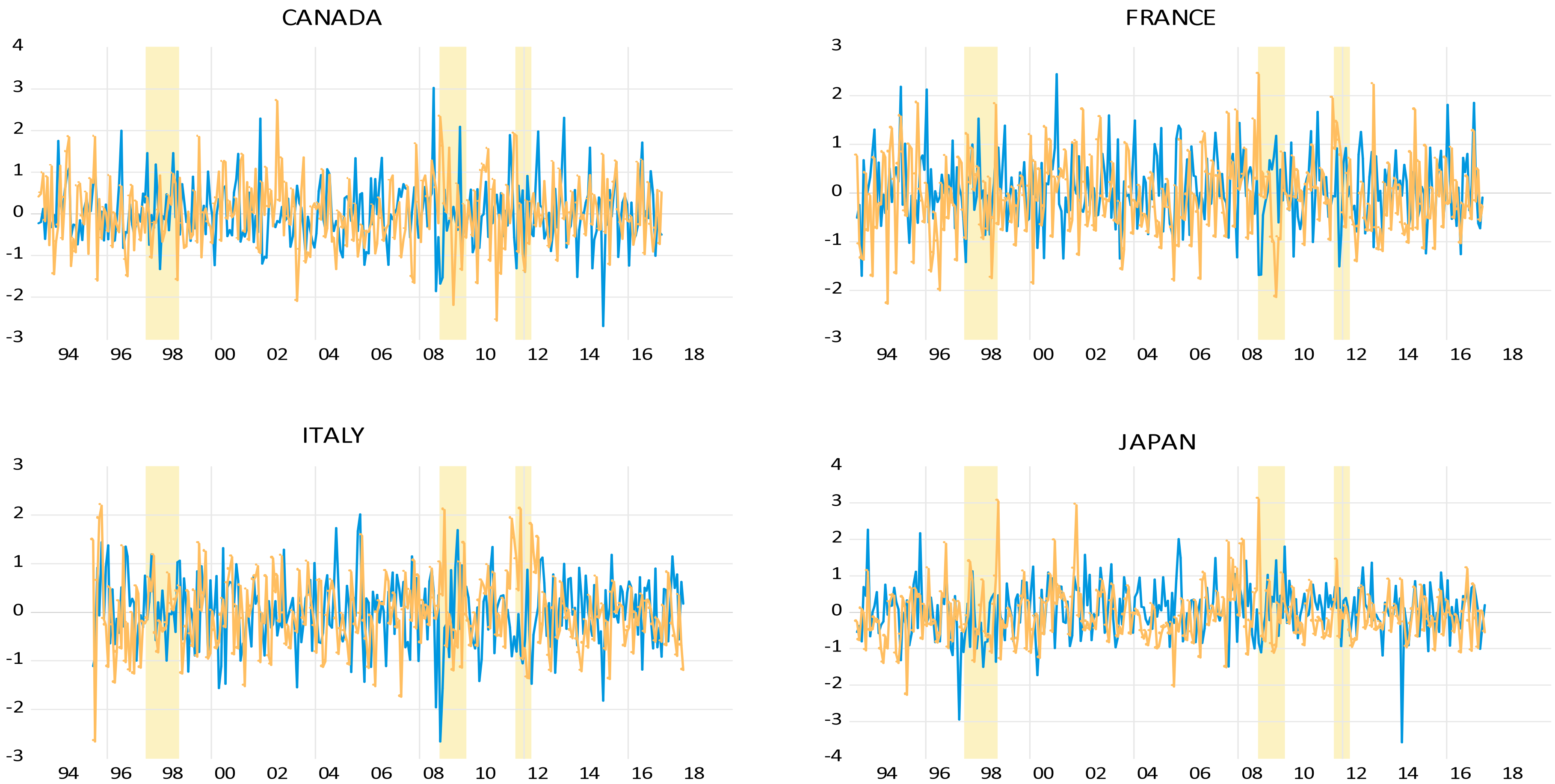


Figure 1A: Time plots of supply and demand shocks

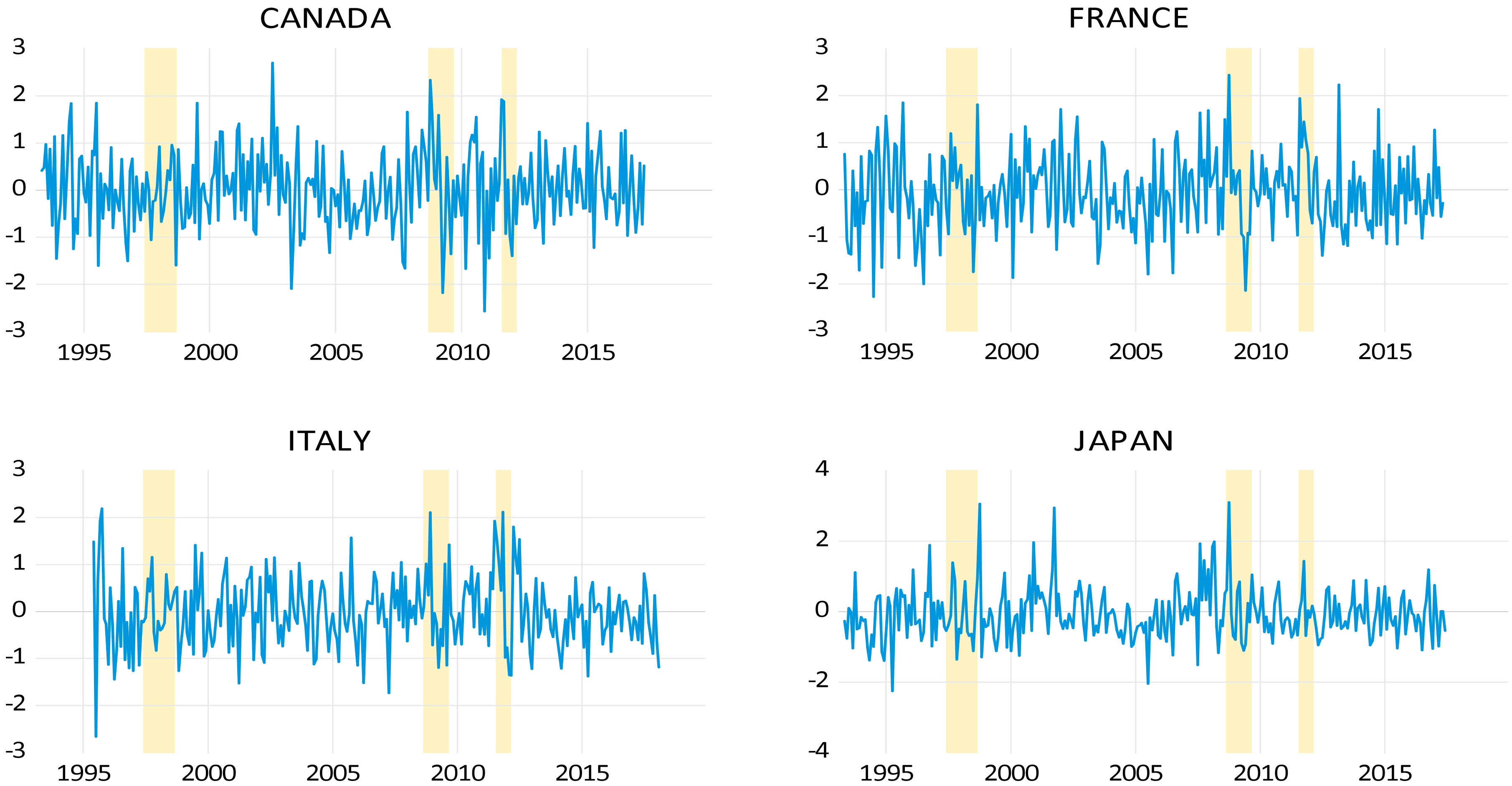
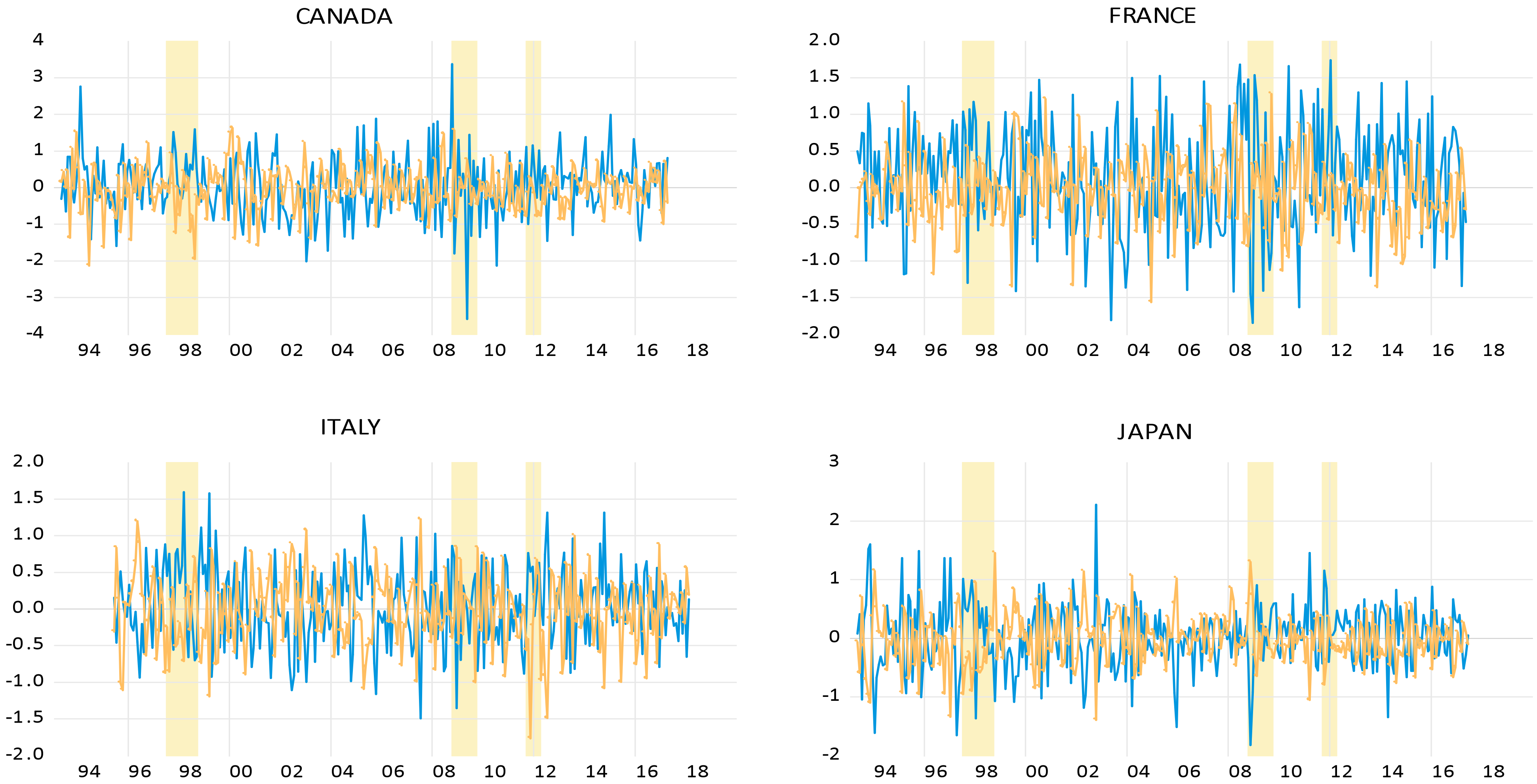


Figure 1B: Time plots of monetary shocks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1
0
-1
-2
-3
-4
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1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
94 96 98 00 02 04 06 08 10 12 14 16 18
ITALY
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
94 96 98 00 02 04 06 08 10 12 14 16 18
JAPAN
3
2
1
0
-1
-2
94 96 98 00 02 04 06 08 10 12 14 16 18

