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Did the Quantitative Easing Policy Contribute to Overcoming Japan's Deflation since the Late 1990s？: The Effectiveness of Monetary Base Channel at Zero Interest Rates

Masanobu　Umeda*

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*Graduate School of Social Sciences, Tokyo Metropolitan University

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Abstract

This paper investigates whether the quantitative easing policy contributed to overcoming Japan's deflation since the late 1990s by using econometric methods. The analysis is based on a VAR model that uses monthly data which sample period just corresponds to the period of zero interest rates. According to the results of impulse response analysis and variance decomposition, it is found that although the current account balance at the Bank of Japan has a positive impact on Nikkei stock average, it does not have the stimulatory effects on output gap and consumer prices while unit labor cost, real exports, and output gap can positively influence consumer prices. Under the circumstance that wage deflation persisted, it can be argued that the monetary base channel at zero interest rates had only a very limited effect on real economy.

Keywords : Quantitative Easing, Monetary Base Channel, Zero Interest Rate Policy
JEL Classification Numbers : C32, E31, E52

*E-mail :umeda-masanobu@center.tmu.ac.jp

1. Introduction

The Bank of Japan (BOJ) adopted the Zero Interest Rate Policy (ZIRP) [1] from February 1999 to August 2000 to cope with increased deflationary concern such as sharp increase in long-term interest rates. On 19 March 2001, the BOJ introduced the unprecedented quantitative easing policy to address deflation, changing the operational target for money market operations from the uncollateralized overnight call rate to the outstanding balance of the current accounts at the BOJ which constitutes the monetary base together with notes and coins on issue, and lifted it on 9 March 2006. The BOJ lifted its ZIRP on 14 July 2006 to raise the uncollateralized overnight call rate to 0.25% and implemented another one-quarter rise on 21 February 2007. Thus, Japanese monetary policy is now on the way to normalization.

The purpose of this paper is to investigate whether the quantitative easing policy contributed to overcoming Japan's deflation since the late 1990s by using econometric methods. Many Japanese and foreign economists are interested in the long stagnated Japan's economic activities since the early 1990 and Japan's deflation since the late 1990s, there are lots of literature regarding these themes. It seems that there is to some extent a consensus as to the points that the quantitative easing policy contributed to the stabilization of impaired financial intermediation by removing liquidity constraints of Japanese banks and the policy duration effect lead to flattening the yield curve. Partly due to data constraints, however, there are only a few empirical studies as to whether providing massive liquidity in the current account balance at the BOJ in far excess of the required level under the quantitative easing framework has had the stimulatory effect on output gap and inflation. In addition, the above-mentioned empirical studies show different results.

With respect to the monetary policy transmission mechanism, there exist two major views. The neo-Wicksellian interpretation argues that an expansion of the monetary base will be ineffective at the zero bound, due to money and short-term government bonds becoming perfect substitutes, denying real balance effects. Generalizing this argument, Eggertsson and Woodford[2003] insist an irrelevance proposition for open market operations at the zero bound[2].

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[1] It was early March 1999 when the uncollateralized overnight call rate virtually declined to almost zero.

[2] Empirical studies by the BOJ's economists have generally denied a stimulatory effect from the increase in the monetary base, in favor of transmission channel via interest rates expectation based on such neo-Wicksellian view. This is consistent with the fact that with respect to the effect of the quantitative easing policy, many of the policy board

On the contrary, the monetarist interpretation supposes various transmission channels at the zero bound. Summarizing the recent literature, Baig[2003] points out four channels as possible channels of transmission at the zero bound : expectation channel, credit channel, exchange rate channel ,and portfolio rebalancing channel. These channels in general can be called as the monetary base channel.

It seems still useful to examine whether monetary base expansion can have the significant effects on output and inflation through the channels discussed above. In particular, examining the Japan's experience, by using the sample period which just matches the period of zero interest rates, will contribute the development of monetary policy analysis.

In this paper, I use a VAR models based on monthly data which incorporates several variables to investigate in broader perspective, not focusing on a specific channel, whether the Japanese data confirm the existence of monetary base channel at zero interest rates.

To preview the results, it is found that although the current account balance at the BOJ has a positive impact on Nikkei stock average, it does not have the stimulatory effects on output gap and consumer prices while unit labor cost, real exports, and output gap can positively influence consumer prices.

The rest of this paper is organized as follows: Section 2 provides a short review of the recent literature. In the section 3 the data set and data properties are discussed. Section 4 presents the baseline models used for the empirical analysis. In Section 5 the baseline model is extended. Section 6 concludes the paper.

2. Review of Literature on Empirical Studies

In this section, I review empirical studies which focus on the effects of monetary variables to output and inflation. As the empirical studies in line with the Japanese data, Baig [2003] is one of the precedent studies. The author, using a VAR model with four variables based on quarterly data from 1980 to 2001, shows that a broad money shock has a significant impact on demand and price. Based on this result, he insists that there are other channels beyond the interest rate channel through which the monetary transmission process takes place. Kimura et al. [2003] criticize that Baig's results do not reflect the effect of the monetary base channel at zero interest rates, but only the average effects of that channel during the whole sample period which includes the

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members of the BOJ have stressed the importance of the policy duration effect exclusively in their speeches.

sample period of zero interest rates. They, using a time-varying VAR based on the same variables and sample period as that of Baig, indicate that the increase in monetary base has a positive effect on inflation at 1985:2, but not at 2002:1. Taking into account this result, they argue that monetary transmission took place through the monetary base channel in the 1980s, but such transmission does not work now at zero interest rates. On the other hand, Yamasawa [2006], using a New-Keynesian model based on the sample data from 1979:2 to 2005:3, concludes that the quantitative easing factor reduced the output gap from FY 2002 to 2004.

Since the above-mentioned empirical studies are all based on long-term quarterly data, their sample periods do not correspond to the period of zero interest rates. In order to investigate the effectiveness of monetary base channel at zero interest rates, we need to use the sample data period which just matches the period of zero interest rates. To secure the degree of freedom, a monthly frequency is desirable. However, so far there are a few empirical studies which use monthly data. Sadahiro [2005], using a VECM[3] with six variables based on the sample data from January 1996 to September 2004, shows that monetary base shock has only a feeble effect on output while the impact effect of domestic prices is slightly negative. Based on the results, the author argues that the effectiveness of monetary base channel was lost at zero interest rates. On the other hand, Jinnai [2007], using a VAR model[4] with three variables based on the sample data from March 1999 to October 2006, finds that the reserve-balance innovation can affect output with the relatively long lags from 12 months to 24months after the shock while the response of price is statistically unreliable.

Thus, empirical studies regarding the effectiveness of monetary base channel at zero interest rates are scarce and the studies show different results. Further empirical studies are needed.

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[3] The VECM is estimated in first differences.

