경제학석사 학위논문

Monetary Policy and Systemic Risk: Cross-Country Panel Analysis

통화 정책과 시스테믹 리스크: 국가간 패널 분석

2020년 8월

서울대학교 대학원

경제학부

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Abstract

Monetary Policy and Systemic Risk: Cross-Country Panel Analysis

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This paper examines the relationship between monetary policy and systemic risk of financial institutions. A cross-country panel vector autoregression model including monthly data of macroeconomic variables and systemic risk measured from firm-level CDS spread data is employed. There is immediate response of systemic risk to monetary tightening. When policy interest rate goes up systemic risk increases in short-run and, after then, it eventually decreases in long-run. Asset price would be a possible channel. In addition, positive systemic risk shock seems decreasing industrial production and, as for response, monetary authority decreases policy interest rate.

Key words: Systemic Risk, Monetary Policy, Macroprudential, Risk Taking Channel, Cross-Country, VAR

Student Number: 2018-29819

목 차

표 목 차

그 림 목 차

1. Introduction

The relationship between monetary policy and systemic risk of financial institutions is expensively explored in these days. As Shin (2017) mentions, since monetary policy has macroprudential aspects, the trade-off of monetary policy, such as the risk-taking channel of financial institutions, needs to be examined carefully. Moreover, as Adrian et al. (2014), systemic-wide financial disruptions are highly damaging and spread fast. In other words, abrupt increase in systemic risk might cause economic downturn, like global financial crisis, and the response of monetary authority to such shock is also an important research topic. With this respect, Borio (2014) states that it is controversial whether monetary policy should include additional independent objective, macroprudential. Therefore, the macroeconomic approach to systemic risk and monetary policy becomes important more and more.

However, most of literatures about risk-taking channel of monetary policy focus on the risk of individual banks. (Dell'Aricca et al. (2017), Ioannidou et al. (2015) etc.) There are not many literatures examining systemic-wide risk of financial institutions or of whole economy. Moreover, sparse are researches having time series perspective. Even, previous researches using quarterly time-series data are inappropriate to capture immediate response of systemic risk. At my best knowledge, there is no existing paper showing the short-run increase of systemic risk in VAR framework. I think this is because almost papers employed quarterly data and the frequency is not enough to capture the immediate response of systemic risk. Cross-country panel analysis is also rare. It is hard to meet regional comparison about systemic risk shock. Literatures about the opposite direction, the response of monetary policy to systemic risk shock, are sparse too.

To this end, this paper examines a cross-country panel vector autoregression model including monthly data of macroeconomic variables and systemic risk of financial institutions. By doing so, I figure out the immediate response of systemic risk to monetary tightening, not observed in previous papers using quarterly data. For interpretation, I check possible economic channel of the response of systemic risk. I include asset price in an extended model. This may show how monetary tightening affects systemic risk through balance-sheet effect. Since this paper examines cross-country panel data, regional comparison between Europe and some Asia countries is also explored. To do all things above, I measure systemic risk of financial firms, using firm level CDS spread data and principal component analysis technique.

I find that there is immediate response of systemic risk to monetary tightening. When policy interest rate goes up systemic risk increases in short-run, until 10th month, and, after then, it eventually decreases in long-run. The immediate increase has not been captured by previous researches. According to the result of an extended model, asset price channel seems having huge contribution to such response. After monetary tightening, asset price goes down in short-run and recovers in long-run. The short-run depreciation deteriorates balance-sheet of financial firms and this makes them deleverage. In this process, the probability of multiple simultaneous defaults of systemic important financial institutions increases.

In opposite direction, positive systemic risk shock seems decreasing industrial production and, as for response, monetary authority decreases policy interest rate. Although monetary tightening decreases systemic risk, policy interest rate would respond more to industrial production than to systemic risk, considering the target of monetary policy. Regional comparison also shows interesting characteristics of Europe and some Asia countries. To systemic risk, monetary authority of Asia countries reacts more than that of Europe. This active response causes an economy to recover faster. Such a difference in monetary stance would come from room for monetary policy. European countries keep their interest rate under 1% and this condition constrains them to decrease interest rate actively. In contrast, Asia countries maintain policy interest rate higher than that of Europe and they are still able to take comparably active reaction.

This paper is structured as follows. Section 2 looks over some related literature about monetary policy and systemic risk. Section 3 presents estimation methodology and the way how I measure systemic risk of financial institutions. Section 4 shows empirical evidence about the effects of monetary tightening on systemic risk and that of systemic risk increase on monetary stance. An extended model having asset price channel and regional comparison are also included in Section 4. We conclude in Section 5.

2. Some Related Literature

This paper would be related to following researches. There are some literatures about the risk-taking channel of monetary policy. In theoretical models, Angeloni & Faia(2013), employing a dynamic stochastic general equilibrium model, shows that when interest rate goes down the leverage ratio of banking sector increases. This is because short-term funding becomes cheaper. Dell'Ariccia et al. (2014), focusing asset risk of bank and using a static banking model, shows that banks want to hold higher risky-return asset after expansionary monetary policy. Those papers state that expansionary monetary policy would cause the increase in systemic risk of financial institutions. However, Lassen et al. (2017), employing a new Keynesian model, argues that, after the unexpected increase in interest rate, systemic risk does not seem to necessarily reduce. In empirical part, Altunbas et al. (2017), using individual bank risk panel data, states that when the difference between real money market interest and natural rate increases the individual bank risk significantly goes down. In addition, most recently, Faia et al. (2019) which measures lots of indicators of systemic risk and employs a vector autoregression model, shows that monetary tightening decreases systemic risk, though there is lag.

How macroeconomic variables react to systemic risk shock is also a topic explored by some authors. De Nicolo et al. (2010) shows that the increase in systemic risk caused by constraints in the aggregate supply of credit is not a key driver of the recession of real activity during global financial crisis. Ranciere et al. (2010) argues that, across European countries, higher systemic risk measured by currency mismatch fosters economic growth in tranquil time but induces severe downturn in economic crisis. Giglio et al. (2016) shows that both financial and aggregate volatility shock contract industrial production. Most recently, Jin & Nadal De Simone (2020) explores the relationship in the context of financial market that the increase in systemic risk induces higher volatility of real estate funds and bond funds.

3. Methodology

In this section, I construct a panel vector autoregressive model to identify monetary policy shock and examine its effect on systemic risk of financial institutions.

3.1 The Panel VAR Model

Assume that an economy of country $i (i = 1, 2, \ldots C)$ is described by the structural form equation below:

$$H(L)\,y_t^i = f^i + D(L)x_t + u_t^i \tag{1}$$

$H(L)$ and $D(L)$ are matrix polynomials and L is the lag operator. y_t^i is a $N \times 1$ data vector of endogenous variables and x_t^i is a $X \times 1$ data vector of exogenous variables for time t and country i respectively.

N and X are the number of endogenous and exogenous variables. f^i is a $N\times 1$ constant matrix for individual fixed effect of each country to control for country-specific factors that are not captured in this model. Let me assume structural disturbances are mutually uncorrelated. Then, var(u_t^i) can be denoted as a diagonal matrix Λ having the diagonal elements as the variances of structural disturbances.

