Cross-Country Differences in the Effects of Monetary Policy Shocks on Output and Prices and Their Determinants

By **Geunhyung Yim*, Seungho Nah**,** and **Daun Oh*****

March 2023

Abstract

This paper investigates with a sample of 19 countries whether there exist differences in the effects of monetary shocks on output and prices between countries, and, if any, which country characteristics incur such differences using sign-restricted VAR, second-stage regression, and small open economy DSGE model. The VAR analysis shows that monetary policy shocks with the same magnitude generate differences between countries in terms of the effects on output and prices. The maximal responses of industrial production indexes to a 25-basis-point shock policy rate cut range from a decrease to an over 3 percent increase with an average of about 1 to 2 percent increase. Those of consumer price indexes range from a 0.3 percent to around a 2 percent increase with an average of a 0.9 percent increase. The results from regression analysis imply that various country characteristics engender disparities in the responses to monetary policy shocks. The magnitude of the output responses to monetary policy shocks is larger in countries with a monetary policy framework closer to inflation-targeting, a more flexible exchange rate regime, more rapid population aging, and a more rigid labor market, and is smaller in countries with a more independent central bank and a more developed financial market. The size of the price responses is larger in countries with higher trade openness and a more rigid labor market, and smaller in countries with a monetary policy framework closer to inflation-targeting and more rapid population aging. Furthermore, the results from the small open economy DSGE model which we use to check whether a monetary policy framework, trade openness and labor market rigidity can make a difference in the effects of monetary policy shocks largely correspond to those of the regression analysis.

Key words: Monetary Policy Shock, Industrial Production Index, Consumer Price Index, Sign-restricted SVAR, Second-stage Regression, Small Open Economy DSGE Model

JEL code: E43, E52, E58

Disclaimer: The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Bank of Korea.

Acknowledgements:

---

* Head, Macroeconomic Model Study Team, Research Department, Bank of Korea, 67, Sejong-daero, Jung-gu, Seoul, Korea, (Tel) +82-2-759-4177, (E-mail) ghyim@bok.or.kr

** Head, Macroeconomics Team, Economic Research Institute, Bank of Korea, 67, Sejong-daero, Jung-gu, Seoul, Korea, (Tel) +82-2-759-5428, (E-mail) shnah@bok.or.kr

*** Junior Economist, Payment Systems Policy Team, Payment & Settlement Systems Department, Bank of Korea, 67, Sejong-daero, Jung-gu, Seoul, Korea, (Tel) +82-2-750-6630, (E-mail) down0923@bok.or.kr

1. Introduction

In the modern economy, monetary policy has become one of the key policy tools to achieve economic stability. Countries around the world not only solved the inflation problem through the appropriate conduct of monetary policy, but also achieved considerable success in preventing the economy from plummeting even in crises such as the collapse of the IT bubble and the Global Financial Crisis.

However, the degree to which monetary policy contributes to economic stability may differ from country to country. This is because monetary policy affects the economy through various channels, and depending on the economic environments of each country, the channels or effects of each channel may differ. For example, the interest rate channel of monetary policy presupposes the existence of a well-developed bond market composed of various maturities, so the effect of monetary policy through the interest rate channel may be limited in countries with shallow bond market depth. Therefore, in order to operate monetary policy efficiently, it is essential to understand the degree to which monetary policy exerts an effect on the economy and the background under which such effect occurs.

With this awareness of the problem, this paper examines the effects of monetary policy shocks on output and prices in major countries, whether there are differences in the effects, and, if so, what factors cause such differences. To this end, we first estimated how output and prices would react to a monetary policy shock using a sing-restricted structural VAR model for 19 major countries, including Brazil, Canada, the euro area, Japan, and the United Kingdom.[1] Then, a regression analysis was conducted with the result of estimating the shock response function as the dependent variable, and the economic conditions of each country, such as the monetary policy framework, exchange rate regime, and trade openness, as explanatory variables and we looked at what relationship exist between them. Furthermore, a simple small open economy DSGE model was used to examine how the response to monetary policy changes when parameters regarding the monetary policy framework and trade openness are changed.

The main results are as follows. First, as a result of the sign restricted structural VAR analysis, most of the 19 target countries showed a statistically significant increase in industrial production when an expansionary monetary policy shock (25bp interest rate cut) occurred. A 25bp interest rate cut shock in many countries caused an increase in industrial production of up to 1-2%, and in countries such as Sweden and Norway, production increased by more than 3%. In the

[1] The 19 countries analyzed are Brazil, Canada, Chile, China, Colombia, Czech Republic, euro area, Hungary, India, Israel, Japan, South Korea, Norway, Philippines, Poland, Russia, South Africa, Sweden, and the United Kingdom.

case of South Africa, however, production reacted with a significant decrease An expansionary monetary policy shock have also been shown to increase prices in the countries analyzed. An interest rate cut shock of 25bp increased the consumer price index of the countries analyzed by an average of 0.9% based on the maximum value after the shock. By country, the Czech Republic, India, China, and Sweden showed an increase of nearly 2%, while the euro area, Korea, the Philippines, Poland, Russia, and the United Kingdom showed a relatively small increase of 0.3% to 0.5%.

Furthermore, as a result of the second-stage regression analysis, the closer a country's monetary policy framework is to the inflation targeting, the closer its exchange rate regime is to a floating exchange rate system, the faster the population aging progresses, and the higher the labor market rigidity, the larger output response to monetary policy shocks is. However, the more independent the central bank, the higher the development of the capital market, the smaller the output response. On the other hand, the price response to monetary policy shocks decreases as the monetary policy framework approached the inflation targeting and population aging progressed, and increases as trade openness and labor market rigidity strengthen. The response of prices to central bank independence, GDP size, and capital market development are affected in both expansion and contraction directions. The results of the DSGE analysis of small open economies are also found to be roughly consistent with these empirical analysis results.

This paper is structured as follows. Chapter II reviews related preceding studies, and Chapter III analyzes the effects of monetary policy shocks on output and prices. Chapter IV analyzes what factors determine the size of the response to monetary policy shocks. In the last chapter V, the results were summarized and implications were presented.

2. Literature Review

Cecchetti (1999) is the first study to investigate the cause of why monetary policy effects differ by country.[2] Based on the results of empirical analysis by Cecchetti (1996) and Cecchetti et al. (1999), Cecchetti (1999) argues that the differences in the effects of monetary policy in European countries are due to differences in the structure of the financial industry, especially the

[2] Kim (1999) is a typical example of a study that comparatively analyzes the effects of various countries' monetary policies. However, studies such as Kim (1999) did not attempt to analyze the determinants of monetary policy effects through a two-stage regression analysis. This study reviewed previous studies that included not only comparison of monetary policy effects but also analysis of determinants of differences in effects.

banking industry. The possibility that each country's legal system is different is suggested.

Studies after Cecchetti (1999) are largely divided into two directions. The first is studies that have conducted a meta-analysis based on the results of an empirical analysis on the effects of existing monetary policies in individual countries. Grauwe and Storti (2005) conclude that there is no difference in the effect of monetary policy on industrial production between the US and the euro area as a result of a meta-analysis using existing empirical analysis results, and Mishra et al. (2010) argue, from a survey of previous studies, that there are differences in monetary policy effects between developed countries and low-income countries, and that the degree of institutional development, the structure of the banking industry, and the stability of the macroeconomic environment may have had an impact. Rusnak et al. (2013) show through a meta-analysis that the size of the effect of monetary policy on prices can depend on the degree of external dependence, economic conditions, and independence of the central bank. Furthermore, Havranek and Rusnak (2013), based on a review of 67 preceding studies, find that there is a significant difference in the time lag of the impact of monetary policy on prices between developed countries and transitional countries, and suggest the possibility that the degree of development of the financial industry in both groups causes this difference.

Unlike this, there have been studies that have attempted to clarify the determinants of the difference in monetary policy effect through a secondary regression analysis using the results after directly estimating the effect of monetary policy using a structural VAR model rather than obtaining an estimate from the existing literature.[3] Elbourne and Haan (2006) find no significant relationship between the effect of monetary policy output and prices and the structure of the financial industry by country as a result of structural VAR analysis on new and prospective countries joining the euro area. According to Berument et al. (2007), as a result of an autoregressive distributed lag model analysis of 29 countries, there is no clear correlation between external dependence and the effect of monetary policy on production and prices. Meanwhile, Aysun et al. (2013), as a result of structural VAR analysis of 56 countries, show that the more severe the financial friction, the greater the impact of monetary policy on production. Matějů (2014), as a result of a time varying analysis of 33 OECD and EU member countries, concludes that the effect of monetary policy on prices is influenced by whether or not the inflation targeting framework is adopted, whether a banking crisis occurs, and how large the size of private debt is. In addition, Ćorić et al. (2014) compare the effects of monetary policy shocks on production in 48 countries, and Ćorić et al. (2015) compared the effects of those in 46 countries. It points out that institutions, external dependence, and the level of development of the banking industry can

[3] In the case of meta-analysis, there is a disadvantage that it is difficult to control the difference in monetary policy effect due to the difference in the analyzed models.

cause differences in policy effects. In addition, Georgiadis (2014) conducts individual country VAR and panel VAR on 20 countries and compares the results of the two to find out that the economic and structural characteristics of individual countries, such as financial industry structure, labor market rigidity, and industrial structure make a significant difference in the effect on production and prices.

This paper first estimates the effect of monetary policy on output and prices using the structural VAR model, and then analyzes the determinants of the difference in the effect of monetary policy through regression analysis in the next step. In this respect, it has a close relationship with the latter stream of studies outlined above. However, the following points are reflected in the analysis to differentiate it from previous studies. First, this paper uses a sign-restricted VAR model, whereas previous studies have chosen the method of imposing short-run restriction to identify monetary policy shocks. Sign-restricted VAR has the advantage of removing anomalies in analysis results, such as price puzzles, by imposing constraints on the impulse response function itself, not on the coefficients of the VAR model. Second, previous studies compared only the effects of interest rate changes as traditional monetary shocks, but this study compared the effects of monetary policies covering both traditional and non-traditional operational tools. After the Global Financial Crisis, central banks in major countries implemented various unconventional monetary policies, such as forward guidance, quantitative easing, and negative interest rates, as well as zero interest rates, to prevent a rapid contraction of the economy. The impact of these untraditional tools on output and prices also needs to be considered. For this purpose, this study used the 'shadow policy rate' of Wu and Xia (2016) in the case of countries implementing unconventional monetary policies. Third, many previous studies used only the average value of the impulse response function or information equivalent to it as the dependent variable, but in the second-stage regression analysis, information about uncertainty around estimation could also be exploited (Miniane and Rogers (2007)). This study adopts the methodology of Miniane and Rogers (2007) and solves this problem by using information included in the confidence interval as well as the average of the impulse response function.

3 The Effects of Monetary Policy Shock on Output and Prices

3.1 Empirical Methodology

This study considered the following reduced-form VAR model to compare the effects of monetary policy on production and prices by country.

$$Y_t = B(L)Y_{t-1} + C(L)X_t + u_t \quad (1)$$

Here, Y_t is an m×1 endogenous variable vector, X_t is an n×1 exogenous variable vector, u_t is an m×1 residual term vector, and $E(u_t)=0$ and $E(u_t u_t')=\Sigma$. And B(L) and C(L) mean the matrix polynomial for the lag operator L, respectively. Since the globalization of the world economy has progressed rapidly since the 2000s, it is reasonable to assume that the influence of external economic variables could not be ignored in many countries, so the influence of foreign factors is controlled by including the vector of exogenous variables in the model.

Policy interest rate, industrial production index, consumer price index, monetary base, 10-year government bond yield, and exchange rate against the US dollar are used as endogenous variables. 3 variables are used as exogenous variables: the overseas industrial production index, the overseas consumer price index, and the US policy interest rate. The 6 endogenous variables are frequently used in analyzing the effects of monetary policy. The US policy rate is intended to reflect global financial conditions.[4] The overseas industrial production index and the overseas consumer price index are included to reflect the external economic condition. the overseas industrial production index and the overseas consumer price index are calculated by taking the weighted average of the industrial production index and consumer price index of the 19 countries to be analyzed plus the United States in terms of nominal GDP.

Monetary policy shocks are identified using the sign-restriction method of Uhlig (2005). First, the price puzzle and the liquidity puzzle, which often appear in VAR analysis, are eliminated by restrict prices to rise and the monetary base to increase when the policy rate falls. In addition, reflecting the expectation hypothesis of the interest rate term structure model that long-term interest rates reflect expectations of future short-term interest rates, we set a restriction that long-term interest rates also decrease when the policy rate is lowered. The restriction is imposed so that the impulse response function from immediately after the shock occurred to 12 months after the shock is consistent with the sign explained above according to Sholl and Uhlig (2008) and Kim and Lim (2018). 5,000 impulse response functions satisfying the sign restriction are extracted and used as data to compare the effects of monetary policy.

