Monetary Policy and Income Inequality in Korea

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This paper analyzes the relationships between monetary policy and income inequality in Korea. We calculate Gini coefficient for various income range using data from the Household Income and Expenditure Survey and then estimate a block-exogeneity VAR representing Korean and US economies to examine the effects of monetary policies on income inequality. The results show that following a one-standard deviation contractionary (expansionary) monetary policy shock, market income Gini coefficient increases (decreases) significantly after one year, reaching its peak to 0.0014 (0.14%p) while GDP and CPI decrease (increase) significantly by 0.48% and 0.15%, respectively. The contributions of monetary policy shocks to income inequality are found to be small as shown by forecast error variance and historical decompositions. In addition, earnings heterogeneity channel is most important among various channels through which monetary policy affects income inequality. Finally, a counterfactual analysis implies that if Bank of Korea held the call rate constant at 5.13% from 2008:Q3 and thereafter, the average of market income Gini coefficient would be higher by 0.009 (0.9%p) during 2008:Q4 - 2015:Q1 under the assumption of static expectations.

Keywords: Monetary Policy, Income Inequality, Block-exogeneity VAR

JEL Classification Numbers: E5, E4, C1

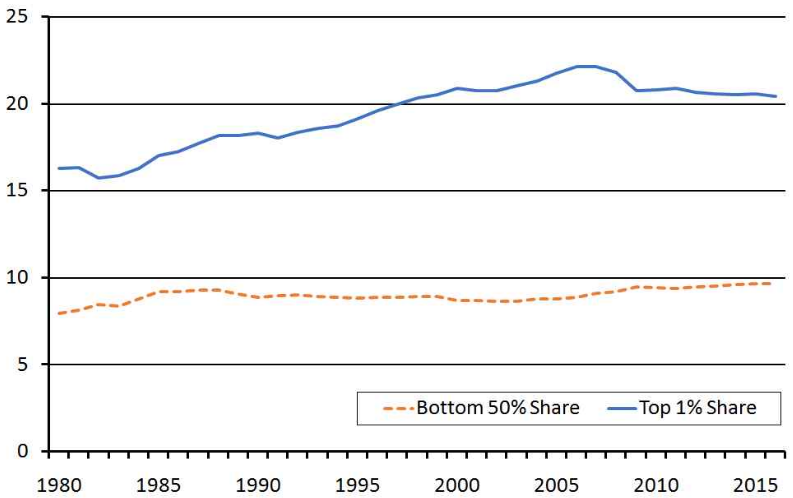
Ⅰ. Introduction

Rising inequality is one of the biggest global issues. According to The World Inequality Report 2018, inequality at the global level has risen sharply since 1980 due to the rise of the global top 1% income and the stagnation of the global bottom 50% income, as shown in Figure 1. In 1980, 16% of global income was received by the top 1% against 8% for the bottom 50%. In 2016, the ratio of global income received by the top 1% increases to 22% (by 6%p) while the ratio received by the bottom 50% increases to only 10% (2%p). Income inequality has increased in nearly all world regions, but at different speeds as described in Figure 2. The divergence in inequality levels has been particularly extreme between Western Europe and North America, which had similar levels of inequality in 1980 but today are in radically different situations. While the top 10% income share was 34.2% in North America and 32.6% in Western Europe in 1980, it rose drastically to 47.0% (by 12.7%p) in North America but it increased only slightly to 37.1% (4.4%p) in Western Europe in 2016. The Occupy Wall Street movement in US shows the growing concern with this issue.

Changes in some deep structural factors have been explored as the main culprits of rising inequality. Bound and Johnson (1992) argue that skill-biased technological progress increases the demand for the highly educated workers, which leads to a huge increase in the relative wages of them. Feenstra and Hanson (2001) find that the main reason for a relative increase in the demand for the skilled workers is the increased international trade instead of technological progress. Card (2001) shows that the decline in union membership can account for up to a quarter of the rise in male wage inequality. On the other hand, monetary policy has been ignored as a source of rising inequality. This is because the effects of monetary policy are believed to be neutral in the long run while the trend of rising inequality is a long-run phenomenon. Central bankers also have doubts about the role of conventional monetary policy in widening inequality (Bernanke, 2015; Mersch, 2014).