Figure 1C: Time plots of CRP and expectation shocks

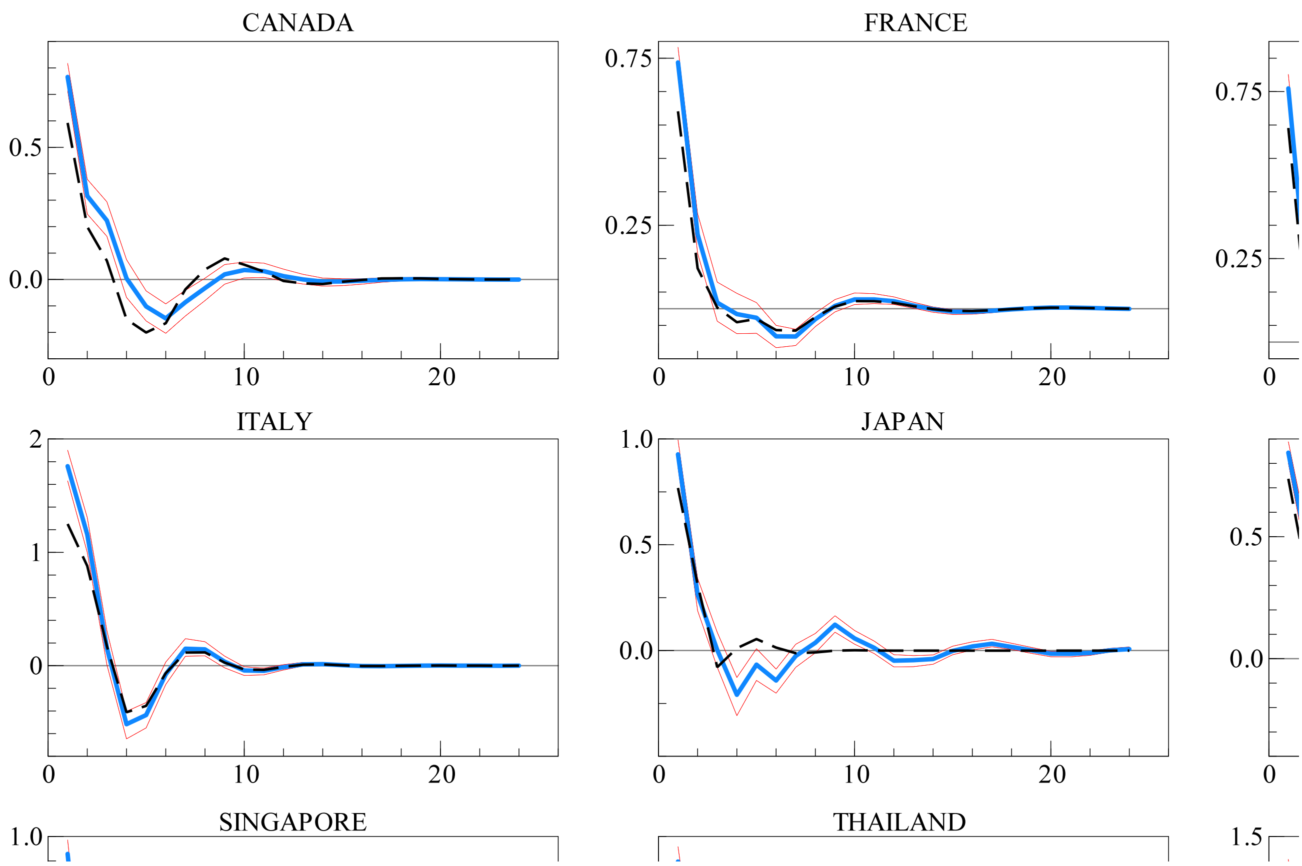


Figure 2A: Relative Output Differential Response to Supply Shock

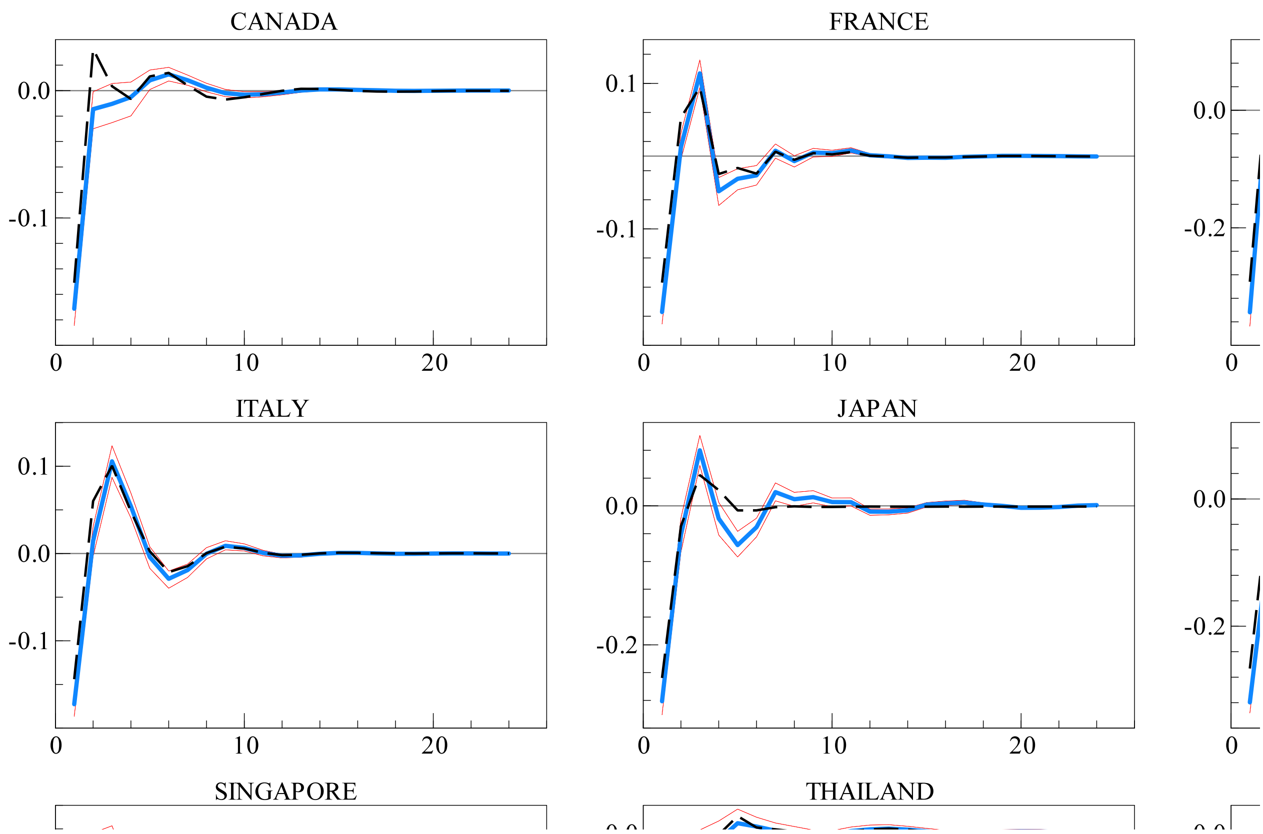


Figure 2B: Relative Price Response to Supply Shock

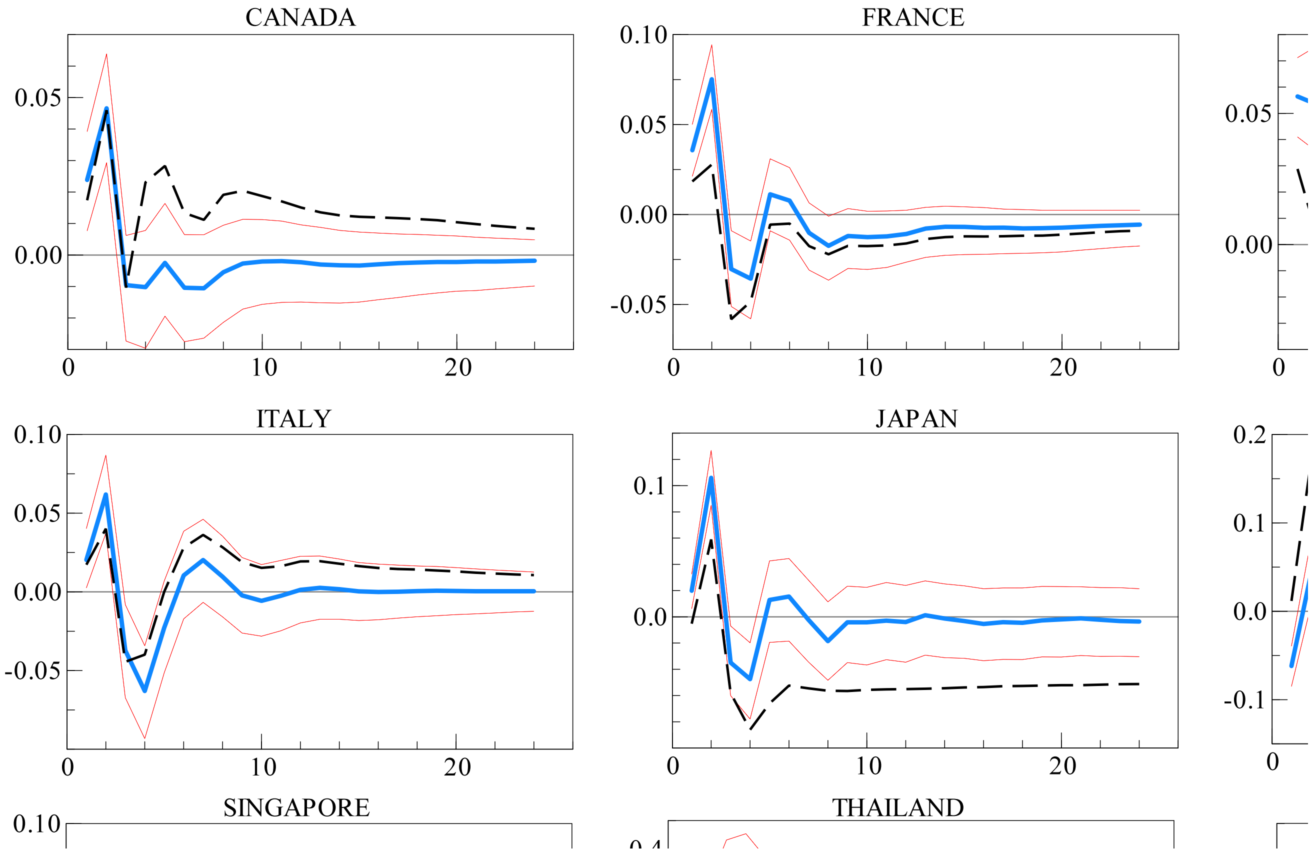


Figure 2C: Real Interest Rate Differential Response to Supply Shock

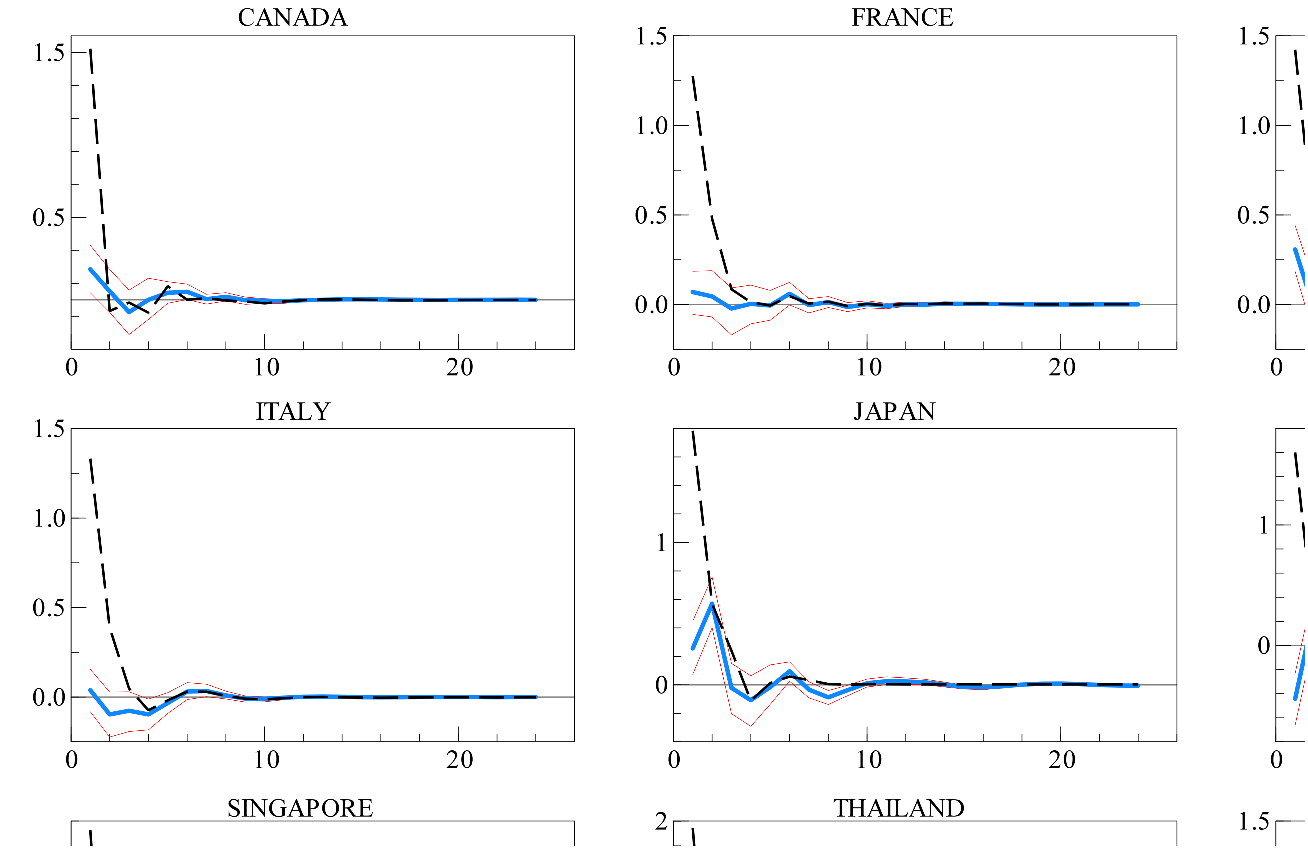