In this paper, the following reduced-form panel VAR is estimated.

$$y_t^i = c^i + G(L)y_{t-1}^i + E(L)x_t + e_t^i \tag{2}$$

$G(L)$ and $E(L)$ are matrix polynomials and L is the lag operator. c^i is a $N\times 1$ constant vector and e_i^t is a $N\times 1$ reduced form residuals. var (e_i^t) is the variance-covariance matrix of reduced form residuals, Σ, having the diagonal elements as the variances and other elements as the covariance of each pair.

The identification follows recursive zero restrictions on contemporaneous structural parameters by applying Cholesky decomposition to Σ as in Sims (1980). By doing so, parameters in the structural-from can be recovered from that in the reduced-form.

3.2 The Empirical Model

This paper employs monthly data set and takes cross-country panel analysis.[1] Because of availability, the data set covers from 2008m4 to

1) Here is the list of country: Austria, France, Germany, Greece, India, Ireland, Italy,

2016m12. In the benchmark model, the endogenous variables are [IP, CPI, POLRATE, SYSRISK]. Since the main topic of this paper is analyzing the impact of monetary policy shock, I include the policy interest rate (POLRATE) as a policy instrument. I also include consumer price index (CPI) and Industrial production (IP) as policy target variable of inflation targeting central banks and as a measure of overall economic activity. Most importantly, systemic risk of financial institutions (SYSRISK), the main variable, is included. This is motivated by the nature of monetary policy that changes asset price and bank leverage.[2] Moreover, some researches argue that the increase in systemic risk bothers economic activities.[3] For the source of data, policy rate, CPI and IP are obtained from IMF IFS, World Bank GEM and monetary authorities. Systemic risk is measured by author calculation using CDS spread data of financial institutions.

The vector of exogenous variable is [USIP, FFR] where USIP and FFR are industrial production and federal funds rate of the United States. Because economic activity and monetary policy in the United States has an impact on the financial conditions, economic activity and monetary policy in other countries, USIP and FFR are included to capture the cross-border impact.[4] USIP and FFR are obtained from World Bank GEM and Wu-Xia Shadow Interest Rate respectively.

As identification, macrovariables in the vector of endogenous

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Japan, Republic of Korea, Malaysia, Netherland, Norway, Russia, Singapore, Spain, Sweden, Turkey, United Kingdom.

2) Such as Faia et al. (2019), and some other literature about global financial crisis.

3) Altunbas et al. (2014), Altunbas et al. (2017), Festic et al. (2013) etc.

4) There are some researches of cross-border impact: Kim and Shin (2015), Chen et al. (2016) and McCauley et al. (2015).

variable (IP and CPI) are set to be contemporaneously exogenous to POLRATE. This ordering allows that monetary authority chooses monetary policy instrument after observing the current economic activity as shown in the macrovariables. This identification may be considered as an extension of the model by Christiano, Eichenbaum and Evans (1999). In the model, monetary authority sets monetary policy stance after observing the current and lagged values of macroeconomic variables. SYSRISK is set behind POLRATE. Since the ultimate goal of this paper is to explore the 'immediate' impact of monetary policy on systemic risk, POLRATE should have contemporaneous effect on SYSRISK. As systemic risk possibly influences on macrovariables but financial variable moves fast, IP and CPI are also contemporaneously exogenous to SYSRISK.[5] Lastly, referring other papers and the characteristics of monthly data, I set lag as 6.

Thus, this identification allows monetary authority to set policy interest rate considering macroeconomic variables and also allows this responsive action to have impact on systemic risk of financial institutions. The theoretical New-Keynesian model by Lassen et al (2017) similarly considers the monetary policy rule which bothered by the presence of falling asset price.

Since this identifying assumption is controversial, I estimated the model under several alternative identifying assumptions and the results are similar. Most importantly, the effect of POLRATE on SYSRISK is similar when I change the order of variables. For

5) According to Faia et al (2019), the risk co-dependency attributed to macreconomic externalities can be captured well in the suggested framework.

example, when I change the ordering between POLRATE and SYSRISK the short-run and long-run response of systemic risk is similar to that of the benchmark model. Even, the result is not much different when I include short-term interest rate or overnight interbank interest rate instead of policy interest rate. Those results are attached in the appendix.

3.3 How to measure 'Systemic Risk?'

Systemic risk is invisible and not real thing to observe. This is a kind of conceptual variable in financial market. Therefore, there are various definitions of it and various methods to measure. I borrow this section to explain how I define and measure systemic risk of financial institutions.

There are various definitions of systemic risk and I provide some examples below. According to Huang et al. (2009) and Emerging Markets and the Global Economy: A Handbook (2014), systemic risk is defined as *"multiple simultaneous defaults of large financial institutions."* De Nicolo & Lucchetta (2010) defines systemic financial risk as *"the risk that a shock will trigger a loss of economic value or confidence in, and attendant increases its uncertainty about, a substantial portion of the financial system."* One definition of systemic risk from Billio et al (2012) is *"any set of circumstances that threatens the stability of or public confidence in the financial system."* In this paper, referring Huang et al. (2009), systemic risk is defined as **"the probability of multiple simultaneous defaults of systemic important financial institutions"**. This approach seems reasonable because the multiple simultaneous defaults mean the systemic-wide disastrous shock on financial and real market. In addition, market participants experience loss of confidence and economic value when the probability increases. Lastly, the increased probability threatens the stability in the financial system.

How to measure the systemic risk above? I measure it as **"the first principal component (FPC) of credit default swap (CDS) spread of financial institutions of each country."** According to Heung et al (2009), systemic risk needs to be measured by market-based measurement. It is usually forward-looking. Changes in market anticipation and valuation on future performance of the underlying institutions are reflected in the asset price movement. Moreover, high frequency measures should be considered to capture the sudden materialization of systemic risk, both from market level and individual institution level. Since CDS spread shows the probability of default of certain entity and high frequent market-based measurement, the price of systemic important financial institutions can properly capture the default probability information. The probability of multiple simultaneous defaults can be obtained from FPC. Also, CDS spread is extensively used variable to measure systemic risk.[6] To figure it out, I employed principal component analysis (PCA). Billio et al. (2010) states that, by using PCA, commonality of interest variables can be empirically detected. Moreover, FPC is the direction along which the data have the most variance. The tendency of securities to rise and fall together as an asset class and the same movement are explained by market factor.