Recently, monetary policy has gained attention as a factor affecting cyclical behavior of inequality. There is an argument that unconventional monetary policy during and after the recent financial crisis increased financial asset prices and so seemed to widen the degree of inequality. But there is still considerable disagreement among economists about whether and how much the unconventional monetary policy affects the degree of inequality. Even central bankers have different views on whether unconventional monetary policy worsens inequality. Fisher, the former president of FRB Dallas, and Mersch (2014), a member of ECB's executive board, argue that quantitative easing program had an impact on inequalities by putting upward pressure on financial asset prices while it did not help stimulating job creation.[1] On the other hand, Bernanke (2015),

Figure 1: Ratio of Global Top 1% and Bottom 50% Income

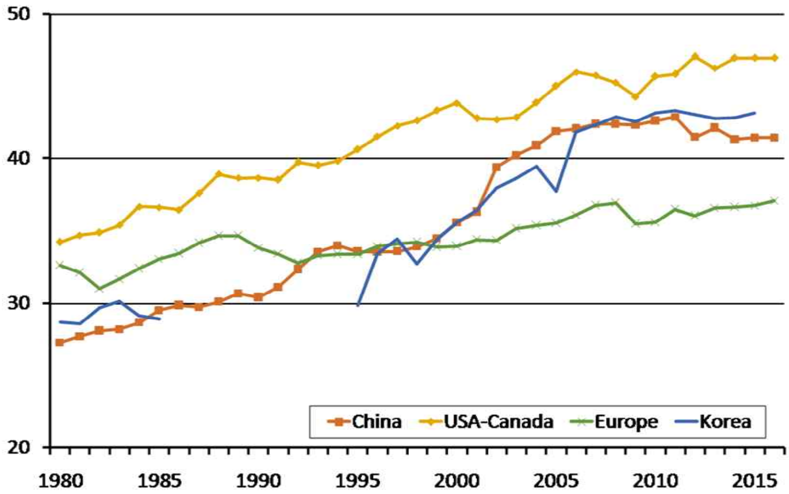


Notes: The solid and dotted lines represent the ratio of global top 1% and bottom 50% income, respectively.

Source: World Inequality Report 2018

1) The former president of FRB Dallas Richard Fisher argued at London School of Economics on 24 March, 2014(http://www.valuewalk.com/2014/03/dallas-fed-president-says-qe-massive-gift-wealth/).

Figure 2: Ratio of Top 10% Income across the World



Source: World Inequality Report 2018

the former chairman of FRB, and Bullard (2014), the president of FRB St. Louis, state that the program did not worsen inequality even though they agree on the fact that the program led to increases in asset prices.

In this paper, we tackle the following two questions about the relationships between monetary policy and income inequality in Korea. First, what are the effects of monetary policy shocks to income inequality? Do monetary policy shocks significantly improve or worsen income inequality? Are the contributions of monetary policy shocks to income inequality large or small? Second, how did monetary policies affect the behavior of income inequality since global financial crisis? Specifically, if Bank of Korea had left the Base Rate unchanged despite the global financial crisis, how would income inequality be?

To answer these questions, we first calculate Gini coefficient for various income range using data from the Household Income and Expenditure Survey. Despite some drawbacks, we believe that the Survey is most appropriate for examining the effect of monetary policy on income inequality since it provides high frequency (quarterly) income data during the longest sample periods among other sources available. Then, a block-exogeneity VAR representing Korean and US economies is estimated to find the effects of monetary policies on income inequality. Since Korean economy is one of small open economies, the block-exogeneity restriction that Korean economy does not affect US economy is imposed.