Figure 2D: Real Exchange Rate Response to Supply Shock

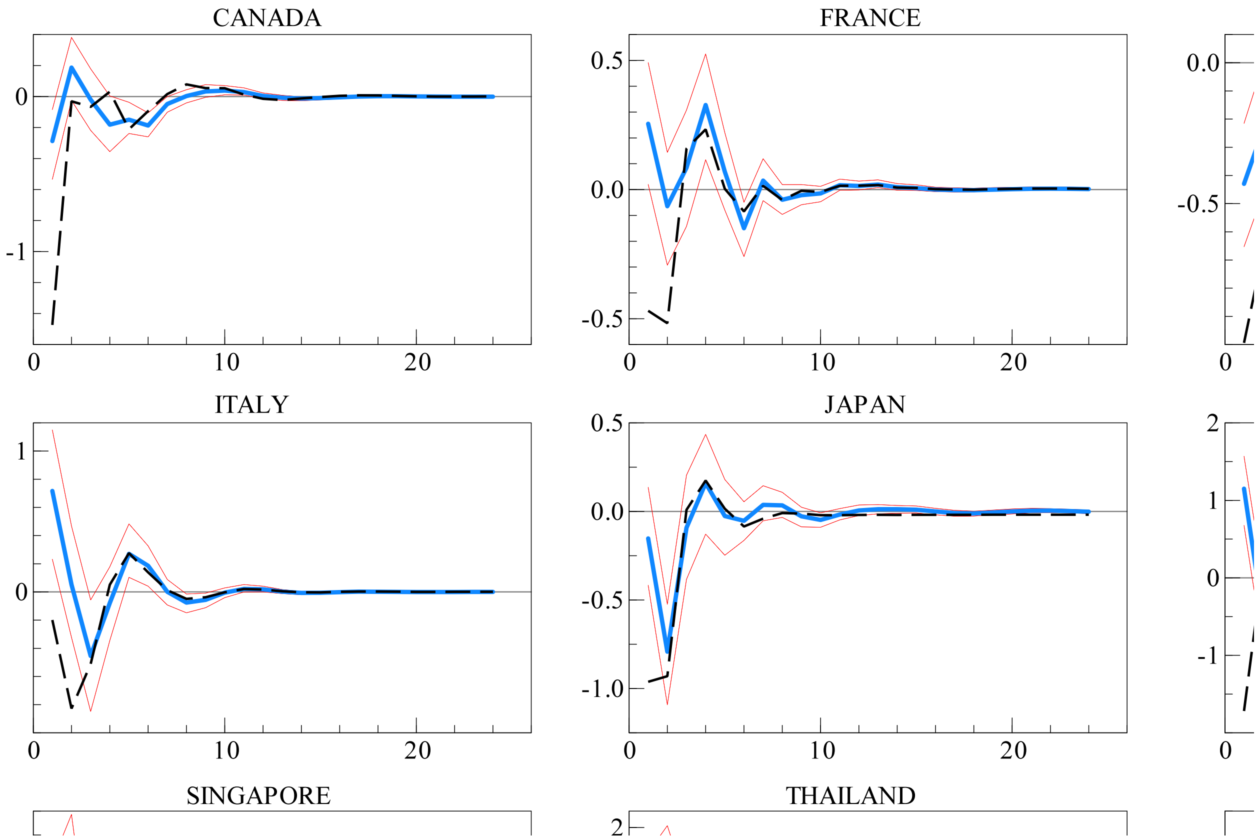


Figure 2E: Relative Stock Differential Response to Supply Shock

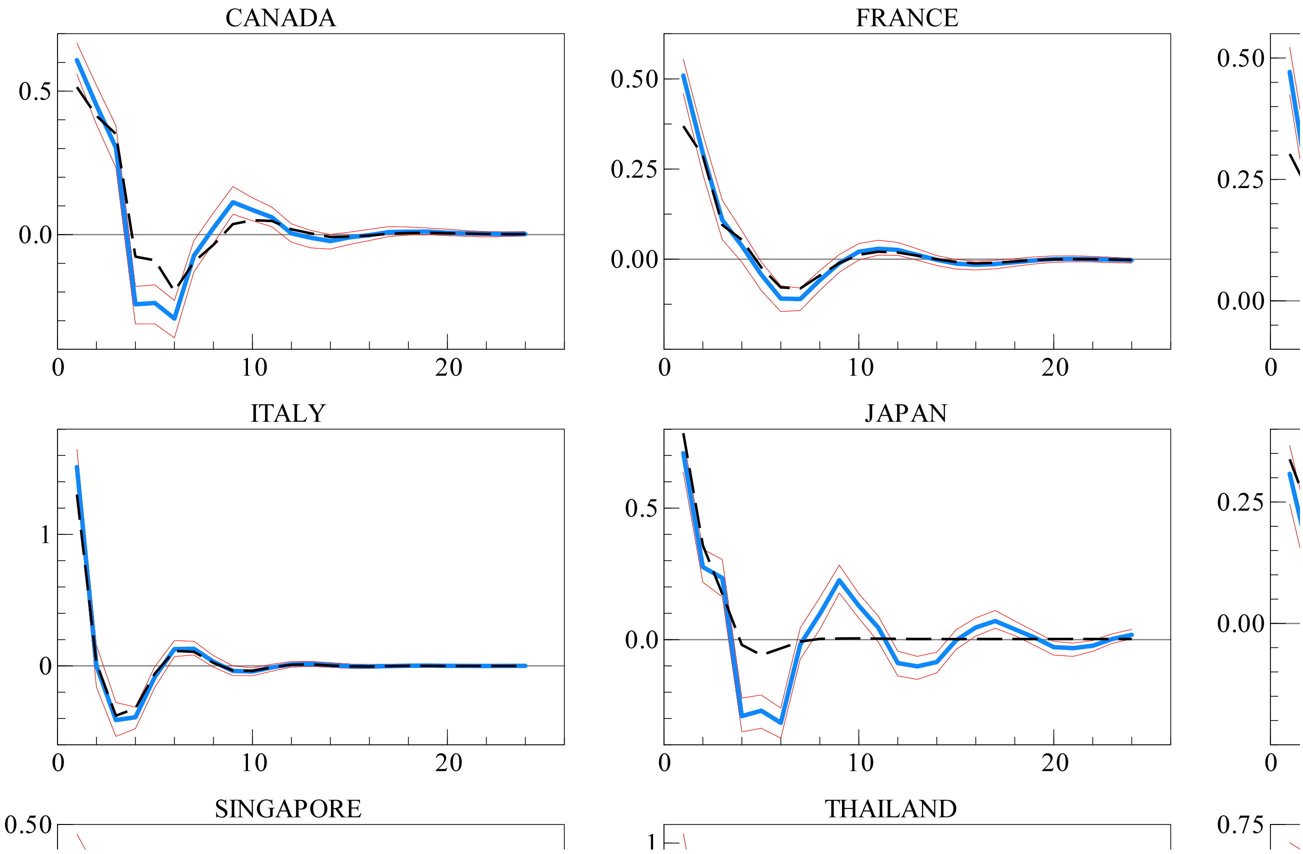


Figure 3A: Relative Output Differential Response to Demand Shock

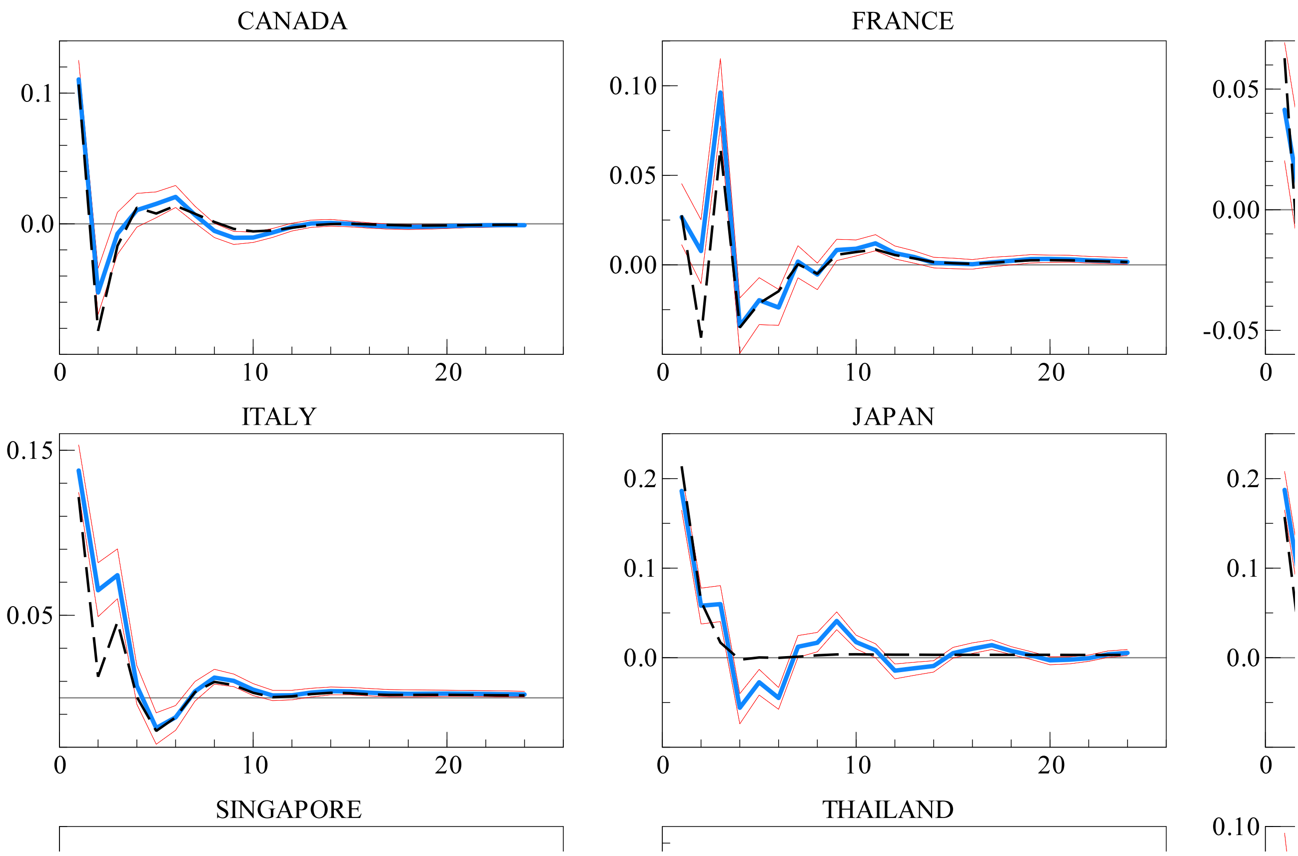


Figure 3B: Relative Price Response to Demand Shock