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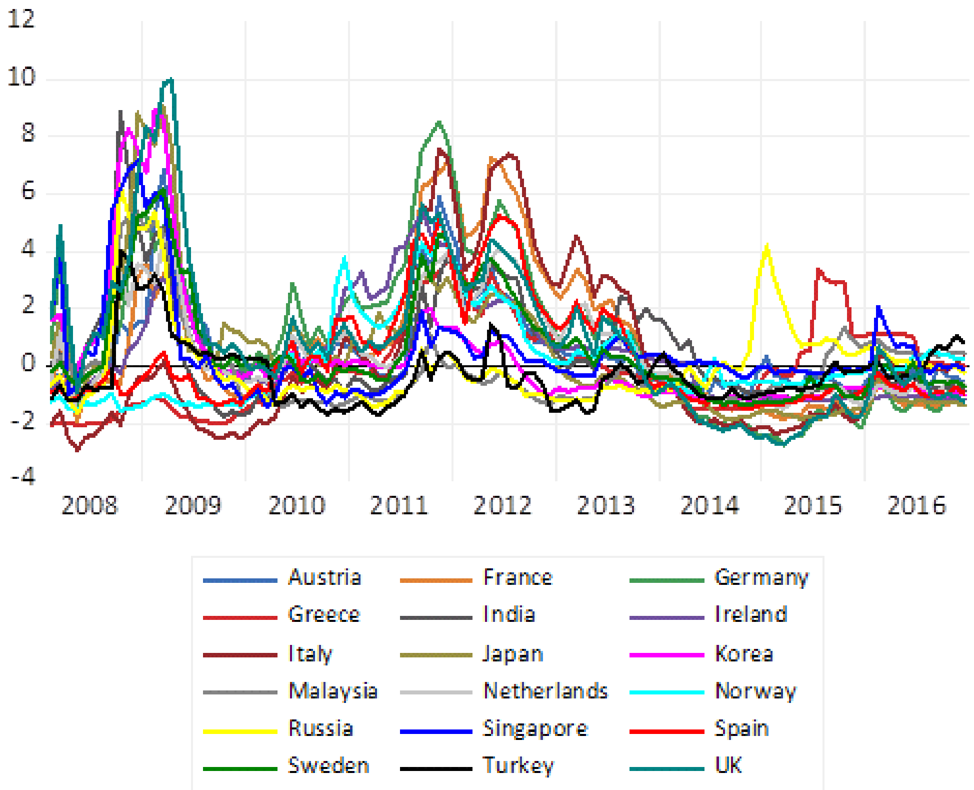
6) Even, Rodriguez-Moreno & Pena (2013) does not report the group of authors using FPC of CDS for systemic risk measurement, stating it is widely employed measure.

Again, FPC contains the common driver of the default risk in the whole portfolio, showing the impairment risk of the portfolio. Therefore, FPC can be interpreted as systemic-wide co-movement of the probability of default risk. Summing up, following Billio et al. (2010), systemic risk can be measured by FPC of CDS spread of financial institutions.[7)]

Figure 1: Systemic Risk of Financial Firms of Each Country



Note. This shows the standard normalized systemic risk of each country. The level on the axis can be interpreted as standard deviation. FPC of each country explains about 85% of the movement of CDS spread of financial institutions. Time sample: 2008m4~2016m12

Source. Author's calculation

7) The list of financial institutions of each country is included in the appendix.

Actually, this approach is still controversial. According to Rodriguez-Moreno & Pena (2013), FPC of CDS spread is the best macro-perspective measure for systemic risk and outperforms other measures obtained from interbank rate or stock market prices. In contrast to this, Bisias et al. (2012) argues that the difference of each method matters and FPC of CDS is a kind of microprudential measurement. However, because of data availability and the lack of research to compare each approach, I take the method above to construct monthly systemic risk series data.

4. Estimation Results

4.1.1 Main Result: Policy Rate Shock

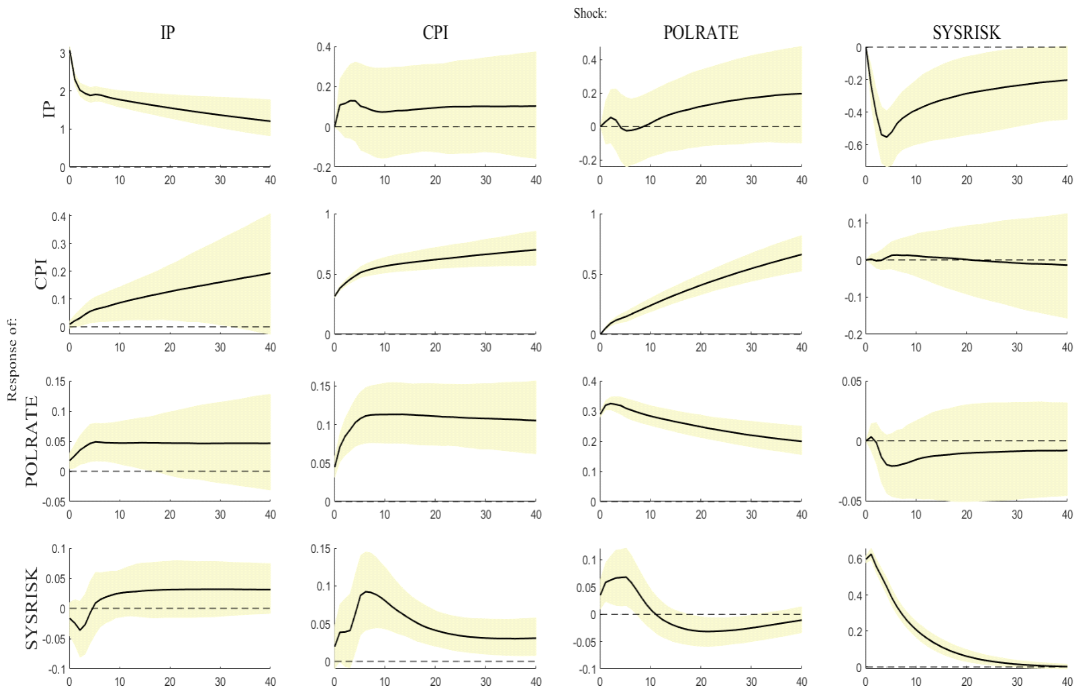
Figure 2 shows the estimation result of the benchmark model. All impulse response from the estimated system are with 95% confidential interval. Each column of the graph shows the responses of four endogenous variables to a different shock. Our focus is on the response SYSRISK to POLRATE shock, shown in the third column of the graph.

First, when POLRATE goes up 0.3%p IP fluctuates around zero in short run and it seems to go up even though it is insignificant. CPI shows 'price puzzle.'[8] SYSRISK significantly increases at most 0.07 standard deviation from 1st month to 8th month(short-run) and decrease at most 0.04 standard deviation from 14th month to 35th

8) Since some papers also have the 'price puzzle', I go with it.

month(long-run). The long after decrease is similar to other previous literatures, such as Faia et al. (2019). They argue that, considering risk-taking channel, in simple, the concept of negative relationship between interest rate and leverage ratio, monetary tightening requires financial firms to deleverage and decreases systemic risk. Since there is time lag for deleveraging, systemic risk of financial firms decreases long after the tightening.

Figure 2: Benchmark Panel VAR



Note. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings. To draw this impulse responses, I referred BEAR Toolbox 4.2.

Source. Author's calculation

What about the short-run increase in systemic risk? This positive sign has not been captured in previous researches using quarterly data. In other words, monthly frequency enables to observe the response. There might be some immediate effects. Surprisingly, this is also explained by risk-taking channel of financial institutions and balance-sheet effect. Considering asset price determined by sum of discounted value of future cash flow, the increase in interest rate will bring depreciation. According to Mishikin (2011), the depreciation causes net worth of constrained firms and banks to decrease and leverage ratio of each firm to increase. From this balance sheet deterioration, financial institutions have incentive to deleveraging in order to reach BIS capital adequacy ratio. However, deleveraging needs time to be taken and financial institutions are exposed to immediate risk from balance sheet deterioration. In this point, constrained firms and financial institutions confront financial tightness of money and they got higher chance to bankrupt than before. Therefore, this immediate risk may cause the short-run increase in systemic risk.