The main findings are as follows. First, the market income Gini coefficient has an upward trend, increasing from 0.296 in 1990:Q1 to 0.349 in 2017:Q2. The Gini coefficient also has seasonality and tends to increase during recessions. Second, the estimation results show that following a one-standard deviation contractionary (expansionary) monetary policy shock, market income Gini coefficient increases (decreases) significantly after one year, reaching its peak to 0.0014 (0.14%p) while GDP and CPI decrease (increase) significantly by 0.48% and 0.15%, respectively. Third, the contributions of monetary policy shocks to income inequality are found to be small as shown by forecast error variance and historical decompositions. Fourth, earnings heterogeneity channel is most important among various channels through which monetary policy affects income inequality. Finally, a counterfactual analysis implies that if Bank of Korea held the call rate constant at 5.13% from 2008:Q3 and thereafter, the market income Gini coefficient would be higher by 0.009 (0.9%p) during 2008:Q4 — 2015:Q1 under the assumption of static expectations.

1. Literature Review

Since monetary policy has been ignored as a source of rising inequality, the early empirical studies on the relationship between monetary policy and inequality were not much available except Romer and Romer (1998). They estimate a univariate linear regression model with the international data and conclude that expansionary monetary policy aimed at rapid output growth improves the well-being of the poor in the short run even though it cannot affect the income distribution. On the other hand, in the long run they find that prudent monetary policy aimed at low inflation and steady output growth is associated with improved well-being of the poor and greater equality in income.

It is only recently that a more rigorous analysis on the effect of monetary policy on inequality is performed. Coibion et al. (2017) is, as far as we know, the first empirical study estimating the effect of monetary policy shocks on inequality. They construct the inequality measures using the Consumer Expenditure Survey from 1980 to 2008 and find that a contractionary monetary policy shock raises the income and consumption inequalities using Local Projection and extended Romer and Romer (1998) monetary shocks. Also they show that monetary policy shocks have played a non-trivial role in accounting for cyclical fluctuations and historical cyclical changes in inequality. Mumtaz and Theophilopoulou (2017) show very similar results for U.K from 1969 to 2012 estimating a Bayesian VAR where the monetary policy shocks are identified by sign restrictions. On the other hand, Inui and Yamada (2017) document the opposite results for Japan adopting Factor-Augmented Local Projection and recursive assumption for monetary shocks.[2] Furceri et al. (2016), using the panel data of 32 countries over the period 1990-2013, find that contractionary monetary policy shocks increase income inequality and the effect is larger for contractionary shocks, especially during expansions.[3]

There is a growing body of literature examining the effect of unconventional monetary policy on inequality during the Great Recession. Domanski et al. (2016) argue that unconventional monetary policy may have widened wealth inequality in US and some European countries through an upsurge in stock prices. Mumtaz and Theophilopoulou (2017) capture the impact of quantitative easing program by comparing the observed inequality to the hypothetical one which is expected in the situation where the program would not be executed.[4] Their result implies

2) In addition, they find that the procyclical responses of inequality to monetary shocks have been reduced after 2000 and account for this by the change in the labor market flexibility.

3) Also they find that the effect is larger in countries with higher labor share of income and smaller redistribution policies and that changes in policy rates driven by an increase in growth are associated with lower inequality.

4) They assume that the yield on long-term government bonds would be higher than the short-term rate by 100 basis points without the program.

that the program contributed to the increase in inequality over the Great Recession in UK. Saiki and Frost (2014) show that unconventional monetary policy increased income inequality in Japan between 2008 and 2013 by estimating a recursive VAR model. On the other hand, Bivens (2015) documents that compared to the alternative of no stimulus, the unconventional monetary policy has reduced inequality significantly in US by boosting the economy. In addition, O'Farrell et al. (2016) and Bunn et al. (2018) analyzes that the effect of unconventional monetary policy on inequality has been small in OECD countries and UK, respectively.