The 19 countries analyzed are Brazil, Canada, Chile, China, Colombia, Czech Republic, euro area, Hungary, India, Israel, Japan, South Korea, Norway, Philippines, Poland, Russia, South Africa, Sweden, and the United Kingdom.[5] Monthly data were used, and the VAR model was

[4] According to Miranda-Aggripino and Rey (2020), US monetary policy is one of the main factors causing fluctuations in the global financial cycle.

[5] It is preferable to include as many countries as possible, but 19 countries are selected in consideration of the availability of data and their share in the world economy. In the case of the United States, it was judged that it was not appropriate to analyze with the model of this paper, so it was excluded from the sample.

estimated using the raw data for the policy interest rate and the 10-year government bond yield, and the values multiplied by 100 after taking the logarithm of the level variables for the rest of the data. Seasonally adjusted values were used for the industrial production index and the monetary base. Meanwhile, as the policy rate, the data published by central banks of most of the countries are used, but the 'shadow policy rate' estimated by Wu and Xia (2016) for the euro area and the UK, and the central bank of New Zealand for Japan and Sweden is used. In the case of countries belonging to the latter category, since they used various non-traditional monetary policies such as quantitative easing, negative interest rates, and yield curve control as their main policy tools during the analysis period, it is judged that only the interest rate announced by the central bank is insufficient to analyze the stance of monetary policy. As in Sholl and Uhlig (2008) and Kim and Lim (2018), it is assumed that six lags are set for endogenous variables and no lag for exogenous variables. The period of analysis is set from July 2004 to September 2019. Detailed information on the data used is included in <Appendix 1>.

.

3.2 Results

<Figure 1> shows the response of industrial production to a 25bp interest rate cut shock in the 19 countries analyzed. Looking at the main results, a significant increase in industrial production is observed in most of the analyzed countries after the shock of interest rate cuts. However, in Brazil, Chile, Japan, Korea, and the United Kingdom, significant increases are observed only for a short period of 1 to 3 months, while the impact on industrial production is uncertain in China, the Czech Republic, and the Philippines. In terms of the size of the response, in many of the countries that respond with a significant increase in industrial production for more than three months, a 25bp rate cut shock caused an increase in industrial production of 1-2% based on the maximum response. Specifically, the size is 2.1% in Poland, followd by Colombia (1.8%), Canada (1.6%), India (1.6%), Euro area (1.2%), and Hungary (0.9%). Compared to these countries, Sweden (3.4%) and Norway (6.9%) increased their production by a maximum of more than 3%, while Israel (0.3%) showed a slight increase. The duration of response for countries that showed a statistically significant increase in industrial production for more than 3 months is 28.5 months on average. Among them, in Israel, Canada, and Colombia, the duration was about a year, while in the euro area, Hungary, India, Poland, and Sweden, the shock response lasted for a long time.

<Figure 2> summarizes the response of the consumer price index when an interest rate cut shock of the same magnitude occurs. When an interest rate cut shock of 25bp occurs, the consumer price index of the analyzed country rises by an average of 0.9% based on the maximum value.

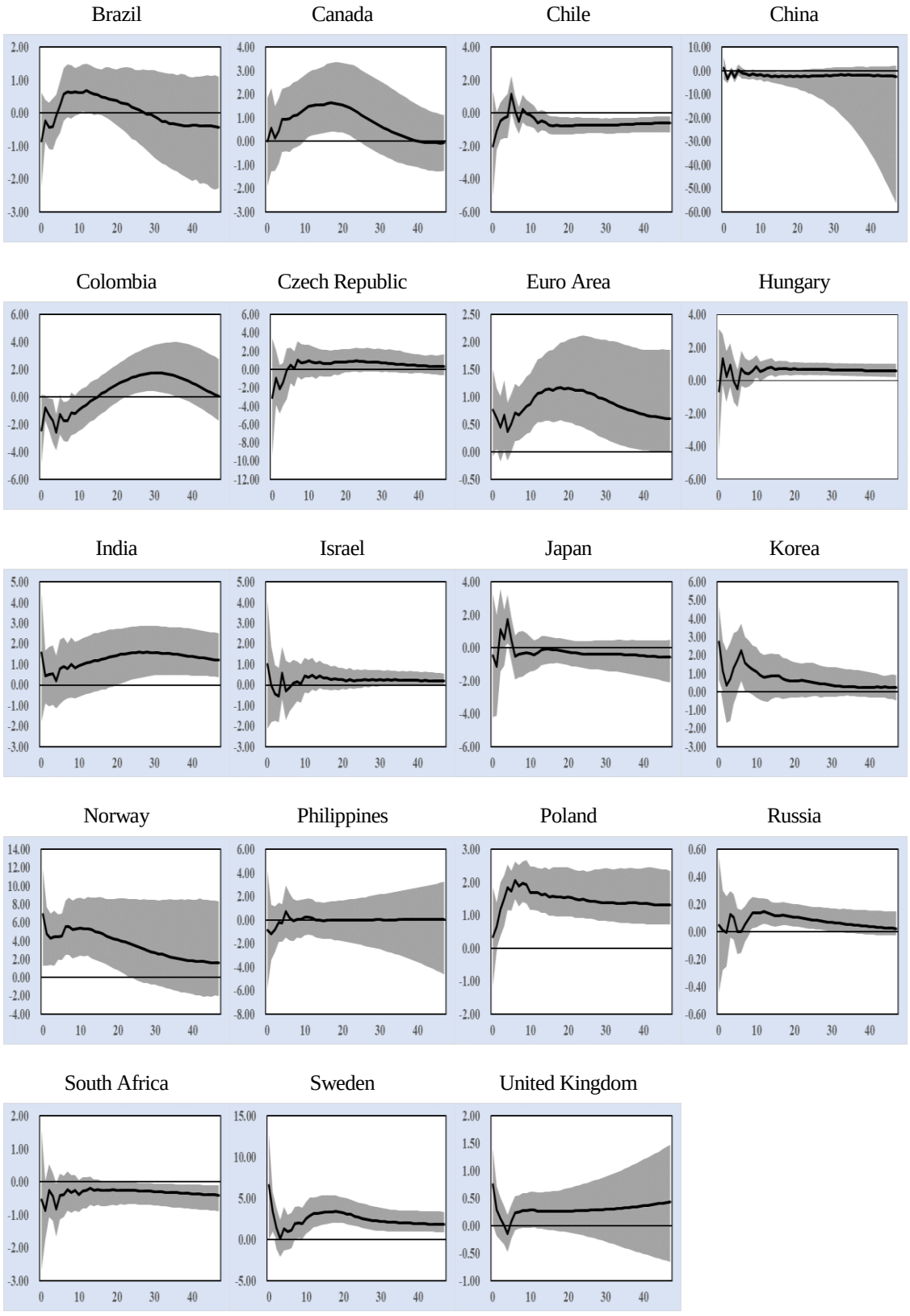
The Czech Republic (2.0%), India (2.0%), China (1.8%), and Sweden (1.8%) show a large increase, followed by the euro area (0.5%), South Korea (0.5%), the Philippines (0.4%), and Poland (0.3%), Russia (0.3%), and the UK (0.3%) show relatively small increases. In addition, in the Czech Republic, Israel, South Korea, and Poland, prices actually decline over time. However, the Czech Republic, South Korea, and Poland's inflation response was not statistically significant. In terms of duration, the inflation response lasts for a very long time in Brazil, Chile, the euro area, India, Norway, the Philippines, South Africa and Sweden.[6]

On the other hand, no clear correlation is observed between the size of the response of output and that of prices. <Figure 3> is a scatter plot showing both the response of output and price to the shock of interest rate cuts. Each point represents the maximum combination of statistically significant output and price response by country, and China, the Czech Republic, and the Philippines, which do not show a significant response in industrial production, are excluded from the figure. According to this, there appears to be a positive correlation between the output and the price response. However, the size of the correlation is small, and even this is largely influenced by India, Norway, and Sweden, which show a large industrial production response. When these three countries are excluded, the correlation turns negative.[7] These results suggest that the response of output and price to monetary policy shocks may be determined by different factors, or even if they are determined by the same factor, there may be differences in their influence.

[6] The impulse response functions of macroeconomic variables other than industrial production and consumer price index are listed in <Appendix 2> by country.

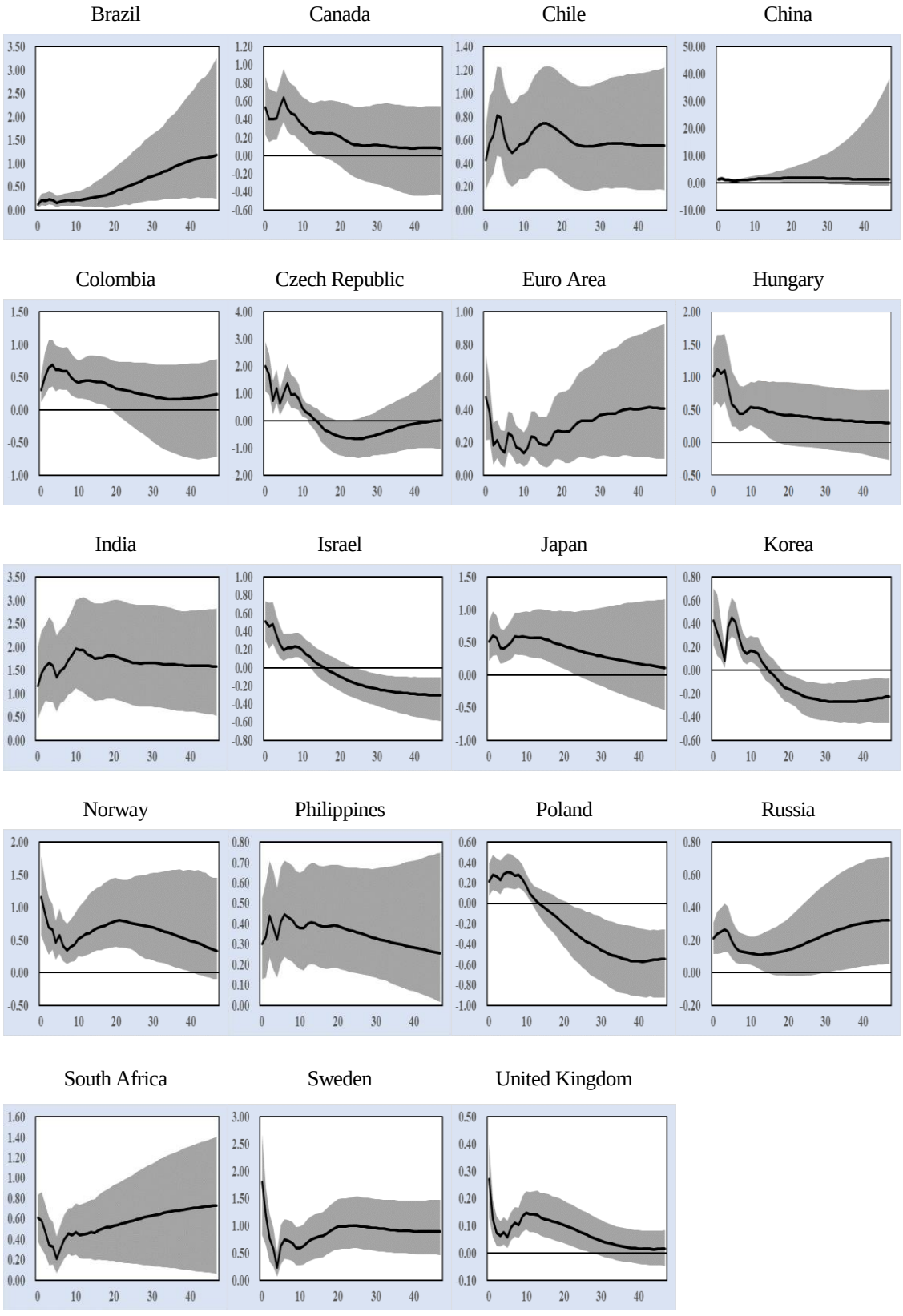
[7] The correlation coefficient between significant production response and price response is calculated to be 0.33. When calculated without India, Norway, and Sweden, the correlation coefficient is -0.18.