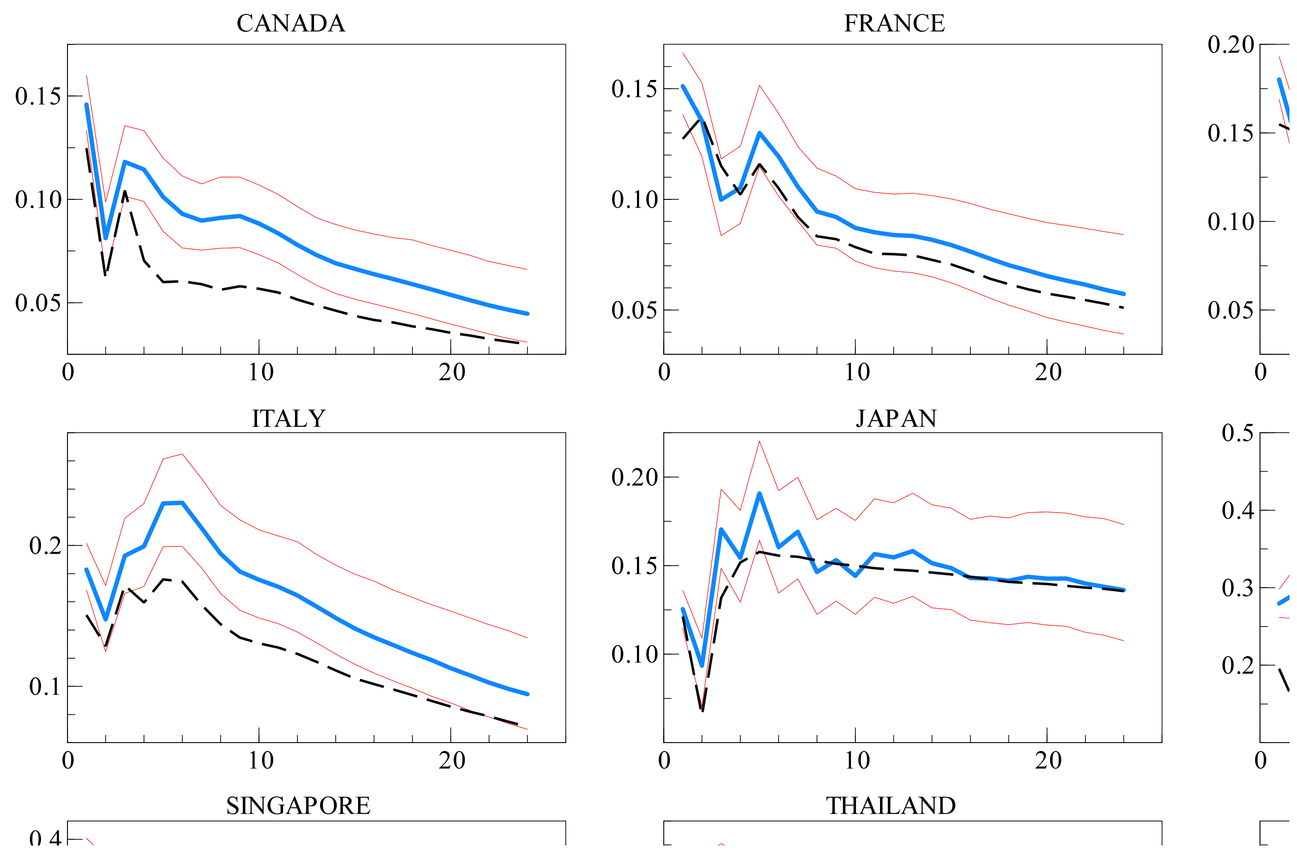


Figure 3C: Real Interest Rate Differential Response to Demand Shock

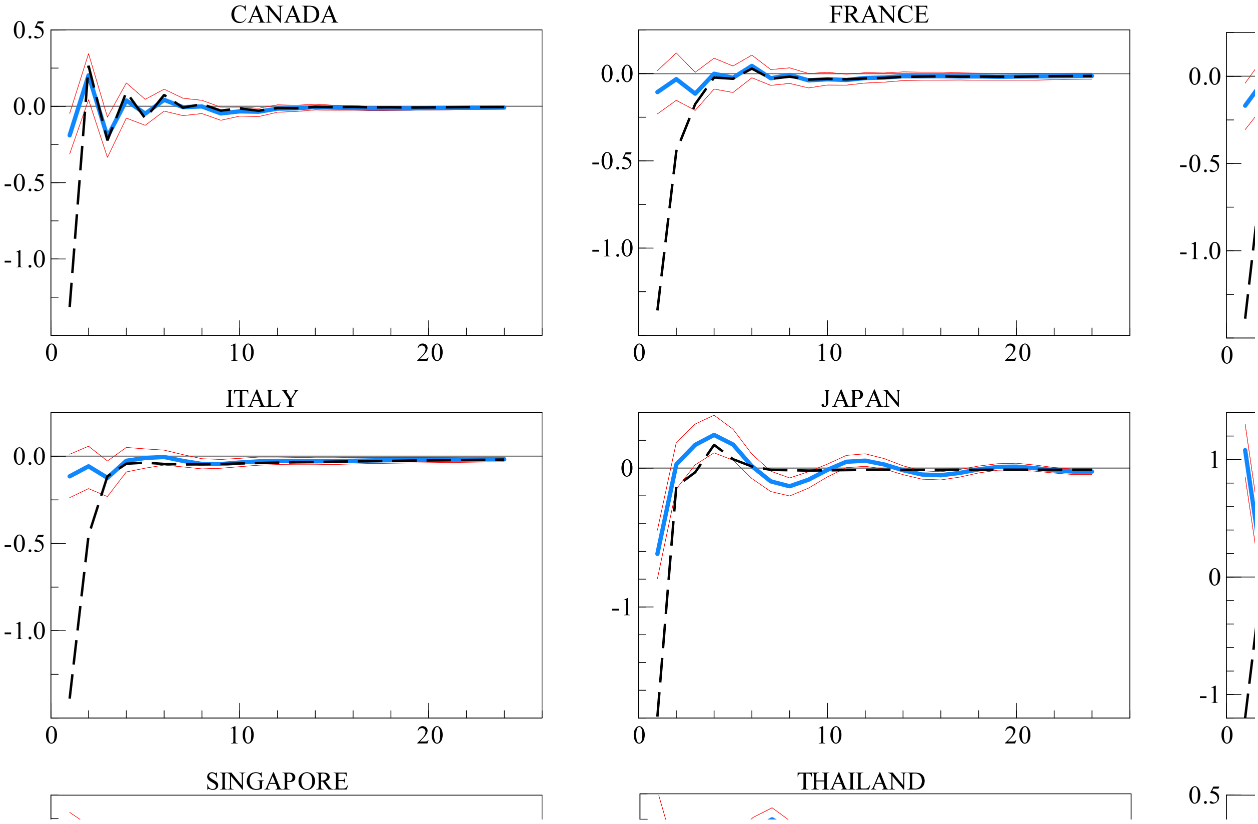


Figure 3D: Real Exchange Rate Response to Demand Shock

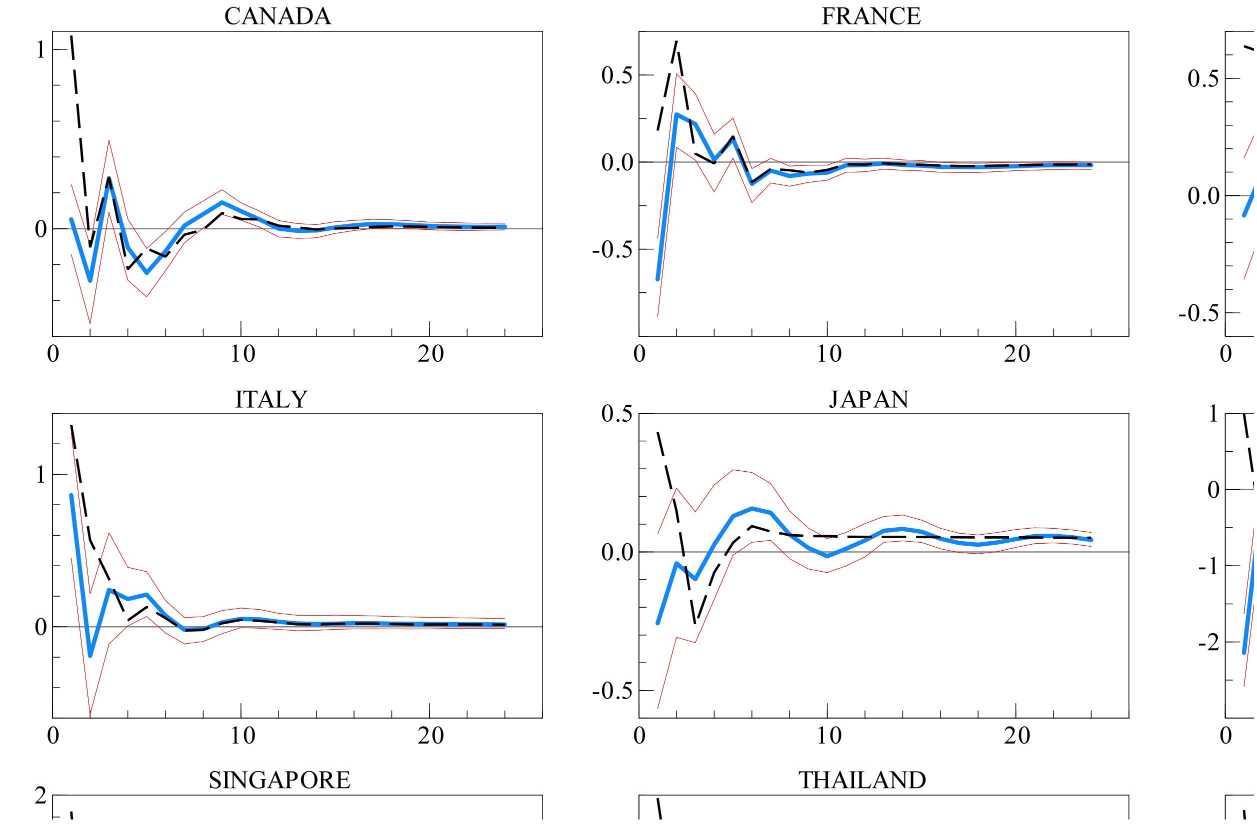


Figure 3E: Relative Stock Differential Response to Demand Shock

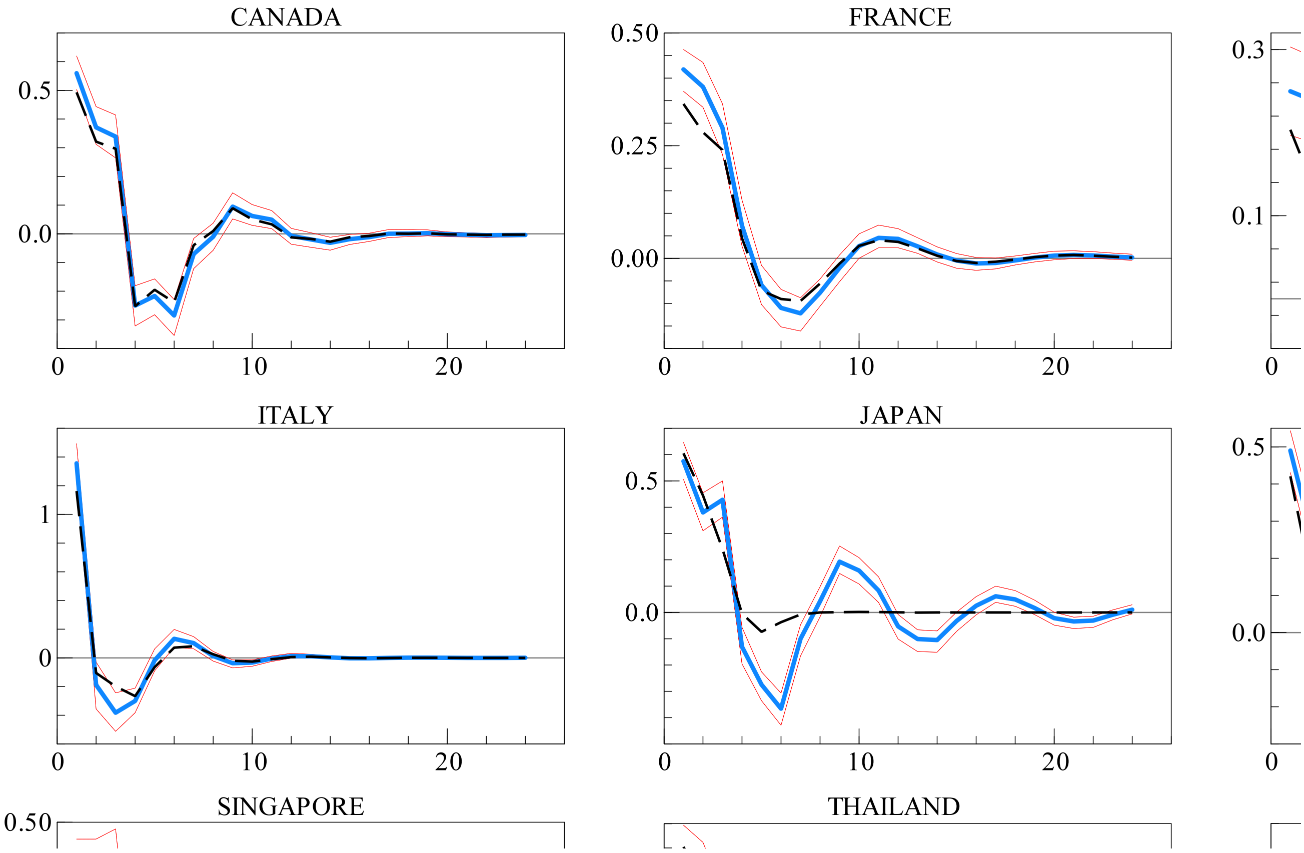


Figure 4A: Relative Output Differential Response to Monetary Shock