A forecasting error variance decomposition for POLRATE shock is also calculated. Table 1 reports the results with 95% probability bands. POLRATE shock explains the volatility of IP as at most 3% in 40^{th} month. It explains CPI as 31% in 95% confidential interval in 40^{th} month. Importantly, the volatility of SYSRISK is explained by POLRATE as at most 4% in 40^{th} month. Considering highly auto-correlated nature of financial variable, policy interest rate shock explains significant portion of systemic risk of financial institutions.

Table 1: forecasting error variance decomposition for policy interest rate shock

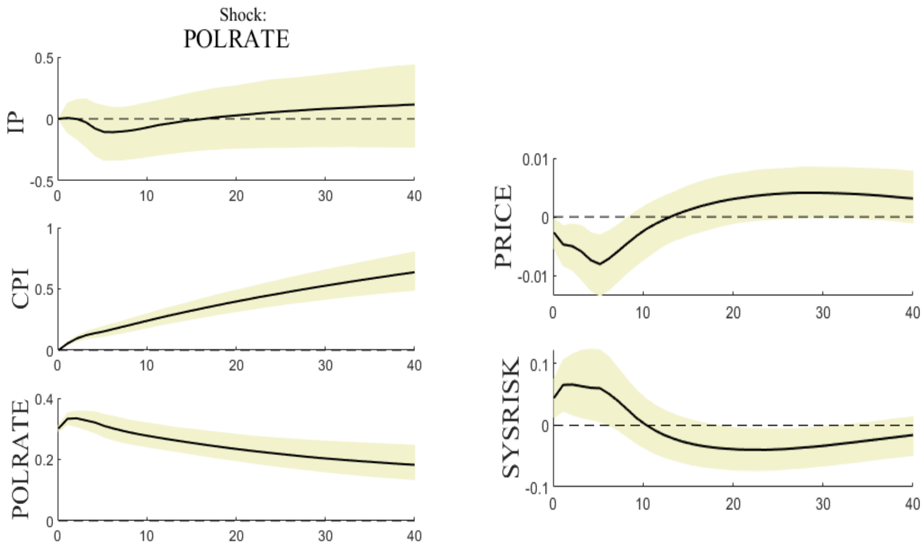
Horizon	IP	CPI	POLRATE	SYSRISK
1	0.0000	0.00	0.97	0.003
	[0.000, 0.000]	[0.00, 0.00]	[0.95, 0.98]	[0.000, 0.011]
5	0.0008	0.04	0.92	0.011
	[0.000, 0.005]	[0.02, 0.07]	[0.88, 0.95]	[0.001, 0.031]
10	0.0011	0.08	0.88	0.014
	[0.000, 0.013]	[0.05, 0.13]	[0.82, 0.93]	[0.002, 0.041]
20	0.0022	0.17	0.85	0.016
	[0.003, 0.015]	[0.11, 0.25]	[0.77, 0.91]	[0.005, 0.040]
40	0.0068	0.31	0.81	0.022
	[0.003, 0.037]	[0.22, 0.42]	[0.70, 0.89]	[0.007, 0.046]

Note. The number on the above of parenthesis is the median of the value of forecasting error variance decomposition. The numbers in the parenthesis shows the 95% confidential interval.
Source. Author's calculation

4.1.2 Asset Price Channel

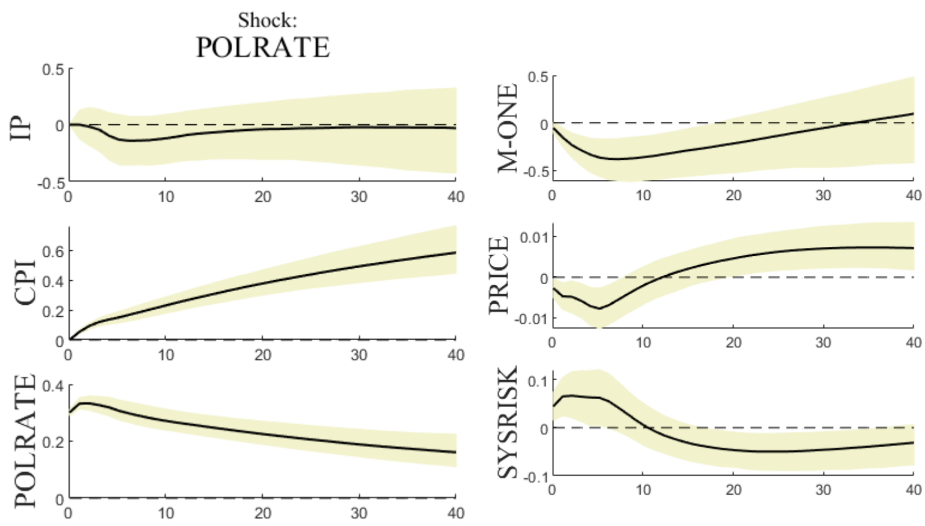
I check whether asset price channel works in the mechanism I suggested above. Figure 3 shows the extended model having endogenous variables [IP, CPI, POLRATE, PRICE, SYSRISK]. PRICE means asset price and I employed equity price index data of each country from OECD for asset price variable. I set asset price variable between policy interest rate and systemic risk of financial institutions. This identification would be helpful to check PRICE as a 'channel' of how monetary policy influences on systemic risk. Moreover, asset price is likely to be affected by policy interest rate and it determines high portion of the fluctuation of systemic risk according to Mishikin (2011). Increasing discount rate, monetary contraction decreases asset price at most 0.9% from 1st month to 8th month. Asset price recovers after 10^{th} month even though it is statistically insignificant. This result matches to the interpretation in the benchmark model. The decrease in asset price seems to be in line with the increase in systemic risk. This is also the same scenario of credit crunch and global financial crisis. In the long run, the end of the adjustment of leverage ratio and the recovery of the asset price result in the decrease of the systemic risk. In a nut shell, the up and down of systemic risk caused by monetary tightening might be influenced by the result of asset price fluctuation and deleveraging of financial institutions.