[Figure 1] Effects of Monetary Policy Shocks on Industrial Production Indexes



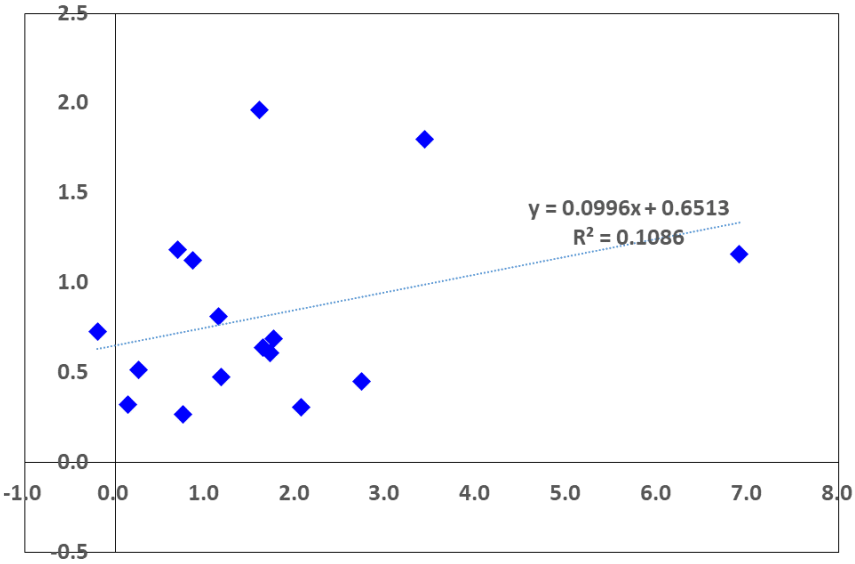
Note: Grey areas are 68% error bands.

[Figure 2] Effects of Monetary Policy Shocks on Consumer Prices Indexes



Note: Grey areas are 68% error bands.

[Figure 3] Relation between Production and Price Responses



Note: This scatter plot shows the relationship between the maximum values of significant responses of industrial production and consumer price indexes from SVAR analysis.

4 The Determinants of the Size of Effects of Monetary Policy Shock

4.1 Model and Data

This chapter analyzes what factors determine the difference between countries in the effect of monetary policy shocks on output and prices. To this end, the following regression equation is estimated with the output and price response values estimated in Chapter III as dependent variables and the various economic characteristics of each country as explanatory variables.

$$IRF_i = \alpha + x_i'\beta + \varepsilon_i, \qquad i = 1, \cdots, 19 \tag{2}$$

Here, IRF_i is the impulse response function derived from the sign-restricted structural VAR analysis in the previous chapter, and x_i is the vector of variables representing the economic characteristics of the country. As mentioned in the introduction, this study uses the methodology of Miniane and Rogers (2007) and conducts a cross-sectional regression analysis including information on all impulse response functions within the confidence interval, rather than using only the average impulse response function. This method has the advantage of not only being able to utilize uncertainty information from the estimation of the impulse response function, but also solving the problem of lack of observations that often occurs in cross-sectional analysis using

national data. Specifically, first, among the impulse response functions within the confidence interval of each country, the nth impulse response functions are collected and cross-sectionally estimated, and this process is repeated for all impulse response functions to obtain the distribution of β. It should be noted that the statistical inference using the estimated values of β is different from classical statistical one. In this paper, in the distribution of β, whether there exists a zero between the upper 95% and the lower 5%, between the upper 97.5% and the lower 2.5%, between the upper 99.5% and the lower 0.5% are the criterion of the possibility of it being significantly different from zero.

As explanatory variables, monetary policy framework (variable name: MPF), exchange rate regime (ERR), financial market openness (FO), central bank independence (CBI), trade openness (TO), GDP Size (SIZE), financial market development (FD), population aging (AGING) and labor market rigidity (SEP, Strictness of Employment Protection) are examined.

Monetary policy framework, exchange rate regime, and financial openness are considered in the context of the Impossible Trinity that appears in international economics. First of all, if the central bank is able to operate its own monetary policy in line with its own economic situation, the effectiveness of monetary policy is highly likely to increase. And according to the Impossible Trinity Hypothesis, the closer the exchange rate regime is to the free floating system and the greater the control over the international movement of capital, the more favorable environment for the implementation of independent monetary policy is created. Therefore, if exchange rates are freely floated and the country can control capital movements so that it can implement independent monetary policies, it can be assumed that the effectiveness of monetary policy shocks on real variables will increase.

Central bank independence can also affect the effectiveness of monetary policy. Central bank independence is an institutional device to solve the problem of time inconsistency in monetary policy, through which inflation expectations can be anchored. In a situation where inflation expectations are well established, even if a monetary policy shock occurs, prices may not fluctuate significantly. On the other hand, it has recently been suggested that central bank independence can reduce the effectiveness of monetary policy by making coordination between monetary and fiscal policies difficult (Summers 2017, Draghi 2018). The coordination problem between monetary and fiscal policies may come to the fore, especially if the economy is in a low-growth phase.

Trade openness and GDP size are included as explanatory variables to reflect whether a country is a small open economy. In the case of a small open economy, there is a possibility that foreign factors will have a great influence on the domestic interest rate decision, and in such a situation, the effect of domestic monetary policy will inevitably be reduced. Ha and So (2017), in

an analysis of representative small open economies such as Canada, the United Kingdom, and Korea, show that US monetary policy shocks can weaken the interest rate channel of monetary policy shocks in these small open economies.

Financial market development can also act as a factor in determining the magnitude of the monetary policy effect. First of all, given that the financial market is a propagation channel connecting monetary policy and the real economy, the existence of a well-developed financial market increases the effect of monetary policy (Luis et al. 2010). However, financial market development may, on the other hand, weaken the effectiveness of monetary policy. According to Bernanke and Gertler's (1995) financial accelerator theory, the magnitude of the effect of monetary policy is enlarged when there is friction in the financial market, and the developed financial market acts in the direction of reducing financial market friction (Ma and Lin, 2016).

The population aging variable is included in the regression equation to reflect recent studies that the demographic structure can affect the monetary policy effect. Population aging can affect the effect of monetary policy through various channels, including changes in the neutral real interest rate, adjustments in household asset structure, and changes in inflation expectations. First, population aging can lead to a decline in the neutral real interest rate through the aggregate supply channel, including a decrease in labor supply and labor productivity (Bielecki et al 2019). On the other hand, in terms of aggregate demand, it is necessary to distinguish between the stage which aging is progressing and the one which aging is mature. In the progressing stage, the motive for asset accumulation for the purpose of maintaining living standards after retirement works, and aggregate demand decreases and the real neutral interest rate decreases (Summers 2015). However, when the aging is mature, consumption and aggregate demand increase according to the life-cycle hypothesis, which may increase the neutral real interest rate. A drop in the neutral real interest rate can act as a factor limiting the effectiveness of monetary policy by reducing policy room for monetary policy. Next, in terms of household asset structure, in the progressing stage, as savings exceed consumption, household assets increase, and as a result, the interest rate sensitivity of household consumption may rise (Berg et al 2020). This will result in strengthening the effectiveness of monetary policy. Conversely, in the mature stage, as consumption exceeds savings, household wealth may decrease and the interest rate sensitivity of household consumption may decrease (Kantur 2013). Furthermore, if inflation expectations of households and businesses stay at a low level along with population aging, the impact of monetary policy shocks on prices may decrease (Shirakawa 2012).

Finally, labor market rigidity is selected as an explanatory variable to reflect the implications of the new Keynesian model, which states that the higher the price or wage rigidity, the stronger the effect of monetary policy.

Data for explanatory variables are chosen from various soursce. First, IMF's Annual Report on Exchange Arrangements and Exchange Restrictions is used for the monetary policy framework and exchange rate regime. The framework is assigned a value of 1 if the inflation targeting system is adopted, and a value of 0 otherwise. For the exchange rate regime, a value ranging from 0 to 9 is assigned depending on the extent to which the exchange rate was free to float.[8] In addition, the index prepared by Bodea and Hicks (2015) is used for central bank independence, and the index prepared by Chinn and Ito (2006) is used for financial openness.[9] The Bodea and Hicks indicator and the Chinn and Ito indicator are designed so that the higher the value, the stronger the independence of the central bank and the higher the degree of financial openness, respectively. The variables representing trade openness and population aging uses World Bank data. Trade openness is the sum of exports and imports divided by nominal GDP, and the population aging variable is replaced by the dependency ratio which is the number of people aged 65 or older divided by the number of people aged 25 to 64 of working age. On the other hand, the IMF's Financial Development index is used as the financial market development, and the share of each country's GDP in the world GDP in the IMF World Economic Outlook is used as the GDP size. Finally, for labor market rigidity, the OECD's Strictness of Employment Protection index is used. For the data, the average from 2004 to 2019 is used as much as possible to match the results of the VAR analysis. Details on statistics such as source, period and average of all data are included in <Appendix 1>.

4.2 The Results

4.2.1 Output

<Table 1> summarizes the results of a regression analysis of the response values of output to monetary policy shocks for each country's unique characteristics. First of all, it is found that the closer the monetary policy framework is to the inflation targeting system and the exchange rate regime to the free-floating exchange rate system, the greater the magnitude of the effect of

[8] Specifically, following the IMF classification system, No separate legal tender is 0, Currency board 1, Conventional Peg 2, Stabilized Arrangement 3, Crawling peg 4, Crawl-like Arrangement 5, and Peg exchange rate within band 6, Other managed arrangement 7, Floating 8, and Free Floating 9.

[9] The Bodea and Hicks indicators are calculated by extracting 16 detailed indicators from the four areas of governor-related regulations, policy-making process, policy goals, and government loan regulations, and averaging them in a weighted average. The Bodea and Hicks index has a value between 0 and 1. Chinn and Ito (2006) quantify the content on cross-border capital movement control among the contents of the IMF's Annual Report on the Exchange Arrangements and Exchange Restrictions and produce an index of capital market openness.

monetary policy shocks on output. This is a result consistent with the implications of the Impossible Trinity Hypothesis. However, there is a difference in that the effect of the exchange rate regime appears in the short-term and the effect of the monetary policy framework is realized in the relatively long-term. The degree of openness of the financial market does not have a meaningful effect on the effect of monetary policy shocks. There is a view (Rey 2020) that emphasizes that the dilemma problem has become more important than the traditional trilemma problem due to the co-movement of financial cycles in each country following the recent globalization of the capital markets.[10] The above result, however, suggests that the trilemma issue may still play an important role in determining the effect of monetary policy shocks.

Central bank independence has been shown to reduce the effect of monetary policy shocks on output. As argued by Summers (2017) and Draghi (2018), in a situation where the role of fiscal policy to overcome low trend growth after the Global Financial Crisis is emphasized, maintaining the traditional central bank independence value could acts as a constraint on smooth coordination between monetary and fiscal policies.

Meanwhile, contrary to theoretical predictions, trade openness and GDP size to reflect the characteristics of small open economies are estimated to have little effect on the effect of monetary policy shocks. All coefficient estimates are found to be insignificant, except for trade openness, which showed a slightly significant coefficient value at the beginning of the shock response. However, in relation to the result of the non-significant estimate of the coefficient of trade openness, it seems to be immature to judge from the result that whether a country is a small open economy is irrelevant to the magnitude of the effect of monetary policy shocks. For example, in the case of trade channels among the propagation mechanisms in which monetary policy shocks change output, the effect of monetary policy shocks on exchange rates may be relatively small in small open economies, but the effects of exchange rate shocks on trade may be large. The effect on trade is because both of these routes must be considered.

In the case of financial market development, it is estimated to have a significant positive effect at the beginning of the shock response, but as time elapsed, the coefficient value is found to change to a significant negative value. This seems to come from the fact that, in the case of countries with a high level of development in the financial market, where both the effect of improving the propagation channel of monetary policy and the effect of relieving friction in the financial market are working simultaneously, the latter becomes more dominant than the former

[10] According to the trilemma view derived from the Impossible Trinity Hypothesis, independent monetary policy can be implemented if a country adopts a floating exchange rate system or can control capital movements. However, the dilemma view argues that due to the co-movement of the global financial cycle, the exchange rate system is no longer irrelevant to the independence of monetary policy, and the control of capital flows is the only prerequisite for independent monetary policy operation.

over time.

Population aging is shown to increase the impact of monetary policy shocks on output. As explained above, population aging can weaken the effect of monetary policy shocks by lowering the neutral real interest rate through a decrease in labor supply, labor productivity, and aggregate demand. However, as interest rate sensitivity increases at the stage which aging is progressing, the effect of monetary policy shocks may intensify. The analysis results suggest that the latter effect is dominant.