[4] The VAR model is estimated in level terms.

3. The Data and Their Properties

3.1 The Data Set and the sample period

The endogenous variables in the VAR are selected based on the following reasons. First, as a monetary variable, the current account balance held by financial institutions at the BOJ is used given that it was the main operating target for money market operations during the quantitative easing policy regime.

Second, as factors which are likely to affect inflation, output gap and unit labor cost are selected. Following MaCarthy [2000], the output gap is estimated by taking the deviations of log of the industrial production index from a linear and quadratic time trend[5]. The unit labor cost is estimated by using total cash earnings index and labor productivity index[6] of all industries.

Third, as a price variable, consumer price index is used given that it was the BOJ's monetary policy target during the quantitative easing policy regime. Fourth, real exports are added to the model, taking into account of the fact that Japan's economic recovery since 2002 was led by exports.

In addition to the endogenous variables listed above, nominal effective exchange rate, Nikkei stock average, and lending attitude of financial institutions of small enterprises are incorporated to the Baseline model to examine whether various transmission channels exist (See the Appendix for data sources). The VAR also includes a Y2K dummy variable as an exogenous variable to take into consideration a Y2K-related temporary increase in liquidity demand in December 1999 and January 2000.

Although the BOJ introduced a new easing policy in sight of ZIRP in February 1999, it was early March 1999 when the uncollateralized overnight call rate virtually declined to almost zero. It was July 2006 when the BOJ lifted its ZIRP. From the view points of investigating the effectiveness of monetary base channel at zero interest rates, the sample period is set up from March 1999 to June 2006 which just corresponds to the period of zero interest rate[7]. This sample period has another merit to exempt from the

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[5] I also try to estimate the output gap using the Hodrick-Prescott filter and the Baxter-king filter, both estimates show unnatural series of output gap which fluctuates irregularly because they fail to decompose the original series into the trend component and the cyclical component effectively.

[6] The labor productivity index is estimated by using all industries activity index and regular employment index.

[7] Although this sample period includes the period of the BOJ's temporary termination of ZIRP between August 2000 to February 2001, I do not exclude the above period to secure the degree of freedom.

problem known as the structural break in the role of monetary policy in 1995 which is pointed out by Miyao [2000].

3.2 The Data Properties

Table 1 shows the results of the Augmented Dickey-Fuller (ADF) and the Phillips Peron (PP) tests. The tests indicate that real exports, current account balance, unit labor cost, output gap, and consumer price index, nominal effective exchange rate, Nikkei stock average, and lending attitudes of financial institutions are all integrated of order one, I(1)[8].

4. The Baseline Model

4.1 Setup and Identification of the Baseline Model

The first step is to set up a Baseline VAR model with the column vector of five variables, $x_t = \left(\Delta r\exp_t, \Delta cab, \Delta ulc_t, \Delta gap_t, \Delta cpi_t\right)'$,

where $r\exp_t$ denotes the natural log of real exports, cab_t that of the current account balance at the BOJ, ulc_t that of unit labor cost, cpi_t that of consumer price index while gap_t denotes output gap. The symbol Δ shows the first difference operator. Except for cab_t, remaining variables are all seasonally adjusted, using X-12 ARIMA. The sample period is from March 1999 to June 2006. The lag in the VAR is set at four based on the sequential modified Likelihood Ratio (LR) test.

The error terms estimated by the reduced form VAR are mutually correlated. Since the error terms of the structural VAR are not mutually correlated, it becomes an economically meaningful estimation to conduct impulse response analysis and variance decomposition by using these structural shocks.

Identification of the structural shocks of this model is conducted by applying the standard Choleski decomposition with the variables ordered as above to the variance-covariance matrix of the reduced form residuals from the VAR, following Sims [1980]. Letting Σ denote the variance-covariance matrix of the reduced form residuals,

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[8] The above unit root tests indicate that there exist non-stationary series in levels terms. Johansen's cointegration test suggests that there are several cointegration relationships among variables. It is well known that Johansen's cointegration test tends to overly reject the null hypothesis for small samples. Following Cheung and Lai [1993], conducting small sample correction, then the null hypothesis is not rejected.

we obtain $\Sigma = BB'$. B is a lower-triangular matrix. Letting e_t denote the reduced form residuals and u_t denote the structural shock, the relationship between them are shown as follows :

$$\begin{pmatrix} e_t^{r\exp} \\ e_t^{cab} \\ e_t^{ulc} \\ e_t^{gap} \\ e_t^{cpi} \end{pmatrix} = \begin{pmatrix} B_{11} & 0 & 0 & 0 & 0 \\ B_{12} & B_{22} & 0 & 0 & 0 \\ B_{13} & B_{32} & B_{33} & 0 & 0 \\ B_{14} & B_{42} & B_{43} & B_{44} & 0 \\ B_{15} & B_{52} & B_{53} & B_{54} & B_{55} \end{pmatrix} \begin{pmatrix} u_t^{r\exp} \\ u_t^{cab} \\ u_t^{ulc} \\ u_t^{gap} \\ u_t^{cpi} \end{pmatrix}$$

To identify the structural model, the n(n-1)/2 economic restrictions are imposed as zero restrictions on the matrix B. These restrictions imply that some of the structural shocks do not have a contemporaneous effect on some of the variables.

The ordering of endogenous variables is decided based on the following considerations. The real exports are ordered first since they are mainly determined by foreign demands and the level of exogeneity of them seems to be high. This means that real exports shocks are likely to affect the reduced form residuals of all variables in the model contemporaneously while the reduced form residuals of real exports may not be affected contemporaneously by any of the other shocks. The current account balance is ordered next as it was determined by the MPC of the BOJ exogenously under the quantitative easing policy regime. The unit labor cost and the output gap are placed third and fourth, respectively as they are considered to be affected by the above variables. The consumer price index is ordered finally as it is assumed to respond last.

4.2 The Empirical Results

4.2.1 Impulse Response Functions

Figure 1 displays the selected impulse responses from the Baseline model. Two standard error and 1.64 standard error bands of the impulse response functions are obtained by analytical method[9]. With respect to the responses of output gap, although the current account balance innovation has a positive impact on output gap, it is statistically insignificant while real exports have a positive effect on output gap at the level of significance 5%.

As regards the responses of consumer prices to the current account balance, the

[9] Monte Carlo simulations on normal draws show similar error bands.

impact effect is slightly negative, suggesting the so-called "price puzzle"[10]. On the other hand, it is revealed that innovations in unit labor cost, output gap, and real exports can positively influence on consumer prices at the level of significance 5%, 10%, 10%, respectively.