Recent studies build calibrated models to examine the transmission mechanisms of monetary policy on inequality and characterize the monetary policy design in the presence of inequality. See, for example, Gornemann et al. (2016), Bilbiie and Ragot (2017), Auclert (2017), and Areosa and Areosa (2016) among others.

The remainder of this paper is organized as follows. In Section 2, we summarize the channels through which monetary policy affects inequality. Section 3 describes the data and calculates the Gini coefficients for various income range. Section 4 presents the econometric specifications and Section 5 shows the estimation results. Finally, Section 6 concludes.

Ⅱ. Channels through which Monetary Policy Affects Income Inequality

There are various channels through which monetary policy affects income and wealth inequalities, which is well summarized by Coibion et al. (2017), Nakajima (2015), and Amaral (2017). One reason why there are disagreements on whether monetary policy increases inequality or not is that those channels work in the opposite direction. This section briefly reviews how monetary policy shocks affect income in-equality via those channels.[5)]

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5) There are at least two channels through which monetary policy shocks affect wealth inequality. First, financial segmentation channel assumes that a central bank injects money supply into the economy through

First, contractionary monetary policy shocks can worsen income inequality via *earnings heterogeneity channel*. Employment (extensive margin) and labor earnings (intensive margin) at the bottom of the income distribution are most affected by business cycle fluctuations, which is shown by Romer and Romer (1998) and Heathcote et al. (2010). Thus contractionary monetary policy shocks can increase income inequality by decreasing the income of low-wage workers. In addition, Gertler and Gilchrist (1994) find that monetary policy shocks affect the sales of small firms more than that of large firms. Therefore, again, contractionary monetary policy shocks can exacerbate income inequality by decreasing the sales (and profits) of small firms more than that of large ones.[6)]

Another channel through which contractionary monetary policy shocks worsen income inequality is the *savings redistribution channel*. Contractionary monetary policy shocks which raise the ex-post real interest rates will benefit savers and hurt borrowers. Since rich and old households are savers they are main winners in the household sector as documented by Doepke and Schneider (2006). Thus contractionary monetary policy shocks increase income inequality.

Finally, *income composition channel* implies that contractionary monetary policy shocks could reduce income inequality. This channel is motivated by the fact that the primary source of income for each household is different and that the households with higher income are likely to rely on business income rather than wage income. If contractionary monetary policy shocks decrease business income more than wage income, then income inequality would reduce.

Therefore, the final effects of monetary policy shocks on income inequality depend on the relative importance of each channel. To clarify

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financial markets and that the households that are most connected to financial markets are likely to be rich. Under these assumptions money supply injected by expansionary monetary policy shocks flows to toward those rich households and so the shocks widen wealth inequality. Second, portfolio channel (inflation tax channel) also implies that expansionary monetary policy shocks increase wealth inequality since poor households tend to hold a large fraction of their wealth as currency whose real value is vulnerable to inflation.

6) Literature tends to consider only heterogeneity in labor earnings when defining the earnings heterogeneity channel. But in this paper, we define the earnings heterogeneity channel broadly by including heterogeneity in business income.

this, suppose that there are only two types of people, high-income (denoted by superscript H) and low-income (superscript L) earners, and that market income (Y) earned by people consists of wage (W), business (B), financial (F), and transfer (O) incomes. Then the change in income inequality can be measured by the gap between the change rates in the market income earned by each group:

$$\frac{\triangle Y^H}{Y^H}-\frac{\triangle Y^L}{Y^L}=r_w^H\frac{\triangle W^H}{W^H}+r_b^H\frac{\triangle B^H}{B^H}+r_f^H\frac{\triangle F^H}{F^H}+r_o^H\frac{\triangle O^H}{O^H}$$
$$-\left(r_w^L\frac{\triangle W^L}{W^L}+r_b^L\frac{\triangle B^L}{B^L}+r_f^L\frac{\triangle F^L}{F^L}+r_o^L\frac{\triangle O^L}{O^L}\right) \qquad (2.1)$$