Figure 3: Extended VAR with Asset Price channel



Note. Because of data availability of asset price, I exclude India, Malaysia and Singapore, and housing price index of each country is not considered. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.
Source. Author's calculation

Figure 4: Extended Model with M1



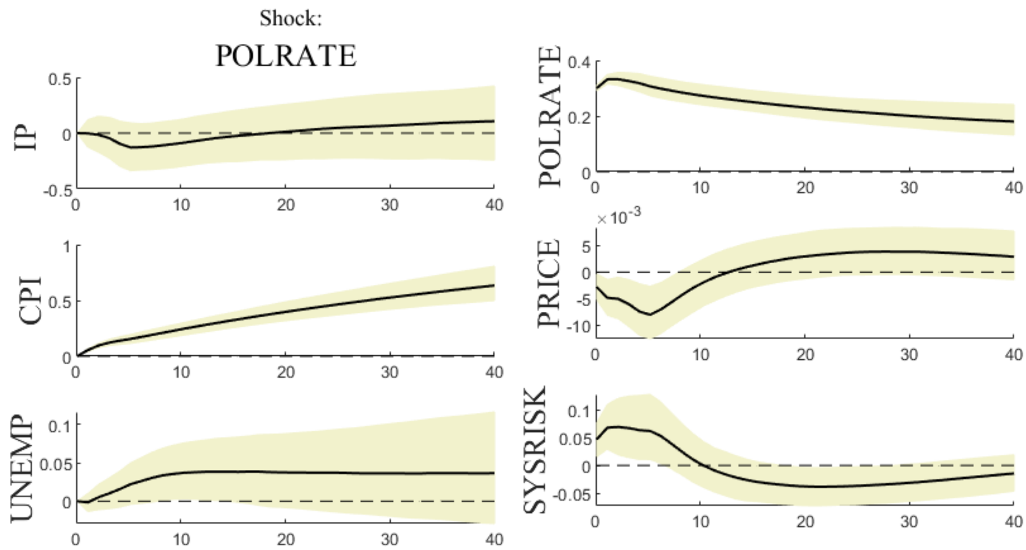
Note. Because of data availability of asset price, I exclude India, Malaysia and Singapore, and housing price index of each country is not considered. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.
Source. Author's calculation

I add two other variables to the extended model. The first one is M1 in order to check whether the identification for the asset price channel is justified. Figure 4 shows the result of additional extended model having endogenous variables [IP, CPI, POLRATE, M-ONE, PRICE, SYSRISK]. M-ONE means M1 of each country and this data comes from World Bank GEM database. I set M-ONE between POLRATE and PRICE. This is because monetary amount is one of the intermediate target of monetary policy and asset price variation is one of the result of it. To monetary tightening, M1 decreases about 0.4% at 8th month. With this additional variable, there is no significant change of the response of asset price and systemic risk.

This means, omission of money amount variables in the Figure 3 does not have crucial effects on the monetary policy shock identification. Lastly, the interest thing is that, after systemic risk begins to decrease, the contraction of M1 becomes statistically insignificant. This might the result of the stop of deleveraging of financial institutions.

4.1.3 Labor Market

Figure 5: Extended Model with Unemployment Rate



Note. Because of data availability of asset price, I exclude India, Malaysia and Singapore, and housing price index of each country is not considered. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.
Source. Author's calculation

In addition, I include unemployment rate to check how labor market reacts to monetary shock and systemic risk variation. This model is [IP, CPI, UNEMP, POLRATE, PRICE, SYSRISK]. UNEMP means unemployment rate and I acquire this data from monetary authorities of each country. I set unemployment rate before policy interest rate. Monetary authorities sometimes consider unemployment rate as one of target variables related to inflation. Moreover, in that position, unemployment rate can be determined by past systemic risk variation and the responses of overall economic activity. After increasing policy interest rate, unemployment rate increases 0.008%p at 10^{th} month. When systemic risk begins to decrease the icreases in unemployment rate becomes statistically insignificant. The short response after 10 month seems the lagged reaction to the increase in systemic risk.

4.2.1 Additional: Systemic Risk Shock

Here, we check how POLRATE reacts to SYSRISK shock. The result of fourth column in Figure 2 shows that monetary authority takes expansionary policy to stimulate economy after economic recession caused by the surge of systemic risk of financial institutions. When SYSRISK increases at most 0.65 standard deviation from 1^{st} to 25^{th} month, IP and POLRATE decreases about 0.5% and 0.03%p respectively. Even though the response of POLRATE is statistically insignificant, the median has negative sign. CPI does not variate much. This result is similar to the negative relationship between GDP and bank risk in Altunbas et al. (2017) and the situation of credit crunch, like global financial crisis. With high probability of defaults, there is incentive for financial institutions to deleveraging and stopping funding for some marginal business. This action causes non-financial firms, such as manufacturing, to be kept in short of money and balance-sheet deterioration. As a result of the credit crunch, some of them are forced to stop expanding their own business or, even, close their production facilities. At the demand side, household and firms will experience short funding for consumption and investment. In this context, the decrease in POLRATE is interpreted as the reaction of monetary authority. After this recession, monetary authority decides to keep decreasing policy interest rate to stimulate economy.

Table 2: forecasting error variance decomposition for systemic risk shock

Horizon	IP	CPI	POLRATE	SYSRISK
1	0.00	0.00	0.00	0.99
	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.98, 0.99]
5	0.03	0.00	0.00	0.97
	[0.01, 0.05]	[0.00, 0.00]	[0.00, 0.01]	[0.95, 0.99]
10	0.04	0.00	0.00	0.95
	[0.02, 0.07]	[0.00, 0.00]	[0.00, 0.02]	[0.91, 0.98]
20	0.04	0.00	0.00	0.93
	[0.01, 0.08]	[0.00, 0.01]	[0.00, 0.02]	[0.88, 0.96]
40	0.03	0.00	0.00	0.90
	[0.01, 0.08]	[0.00, 0.02]	[0.00, 0.03]	[0.84, 0.95]

Note. The number on the above of parenthesis is the median of the value of forecasting error variance decomposition. The numbers in the parenthesis shows the 95% confidential interval.
Source. Author's calculation

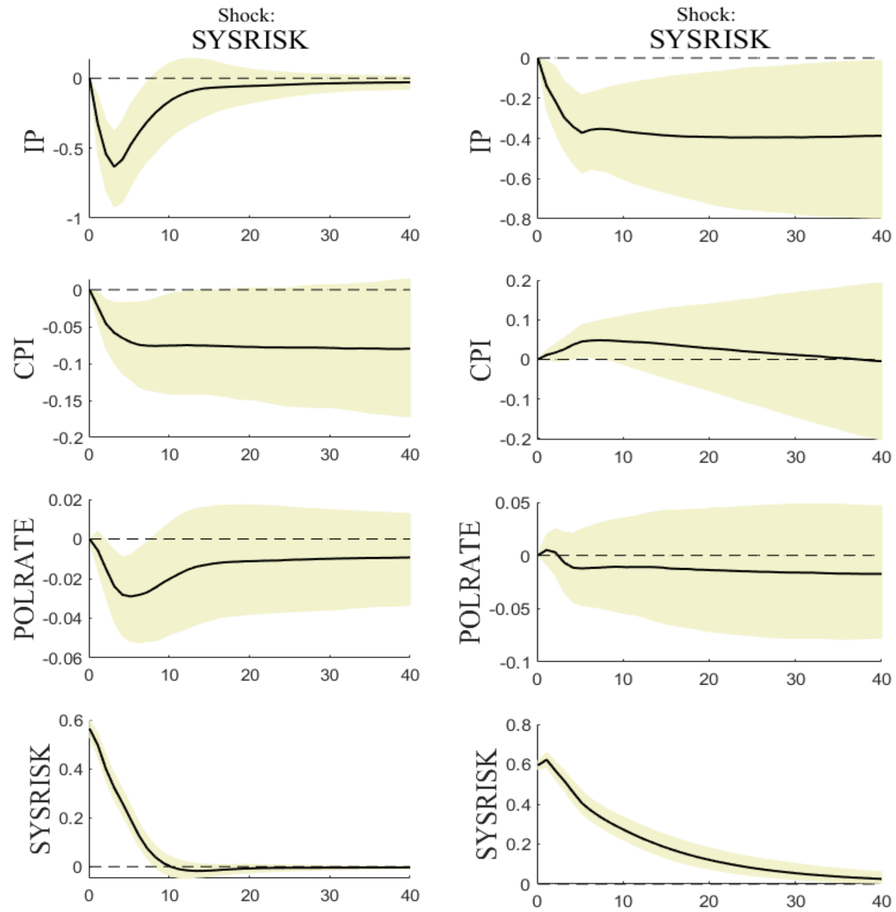
To infer the importance of the systemic risk in explaining the volatility of other variables, a forecasting error variance decomposition is calculated. Table 2 reports the results with 95% probability bands.