As for labor market rigidity, as the theory predicts, the higher the rigidity, the greater the effect of monetary policy shocks.

In summary, the more closely to inflation targeting system a country operates its monetary policy framework, the closer its exchange rate regime is to a floating exchange rate system, the faster the population aging progresses, and the higher the rigidity of the labor market, the greater the response of output to monetary policy shocks. And itis found that the more independent the central bank and the higher the financial market development, the less the response. Financial market openness, trade openness, and GDP size variables are estimated to have no significant effect on the degree of response to monetary policy shocks.

[Table 1] Estimation results for industrial production indexes

Variable / Horizon	MPF	ERR	FO	CBI	TO	SIZE	FD	AGING	SEP
1	0.005	1.053	0.216	-2.121	-0.006	-0.005	12.326***	-0.125	4.997**
2	0.873	1.030*	0.177	-2.821	0.013	-0.005	2.280***	-0.023	2.072***
3	-0.686	0.745*	-0.181	-1.794	0.005	0.031	2.161**	0.031	1.170
4	-1.186	1.313**	-0.041	-3.402**	0.027**	0.094	-0.525	0.003	0.645
5	-0.953	0.563	0.091	-2.773**	0.010	0.011	2.781	0.023***	1.345
6	-0.122	0.855*	0.197	-2.590*	0.009	0.030	1.636	-0.041***	1.542
7	0.037	0.979**	0.097	-3.774**	0.024**	0.059	2.200	-0.051***	1.604
8	1.054	0.766	0.065	-4.523***	0.016	0.006	1.450	0.009	1.943
9	0.654	0.755	0.154	-3.363**	0.011	0.007	1.286	-0.018	1.777
10	0.870	0.779**	0.111	-3.731**	0.013	0.009	0.758	0.002	1.664
11	0.958	0.669*	0.241	-3.655***	0.010	-0.011	0.877	-0.002	1.822
12	1.262	0.764**	0.186	-3.567***	0.007	-0.011	0.846	0.004	1.968
13	1.461	0.679*	0.145	-3.671***	0.005	-0.017	0.754	0.019***	1.992
14	1.548*	0.722*	0.118	-3.637***	0.005	-0.022	0.378	0.028***	1.939
15	1.441	0.727*	0.105	-3.372***	0.005	-0.018	0.513	0.025***	1.896
16	1.733*	0.700*	0.073	-3.497***	0.003	-0.023	0.468	0.033**	1.984
17	1.721**	0.654	0.061	-3.238***	0.002	-0.028	0.531	0.033***	1.970
18	1.766***	0.659	0.043	-3.157***	0.002	-0.028	0.139	0.040***	1.881*
19	1.795***	0.617	0.033	-2.953***	0.000	-0.032	0.095	0.041***	1.879*
20	1.858***	0.615	0.023	-2.838***	0.000	-0.034	-0.150	0.042***	1.841*
21	1.860***	0.576	0.023	-2.820***	-0.001	-0.035	-0.183	0.042***	1.836*
22	1.923***	0.591	0.021	-2.932***	-0.001	-0.035	-0.531	0.042***	1.815*
23	1.886***	0.545	0.030	-2.805***	-0.002	-0.036	-0.509	0.039***	1.804*
24	1.922***	0.567	0.023	-2.879***	-0.002	-0.033	-0.980	0.041***	1.740
25	1.871***	0.529	0.020	-2.746***	-0.003	-0.033	-1.006	0.038***	1.723
26	1.876***	0.536	0.012	-2.802***	-0.003	-0.033	-1.264***	0.039***	1.668
27	1.880***	0.509	0.008	-2.743***	-0.003	-0.033	-1.291***	0.039***	1.647
28	1.897***	0.500	0.006	-2.735***	-0.004	-0.035	-1.460***	0.041***	1.634
29	1.860***	0.480	-0.006	-2.677***	-0.004	-0.037	-1.496***	0.042***	1.605
30	1.864***	0.482	-0.018	-2.678***	-0.004	-0.036	-1.596***	0.045***	1.557
31	1.823***	0.451	-0.022	-2.624***	-0.005	-0.038	-1.563***	0.043***	1.558
32	1.785***	0.470	-0.033	-2.605***	-0.004	-0.038	-1.707***	0.044***	1.549
33	1.769***	0.443	-0.033	-2.578***	-0.005	-0.039	-1.595***	0.044***	1.558
34	1.797***	0.471	-0.047	-2.577***	-0.004	-0.038	-1.684***	0.046***	1.505
35	1.756***	0.459	-0.038	-2.572***	-0.004	-0.037	-1.601***	0.045***	1.490
36	1.792***	0.488	-0.031	-2.594***	-0.003	-0.035	-1.726***	0.045***	1.462
37	1.771***	0.493	-0.020	-2.558***	-0.003	-0.034	-1.685***	0.043***	1.454
38	1.779***	0.523	-0.026	-2.582***	-0.002	-0.031	-1.803***	0.045***	1.433
39	1.742***	0.534	-0.022	-2.572***	-0.001	-0.029	-1.790***	0.044***	1.420
40	1.726***	0.567	-0.025	-2.638***	0.000	-0.026	-1.841***	0.044***	1.401
41	1.701***	0.580	-0.023	-2.636***	0.001	-0.023	-1.816***	0.043***	1.375
42	1.687***	0.632	-0.022	-2.718***	0.002	-0.020	-1.877***	0.043***	1.355
43	1.627***	0.630	-0.025	-2.736***	0.003	-0.017	-1.749***	0.041***	1.353
44	1.604***	0.688	-0.027	-2.829***	0.005	-0.011	-1.825***	0.041***	1.313
45	1.530***	0.705	-0.021	-2.885***	0.006	-0.008	-1.693***	0.038***	1.281
46	1.482***	0.737	-0.026	-2.951***	0.007	-0.004	-1.717***	0.038	1.253
47	1.422***	0.761	-0.019	-3.015***	0.008	-0.001	-1.691	0.037	1.241
48	1.366***	0.794	-0.018	-3.124***	0.009	0.004	-1.616	0.036	1.223

Note: *, **, *** mean that zero does not lie within the interval from the 5th percentile to the 95th percentile, from the 2.5th percentile to the 97.5th percentile, and from the 0.5th percentile to the 99.5th percentile, respectively.

4.2.2 Prices

<Table 2> summarizes the regression result on which factors determine the magnitude of the effect of monetary policy shocks on prices. Unlike output, in the case of inflation, the closer the monetary policy framework is to the inflation targeting system, the less effective the monetary policy shock is. These results need to be understood in light of the purpose of the inflation targeting system. The inflation targeting system refers to a system in which the central bank presents an appropriate inflation target and strives to achieve it, thereby anchoring the expectations of economic agents and ultimately achieving price stability. If inflation expectations of economic agents are well established through the successful conduct of the inflation targeting system, there is a possibility that actual prices will not fluctuate significantly around the inflation target despite the occurrence of monetary policy shocks. The analysis results in this paper support this. Therefore, the results of this paper's analysis can be interpreted as the result of the effective operation of the monetary policy system, rather than the weakening of the effectiveness of monetary policy itself.

It is found that the exchange rate regime and the degree of openness of the financial market do not have a significant effect on the size of the effect of monetary policy shocks. However, at the beginning, a few of the coefficients are estimated to be statistically significant, with being negative for exchange rate regime and the positive for financial market openness. This seems to be partly a reflection of the fact that independent monetary policy can be implemented under a flexible exchange rate system and inflation expectations can be established based on this, but it is difficult to perform this function smoothly under an open capital market.

As for central bank independence indicator, some coefficients are estimated to be positive values, but in general, the effect of monetary policy shocks on prices is reduced. The reason for this can be found in the fact that the independence of the central bank stabilizes the inflation expectations of the private sector.

On the other hand, in the case of trade openness and GDP size, the effect of the monetary policy shock on prices was relatively clear, unlike the analysis on output. Trade openness is estimated to have positive coefficient values, although they are mainly concentrated in the early part of the shock response. As for the size of GDP, the signs of the coefficient are mixed without a clear direction. It should be noted that trade openness has a positive coefficient value because, in the case of a small open economy, the effect of a monetary policy shock on exchange rates could be limited by foreign factors, but the effect of exchange rates on import prices may be large.

As with the analysis of output, the degree of development of the financial market is found to have both the effect of improving the propagation channel of monetary policy and the effect of

relieving friction in the financial market. However, while, in the case of output, the effect of relieving friction in the financial market increases over time, the effect of relieving friction in the financial market mainly works in the early part of the shock response in the case of prices.

Population aging increases the effect of monetary policy shock on output, but decreases the size of the effect on price. It is possible to consider the possibility that the expectation channel suggested by Shirakawa (2012) acted as a major factor in this. Population aging reduces aggregate demand and aggregate supply, resulting in a decrease in growth rate, and expectations of low inflation are formed among economic agents. In the aging progressing stage, as household assets increase, and as a result, the interest rate sensitivity of household consumption rise. Under these circumstances, it becomes possible for aging to reduce the magnitude of prices response and to amplify the magnitude of the output response.

In the case of labor rigidity, monetary policy shocks appear to amplify the effect on prices, as predicted by theory.

In summary, The closer the monetary policy framework is to the inflation targeting system, the more the population aging progresses, the more the response is reduced, and the higher the trade openness and labor market rigidity, the more it expands. Central bank independence, GDP size, and financial market development are found to have an impact in both expansion and contraction directions in determining the price response to monetary policy shocks. In addition, the analysis results so far suggest that expectations can play a particularly important role in the response of prices to monetary policy shocks.[11]

[11] This result can be considered in connection with the flattening phenomenon of the Phillips curve. In his testimony before Congress in 2019, current Fed Chairman Jerome Powell said that he believed that the Phillips curve has steadily flattened thanks to the central bank's price stabilization efforts, and that the stabilization of inflation expectations played an important role in this. The flattening of the Phillips curve means that the central bank can influence the real economy, including employment and growth, without large inflation fluctuations.