4.2.2 Variance Decomposition

To obtain information on the percentage contribution of different shocks to the variance of the k-step ahead forecast errors of variables, variance decomposition is conducted. Table 2 summarizes the results on the variance decompositions of output gap and consumer prices. As regards the variance decomposition of output gap, the most important shock except for its own shock is real exports shock which contributes nearly 20% while the current account balance accounts for less than 6% at the point in time of ten months later.

As for the variance decomposition of consumer price index, unit labor cost explains the largest fraction except for its own shock which contributes nearly 13%, followed by real exports and output gap while the current account balance accounts for little at the point in time of ten months later.

To sum up, the current account balance can hardly account for the variances of output gap and consumer prices.

4.2.3 VAR Granger Causality/Block Exogeneity Wald Test

To generalize Granger causality tests to a multivariate context, VAR Granger causality/block exogeneity Wald test is conducted to examine if monetary shock and other shocks have predictive power in the sense of Granger for one another. The result of block exogeneity test is shown in Table 3.

As for output gap, the null hypothesis that the current account balance does not have Granger causality on output gap is not rejected even at the level of significance 10% while real exports Granger-cause output gap at the level of significance 1%[11].

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[10] Rerunning the VAR by replacing the current account balance with the monetary base produces very similar results.

[11] As regards consumer price index, the null hypothesis that the current account balance does not have Granger causality on consumer prices is not rejected even at the level of significance 10%.

4.2.4 Sensitivity Analysis

In this part, the robustness of the results across alternative plausible orderings of the variables in the Choleski decomposition is checked. Here two cases are examined by using variance decomposition. In the case 1, by assuming that the central bank responds to all shocks contemporaneously, the current account balance is ordered last. In the case 2, unit labor cost is placed prior to output gap. The Table 4 shows the results of variance decompositions. With respect to the variance decompositions of output gap and consumer price index, the results of the above two cases are very similar to those of the baseline model[12].

5. The Augmented Model

5.1 Setup of the Augmented Model

To examine whether various transmission channels exist, the Baseline VAR is extended by incorporating nominal effective exchange rate (efr) [13], Nikkei stock average (nik), and lending attitude of financial institutions of small enterprises (la). The former two variables are expressed in logs. The above three variables are first differenced according to the results of unit root tests and seasonally adjusted, using X-12ARIMA. The lending attitude of financial institutions of small enterprises, which is transformed from quarterly data to monthly data by a linear interpolation, is used as a proxy variable which shows the condition in financial intermediation. Taking into account that the sample size is small, each variable is incorporated to the Baseline model one at a time, constituting a VAR model with six variables. Each variable is assumed to react more quickly, immediately after a monetary shock.

[12] Reversing the order of endogenous variables in the Baseline model, the empirical results remained basically unchanged.
[13] With respect to nominal effective exchange rate, an increase in the variable's value means an appreciation, and vice versa.

5.2 Empirical Results

5.2.1 Impulse Response Functions

Figure 2 reports the results of impulse response analysis. With respect to Nikkei stock average, it is found that the current account balance has a positive impact on Nikkei stock average at the level of significance 5%.

On the other hand, as for nominal effective exchange rate, although the current account balance depreciates the nominal effective exchange rate only in the first few months, it is statistically insignificant and rather appreciates the nominal effective exchange rate in the later months. This means that exchange rate channel does not work.

Turing to the lending attitude of financial institutions, it can scarcely respond to the current account balance innovation. This implies that the credit channel also does not work.

5.2.2 Variance Decomposition

As shown in Table 5, the Nikkei stock average variance is mostly explained by shocks to itself and the current account balance shock which contributes 12.1% over different forecast horizon at the point in time of ten months later.

5.2.3 VAR Granger Causality/Block Exogeneity Wald Test

With respect to Nikkei stock average, the null hypothesis that the current account balance does not have Granger causality on Nikkei stock average is rejected at the level of significance 1%[14] as shown in Table 6.

[14] As for nominal effective exchange rate and lending attitude of financial institutions, the current account balance does not Granger-cause them even at the level of significance 10%.

6. Conclusion and Interpretation

This paper investigates whether the quantitative easing policy contributed to overcoming Japan's deflation since the late 1990s by using econometric methods. Summing up the above empirical studies, the main findings are as follows.

First, according to the impulse response analysis, the current account balance has a positive impact on the stock prices at the level of significance 5%. In addition, block exogeneity test indicates that the current account balance Granger-causes the stock prices at the level of significance 1%. These results suggest the possibility that a sort of portfolio rebalancing effect worked. The recovery in stock prices, however, was induced by the massive purchase by foreign investors while Japanese banks drastically reduced their equity holdings since the late 1990s through the unwinding of cross-share holdings and the massive purchase of equity owned by Japanese banks by public financial institutions. Thus, such portfolio rebalancing effect can be interpreted as an indirect effect in the sense that the quantitative easing policy enhanced foreign investors' confidence to buy Japanese stocks. On the other hand, there is no evidence that exchange rate channel and credit channel worked well.

Second, with respect to the response of output gap, although the current account balance has a positive effect on output gap, it is statistically insignificant. Instead, real exports have a positive effect on output gap at the level of significance 5%. Turning to block exogeneity test, the current account balance does not Granger-cause output gap while real exports Granger-cause output gap at the level of significance 1%.

Third, as regards the response of consumer prices, the current account balance has a negative effect on consumer prices while the CPI responds positively to innovations in unit labor cost, real exports, and output gap at the level of significance of 5%, 10%, 10%, respectively.

These findings suggest that although the current account balance has a sort of indirect portfolio rebalancing effect on stock prices, it does not have the stimulatory effects on output gap and consumer prices while innovations in unit labor cost, real exports, and output gap can positively influence consumer prices.

As shown in the above empirical studies, with respect to the impulse response as well as variance decomposition of consumer prices, unit labor cost has relatively the most significant impact on consumer prices among the endogenous variables. The unit labor cost continued to decline since the late 1990s and almost ceased to drop in 2006.

As backgrounds of this declining trend, the following factors can be pointed out. Japanese enterprises made every effort to enhance ROA which showed a downward

trend with cyclical fluctuations since around the middle 1980s through business restructuring since the late 1990s. As part of such effort, many Japanese enterprises reduced wage cost to decrease the labor income share to total income through curbing wage and increasing non-regular employments. Taking into consideration these facts, it appears that Japan's deflation since the late 1990s was mainly due to the decline in unit labor cost along with the deterioration in output gap.

Against this background, the monetary base channel at zero interest rates had a very limited effect on real economy. Under the circumstance that wage deflation persisted, it can be argued that the quantitative easing policy played only a complementary role in Japan's economic recovery since 2002 and reducing deflation.