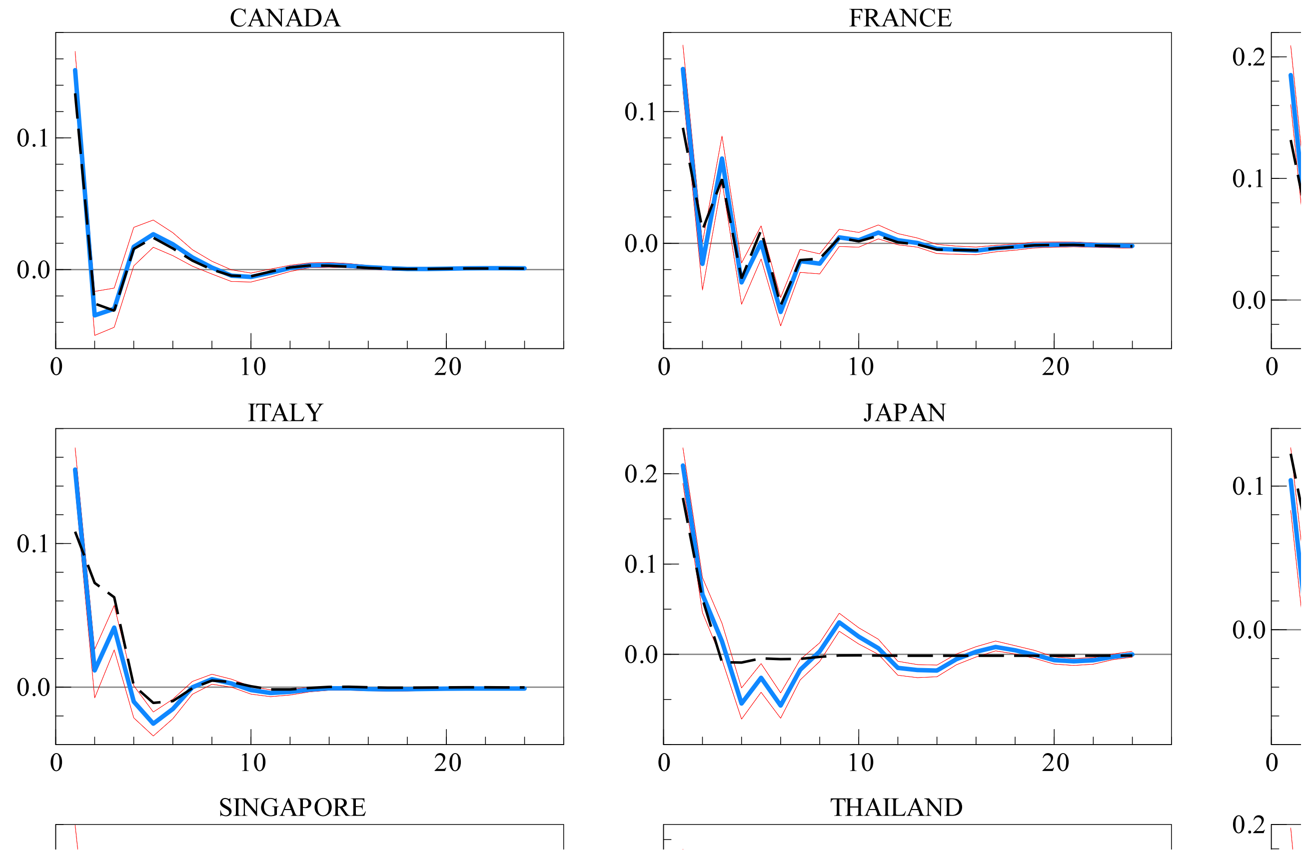


Figure 4B: Relative Price Response to Monetary Shock

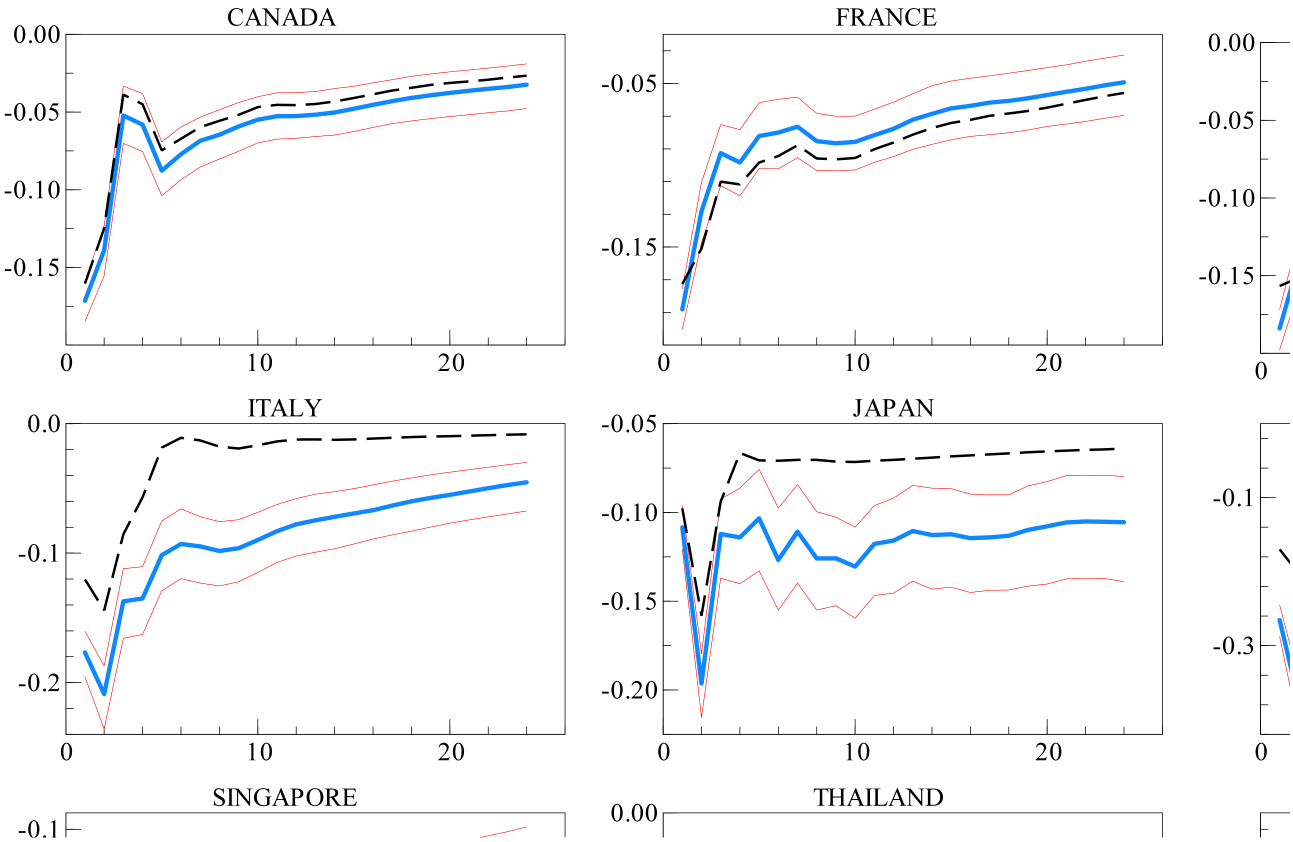


Figure 4C: Real Interest Rate Differential Response to Monetary Shock

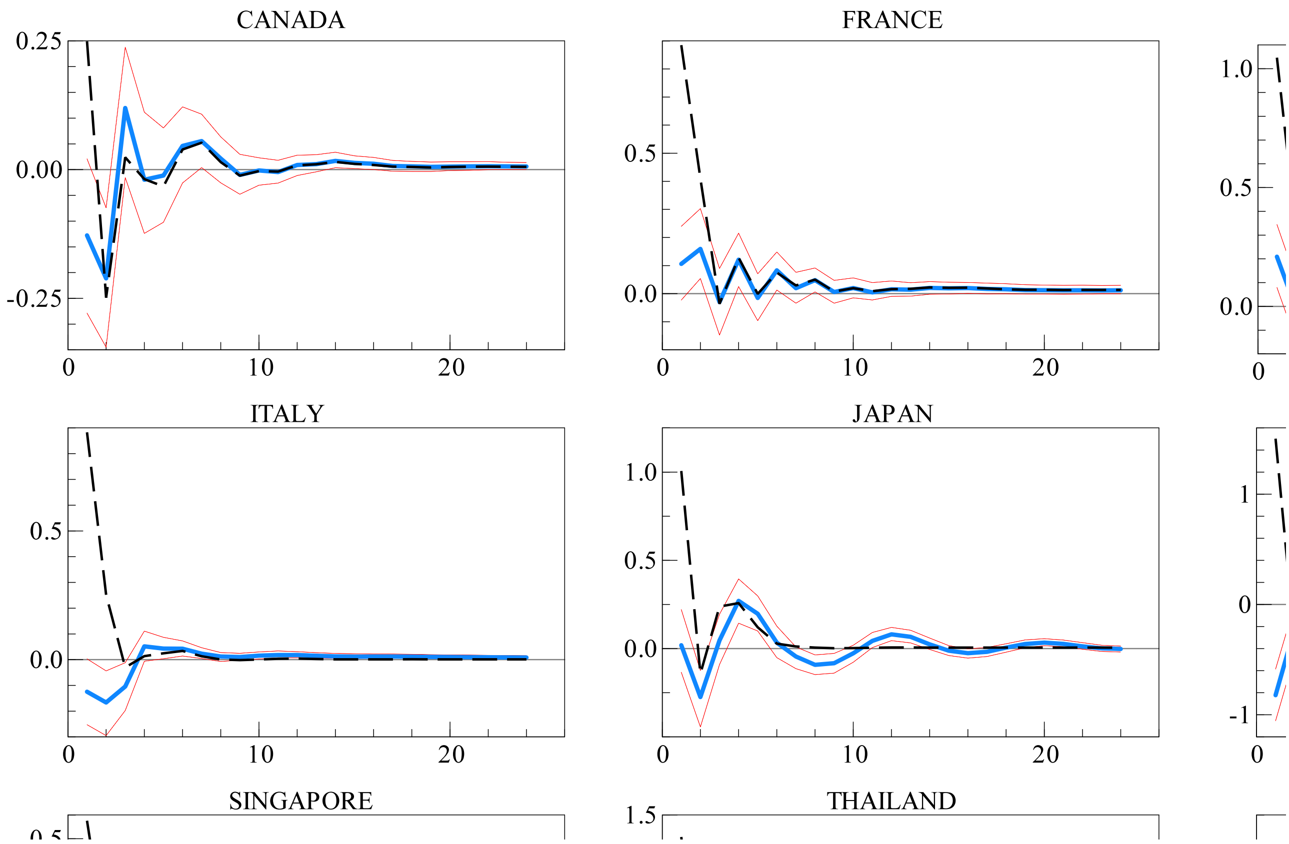


Figure 4D: Real Exchange Rate Response to Monetary Shock

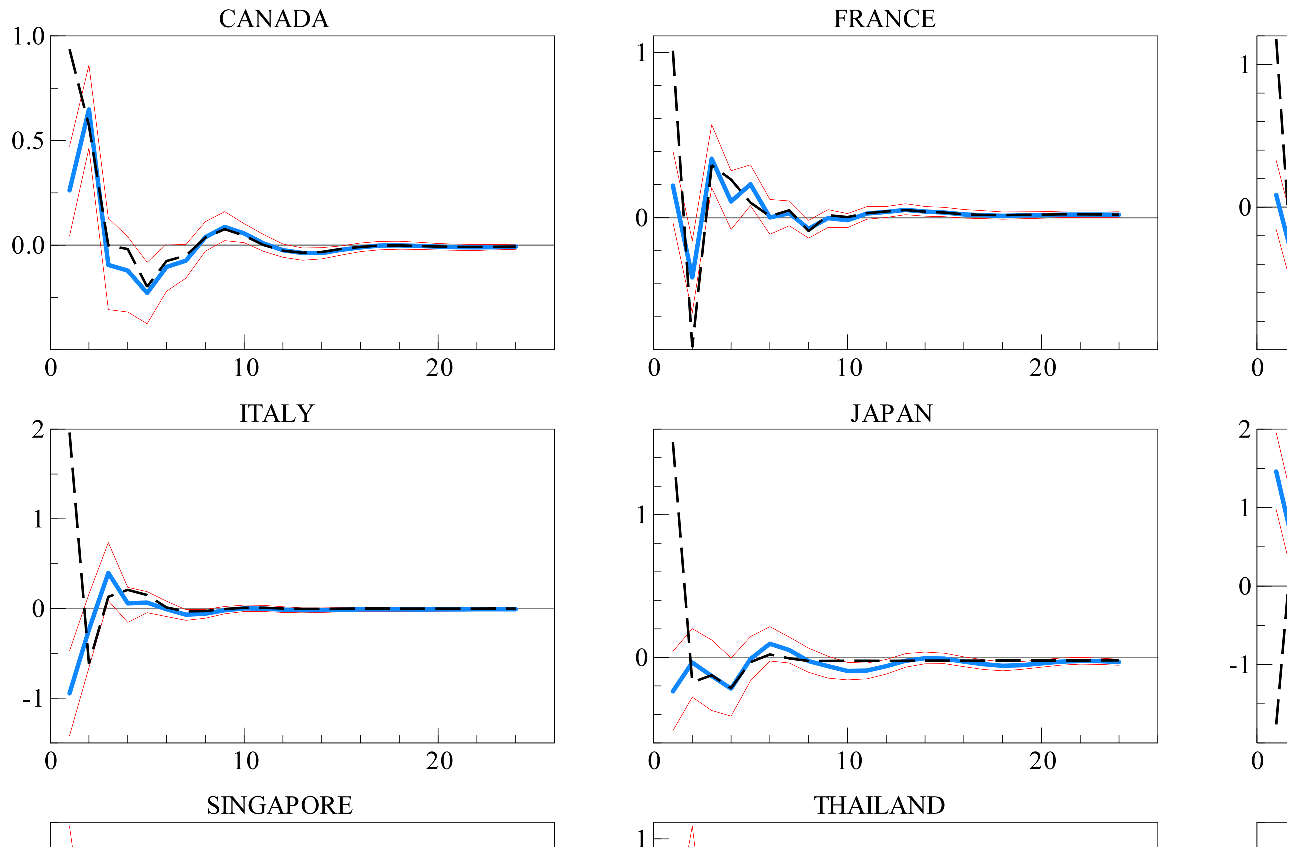