[Table 2] Estimation results for consumer price indexes

Variable / Horizon	MPF	ERR	FO	CBI	TO	SIZE	FD	AGING	SEP
1	0.210 **	-0.250 ***	0.066 **	-0.687 ***	0.002 ***	-0.046 ***	0.634 ***	0.012 ***	0.702 ***
2	-0.257 *	-0.218 ***	0.041	-0.607 ***	0.003 ***	-0.032 ***	-0.226 ***	0.009 **	0.335 ***
3	-0.876 ***	0.033	0.056 ***	-0.370 ***	0.005 ***	-0.011	-0.645 ***	-0.010 ***	0.020
4	-0.869 ***	-0.022	0.115 ***	-0.481 ***	0.006 ***	-0.012 ***	-1.292 ***	-0.012 ***	-0.050 **
5	-1.126 ***	0.161 ***	0.080 ***	-0.336 **	0.008 ***	0.011 **	-0.866 ***	-0.028 ***	-0.176 ***
6	-0.591 ***	-0.007	0.067 ***	-0.305 ***	0.003 ***	-0.014 ***	-0.202	-0.012 ***	0.124 ***
7	-0.394 ***	-0.052 *	0.027 ***	-0.460 ***	0.003 ***	-0.014 ***	-0.322 ***	-0.003 ***	0.217 ***
8	-0.532 ***	-0.010	-0.011	-0.323 ***	0.002 ***	-0.008 **	-0.231 ***	-0.003	0.153 ***
9	-0.710 ***	0.022	-0.009	-0.437 ***	0.003 ***	-0.006	-0.359 ***	-0.006 ***	0.130 ***
10	-0.930 ***	0.030	0.003	-0.418 ***	0.004 ***	0.000	-0.333 ***	-0.012 ***	0.081 *
11	-1.172 ***	0.083	-0.003	-0.376 ***	0.005 ***	0.009 **	-0.074 ***	-0.021 ***	0.054 **
12	-1.196 ***	0.074	0.005	-0.268 ***	0.004 ***	0.011 ***	0.052	-0.025 ***	0.065 ***
13	-1.186 ***	0.102	0.012	-0.218	0.004 ***	0.015 ***	0.090 ***	-0.027 ***	0.089 *
14	-1.171 ***	0.095	0.010	-0.078	0.003 **	0.015 ***	0.180 ***	-0.026 ***	0.071 *
15	-1.181 ***	0.092	0.009	-0.032	0.002 *	0.014 **	0.263 ***	-0.027 ***	0.061 *
16	-1.188 ***	0.090	0.010	0.082 *	0.001	0.014 **	0.419 ***	-0.028 ***	0.051 **
17	-1.245 ***	0.101	0.003	0.169 ***	0.001	0.017 **	0.515 ***	-0.031 ***	0.036 ***
18	-1.235 ***	0.103	-0.002	0.193 ***	0.001	0.018 **	0.585 ***	-0.031 ***	0.049 ***
19	-1.255 ***	0.112	-0.005 *	0.191 ***	0.001	0.023 **	0.645 ***	-0.033 ***	0.061 ***
20	-1.253 ***	0.114	-0.009	0.180 ***	0.001	0.024 **	0.676 ***	-0.033 ***	0.062 ***
21	-1.245 ***	0.117	-0.015	0.152 ***	0.001	0.024 *	0.722 ***	-0.033 ***	0.071 ***
22	-1.209 ***	0.098	-0.022	0.145 ***	0.001	0.024 *	0.750 ***	-0.032 ***	0.068 ***
23	-1.170 ***	0.091	-0.028	0.120 ***	0.001	0.024	0.766 ***	-0.031 ***	0.067 ***
24	-1.116 ***	0.073	-0.033	0.098 ***	0.001	0.025	0.757 ***	-0.030 ***	0.065 ***
25	-1.083 ***	0.066	-0.037	0.043	0.001	0.026	0.721 ***	-0.030 ***	0.060 ***
26	-1.060 ***	0.056	-0.038	0.037	0.000	0.027	0.715 ***	-0.029 ***	0.050 ***
27	-1.045 ***	0.051	-0.040	0.017	0.000	0.028	0.696 ***	-0.029 ***	0.038 ***
28	-1.016 ***	0.040	-0.041	-0.007	0.000	0.027	0.664 ***	-0.028 ***	0.025 ***
29	-1.012 ***	0.039	-0.039	-0.033	0.001	0.028	0.626 ***	-0.029 ***	0.014
30	-0.993 ***	0.032	-0.038	-0.052	0.001	0.029	0.576 ***	-0.029 ***	0.004
31	-1.010 ***	0.032	-0.033	-0.084	0.001	0.030	0.506 ***	-0.029 ***	-0.005
32	-1.000 ***	0.027	-0.033	-0.105	0.001	0.030	0.470 ***	-0.028 ***	-0.014
33	-0.987 ***	0.026	-0.032	-0.145	0.001	0.030	0.416 **	-0.028 ***	-0.023
34	-0.971 ***	0.018	-0.033	-0.178	0.001	0.030	0.373	-0.028 ***	-0.028
35	-0.963 ***	0.017	-0.034	-0.212	0.001	0.030	0.307	-0.028 ***	-0.033
36	-0.933 ***	0.011	-0.033	-0.249	0.001	0.029	0.256	-0.027 ***	-0.036
37	-0.909 ***	0.006	-0.036	-0.286	0.001	0.030	0.214	-0.027 ***	-0.038
38	-0.893 ***	0.003	-0.037	-0.300	0.001	0.030	0.186	-0.026 ***	-0.040
39	-0.879 ***	0.000	-0.039	-0.314	0.001	0.029	0.173	-0.026 ***	-0.044
40	-0.871 ***	-0.002	-0.042	-0.320	0.001	0.029	0.163	-0.026 ***	-0.049
41	-0.864 ***	-0.001	-0.046	-0.330	0.001	0.029	0.147	-0.026 ***	-0.051
42	-0.840 ***	-0.008	-0.048	-0.339	0.001	0.028	0.134	-0.026 ***	-0.053
43	-0.816 ***	-0.012	-0.053	-0.351	0.001	0.028	0.114	-0.026 ***	-0.053
44	-0.798 ***	-0.017	-0.057	-0.335	0.001	0.028	0.111	-0.027 ***	-0.058
45	-0.777 ***	-0.024	-0.061	-0.319	0.001	0.028	0.114	-0.027 ***	-0.063
46	-0.761 ***	-0.026	-0.062	-0.285	0.001	0.027	0.139	-0.027 ***	-0.068
47	-0.742 ***	-0.030	-0.067	-0.260	0.001	0.027	0.153	-0.028 ***	-0.067
48	-0.721 ***	-0.039	-0.070	-0.233	0.001	0.026	0.176	-0.028 ***	-0.064

Note: *, **, *** mean that zero does not lie within the interval from the 5th percentile to the 95th percentile, from the 2.5th percentile to the 97.5th percentile, and from the 0.5th percentile to the 99.5th percentile, respectively.

4.3 Comparison with Small Open Economy DSGE Model

In this section, using the small open economy DSGE model of Gali and Monacelli (2005), we examine how the response to monetary policy shock changes when several economic environments change, and compare the results with the results of the empirical analysis previously examined.

4.3.1 Small Open Economy DSGE Model

The Gali and Monacelli (2005) model consists of the open economy IS equation (3), the open economy New Keynesian Phillips curve (4), and the Taylor rule (5). All the variables below mean the percentage deviation from the steady state, and the inflation rate, nominal policy interest rate, and exchange rate depreciation rate mean the difference from the steady state (%p), respectively (For detailed variable names and parameter definitions, refer to the paper)[12]. Here, it is assumed that monetary policy shocks follow the AR (1) process, $\upsilon_t = \rho_\upsilon \upsilon_{t-1} + \varepsilon_t^\upsilon$.

$$x_t = E_t x_{t+1} - \frac{1}{\sigma_\alpha}(r_t - \pi_{h,t+1} - \overline{r_t}) \quad (3)$$

$$\pi_{h,t} = \beta E_t \pi_{h,t+1} + \kappa_\alpha x_t \quad (4)$$

$$r_t = \phi_\pi \pi_t + \phi_x x_t + \upsilon_t \quad (5)$$

Regarding Equation (3), the natural rate of interest, the natural level of output, and the output gap are in equilibrium:

$$\overline{r_t} = \rho - \sigma_\alpha \Gamma(1-\rho_\alpha) a_t + \alpha\sigma_\alpha(\Theta + \Psi) E_t \Delta y_{t+1}^* \quad (6)$$

$$\overline{y_t} = \Omega + \Gamma a_t + \alpha \Psi y_t^* \quad (7)$$

$$x_t = y_t - \overline{y_t} \quad (8)$$

In addition, the following relational expression can be obtained from the equilibrium equation of consumer prices, terms of trade, purchasing power parity, and the definition of the real effective exchange rate.

[12] The main parameters derived from the equilibrium equations are as follows:
$\omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1)$, $\sigma_\alpha = \frac{\sigma}{1-\alpha+\alpha\omega}$, $\kappa_\alpha = \frac{(1-\beta\theta)(1-\theta)}{\theta}(\varphi + \sigma_\alpha)$.

$$\pi_t = \pi_{h,t} + \alpha(s_t - s_{t-1}) \quad (9)$$

$$s_t = s_{t-1} + \Delta e_t - \pi_{h,t} \quad (10)$$

$$q_t = (1-\alpha)s_t \quad (11)$$

In addition, the following can be obtained from the household labor supply first-order condition, product market, labor market equilibrium equation, and trade balance definition equation.

$$w_t - p_t = \sigma c_t + \varphi n_t \quad (12)$$

$$y_t = c_t + \frac{\alpha\omega}{\sigma} s_t \quad (13)$$

$$y_t = a_t + n_t \quad (14)$$

$$nx_t = \alpha\left(\frac{\omega}{\sigma} - 1\right) s_t \quad (15)$$

Finally, when all the Euler equations of each country are combined, the following international risk sharing condition is derived.

$$y_t = y_t^* + \frac{1}{\sigma_\alpha} s_t \quad (16)$$

Parameter values for simulation are as follows. For the parameters of the benchmark model, the values commonly used in related literature are selected, and the parameters are changed to alternative values for comparison with the empirical analysis.

[Table 3] Calibration

parameter	definition	value (benchmark)	value (alternative)
σ	risk aversion	1	
η	elasticity of substitution between domestic and foreign goods	1	
γ	elasticity of substitution between goods produced in different countries	1	
φ	inverse Frisch elasticity	3	6
ε	elasticity of substitution between domestic goods	6	
θ	Calvo parameter	0.75	
β	discount factor	0.99	
α	openness	0.4	0.6, 0.8
ϕ_π	inflation sensitivity of policy interest rate	1.5	1.1
ϕ_x	output gap sensitivity of policy interest rate	0.13	
ρ_v	persistence of monetary policy shock	0.2	

4.3.1 Comparison with the Empirical Results

The results presented in the literature, the previous empirical analysis, and the theoretical results of the DSGE model in this paper are summarized as follows with respect to factors influencing the magnitude of the of monetary policy on output and prices.

[Table 4] Comparison between theoretical and empirical results of output response

Variable	MPF	ERR	FO	CBI	TO	SIZE	FD	AGING	SEP
Literature	+	+	-	-	-	-	+, -	+, -	+
Empirical result	+	+	N	-	N	N	+, -	+	+
DSGE	-				N or - -				N or -

Note: +, -, N denote positiive, negative effects and no statistical significance.

[Table 5] Comparison between theoretical and empirical results of price response

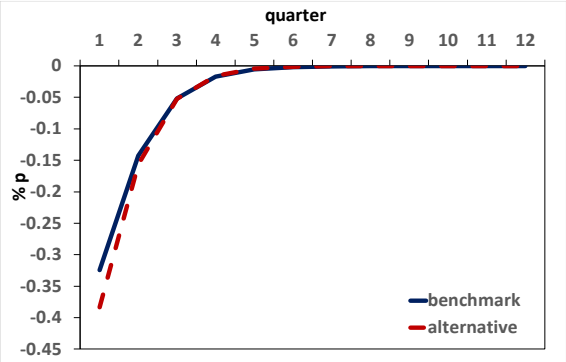
Variable	MPF	ERR	FO	CBI	TO	SIZE	FD	AGING	SEP
Literature	+	+	-	-	-	-	+, -	+, -	+
Empirical result	-	-	+	-	+	-, +	-, +	-	+
DSGE	-				+				+

Note: +, -, N denote positiive, negative effects and no statistical significance.

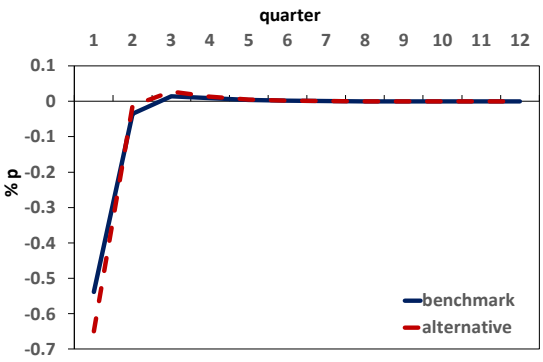
Benchmark The "benchmark" in <Figure 4> shows the impulse response of each variable when an unexpected monetary policy shock occurs under the setting of the parameters of the baseline model. The magnitude of the shock is + 25 basis point, which is equivalent to the effect of a 100 basis point increase per year. The inflation rate, the nominal policy interest rate, and the exchange rate depreciation rate are all annualized. Positive shocks cause domestic goods inflation, CPI inflation, and output to all fall. The reason why the increase in the nominal policy rate (13bp) does not match the size of the shock (100bp) is due to the endogenous response of the monetary authority to the decline in inflation and output. As a result of the fall in the inflation rate of domestic goods, the nominal exchange rate was to a large extent appreciated to reflect the purchasing power parity theory. As the nominal exchange rate appreciation exceeds the rate of decline in the inflation rate of domestic goods, the prices of foreign goods denominated in the local currency fall more than the prices of domestic goods, and as a result, the terms of trade improve (decrease) (see Equation (10)). Due to the decline in the terms of trade, the decline in the CPI inflation rate is greater than the decline in the domestic goods inflation rate (see Equation (9)).