Appendix for Data Sources

Real exports: This is the real exports index estimated by the BOJ (CY2000=100, seasonally adjusted)
Current account balance : This is the outstanding balance of the current-accounts held by commercial financial institutions at the BOJ(million Yen)
Nominal effective exchange rate : This is the BOJ-calculated nominal effective exchange index versus 15 currencies(March 1973=100)
Nikkei stock average : This is calculated by Nihon Keizai Shinbun (TSE 225 Issues)
Lending attitude of financial institutions: This is the diffusion index of "Accommodative" minus "Severe" of Tankan Survey by the BOJ (small enterprises, all industries)
Unit labor cost : Labor productivity is calculated as the ratio of all industry activity index(excludes agriculture, CY2000=100) by the Ministry of economy, trade, and industry to regular employment index(industries covered, CY2000=100) by the Ministry of health, Labor, and welfare. Unit labor cost is calculated as the ratio of total cash earnings index (industries covered, CY2000=100) by the Ministry of health, Labor, and welfare to labor productivity.
Output gap : As discussed in this paper, the output gap is calculated as the residuals from a regression of the logarithm of industrial production index(CY2000=100) by the Ministry of economy, trade, and industry on a constant plus linear and quadratic time trends.
Consumer price index: This is taken form the Bureau of Statistics (CY2005=100).

References

Baig, T.[2003], "Monetary Policy in a Deflationary Environment," Chapter 10, *Japan's Lost Decade*, IMF, pp.206-223.

Bernanke, B. S. and V. R. Reinhart [2004], "Conducting Monetary Policy at Very Low Short-term Interest Rates," *American Economic Review*, 94, pp.85-90.

Cheung,Y. and K. Lai [1993], "Finite-sample sizes of Johansen's likelihood ratio tests for cointegration," *Oxford Bulletin of Economics and Statistics*, 55.3, pp.313-328.

Eggertsson, G. and M. Woodford [2003], "The Zero Bound on Interest Rates and Optimal Monetary Policy," *Brookings Papers on Economic Activity*, 2003, pp.139-233.

Fujiwara, I. [2006], "Evaluating Monetary Policy Effects When Interest Rates are Almost Zero", *Journal of the Japanese and International Economics*, 20, pp.433-453.

Iwata, S. and S. Wu [2006], "Estimating Monetary Policy Effects When Interest Rates are Close to Zero," *Journal of Monetary Economics*," 53, pp.1395-1408.

Kimura, T., H. Kobayashi, J. Muranaga, and H. Ugai [2003], "The Effect of the Increase in the Monetary Base on Japan's Economy at Zero Interest Rates : An Empirical Analysis," in Monetary Policy in a Changing Environment, *Bank for International Settlements Conference Series*, No.19, pp.276-312.

Jinnai, R. [2007], "An Empirical Study of Monetary Policy at Zero Short-Term Nominal Interest Rates," mimeo.

MaCarthy, J. [2000], "Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies," Federal Reserve Bank of New York.

Meltzer, A. H. [1995], "Monetary, Credit and (Other) Transmission Processes: A Monetarist Perspective," *Journal of Economic Perspectives*, 9, pp49-72.

Miyao, R. [2000], "The Role of Monetary Policy in Japan : A Break in the 1990s?," *Journal of the Japanese and International Economics*, 14, pp.366-384.

Sadahiro,A. [2005], "The Evaluation on the Monetary Policy since the early 1990s," Chapter 9, *Macro-economic Analysis in the Post World War II Japan*, Toyo Keizai INC.,(in Japanese), pp.241-278.

Sims, C. A. [1980], "Macroeconomics and Reality," *Econometrica*, 48(1), pp.1-48.

Yamasawa, N. [2006], "An Analysis: Quantitative Easing Policy Was Effective in Buoying the Japanese Economy," *JCER Staff Report*.

Figure 1　Selected Impulse Responses (the Baseline Model)

Figure 1-1 Impulse response of Δgap to $\Delta r\exp$

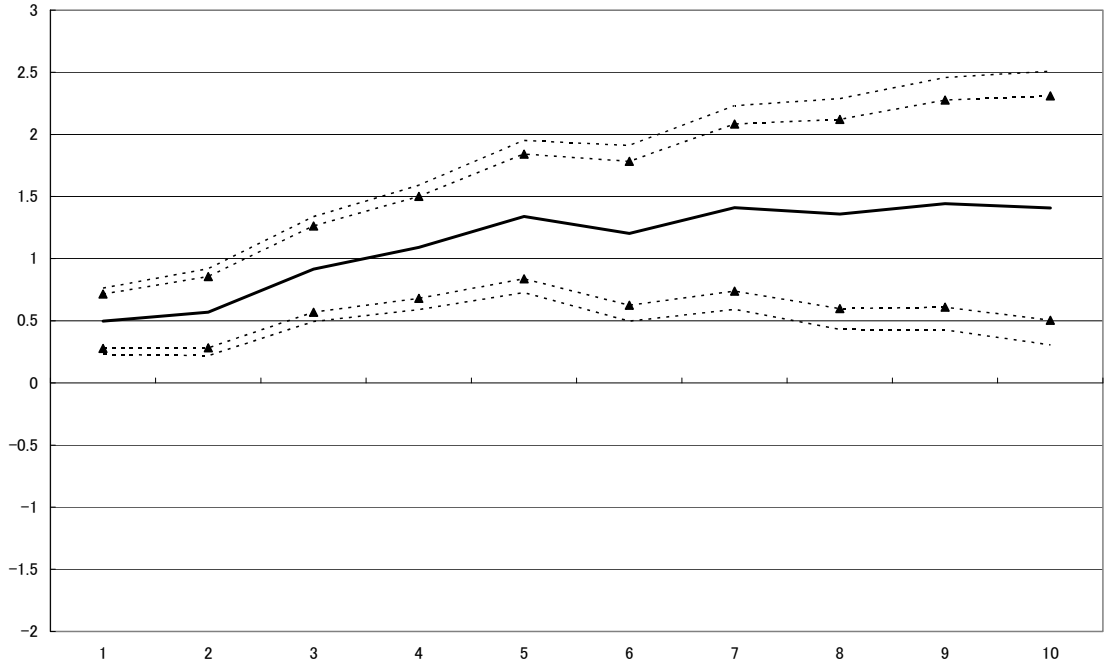
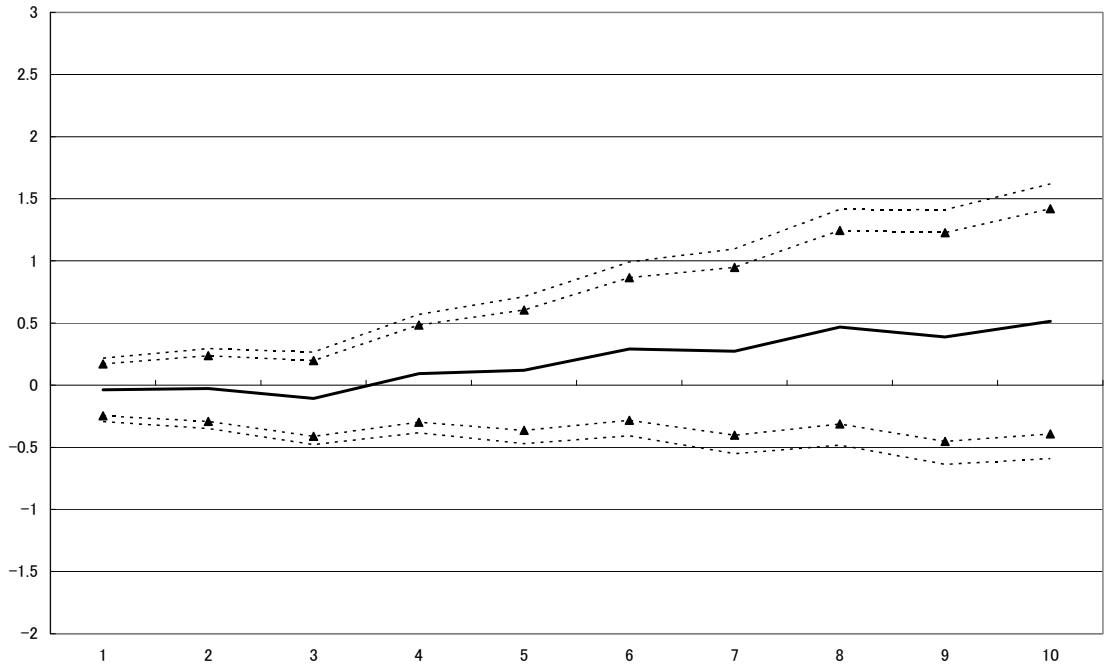