Figure 4E: Relative Stock Differential Response to Monetary Shock

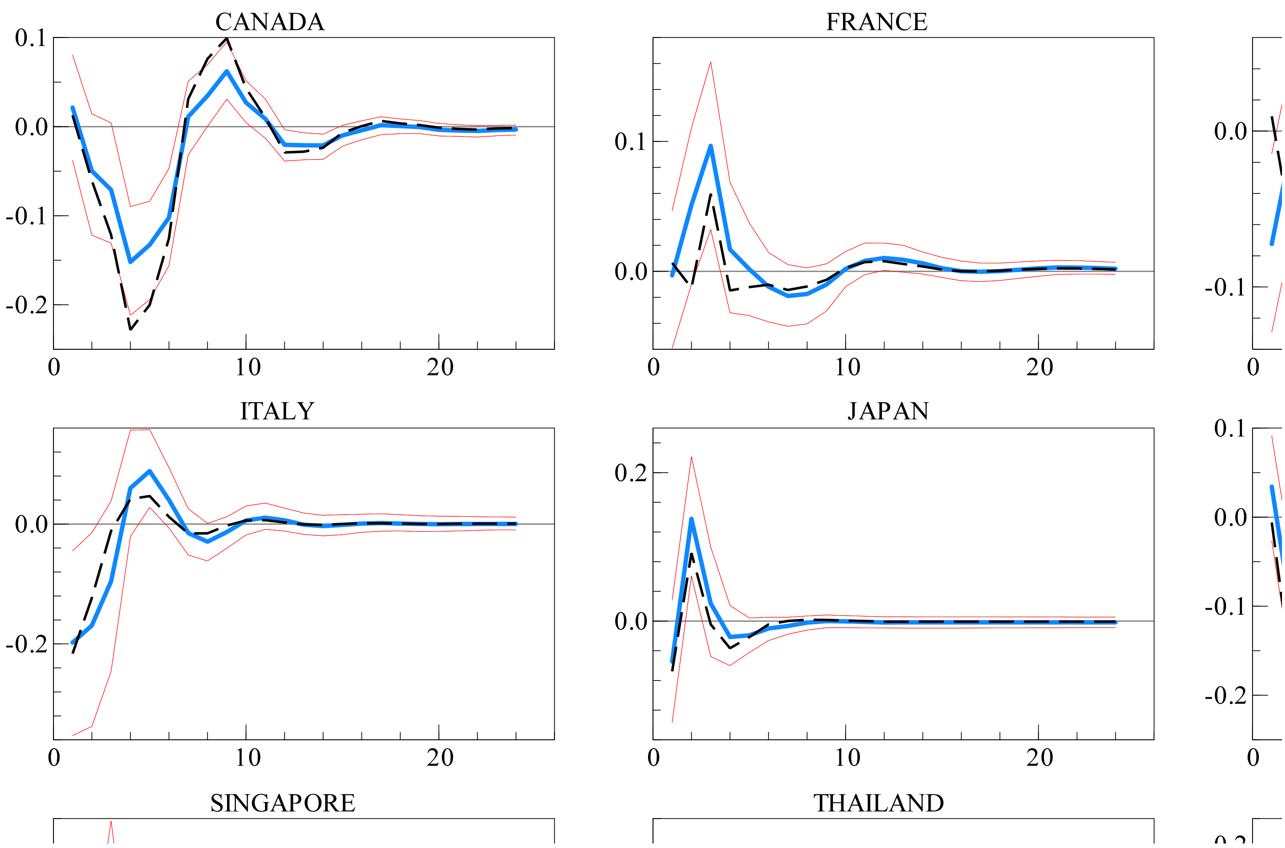


Figure 5A: Relative Output Differential Response to CRP Shock

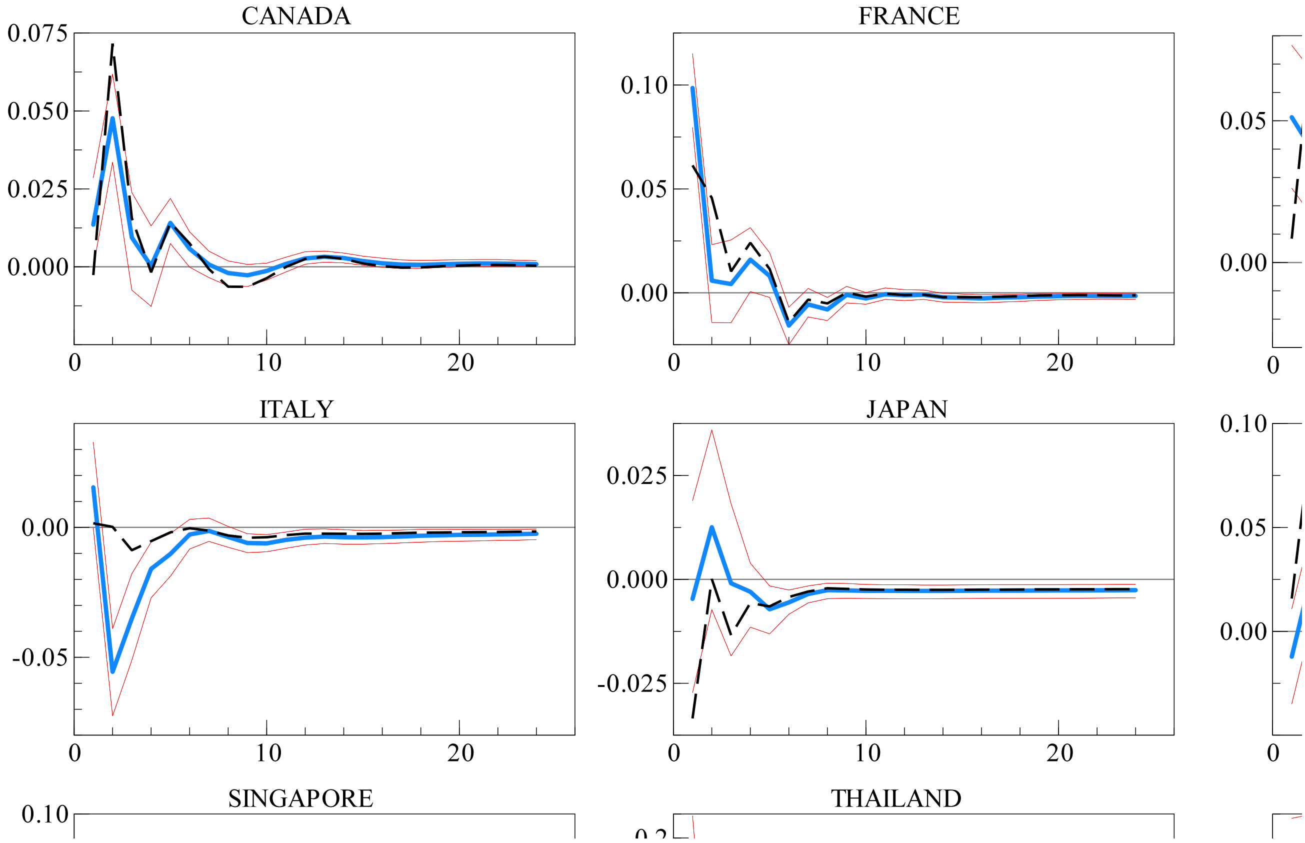


Figure 5B: Relative Price Response to CRP Shock

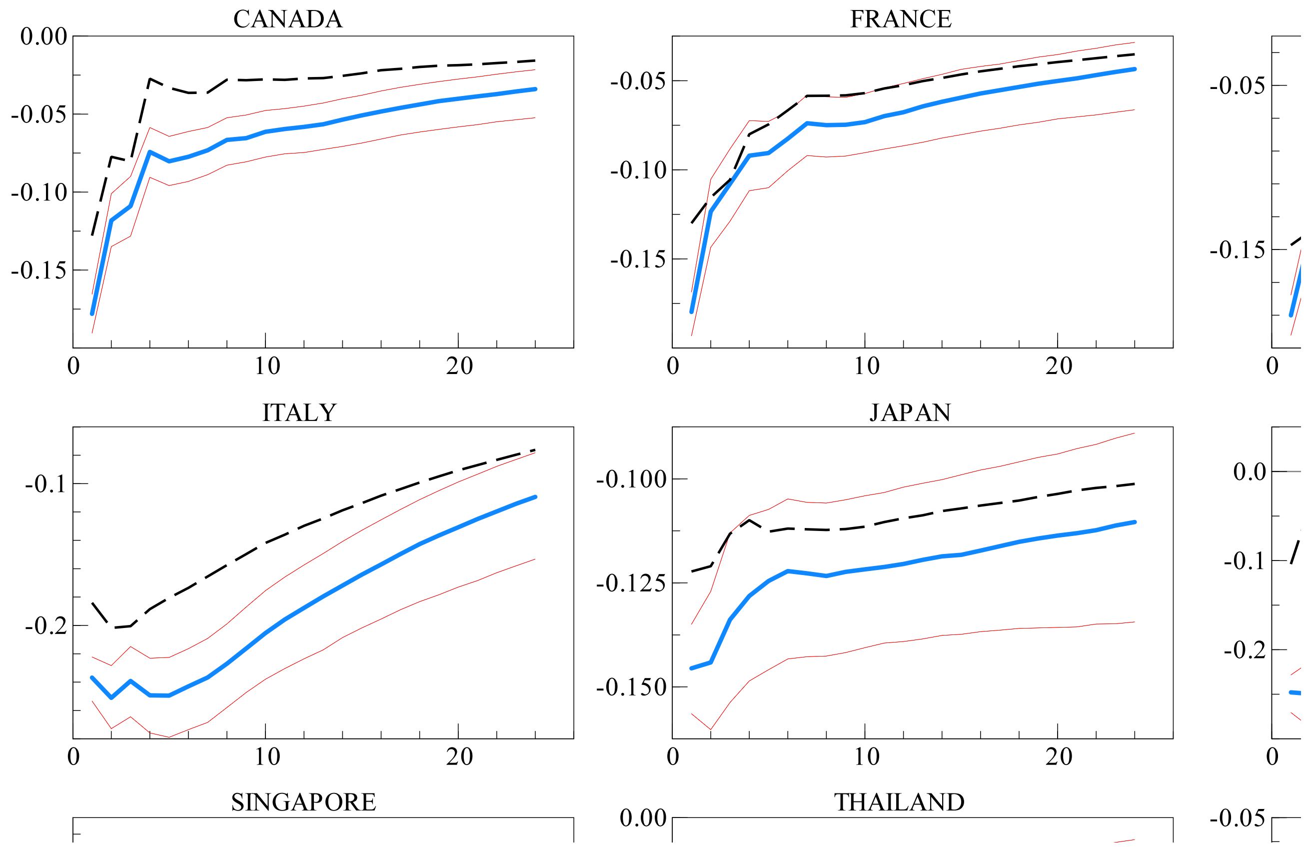


Figure 5C: Real Interest Rate Differential Response to CRP Shock

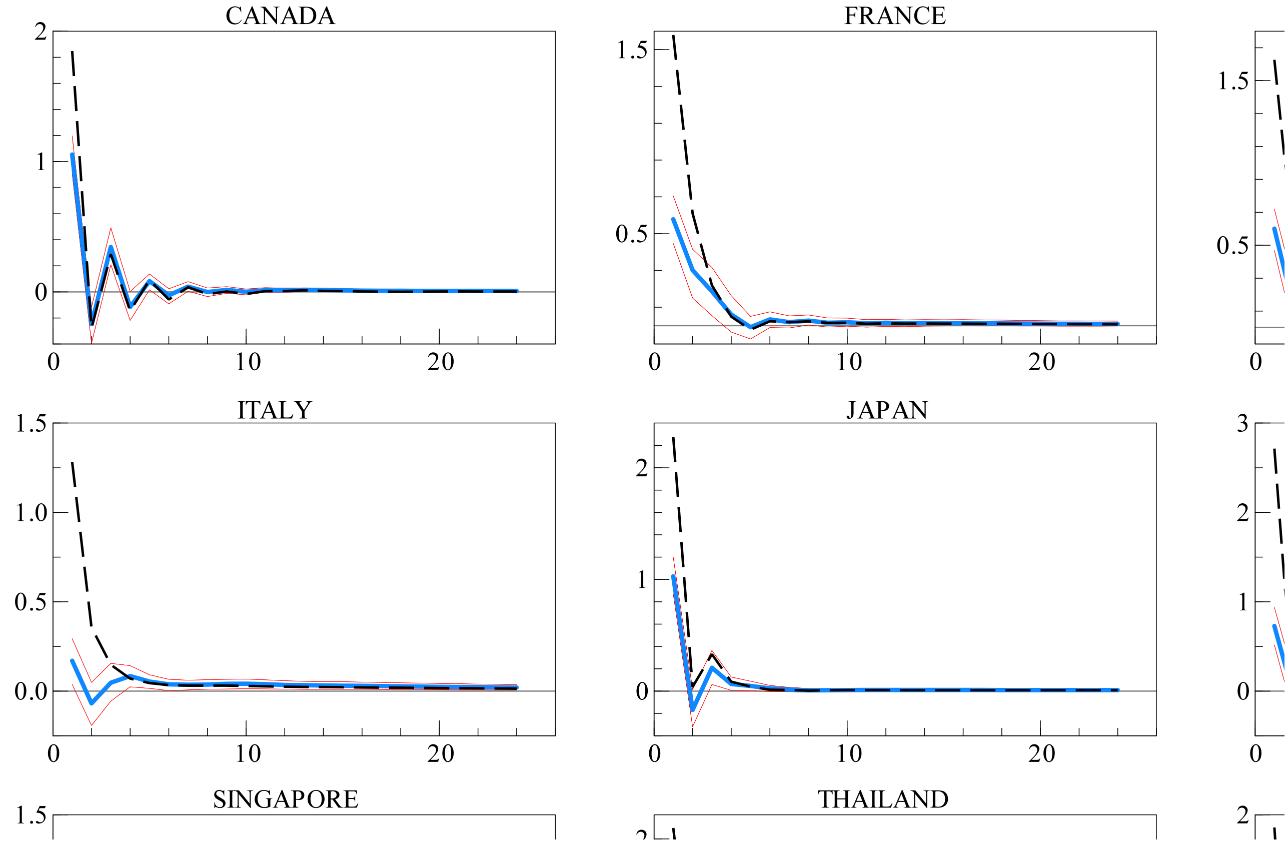