[Figure 4] Impulse response to contractionary monetary shock with different parameters (inflation sensitivity (ϕ_π): benchmark=1.5, alternative=1.1)

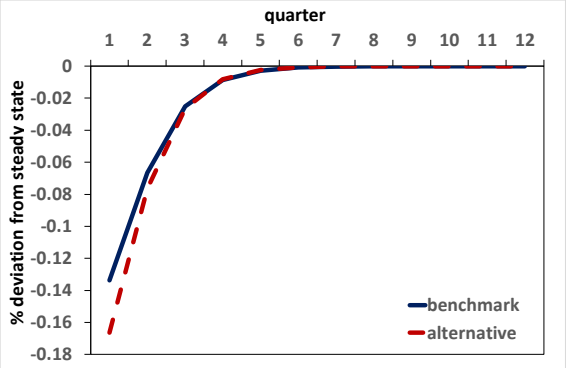
Inflation rate of domestic goods ($\pi_{h,t}$)



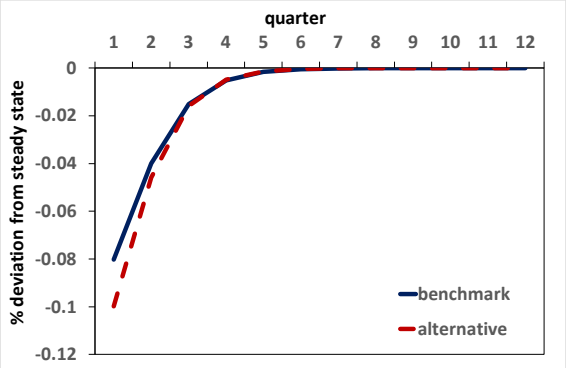
CPI inflation rate (π_t)



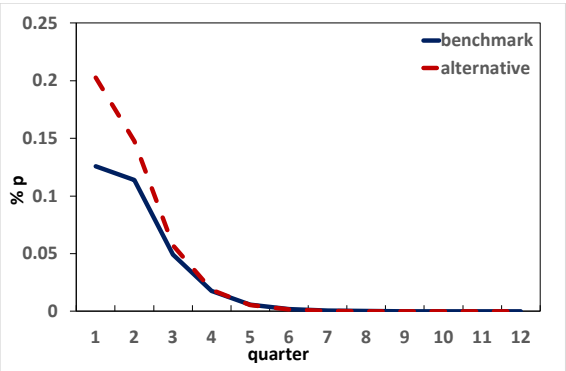
Output (y_t)



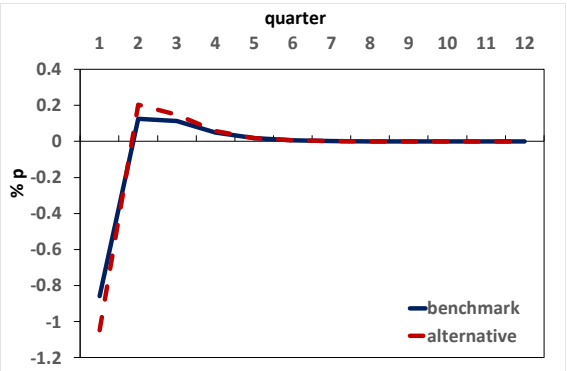
Consumption (c_t)



Nominal policy interest rate (r_t)



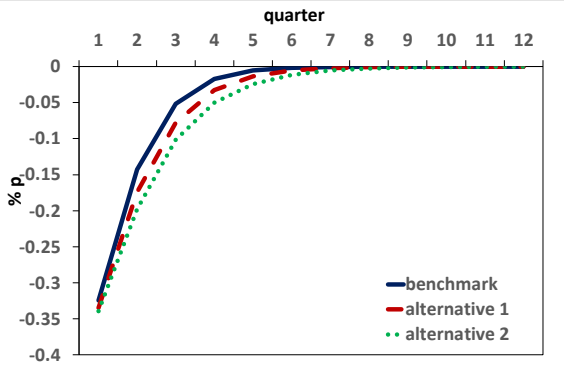
Depreciation rate of nominal effective exchange rate (Δe_t)



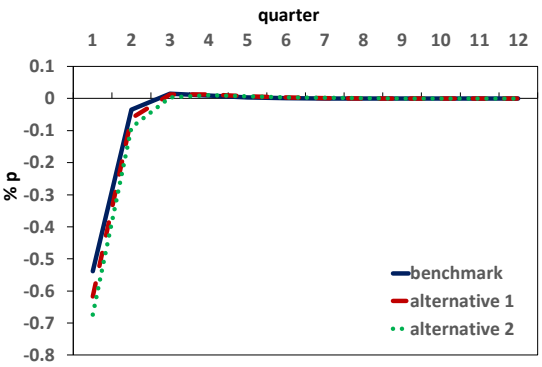
Monetary Policy Framework (MPF) Simulation results show that the effect of positive monetary policy shocks on prices and output is smaller when the inflation targeting system is adopted (benchmark, ϕ_π=1.5) than when it is not (alternative, ϕ_π=1.1). Under the inflation targeting system, the Taylor rule's sensitivity to inflation is greater, so the policy authorities are more sensitive to the deflationary pressure caused by an unexpected positive monetary shock, and therefore the rate of increase in the policy rate is smaller than in the case where it is not. As a result,

[Figure 5] Impulse response to contractionary monetary shock with different parameters (openness (α): benchmark=0.4, alternative 1=0.6, alternative 2=0.8)

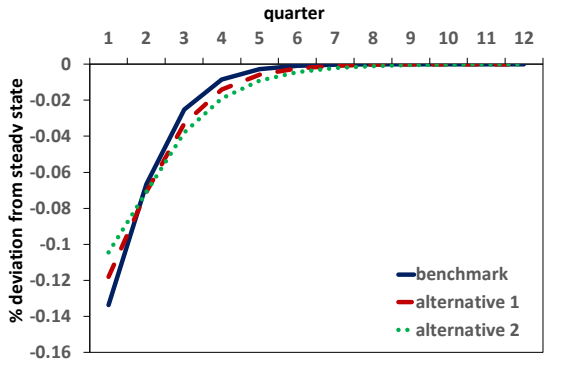
Inflation rate of domestic goods ($\pi_{h,t}$)



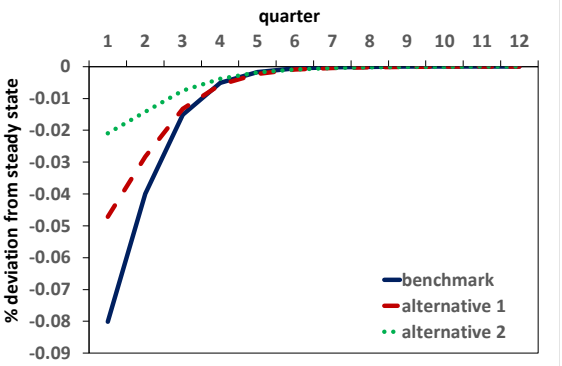
CPI inflation rate (π_t)



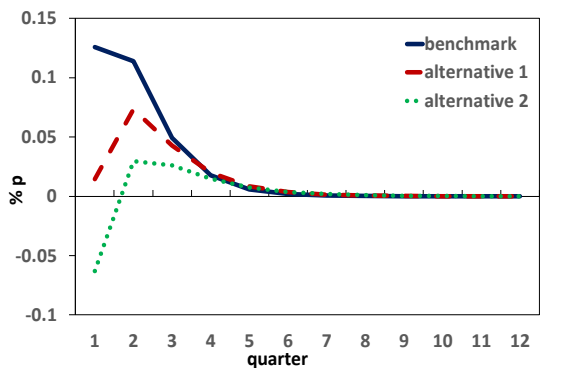
Output (y_t)



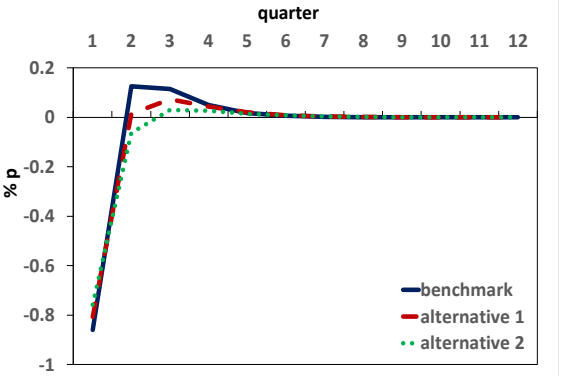
Consumption (c_t)



Nominal policy interest rate (r_t)



Depreciation rate of nominal effective exchange rate (Δe_t)

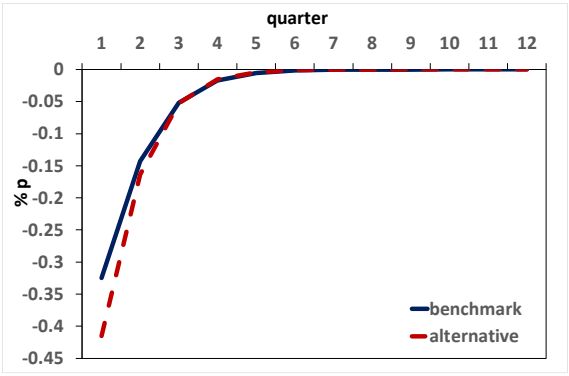


price volatility is reduced. In the case of output, due to the nature of the model, the so-called "divine coincidence" reduces the volatility of output when the inflation targeting system is adopted.

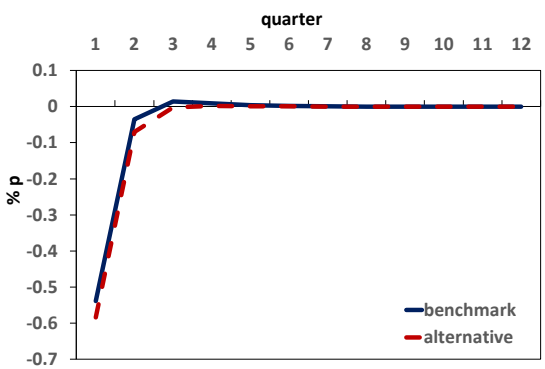
The "divine coincidence" appears when the desired markup rate is fixed in the model, so the empirical results in this paper that the effect on output is greater when the inflation targeting is selected can be interpreted as reflecting the fact that, in reality, the desired markup is time-varying.

[Figure 6] Impulse response to contractionary monetary shock with different parameters (inverse Frisch elasticity (φ): benchmark=3, alternative=6)

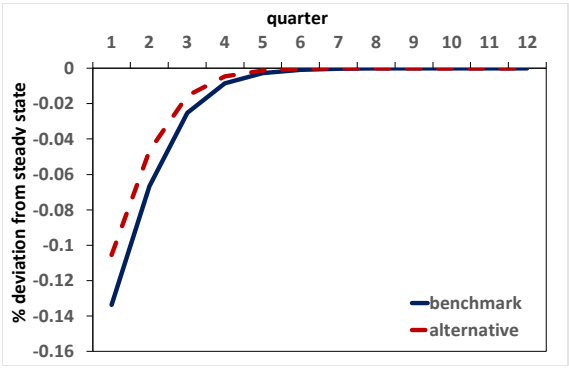
Inflation rate of domestic goods ($\pi_{h,t}$)



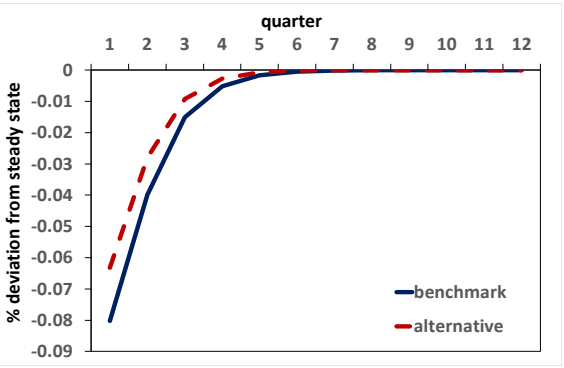
CPI inflation rate (π_t)



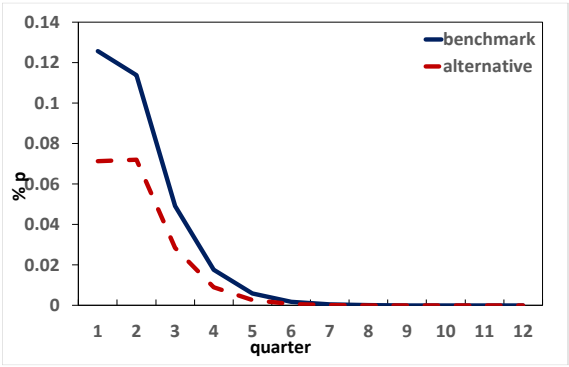
Output (y_t)



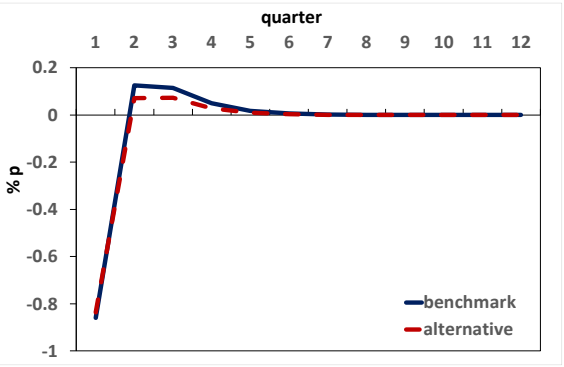
Consumption (c_t)



Nominal policy interest rate (r_t)



Depreciation rate of nominal effective exchange rate (Δe_t)



Trade Openness (TO) The higher the degree of openness to the outside world, the greater the response of the inflation rate, but in the case of output, the effects are mixed, which is generally consistent with the results of the empirical analysis in this paper. When the degree of trade openness is high, the degree of decline in output is smaller because external demand is transferred more to domestic demand following a drop in domestic goods prices. However, as the extent of the decline in the CPI inflation rate expands, the size of the increase in the nominal interest rate

is limited compared to the case where the degree of openness is low. On the other hand, the positive effect on consumption due to the improvement in the terms of trade appears to be larger than the benchmark, and therefore the reduction in consumption is smaller (Equation (13)).