Figure 1-2 Impulse response of Δgap to Δcab



Note：The dotted lines indicate the 95% and the 90% error bands.

Figure1-3 Impulse response of Δcpi to $\Delta r\exp$

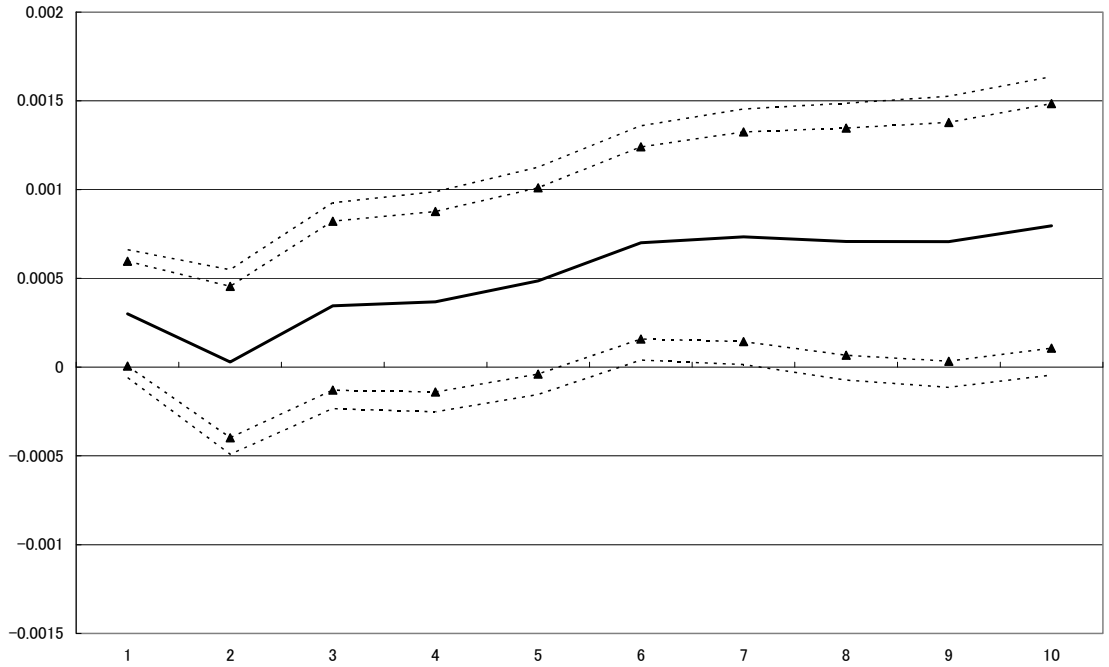
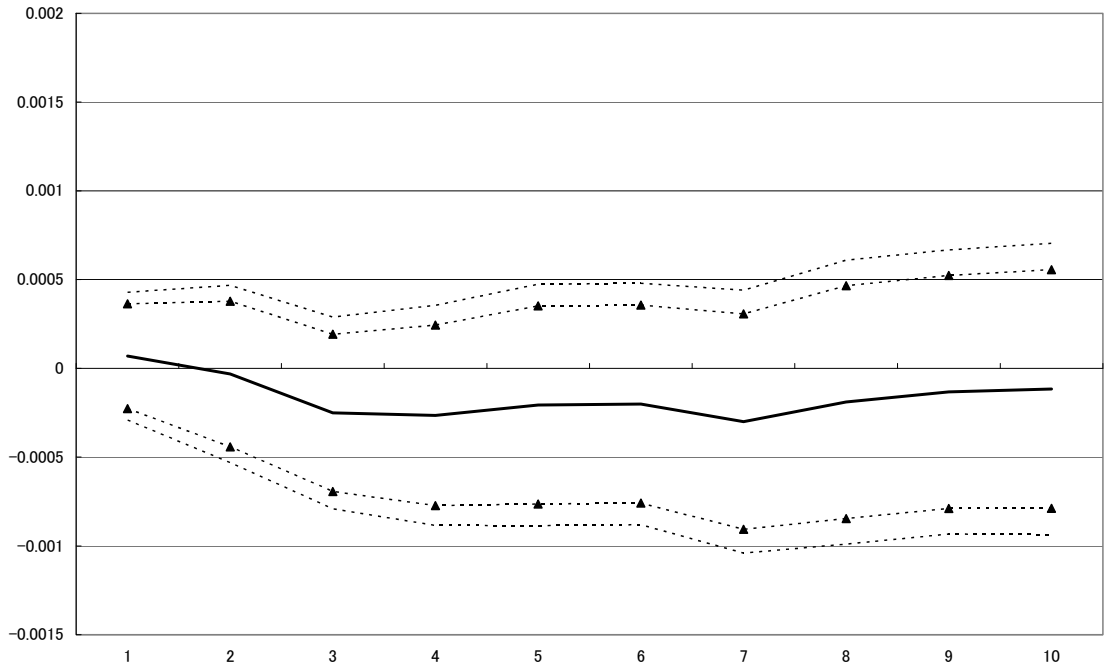


Figure1-4 Impulse response of Δcpi to Δcab



Note：The dotted lines indicate the 95% and the 90% error bands.