where r_w, r_b, r_f, and r_o represents the ratio of wage, business, financial, and other incomes for each group, respectively. The positive value of the gap implies that income of high-income earners increases more than that of low-income earners and so that income inequality increases. Equation (2.1) can be rewritten as

$$\frac{\triangle Y^H}{Y^H}-\frac{\triangle Y^L}{Y^L}=\underbrace{\frac{r_w^H+r_w^L}{2}\left(\frac{\triangle W^H}{W^H}-\frac{\triangle W^L}{W^L}\right)+\frac{r_b^H+r_b^L}{2}\left(\frac{\triangle B^H}{B^H}-\frac{\triangle B^L}{B^L}\right)}_{Earnings\ heterogeneity\ channel}$$
$$+\underbrace{\frac{r_f^H+r_f^L}{2}\left(\frac{\triangle F^H}{F^H}-\frac{\triangle F^L}{F^L}\right)}_{Saving\ redistribution\ channel}+\underbrace{\frac{r_o^H+r_o^L}{2}\left(\frac{\triangle O^H}{O^H}-\frac{\triangle O^L}{O^L}\right)}_{Transfers\ heterogeneity\ channel}$$
$$+\underbrace{(r_w^H-r_w^L)\frac{\frac{\triangle W^H}{W^H}+\frac{\triangle W^L}{W^L}}{2}+(r_b^H-r_b^L)\frac{\frac{\triangle B^H}{B^H}+\frac{\triangle B^L}{B^L}}{2}}_{Income\ composition\ channel}$$
$$+\underbrace{(r_f^H-r_f^L)\frac{\frac{\triangle F^H}{F^H}+\frac{\triangle F^L}{F^L}}{2}+(r_o^H-r_o^L)\frac{\frac{\triangle O^H}{O^H}+\frac{\triangle O^L}{O^L}}{2}}_{Income\ composition\ channel} \qquad (2.2)$$

Earnings heterogeneity channel predicts that contractionary monetary policy shocks would worsen income inequality by decreasing the wage of low-wage workers more than that of high-wage workers $\left(0 > \frac{\triangle W^H}{W^H} > \frac{\triangle W^L}{W^L}\right)$ and/or by decreasing the profits of small firms more than those of large firms $\left(0 > \frac{\triangle B^H}{B^H} > \frac{\triangle B^L}{B^L}\right)$. The contribution of this channel can be measured as the first line in Equation (2.2). Savings redistribution channel also implies that contractionary monetary policy shocks worsens income inequality by benefiting savers and hurting borrowers $\left(\frac{\triangle F^H}{F^H} > 0 > \frac{\triangle F^L}{F^L}\right)$, which can be captured by the first term of the second line in Equation (2.2).

On the other hand, since income transfer from high-income earners to low-income ones is likely to happen during the recession, contractionary monetary policy shocks could improve the income inequality $\left(\frac{\triangle O^L}{O^L} > 0 > \frac{\triangle O^H}{O^H}\right)$. We call it 'transfers heterogeneity channel' which can be captured by the second term of the second line in Equation (2.2).

The final two lines in Equation (2.2) represent the income composition channel. If the ratio of business income is large for the high-income earners $\left(r_b^H > r_b^L\right)$ and a contractionary monetary policy shock decreases business income more than wage income $\left(0 > \frac{\frac{\triangle W^H}{W^H} + \frac{\triangle W^L}{W^L}}{2} > \frac{\frac{\triangle B^H}{B^H} + \frac{\triangle B^L}{B^L}}{2}\right)$, then contractionary monetary policy shocks could reduce income inequality.

We examine the relative importance of each channel using Equation (2.2) in Section 5.3.

Ⅲ. Data

In this section, we describe data and how to calculate income Gini coefficients from it.