Labor Market Rigidity (SEP) The higher the labor market rigidity, the larger the response of the domestic goods price inflation rate to output since κ_α is increasing in φ, and, accordingly, the decline in the domestic goods price inflation rate and the CPI inflation rate are amplified, consistent with the results of the empirical analysis.[13] However, in the case of output, when rigidity increases, the effect is found to be slightly reduced.

What is commonly found in simulations of the response of output and prices to changes in the parameters of trade openness and labor market rigidity is that the endogenous response of the nominal policy interest rate plays an important role in determining the size of response. It is worth noting that as trade openness and labor market rigidity increase, the size of the decline in the domestic inflation rate increases, respectively. As a result, the increase in the nominal interest rate according to the Taylor rule is suppressed so that the effects of parameter changes are offset to a certain extent.

5 Concluding Remarks

This paper examines whether there are differences in the effects of monetary policy shocks on output and prices in major countries and, if so, what factors cause such differences by using a sign-constrained structural VAR model, a two-step regression analysis, and a simple small-scale open economy DSGE model.

As a result of the analysis, the effect of a monetary policy shock of the same size on output and prices differs by country. Looking at the effect on output, in many countries, when a 25bp interest rate cut shock occurs, industrial production increases by up to 1-2%, ranging from countries where industrial production increases by more than 3% to countries where it decreases. In terms of inflation, the average increase was 0.9%, but there is a wide range of estimates from nearly 2.0% to 0.3%.

[13] In order to model labor market rigidity, wage rigidity or matching friction should be introduced explicitly, but for convenience of analysis, the rigidity is assumed to increase when the elasticity of labor supply to real wage is lowered.

The difference in response to such monetary policy shocks is found to be influenced by various factors. In the case of output, the closer the monetary policy framework is to the inflation targeting system, the closer the exchange rate system is to the floating exchange rate system, the faster the population aging progresses, the higher the labor market rigidity, the larger the response. On the other hand, the more independent the central bank, and the more developed the financial market, the smaller the response. The price response is reduced as the monetary policy system approaches the inflation targeting system and population aging progresses, and expanded as trade openness and labor market rigidity increase. The results of simulating the effects of the monetary policy framework, trade openness, and labor market rigidity on the monetary policy shock response, using Gali and Monacelli's (2005) small open economy DSGE model, also support the findings from the empirical analysis. .

Considering the above research results, it is judged that a central bank should establish its own monetary policy operation strategies based on a detailed analysis of the effects of policies and its specific economic environment. In addition, it is necessary to make efforts to improve economic conditions and improve related institutions so that monetary policy can enhance the macroeconomic stabilization function.

References

Aysun, Uluc, Ryan Brady, and Adam Honig (2013): "Financial Frictions and the Strength of Monetary Transmission," *Journal of International Money and Finance*, 32

Berben, Robert-Paul, Alberto Locarno, Julian Morgan, and Javier Valles (2004): "Cross-country Differences in Monetary Policy Transmission," *European Central Bank Working Paper*, No. 400

Berg, Kimberly A., Chadwick C. Curtis, Steven Lugauer, and Nelson C. Mark (2020): "Demographics and Monetary Policy Shocks," *mimeo*

Berument, Hakan, Nazli Konac, and Ozge Senay (2007): "Openness and the Effectiveness of Monetary Policy: A Cross-country Analysis," *International Economic Journal*, 21(4)

Bielecki, Marcin, Michal Brzoza-Brzezina, and Marcin Kolasa (2019): "The Impact of Population Ageing on Monetary Policy," *VOX Column*, https://cepr.org/voxeu/columns/impact-population-ageing-monetary-policy

Bodea, Cristina and Raymond Hicks (2015): "Price Stability and Central Bank Independence: Discipline, Credibility, and Democratic Institutions," *International Organization*, 69 (1), 35-61

Cecchetti, Stephen G. (1999): "Legal Structure, Financial Structure, and the Monetary Policy Transmission Mechanism," *FRBNY Economic Policy Review*

Chinn, Menzie D. and Hiro Ito (2006): "What Matters for Financial Development? Capital Controls, Institutions, and Interactions," *Journal of Development Economics*, 81 (1), 163-192

Ćorić, Bruno, Lena Malešević Perović, and Vladmir Šimić (2014): "Openness and the Strength of Monetary Policy Transmission: International Evidence," *mimeo*

Ćorić, Bruno, Lena Malešević Perović, and Vladmir Šimić (2015): "A Cross-country Analysis of Monetary Policy Effects on Prices," *Czech Journal of Economics and Finance*, 65

Draghi, Mario (2018): "Central Bank Independence," Lamfalussy Lecture at the Banque Nationale de Belgique

Elbourne, Adam, and Jacob de Haan (2006): "Financial Structure and Monetary Transmission in Transition Countries," *Journal of Comparative Economics*, 34

Georgiadis, Georgios (2014): "Towards an Explanation of Cross-country Asymmetries in Monetary Policy Transmission," *Journal of Macroeconomics*, 39

Grauwe, Paul de, and Claudia Costa Storti (2005): "Is Monetary Policy in the Eurozone Less Effective Than in the US?," *CESIFO Working Paper*, No. 1606

Ha, Jongrim and Inwhan So (2017): "Which Monetary Shocks Matter in Small Open Economies? Evidence from SVARs," *BOK Working Paper* No. 2017-2

Havranek, Tomas, and Marek Rusnak (2013): "Transmission Lags of Monetary Policy: A Meta-Analysis," *International Journal of Central Banking*, 9(4)

Kantur, Zeynep (2013): "Aging and Monetary Policy," *mimeo*

Kim, Soyoung (1999): "Do Monetary Policy Shocks Matter in the G-7 Countries? Using Common Identifying Assumptions about Monetary Policy across Countries," *Journal of International Economics*, 48 (2), 387-412

Kim, Soyoung, and Kuntae Lim (2018): "Effects of Monetary Policy Shocks on Exchange Rate in Small Open Economies," *Journal of Macroeconomics*, 56

Luis C., José E. G. S., and Javier G. B. (2010): "Understanding the Relationship between Financial Development and Monetary Policy," *Review of International Economics* 18 (5), 849-864

Ma, Yong, and Xingkai Lin (2016): "Financial Development and the Effectiveness of Monetary Policy," *Journal of Banking and Finance*, 68, 1-11

Matějů, Jakub (2014): "Explaining the Strength and Efficiency of Monetary Policy Transmission: A Panel of Impulse Responses from a Time-Varying Parameter Model," *Czech National Bank Working Paper*, No. 4/2014

Miniane, J. and J.H. Rogers (2007): "Capital Controls and International Transmission of U.S. Money Shocks," *Journal of Money, Credit, and Banking* 39 (5), 1003-1035.

Mishra, Prachi, Peter J. Montiel, and Antonio Spilimbergo (2010): "Monetary Transmission in Low Income Countries," *International Monetary Fund Working Paper*, No. 10/223

Rusnak, Marek, Tomas Hvranek, and Roman Horvath (2013): "How to Solve the Price Puzzle? A Meta-Analysis," *Journal of Money, Credit, and Banking*, 45(1)

Scholl, Almuth, and Harald Uhlig (2008): "New Evidence on the Puzzles: Results from Agnostic Identification on Monetary Policy and Exchange Rate," *Journal of International Economics*, 76

Shirakawa, M. (2012): "Demographic Changes and Macroeconomic Performance: Japanese Experience," Opening Remarks at 2012 BOJ-IMEC Conference, Bank of Japan

Summers, Lawrence H. (2015): “Demand Side Secular Stagnation,” *American Economic Review Papers & Proceedings*, 105 (5), 305-327

Summers, Lawrence H. (2017): “Central Bank Independence,” Remarks at the ‘Independence – 20 Years On’ Conference, Bank of England

Uhlig, Harald (2005): “What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure,” *Journal of Monetary Economics*, 52

Appendix 2: Data Sources

1. Sign-restricted VAR

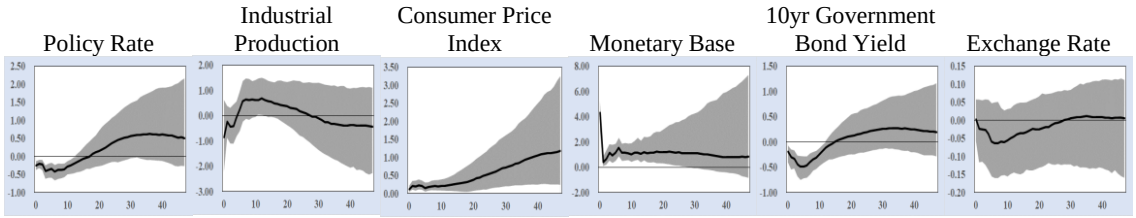
Variable	Sources
Policy interest rate	China, India, Norway, Philippines, Russia: BIS, Euro Area, UK: Wu's webpage, Japan, Sweden: Reserve Bank of New Zealand, Other countries: IMF
Monetary base	Euro Area, UK: FRED database, Philippines: CEIC, Other countries: OECD
10year government bond yield	Brazil, Philippines: Bloomberg, Chile: Central Bank of Chile, China: investing.com, India: CEIC, UK: FRED database, Other countries: OECD
Industrial production index	Philippines: CEIC, China: IMF & People's Bank of China, Brazil, Euro Area, Japan, Korea, Russia, UK: OECD, Other countries: IMF
Consumer price index	Philippines: Central Bank of Philippines, China: Bank of Korea ECOS, Brazil, Colombia, Euro Area, Japan, Korea, South Africa: OECD, Other countries: IMF
Exchange rate against USD	India, Korea: BIS, Other countries: IMF

2. Second-stage regression

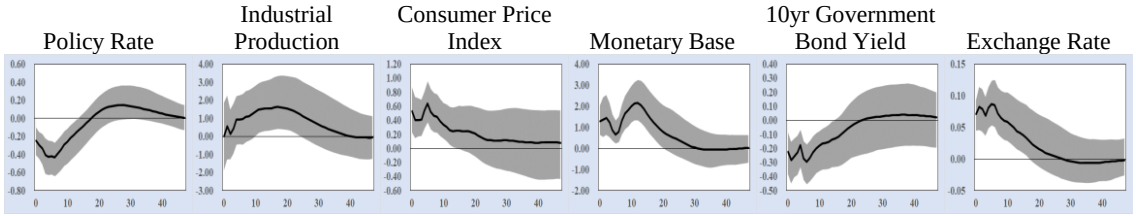
Variable	Sources	Period	Average	Standard Deviation	Max	Min
Monetary policy framework	IMF: Annual Reports on Exchange Arrangements and Exchange Restrictions	2004-2019	0.85	0.31	1.00	0.00
Exchange rate regime	IMF Annual Reports on Exchange Arrangements and Exchange Restrictions	2004-2019	8.17	1.09	9.00	4.38
Central bank independence	Bodea and Hicks (2015) (author's webpage)	2004-2014	0.60	0.22	0.89	0.22
Financial openness	Chinn and Ito (2006) (author's webpage)	2004-2018	1.04	1.42	2.33	-1.22
Trade openness	World Bank: World Development Indicators	2004-2019	69.79	33.52	156.30	31.51
Size of GDP	IMF: World Economic Outlook Database	2004-2019	2.99	4.69	18.70	0.20
Financial Development	IMF: Financial Development Index Database	2004-2018	0.59	0.17	0.89	0.35
Population aging	World Bank: World Development Indicators	2004-2019	19.06	8.31	37.60	6.89
Labor market rigidity	OECD: Indicators of Employment Protection	2004-2018	2.26	0.49	3.02	1.29