Figure1-5 Impulse response of Δcpi to Δulc

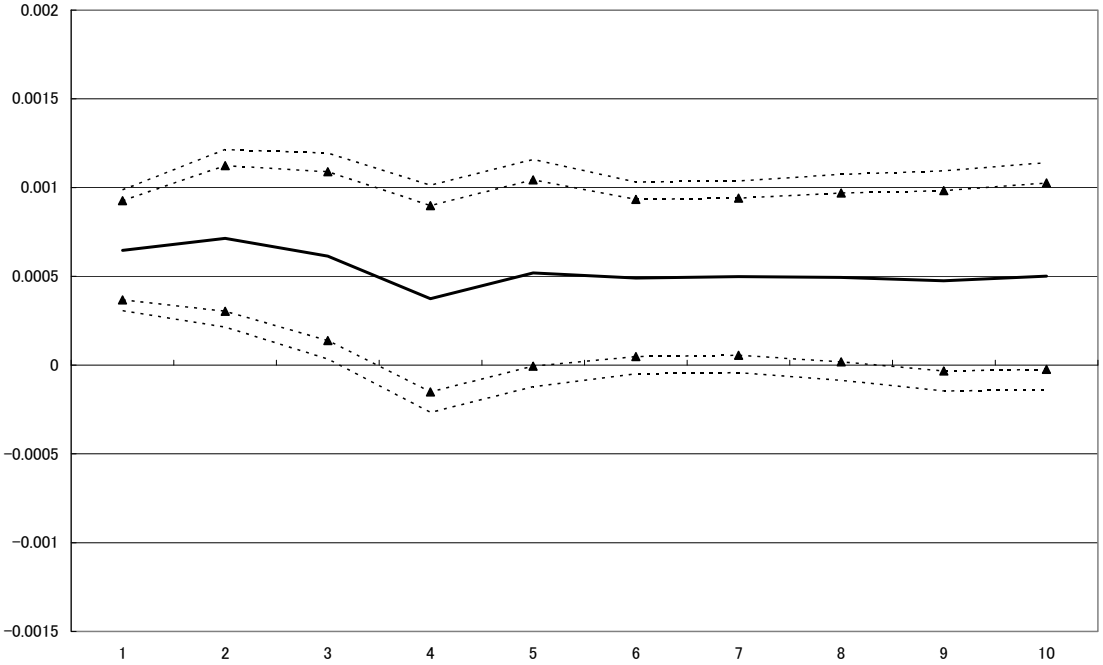
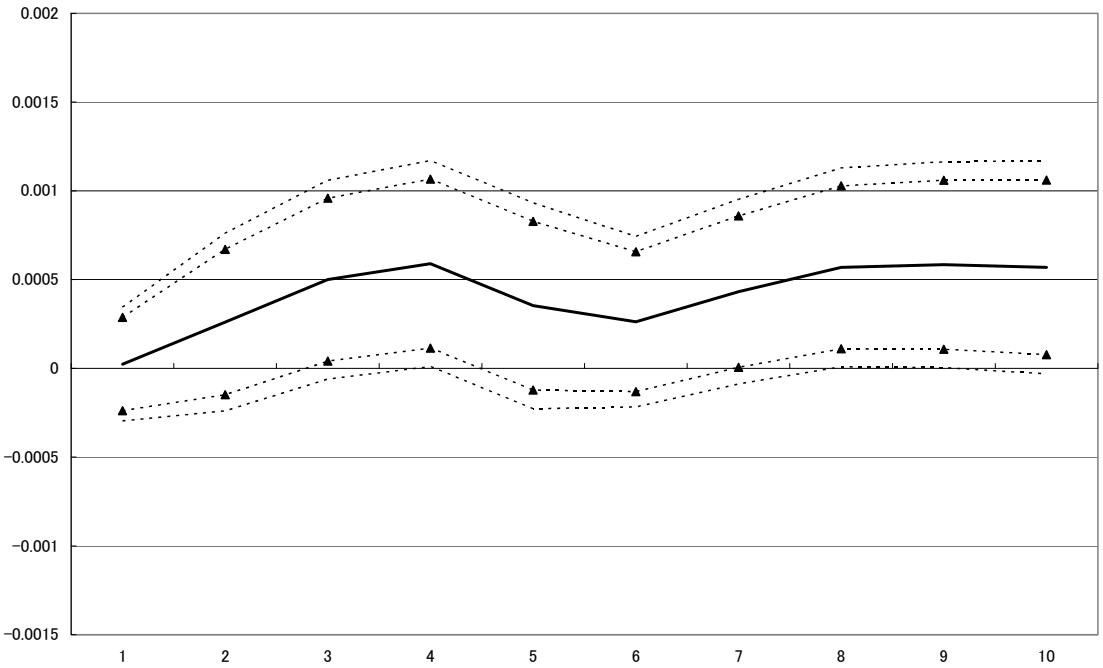


Figure1-6 Impulse response of Δcpi to Δgap



Note：The dotted lines indicate the 95% and the 90% error bands.

Figure 2 Selected Impulse Responses (the Augmented Model)