1. Household Income and Expenditure Survey

We use data from the Household Income and Expenditure Survey produced by Statistics Korea. It provides information on income and expenditure of households. It has started from 1963, but the raw data available to the public starts from 1990.[7]

Even though there are other data sources from which we can obtain income data,[8] we believe that the Household Income and Expenditure Survey is most appropriate for examining the effect of monetary policy on income inequality. First, the Survey provides high frequency (quarterly) income data which are necessary to analyze the effect of monetary policy because monetary policy is believed to have the short-run effects. Second, the Survey covers, as far as we know, the longest sample periods which is essential for time series analysis. Finally, the Survey includes various sources of income and so it allows us to examine the relative importance of each channel through which monetary policy affects income inequality.

Despite these advantages, the Survey also has some drawbacks. First, the credibility of answers is always questioned in survey data. Especially, many respondents would not like to report the true amount of their income. We will discuss this issue in the next subsection. Second, the data from the Survey are a lack of consistency due to multiple changes in the sampling frame of the Survey since it has started. For instance, rural households and single-person households have been included in the samples since 2003 and 2006, respectively. Especially, the income level of

7) The raw data can be downloaded from the website of MDIS (MicroData Integrated Service): https://mdis.kostat.go.kr/index.do.

8) For example, Survey on Labor Conditions by Employment Type, KLIPS, and income tax statistics include income data.

rural households is likely to differ from that of urban households. Thus, in order to get homogeneous series, we restrict the sample to the households residing in the cities.[9)]

2. Trends of Income Inequality

We calculate and examine Gini coefficient which has been well known and widely used as a measurement for the degree of inequality. When compared to other measurements which are constructed using data from only a few specific income brackets such as the ratio of the upper bound value of the ninth decile to the first decile (that is, P90/P10), Gini coefficient is thought to be relatively robust to the outliers because it considers the whole distribution.

The Gini coefficient is defined as a half of relative mean absolute difference where the relative mean absolute difference is the mean absolute difference divided by the mean. The income Gini coefficient with weighted data can be written as

$$G = \frac{\Sigma_{i=1}^{n} f(Y_i) \Sigma_{j=1}^{n} f(Y_j) | Y_i - Y_j |}{2\overline{Y}} \tag{3.1}$$

where $f(Y_i)$ is the frequency of the people with income of Y_i and $\overline{Y} = \Sigma_{i=1}^{n} f(Y_i) Y_i$ is the average income.

We construct the income Gini coefficient using the Household Income and Expenditure Survey as follows. First, in each quarter we calculate market income for each household defined as the sum of wage, business, financial, and private transfer incomes.[10)] Next, the income values are deflated by CPI and then, to take economies of scale in consumption into account, the real incomes are equivalized by the

9) See the Appendix A for some characteristics of samples.

10) Business income includes business and rental incomes. Financial income includes interest, dividend, and other financial incomes. Private transfer income includes transfers between households, discounts, and other transfer income.

square root of the number of household members. These equivalized real incomes are Y in Equation (3.1). Finally, the weights for each household provided by the Survey are adjusted to reflect person weight and the adjusted weights are $f(Y)$ in Equation (3.1).

Before we examine the trend of Gini coefficient, it is worth to see the trend of ratio of each income source to market income. Table 1 describes the trend of ratio of each income source to market income for total population and for each market income bracket. Several findings are as follows. First, wage income which makes up more than 50% is the primary income source for all people. In addition, the importance of wage income has increased over the sample period and this is more evident for the population in higher income brackets. Second, business income is the second most important source for all people, but the ratio has decreased. Third, financial income forms only a trivial part for all people. Lastly, private transfer income is also small except for the people in the lowest income brackets.

Note that the ratios of business and financial incomes in Table 1 are not high for high-income earners, which is contrast to the common sense. Thus it is possible that people report their business and financial incomes less than true amounts and so that the ratios of business and financial income are downward biased, especially for the highest income bracket. We will discuss how this bias affects in examining the income composition channel later.