Appendix 2: Impulse Responses of Macro Variables to Monetary Policy Shocks

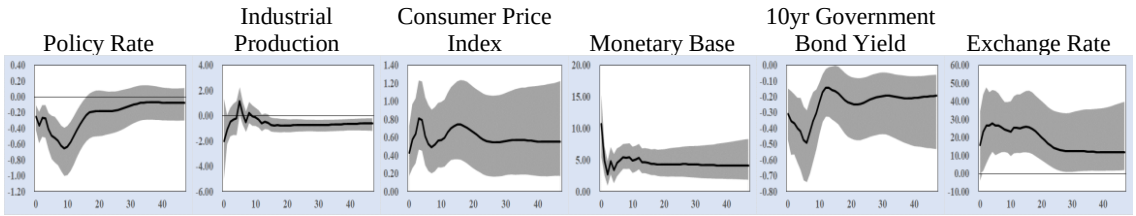
- **Brazil**



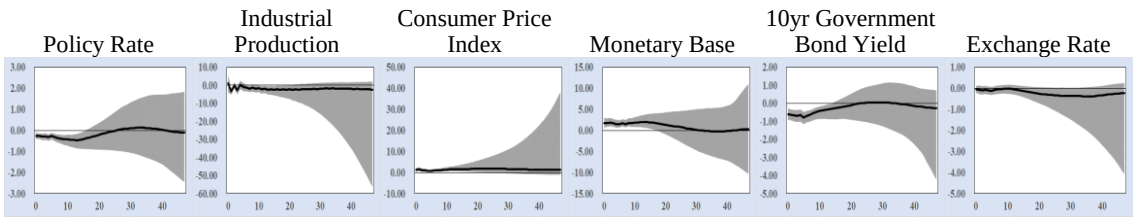
- **Canada**



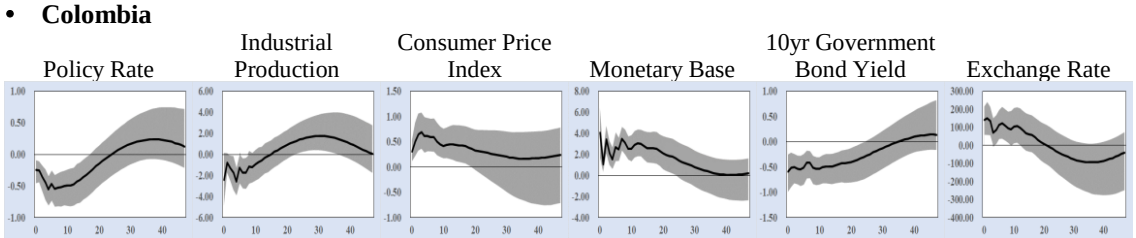
- **Chile**



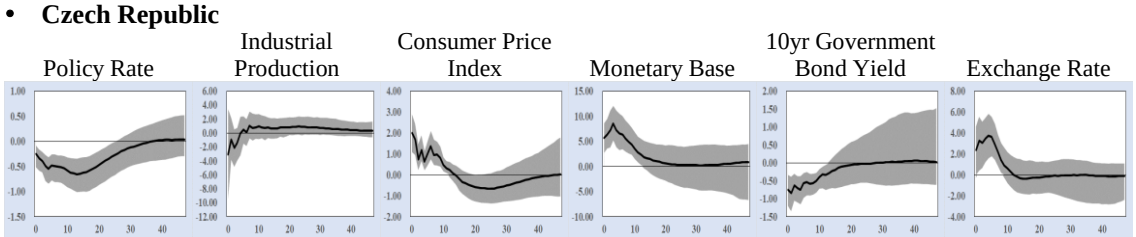
- **China**



- **Colombia**

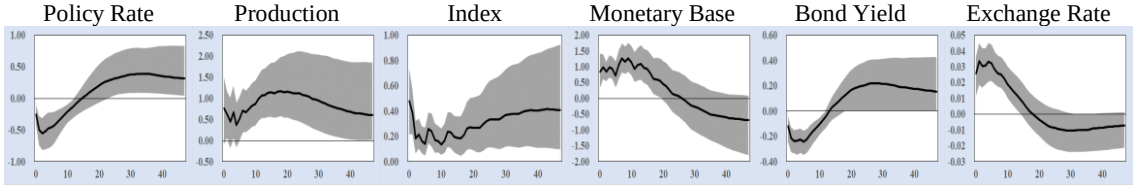


- **Czech Republic**



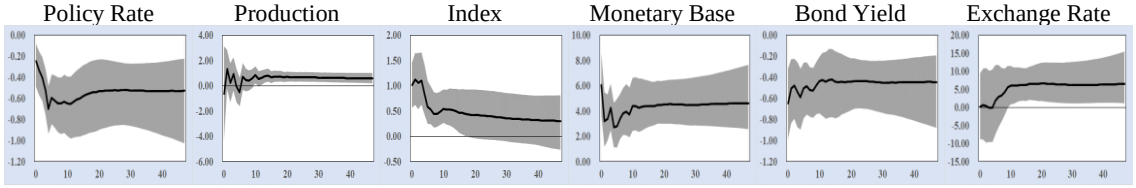
- **Euro Area**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



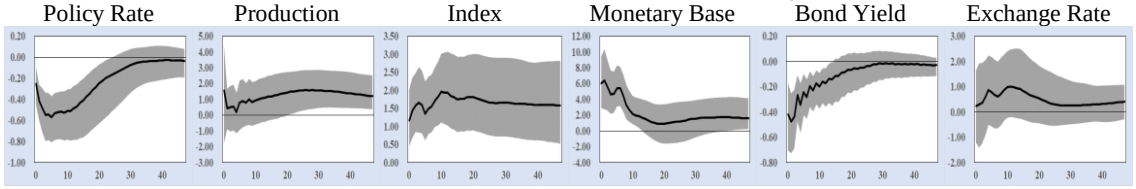
- **Hungary**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



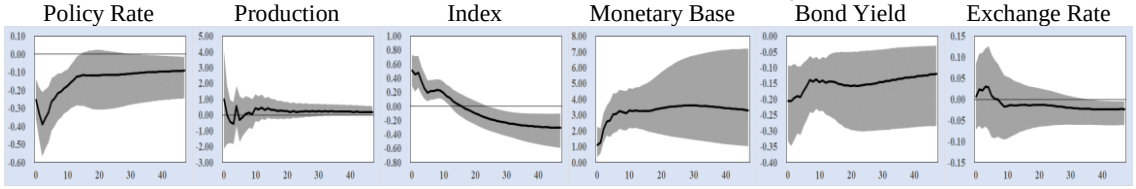
- **India**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



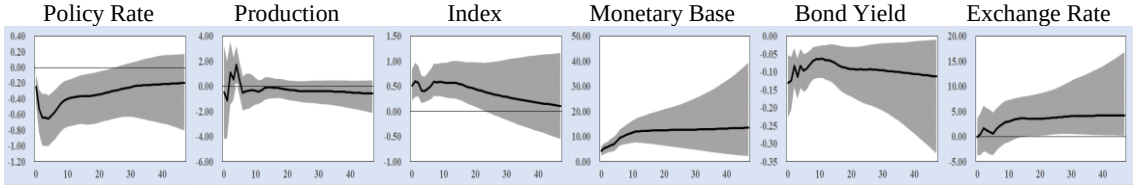
- **Israel**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



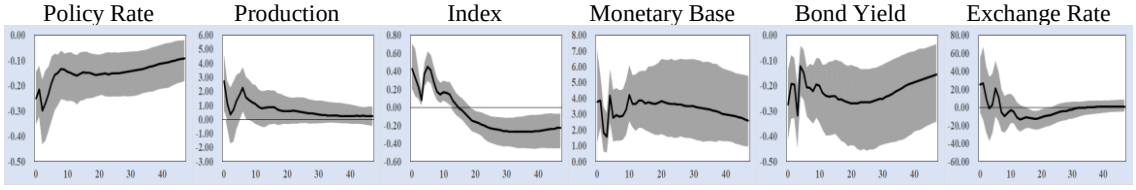
- **Japan**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



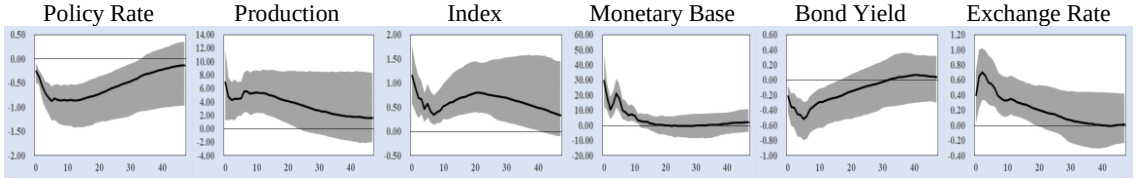
- **Korea**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



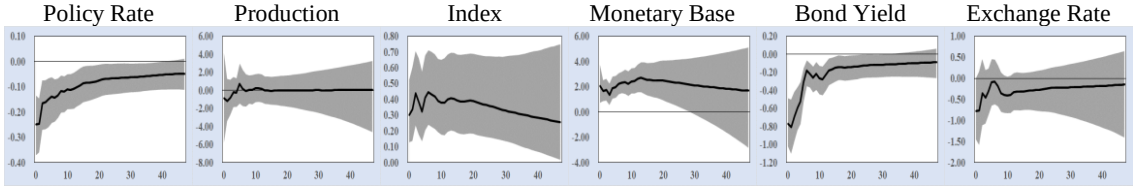
- **Norway**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



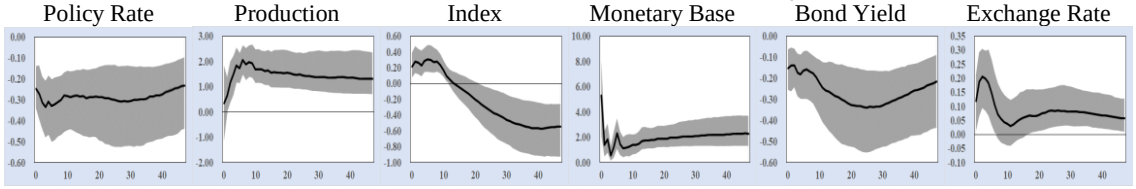
- **Philippines**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



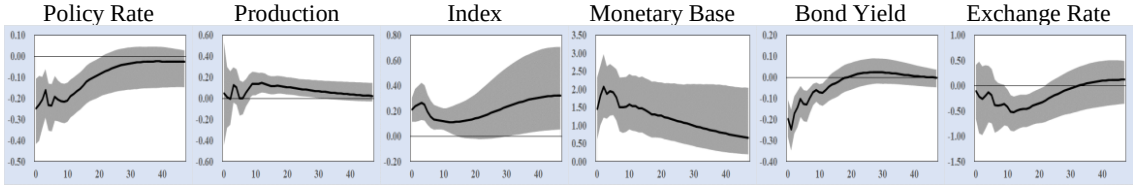
- **Poland**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



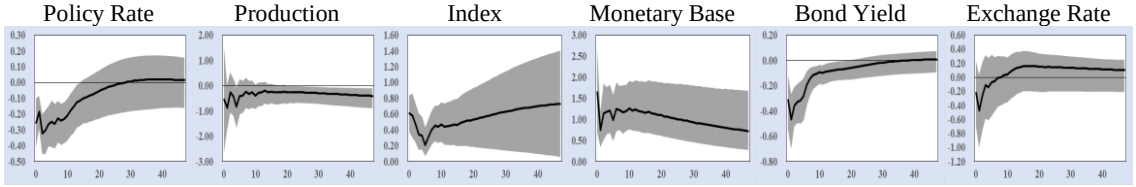
- **Russia**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



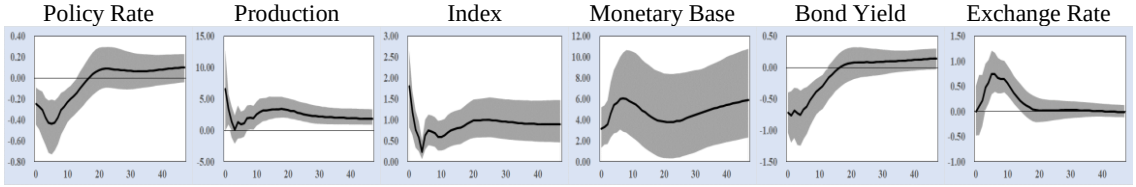
- **South Africa**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



- **Sweden**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate



- **United Kingdom**

Policy Rate | Industrial Production | Consumer Price Index | Monetary Base | 10yr Government Bond Yield | Exchange Rate