Figure 5D: Real Exchange Rate Response to CRP Shock

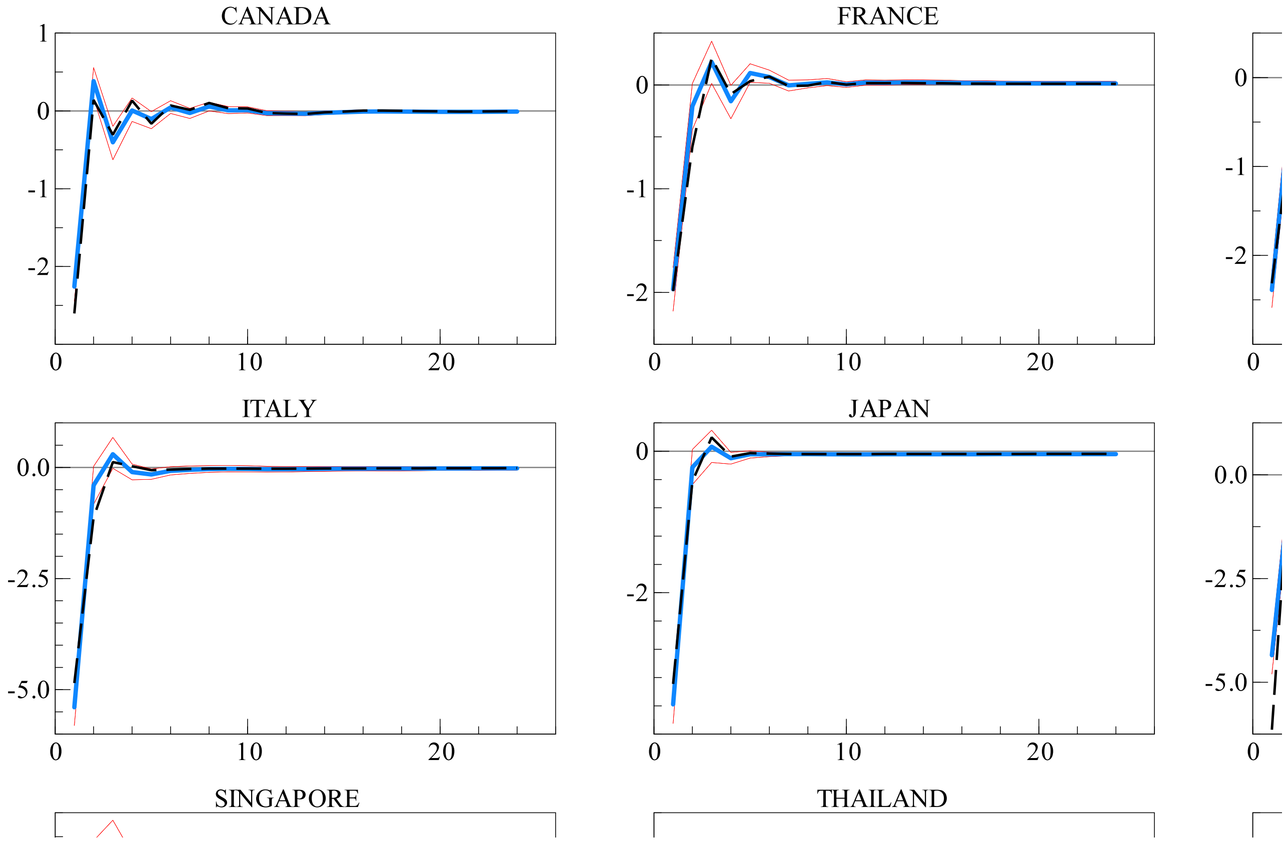


Figure 5E: Relative Stock Differential Response to CRP Shock

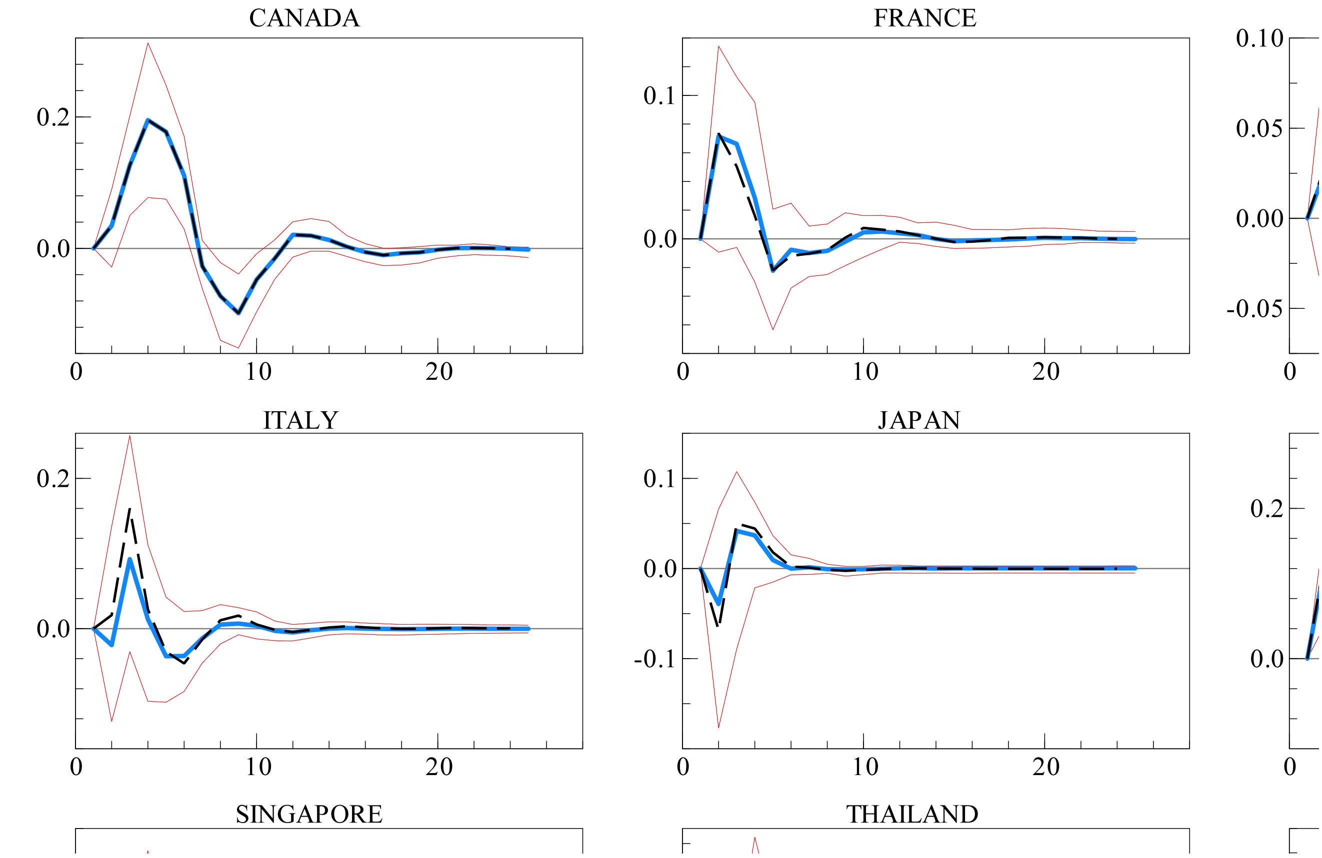


Figure 6A: Relative Output Differential Response to Expectation Shock

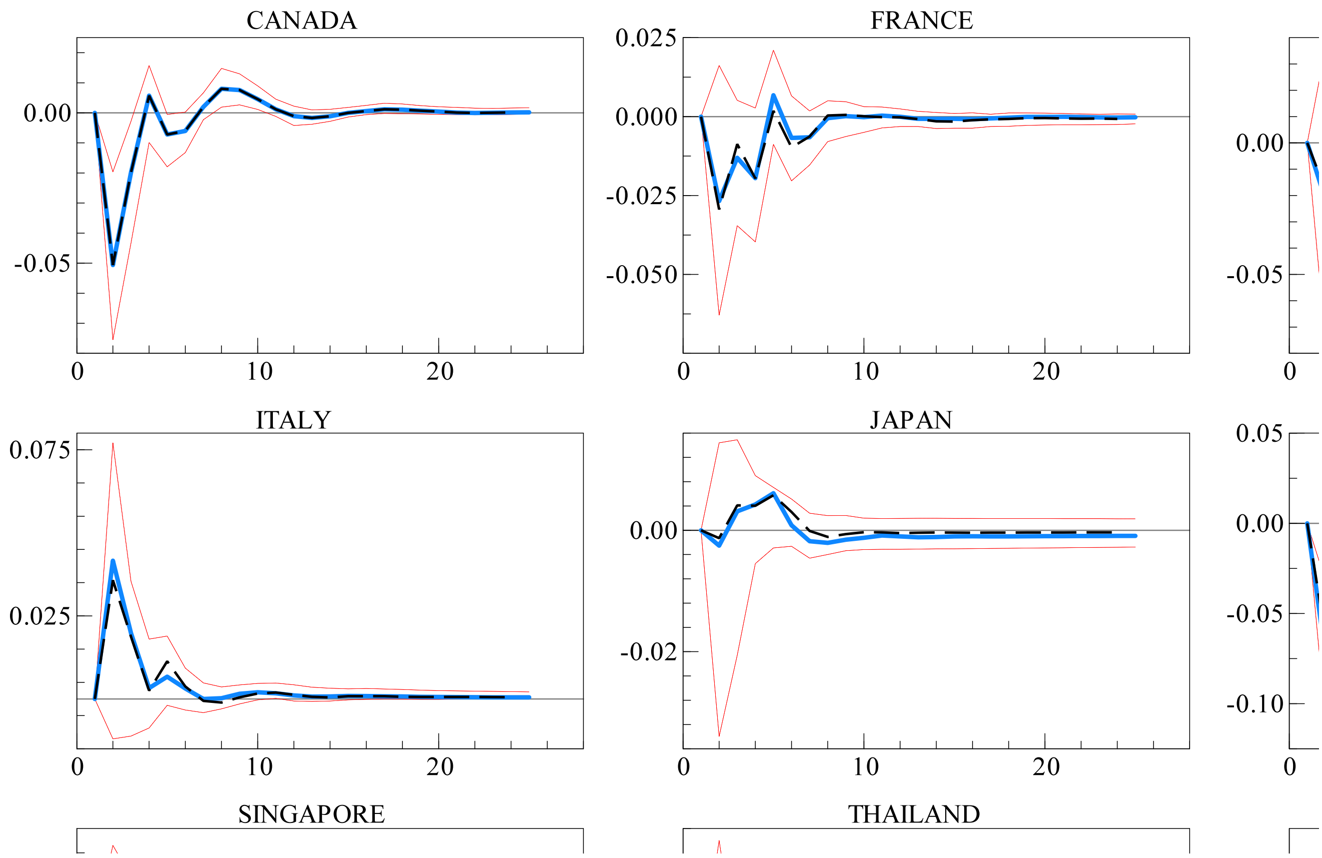


Figure 6B: Relative Price Response to Expectation Shock

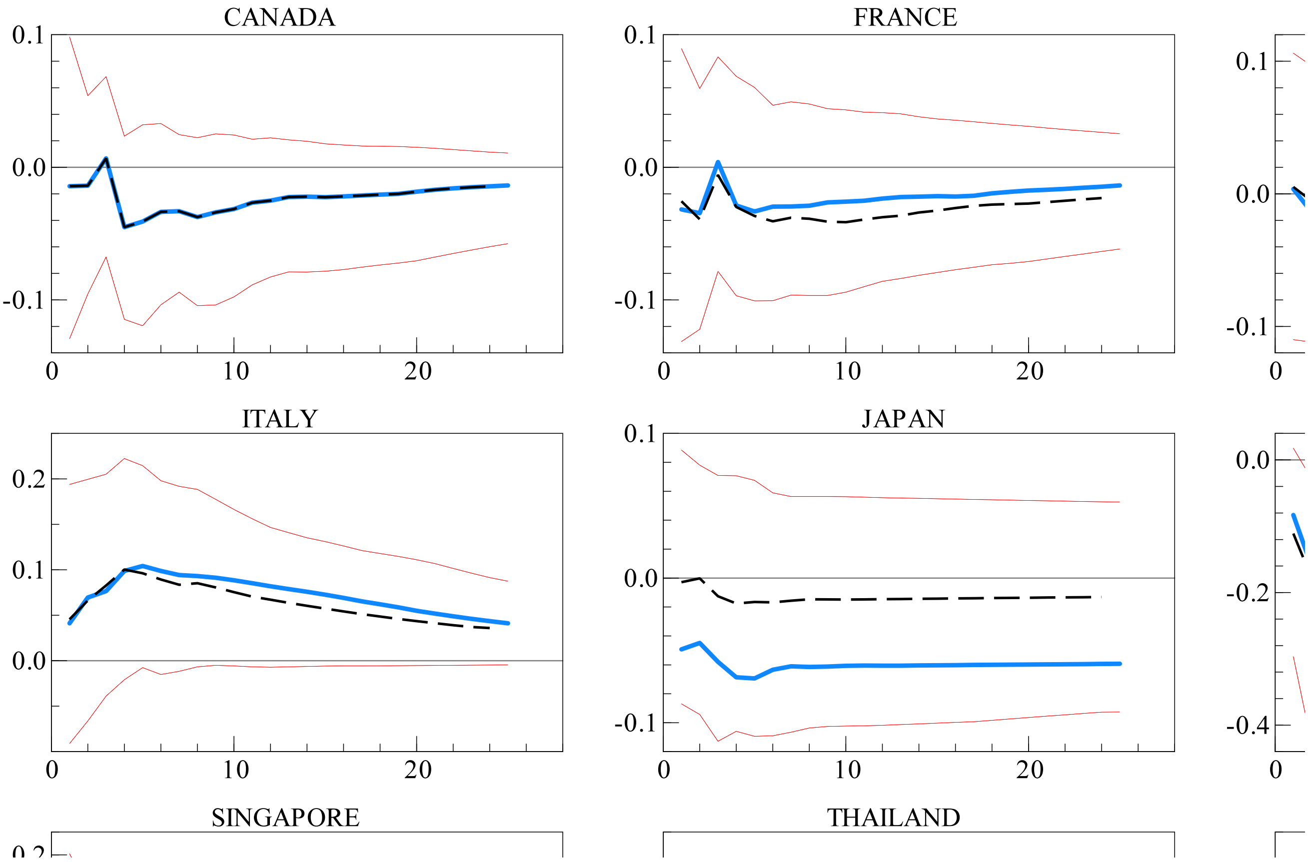