Figure 3 describes the trends of income Gini coefficients from 1990:Q1 to 2017:Q2. By enhancing income range, we identify the effect of each income source. Let us start with wage income which is the primary source for all people as documented in Table 1. The wage income Gini coefficient does not have any long-run trends while it has gone through the ups and downs hovering around 0.5 over the sample period. When business income, the second most important source, is added to wage income, the Gini coefficient shifts downward (i.e. the degree of inequality is reduced), which implies that people with high

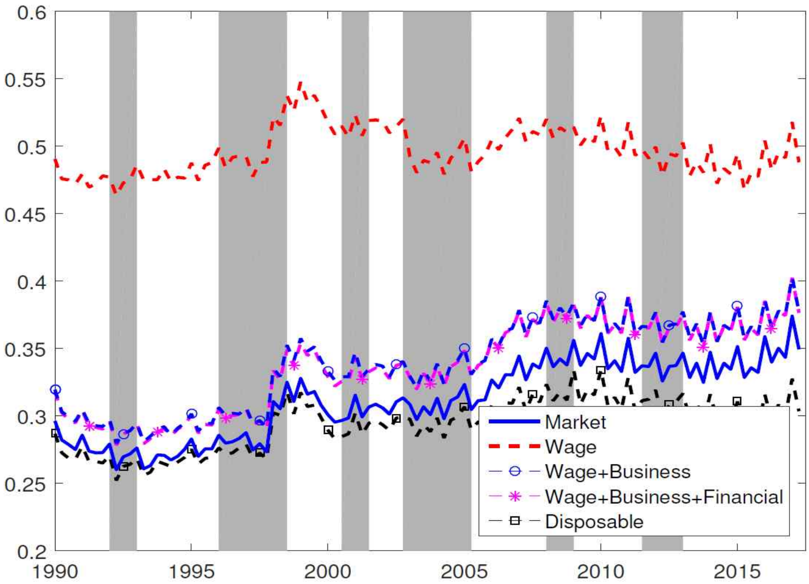
Table 1: Ratio of Each Income Source

		1990–1995	1996–2000	2001–2005	2006–2010	2011–2017.Q2
Total population	Wage	0.638	0.629	0.663	0.705	0.729
	Business	0.311	0.310	0.281	0.238	0.218
	Financial	0.012	0.014	0.008	0.005	0.004
	Private transfer	0.039	0.047	0.048	0.052	0.050
0-20%	Wage	0.597	0.532	0.537	0.531	0.559
	Business	0.311	0.337	0.318	0.263	0.238
	Financial	0.012	0.018	0.013	0.013	0.011
	Private transfer	0.081	0.113	0.132	0.193	0.192
20-40%	Wage	0.659	0.598	0.601	0.630	0.683
	Business	0.299	0.343	0.338	0.296	0.254
	Financial	0.008	0.011	0.006	0.005	0.004
	Private transfer	0.034	0.049	0.055	0.070	0.060
40-60%	Wage	0.671	0.624	0.642	0.675	0.718
	Business	0.291	0.327	0.307	0.275	0.240
	Financial	0.009	0.010	0.006	0.004	0.002
	Private transfer	0.029	0.038	0.044	0.046	0.040
60-80%	Wage	0.661	0.655	0.670	0.719	0.736
	Business	0.297	0.294	0.282	0.240	0.221
	Financial	0.011	0.011	0.007	0.004	0.003
	Private transfer	0.031	0.039	0.041	0.037	0.040
80-100%	Wage	0.608	0.644	0.713	0.758	0.765
	Business	0.336	0.296	0.241	0.198	0.191
	Financial	0.015	0.018	0.010	0.006	0.004
	Private transfer	0.041	0.042	0.036	0.038	0.039

Note: '0-20%' represents the population at the 0-20th percentile, '20-40%' represents the population at the 20th-40th percentile, and so on.

business income are likely to have low wage income. Actually, wage income is negatively correlated with the other income sources as shown in Table 2. Note that the Gini coefficient for the sum of wage and business incomes has increased while the wage income Gini has not, and thus the gap between two coefficients has reduced. This means that the inequality of business income has worsen. Next, the addition of financial income has small effects on Gini coefficient. This is because the ratio

Figure 3: Income Gini Coefficient



Note: The solid line, dashed line, dashed line with circle markers represent market, wage, and 'wage and business' income Gini coefficient, respectively. Also dashed line with asterisk and with square markers represent the 'wage, business, and financial' and disposable income Gini coefficient, respectively. The shaded areas represent economic recessions.

of financial income is trivial as documented in Table 1. Finally, market income is obtained by adding private transfer income and Gini coefficient for it is reduced more since private transfer income is distributed mainly in the lowest income bracket as shown in Table 1.