Because of the nature of financial variables, the explanatory power of SYSRISK is very small. SYSRISK shock explains the volatility of IP as 3% or 4% in 40^{th} month. However, it explains CPI and POLRATE at most 2% or 3% in 95% confidential interval in 40^{th} month. This indirectly shows that SYSRISK shock is much more related to IP than POLRATE. In other words, systemic risk of financial firms significantly reduces industrial production, but policy interest rate responses not to systemic risk shock itself but to the recession regarded as the decrease in industrial production.

4.2.2 Regional Comparison

In addition, I explore the regional difference of the response of variables to SYSRISK shock. The left graph is the response of Asia countries and the right one is that of Europe. The most conspicuous difference is in the response of IP and POLRATE. In Asia countries, to positive one standard deviation SYSRISK shock, POLRATE decreases 0.35%p and IP decreases 0.6% at 5th month. However, the decrease in IP is statistically insignificant from 9th month. In other words, Asia countries keep IP from contracting within 10 months. The expansionary monetary policy maintains, though it is statistically insignificant. CPI decreases -0.8% at 6th month. In contrast, in Europe, there is no such activate monetary expansion, like Asia countries. To SYSRISK shock, POLRATE does not show any statistically significant results. IP persistently decreases, about 0.3%, after the systemic risk shock occurs. CPI persistently shows insignificant response. SYSRISK shock is more persistent than that of Asia countries.

Figure 6: Regional Comparison of Benchmark VAR Model



Note. The left is for Asia countries and the Right is for Europe. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.

Source. Author's calculation

For interpretation, we need to consider time period of data, from 2008m4 to 2016m12. In that period, examined Asia countries have more room for monetary expansionary policy than Europe countries.

Except Turkey and Russia, policy interest rate of European countries is 1% or less from 2009m4. This number is quite less than that of Asia countries. Countries in Asia can take comparably active monetary expansionary policy to recover IP contraction. Although the amount of the immediate decrease of IP in Asia countries is much more, the possibility of active monetary policy enables them to promptly recover from economic recession caused by the increase in systemic risk. This reaction makes systemic risk shock less persistent. On the other hand, European countries cannot take expansionary monetary policy actively. The decrease in policy interest rate is less significant than that of Asia countries. As a result, in Europe, contraction of industrial production and systemic risk shock are more persistent. Summing up, each region has different room for monetary policy and this discrepancy causes how monetary authority reacts to systemic risk shock and how economic recovers.

5. Conclusion

The relationship between monetary policy and systemic risk of financial institutions is expensively explored in these days. As Shin (2017) mentions, since monetary policy has macroprudential aspects, the trade-off of monetary policy, such as the risk-taking channel of financial institutions, needs to be examined carefully. Moreover, in contrast, as Adrian et al. (2014), systemic-wide financial disruptions are highly damaging and spread fast.

This paper examines the relationship between monetary policy and systemic risk using a cross-country panel vector autoregression model including monthly data of macroeconomic variables and systemic risk of financial institutions measured from firm level CDS spread data. First, I examined the response of systemic risk to monetary tightening. I find that there is immediate reaction of systemic risk. When policy interest rate goes up systemic risk increases in short-run, until 10th month, and, after then, it eventually decreases in long-run. According to the result of an extended model, asset price channel seems having huge contribution to such response.

Second, I explored the opposite direction, the response of policy interest rate to systemic risk shock. Positive systemic risk shock seems decreasing industrial production and, as for resopnse, monetary authority decreases policy interest rate. Regional comparison also shows interesting characteristics of Europe and some Asia countries. To systemic risk, monetary authority of Asia countries reacts more than that of Europe. This active response causes an economy to recover faster. Such a difference in monetary stance would come from room for monetary policy. European countries keep their interest rate under 1% and this condition constrains them to decrease interest rate actively. In contrast, Asia countries maintain policy interest rate higher than that of Europe and they are still able to take comparably active reaction.

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Appendix

A.1 The list of financial institutions.

When I constructed systemic risk time series data, I employed CDS spread and premium data of financial firms in Table A1.

Table A1: the List of Financial Firms

Country	Financial Firms
Austria	Erste Group bank, RZB group, unicredit bank austria AG, Bawag P.S.K, Raiffeisen Bank International AG, Oesterreichische Kontrollbank AG, Raiffeisen Bank Niederosterreich, OberBank AG, HYPO NOE Gruppe, Adria Bank AG, Advicum Consulting GmbH, ALARIS AG, Austrian Andi Bank
Belgium	Asphales, Bancontact Payconiq Company, Eufiserv, Euroclear, Europay International, Fortis Carbon Banking Services, Keytrade Bank, Sofina, Solvac
Canada	CanDeal, Equirex, Great-West Lifeco, Monex Group, Interac, Primerica, Zafin
Chile	C.S. Fondy, Emma Capital, Home Credit, NN Penzijni Spolecnost
Denmark	Danske Bank, FIH A S Fin For Danish Ind, Nordea Bank Danmark, Cophenhagen Infrastructure Partners, Former Building Societies of Denmark
France	Wendel, Thales, Scor Se, Gecina, Auchan Holdings, Dexia Credit Local, Axa, Banque Psa Finance, Credit Lyonnais, Societe Generale, Credit Agricole, BNP Paribas, Natixis
Germany	Portigon, Deutsche Bank, Commerzbank, Bayerische Landesbk, Hamburg Coml Bank, Linde, Hannover Rueck, Deutsche Post, Munich Reinsurance, Henkel & Co KGAA, Kabel Deutschland, Allianz Se
Greece	Alpha Bank, National Bank of Greece, Hellenic Rep