Figure 6C: Real Interest Rate Differential Response to Expectation Shock

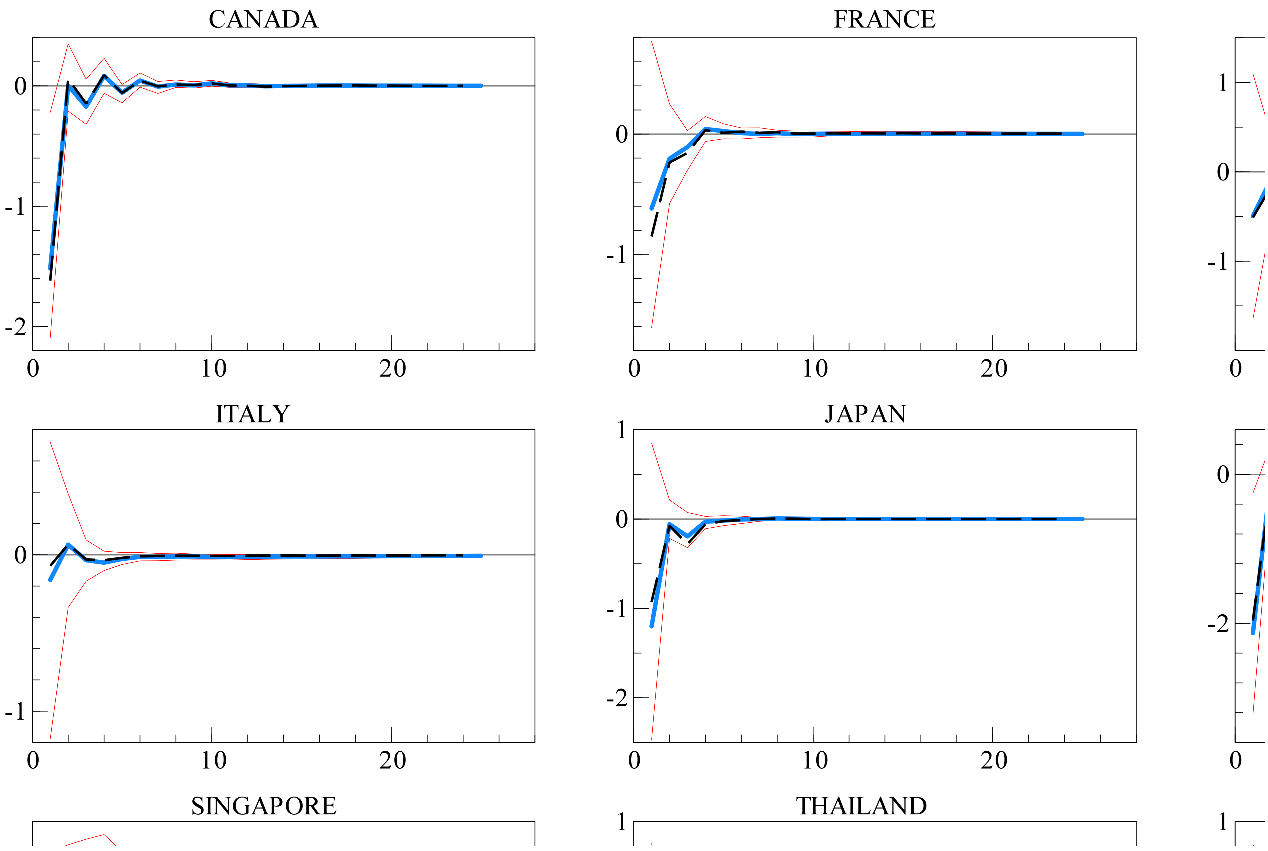


Figure 6D: Real Exchange Rate Response to Expectation Shock

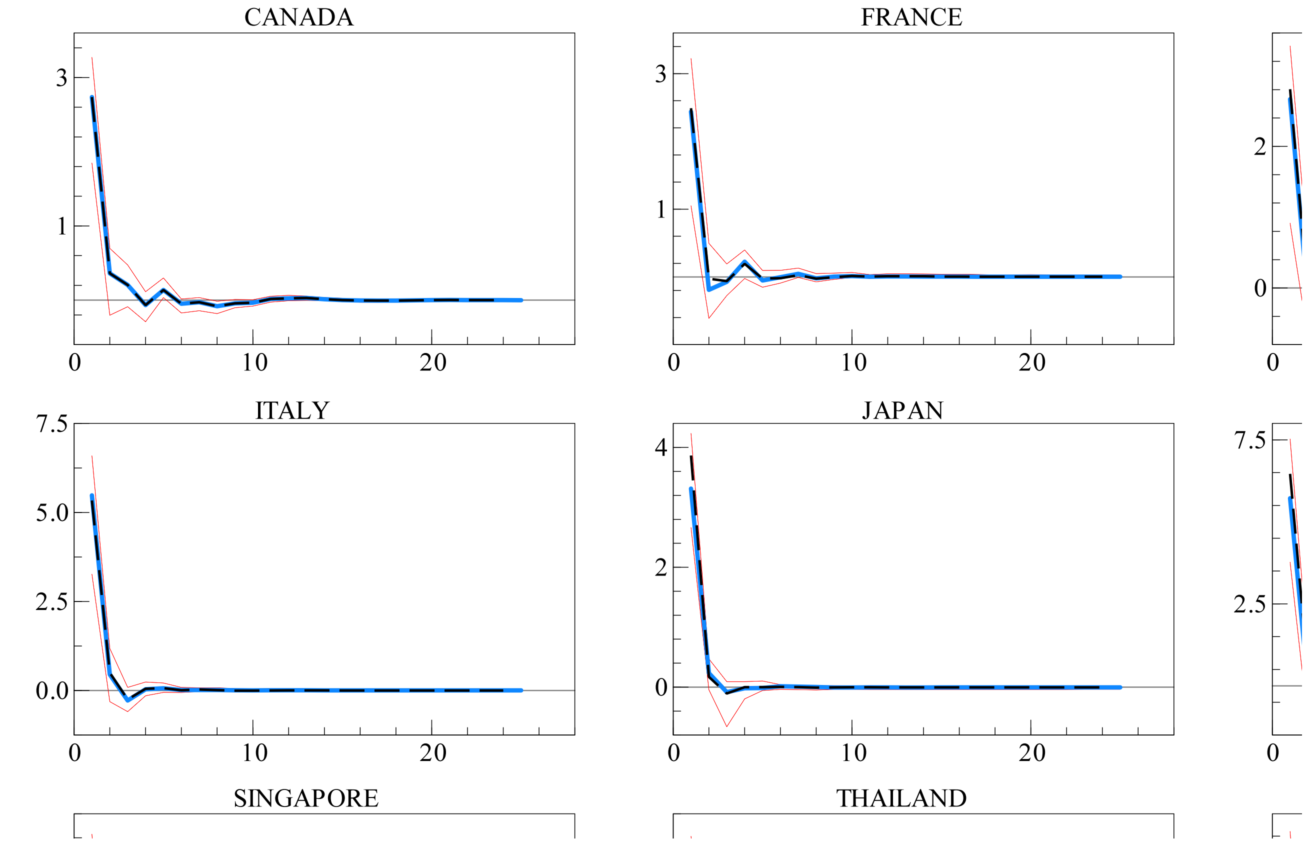
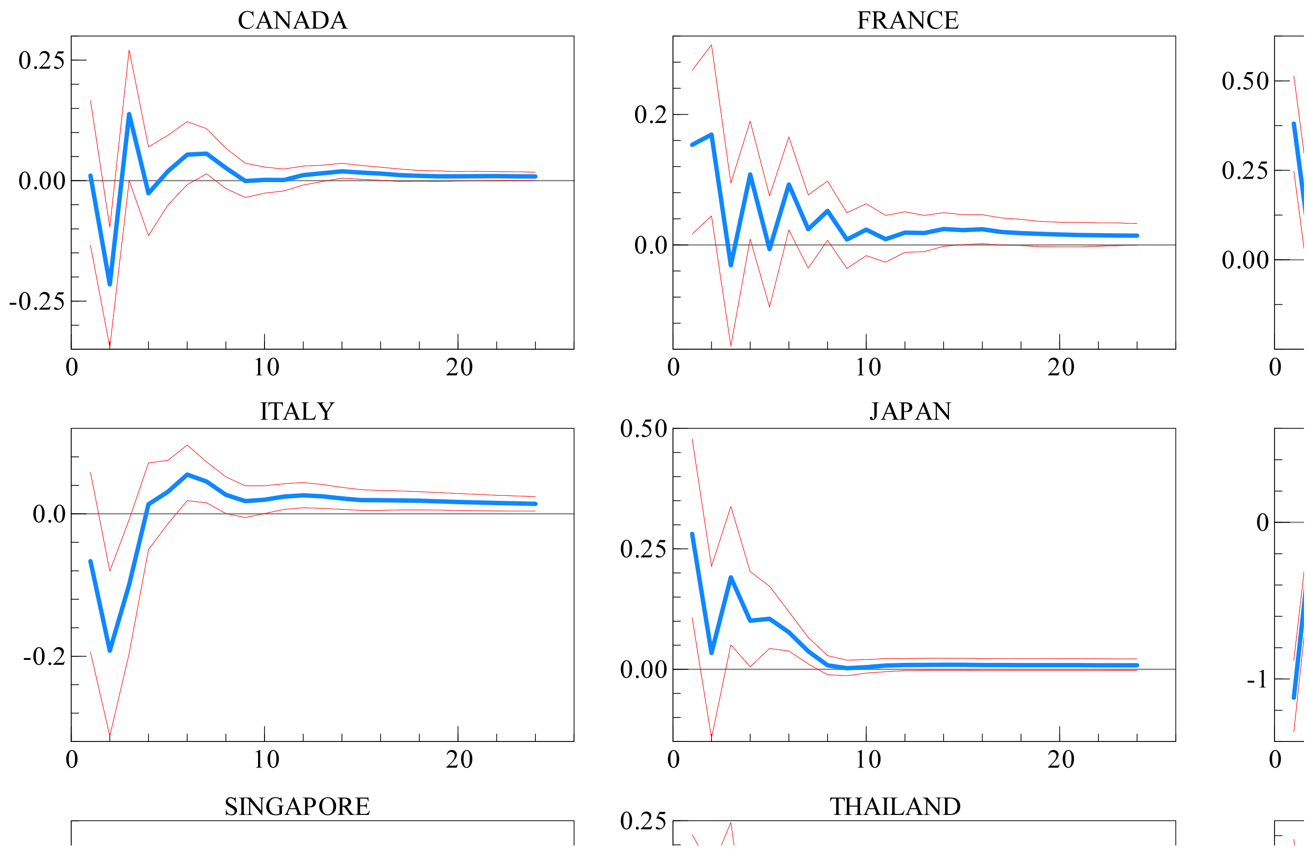


Figure 6E: Relative Stock Differential Response to Expectation Shock



Appendix 1: Real Exchange Rate Response to Monetary Shock