Figure2-1 Impulse response of Δefr to Δcab

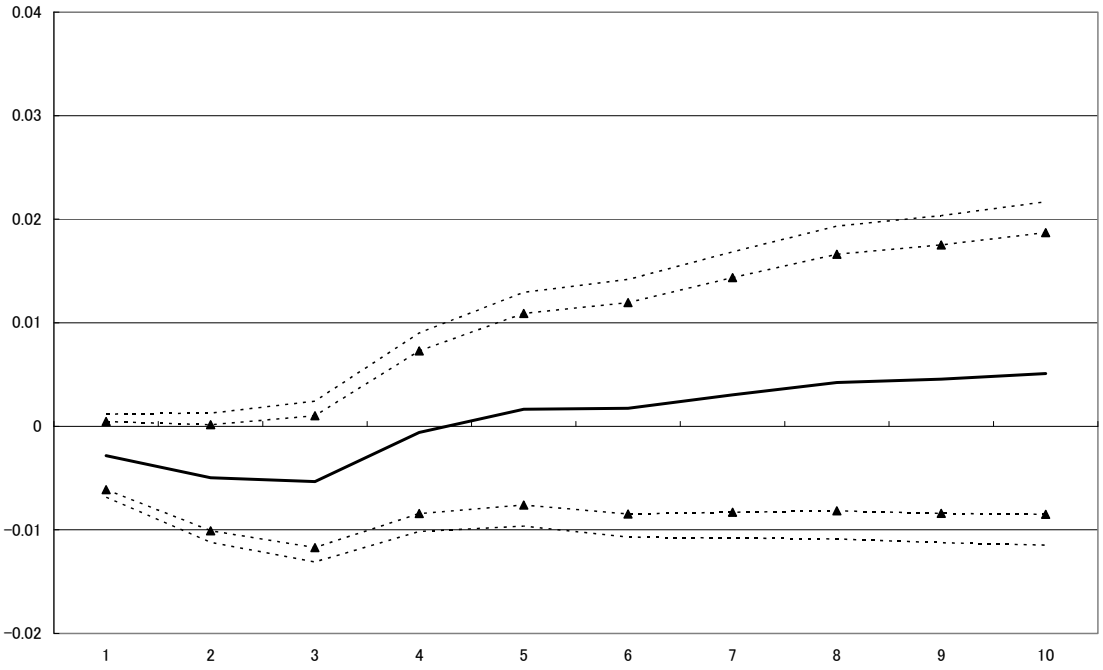
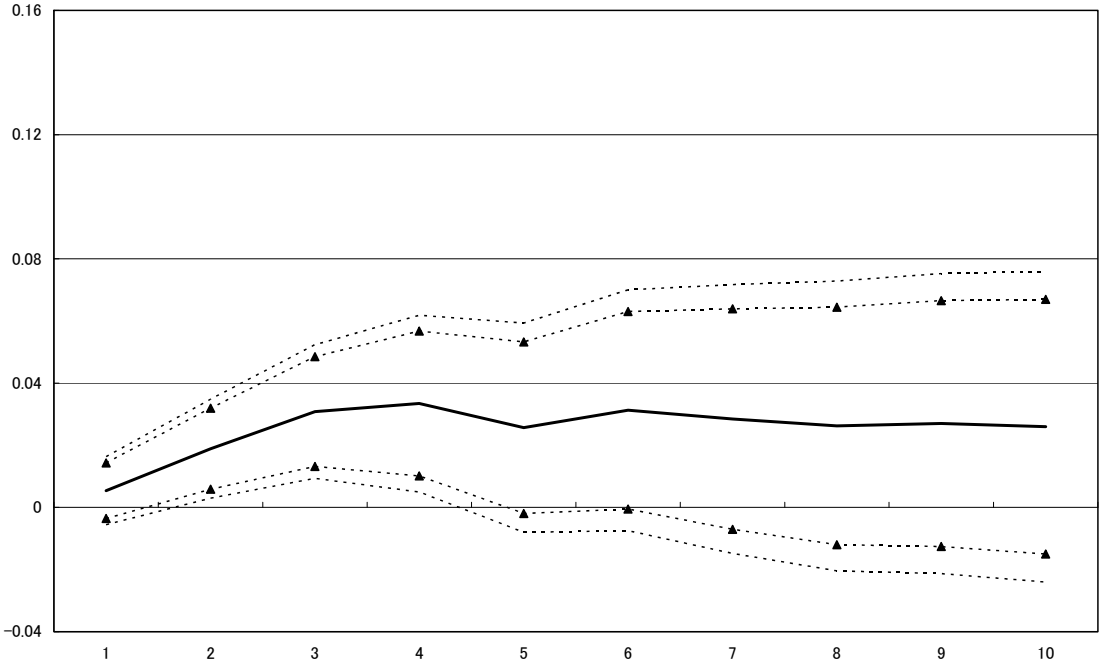
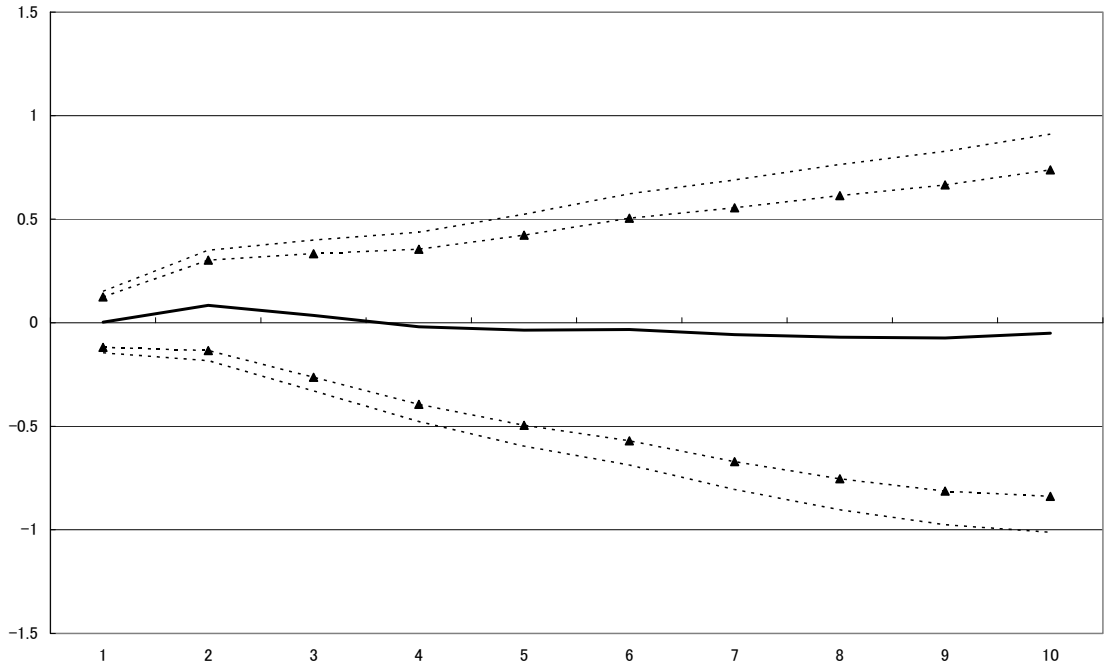


Figure2-2 Impulse response of Δnik to Δcab



Note：The dotted lines indicate the 95% and the 90% error bands.

Figure2-3 Impulse response of Δla to Δcab



Note：The dotted lines indicate the 95% and the 90% error bands.

Table 1　Unit Root Tests

Variable	ADF Test		PP Test		Decision
	Statistic	(p- value)	Statistic	(p- value)	
r exp	0.62	(0.98)	0.27	(0.97)	I(1)
Δr exp	-12.82	(0.00)	-13.45	(0.00)	
cab	-1.28	(0.63)	-1.28	(0.63)	I(1)
Δ*cab*	-6.74	(0.00)	-6.81	(0.00)	
ulc	-1.34	(0.60)	-1.65	(0.44)	I(1)
Δ*ulc*	-13.52	(0.00)	-15.95	(0.00)	
gap	-1.55	(0.50)	-1.57	(0.48)	I(1)
Δ*gap*	-12.27	(0.00)	-11.80	(0.00)	
cpi	-1.97	(0.29)	-2.42	(0.13)	I(1)
Δ*cpi*	-8.27	(0.00)	-9.67	(0.00)	
efr	-1.72	(0.41)	-1.92	(0.31)	I(1)
Δ*efr*	-8.64	(0.00)	-8.64	(0.00)	
nik	-1.01	(0.74)	-1.20	(0.67)	I(1)
Δ*nik*	-8.53	(0.00)	-8.63	(0.00)	
la	-0.60	(0.86)	-0.35	(0.91)	I(1)
Δ*la*	-5.45	(0.00)	-5.44	(0.00)	

Note：p-values show Mackinnon (1996) one-sided p-values.