India	Icici Bank Limited, Bank of India LTD, India Overseas Bank, State Bank of India, Housing Development Finance Corporation LTD, India Rwy Fin Corp Ltd
Ireland	Bank of Ireland, Allied Irish Banks, Smurfit Kappa, Ono Fin PLC, Ono Finance II PLC, Permanent TSB PLC
Italy	Banca Monte Paschi, Intesa Sanpaolo SPA, Medibanca SPA, Bca Naz Del Lavoro, Assic Geni - So, Atlantia S.P.A., CIR SPA - Cie Indi
Japan	Mizuho Bank LTD, Sumitomo Mitsui BKC, MUFG Bank LTD, Norinchukin Bank LTD, Nomura Holdings, Mitsui Sumimoto INS, Matsui SECS Co LTD, ACOM CO.LTD, Hitachi Capital Corporation, Daiwa Securities GP, Tokio M&Fins Co LTD
South Korea	Shinhan Bank, National Agriculture Cooperative federation, Kookmin Bank, Hana Bank, Industrial Bank of Korea, Korea Deposit Insurance CR
Malaysia	Malayan Bkg Berhad, Cimb Bank Berhad, Cimb Investment Bank Berhad, Genting Bhd
Netherlands	Ing Bank N.V., Coop Rabobank, De Volksbank, Duplicatte of Abn, Aegon N.V., The Nielsen Co B.V., Nielsen Fin LLC, Nelsen Fin Group Inc, Ing Group N.V., SNS Bank, Suedzucker International Fin Bank
New Zealand	Hanover Compressor Co, ANZ Bank New Zealand, Rabobank, FMG, IAG New Zealand
Norway	Banco Com Portugues, BNC Espirito Santo
Singapole	DBS Bank LTD, DEV Bank Singapore, United OS BK LTD, Oversea-Chinese BKC
Spain	BBV Argentina, Banco De Sabadell, Banco Pop Espanol, Bankinter SA, Cda Cel Mediterraneo
Russia	Sberbank of Russia, Bank of Moscow, Russian Agric Bank, Russian Ministry Fin
Sweden	Nordea Bank, Svenska HB, Skandinaviska Ensk Bnkn, Investor Aktiebolag, Swedish Natl Hsg Fin, Swedbank

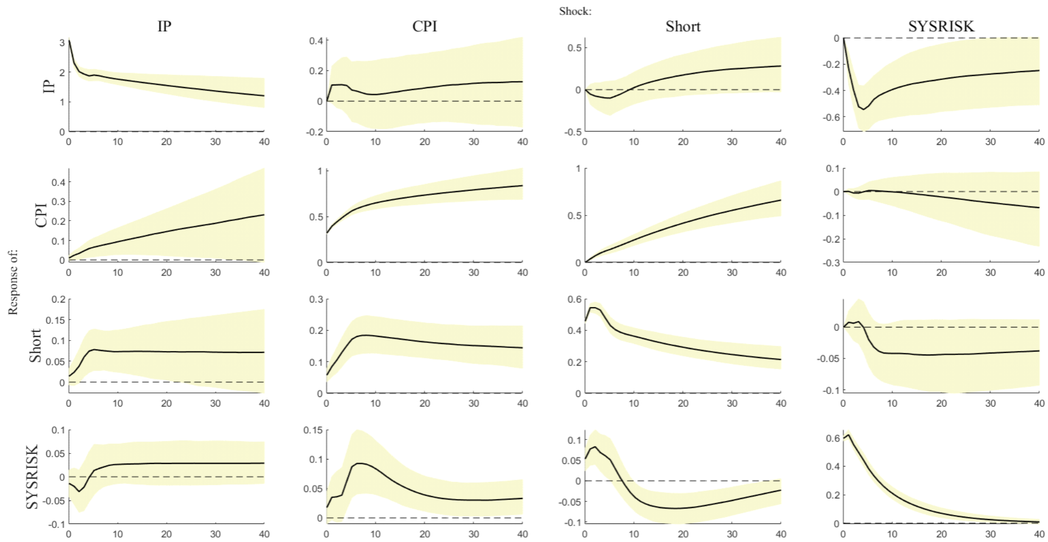
Turkey	Turkiye Is Bankasi, Turkiye Garanti Bankasi, Akbank Turk Anonim
United Kingdom	Lloyds Bank, HSBC Bank, Barclays Bank, Natwest Markets PLC, Standard Charted Bank, Brush Holdings LTD, WPP 2005 Limited, GKN Holding LTD, Anglo American PLC, Nationwide BS, Legal & Gen GP PLC, MZ UK HDG.& SRVS., Experian Finance, Aviva PLC, UTD Utilities PLC.

A2. Robustness Check

Here is robustness check of the benchmark model. First, instead of policy interest rate, I include short-term interest rate and overnight interbank interest rate as depicted in Figure A1 and Figure A2 respectively. Moreover, I calculate new systemic risk series from CDS 'premium' data. The result of a model including the new series is Figure A3. Moreover, I examined the benchmark model with various time lags. Figure A4 shows the results from different lags. There is some difference in significance of each response. Overall, all responses show similar results to that of the benchmark model.

Figure A5 shows the benchmark model with different ordering, [IP, CPI, SYSRISK, POLRATE]. Every result is the same but the response of monetary policy to systemic risk. In benchmark model, systemic risk has effects on policy interest rate through industrial production and consumer price index. It is possible that, since industrial production decreases after the increase in systemic risk, monetary policy reacts to recover overall activity. In contrast, in the model with different ordering having systemic risk before policy interest rate, systemic risk shock has an effect on monetary stance first. To this immediate shock, monetary authority set tightening policy to reduce systemic risk, though this reaction is statistically insignificant.

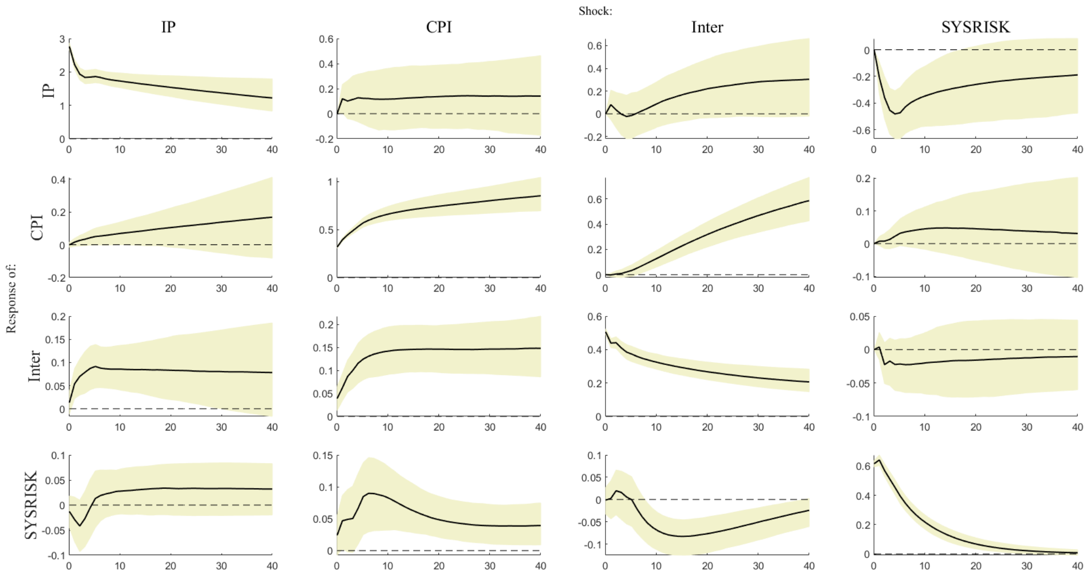
Figure A1: Benchmark VAR Model with Short-Term Interest Rate



Note. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.