Table 2 Variance Decompositions

2-1 Variance Decomposition of Δgap

Period	Δr exp	Δcab	Δulc	Δgap	Δcpi
1	15.42	0.08	8.35	76.13	0.00
2	13.03	0.07	7.19	79.49	0.20
3	17.37	0.36	8.61	73.39	0.25
4	17.78	2.09	10.38	69.48	0.25
5	19.11	1.98	9.93	67.88	1.07
6	19.36	3.10	10.17	66.30	1.05
7	20.66	3.05	9.98	64.98	1.31
8	20.35	4.44	10.16	63.72	1.31
9	20.40	4.62	10.11	63.07	1.77
10	20.28	5.19	10.07	62.56	1.87

2-1 Variance Decomposition of Δcpi

Period	Δr exp	Δcab	Δulc	Δgap	Δcpi
1	3.27	0.17	15.10	0.02	81.43
2	5.59	0.50	14.37	1.93	77.58
3	7.76	1.84	12.66	3.33	74.38
4	7.62	1.81	14.05	3.49	73.00
5	7.79	1.85	14.24	4.96	71.12
6	8.90	1.82	14.01	5.10	70.15
7	8.81	2.06	13.81	5.80	69.49
8	8.75	2.37	13.68	6.25	68.93
9	8.74	2.45	13.68	6.25	68.86
10	8.93	2.45	13.66	6.23	68.70

Notes: 1.The figures indicate the percentage of forecast variance attributed to:

2. The period shows the forecast horizon (n-months later).

Table 3 Block Exogeneity Wald Test

Dependent variable : Δgap

Excluded variable	χ^2-value	p-value
$\Delta r\exp$	15.07***	0.00
Δcab	0.42	0.98
Δulc	5.74	0.22
Δcpi	1.07	0.89

Note: ***shows that the variable Granger-causes the dependent variable at the level of significance 1%.

Table 4 Sensitivity Analysis

4-1 The Case 1

Variance Decomposition of Δgap

Period	$\Delta r\exp$	Δulc	Δgap	Δcpi	Δcab
1	15.42	7.80	76.77	0.00	0.00
2	13.03	6.74	79.86	0.24	0.11
3	17.37	8.42	73.78	0.30	0.11
4	17.78	10.87	69.88	0.28	0.17
5	19.11	10.34	68.14	1.00	1.38
6	19.36	10.85	66.49	1.00	2.27
7	20.66	10.65	65.17	1.27	2.22
8	20.35	11.11	63.89	1.33	3.30
9	20.40	11.02	63.23	1.89	3.46
10	20.28	11.04	62.73	2.03	3.89

4-2 The Case 1

Variance Decomposition of Δcpi

Period	$\Delta r\exp$	Δulc	Δgap	Δcpi	Δcab
1	3.27	14.09	0.00	82.63	0.00
2	5.59	13.50	2.02	78.79	0.06
3	7.76	11.73	3.71	76.08	0.69
4	7.62	13.05	3.89	74.69	0.72
5	7.79	13.17	5.44	72.80	0.77
6	8.90	12.96	5.56	71.78	0.77
7	8.81	12.79	6.33	71.16	0.88
8	8.75	12.69	6.70	70.54	1.31
9	8.74	12.69	6.70	70.46	1.38
10	8.93	12.67	6.69	70.30	1.39

Notes: 1. The figures indicate the percentage of forecast variance attributed to:

2. The period shows the forecast horizon (n-months later).

Table 4 Sensitivity Analysis

4-1 The Case 2

Variance Decomposition of Δgap

Period	$\Delta r\exp$	Δcab	Δgap	Δulc	Δcpi
1	3.27	0.08	84.49	0.00	0.00
2	5.59	0.07	83.51	3.16	0.20
3	7.76	0.36	75.93	6.07	0.25
4	7.62	2.09	72.02	7.84	0.25
5	7.79	1.98	69.40	8.41	1.07
6	8.90	3.10	67.97	8.49	1.05
7	8.81	3.05	66.60	8.36	1.38
8	8.75	4.44	65.40	8.48	1.31
9	8.74	4.62	64.73	8.45	1.77
10	8.93	5.19	64.21	8.42	1.87

4-2 The Case 2

Variance Decomposition of Δcpi

Period	$\Delta r\exp$	Δcab	Δgap	Δulc	Δcpi
1	0.19	0.17	1.17	13.95	81.43
2	2.10	0.50	2.52	13.78	77.58
3	8.50	1.84	4.12	11.88	74.38
4	8.31	1.81	4.77	12.77	73.00
5	9.05	1.85	6.68	12.52	71.12
6	9.99	1.82	6.73	12.38	70.15
7	9.88	2.06	7.31	12.30	69.49
8	9.93	2.37	7.70	12.23	68.93
9	9.83	2.45	7.70	12.22	68.86
10	10.12	2.45	7.70	12.20	68.70

Notes: 1.The figures indicate the percentage of forecast variance attributed to:

2. The period shows the forecast horizon (n-months later).

Table 5 Variance Decomposition of Δnik by the Augmented VAR

	$\Delta r\exp$	Δcab	Δnik	Δulc	Δgap	Δcpi
1	2.06	0.56	97.37	0.00	0.00	0.00
2	4.01	8.58	85.27	0.14	0.00	1.96
3	5.52	14.04	78.35	0.27	0.06	1.73
4	5.46	14.08	78.14	0.27	0.31	1.70
5	5.42	15.10	74.34	1.16	0.50	3.45
6	5.49	15.62	73.29	1.15	0.98	3.45
7	5.98	15.77	72.33	1.18	0.96	3.75
8	5.99	16.29	71.48	1.19	0.98	4.05
9	5.94	16.15	71.12	1.39	1.27	4.10
10	6.05	16.17	70.97	1.42	1.28	4.09

Notes: 1.The figures indicate the percentage of forecast variance attributed to:

2. The period shows the forecast horizon (n-months later).

Table 6 Block Exogeneity Wald Test by the Augmented VAR

Dependent variable : Δnik

Excluded variable	χ^2-value	p-value
$\Delta r\exp$	2.90	0.57
Δcab	14.52***	0.00
Δulc	0.99	0.91
Δgap	0.03	0.99
Δcpi	6.63	0.15

Note: *** shows that the variable Granger-causes the dependent variable at the level of significance 1%.