Source. Author's calculation

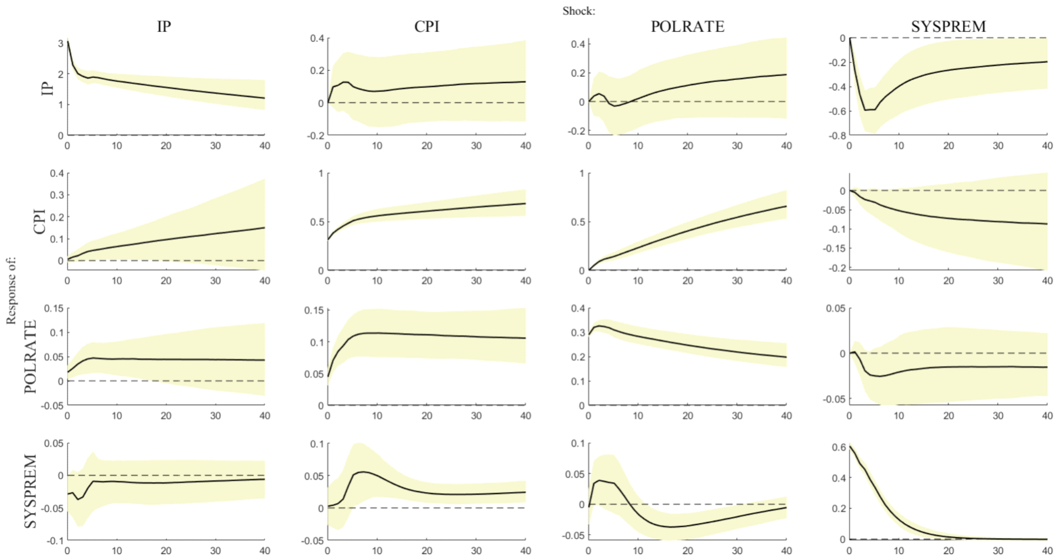
Figure A2: Benchmark VAR model with Overnight Interbank Interest Rate



Note. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.

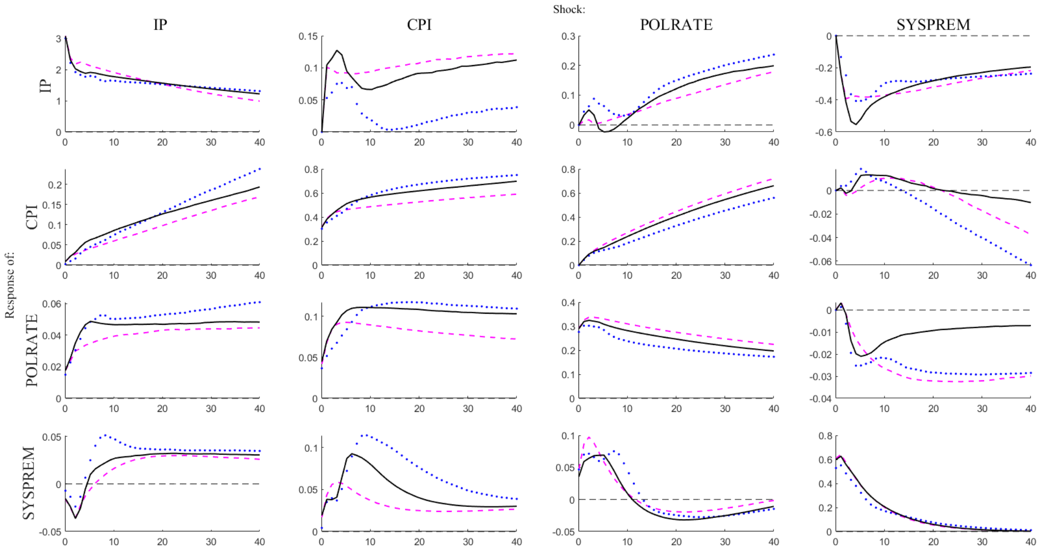
Source. Author's calculation

Figure A3: Benchmark VAR Model with New Systemic Risk Series Computed from CDS ‘Premium’



Note. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.

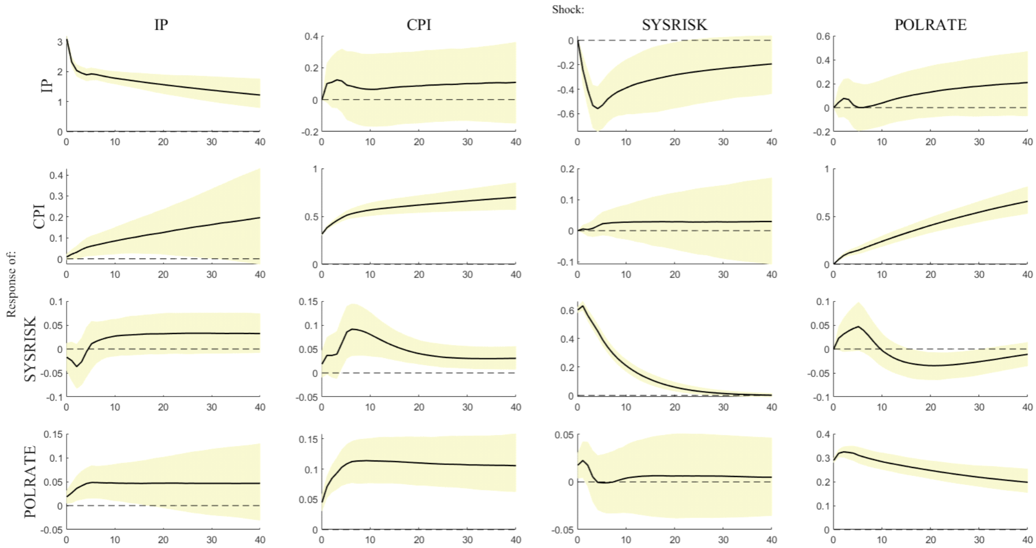
Figure A4: Different Time Lags Comparison



Note. The dash-single dotted purple line has lag 3; the black line has lag 6; the dotted blue line has lag9.

Source. Author's calculation

Figure A5: Benchmark Panel VAR with Different Ordering



Note. The ordering is [IP, CPI, SYSRISK, POLRATE]. The shaded gray areas are the two standard deviation confidence bands from a residual-based 2000 bootstrap repetitions. The bold line is the medium of the drawings.
Source. Author's calculation

국문 초록

통화 정책과 시스테믹 리스크: 국가간 패널 분석

성 명: 이 연 직

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본 연구를 통해 통화 정책과 금융기관들의 시스테믹 리스크의 관계를 살펴보았다. CDS 스프레드 데이터를 이용해 구축한 시스테믹 리스크 월별 데이터와 거시경제 변수 월별 데이터를 이용했고, 국가간 패널 자기회귀모형 분석을 실시했다. 기존 연구들과는 다르게 통화 긴축 정책에 대해 시스테믹 리스크의 즉각적인 움직임이 관찰되었다. 정책 이자율 상승 시 비교적 단기간에는 시스테믹 리스크는 증가하지만 시간이 지남에 따라 점점 감소한다. 이러한 움직임의 가능한 원인 중 하나로 자산 가격 경로를 살펴보았다. 반대의 경우로는, 시스테믹 리스크가 증가하는 경우에 산업 생산은 감소하고 이에 대한 반응으로 정책 이자율은 낮아졌다.

키워드 : 시스테믹 리스크, 통화 정책, 거시안정성, 위험선호경로, 국가간 분석, 벡터자기회귀

학번 : 2018-29819