Several findings on the market income Gini coefficient on which this paper focus are as follows. First, it has an upward trend and seasonality over the sample period. Also except the most recent recessions 2011:Q3-2013:Q1, the Gini coefficient has increased during recessions, especially during 1998 Korean financial crisis when there was a sudden increase in it. On the other hand, the behavior of the Gini coefficient is more or less subtle during booms. It has increased during some booms, but it has dropped during others. This implies that the Gini coefficient has a state-dependent asymmetry depending on the phase of the

Table 2: Correlation among Income Sources

	Market	Wage	Business	Financial	Private Transfer
Market	1				
Wage	0.724	1			
Financial	0.332	−0.329	1		
Financial	0.096	−0.012	0.006	1	
Private Transfer	0.116	−0.148	−0.091	0.010	1

Note: This table describes the correlations among real equivalized income sources during 1990:Q1-2017:Q2.

business cycle. Finally, the Gini coefficient has risen since the most recent recessions 2011:Q3-2013:Q1, reaching to 0.374 at 2017:Q1 which is the maximum value in the sample period.

Meanwhile, it is meaningful to examine the disposable income Gini coefficient for disposable income since disposable income, the sum of market income and public transfer income minus public transfer expenditure, is the most critical factor affecting one's welfare. Interestingly, it does not have any long-run trends after a sudden increase during 1998 Korean financial crisis. This means that the redistribution policies have been effective in reducing the degree of inequality. Even though disposable income is directly related to one's welfare, we focus on market income inequality in this paper since public transfer income and expenditure are determined by redistribution policies, not by monetary policies.

Ⅳ. Econometric Specification

In this section, we set up the model, identify monetary policy shocks, and evaluate the estimated monetary shocks.

1. Block-Exogeneity VAR

The VAR models with block exogeneity have been proposed to analyze small open economies. For instance, Cushman and Zha (1997) apply a block-exogeneity VAR to Canada and US data and show that the exchange rate puzzle in Canada can be reduced under this restriction. We set up and estimate this type of VAR since we believe that the block-exogeneity restriction is reasonable in analyzing Korean economy, one of small open economies.

Let us begin with a reduced-form VAR model representing Korean and US economies (omitting a constant term):

$$\begin{bmatrix} Y_t^{KOR} \\ Y_t^{US} \end{bmatrix} = \begin{bmatrix} B_{11}^1 & B_{12}^1 \\ B_{21}^1 & B_{22}^1 \end{bmatrix} \begin{bmatrix} Y_{t-1}^{KOR} \\ Y_{t-1}^{US} \end{bmatrix} + \cdots + \begin{bmatrix} B_{11}^p & B_{12}^p \\ B_{21}^p & B_{22}^p \end{bmatrix} \begin{bmatrix} Y_{t-p}^{KOR} \\ Y_{t-p}^{US} \end{bmatrix} + \begin{bmatrix} u_t^{KOR} \\ u_t^{US} \end{bmatrix} \quad (4.1)$$

where $Y_t^{KOR} = [FX_t, Gini_t, CR_t, GDP_t^{KOR}, CPI_t^{KOR}]'$ and $Y_t^{US} = [EBP_t, GDP_t^{US}, CPI_t^{US}, FFR_t]'$ and u_t the reduced form errors or VAR innovations, are allowed to be contemporaneously correlated. FX_t, CR_t, and FFR_t represent the won-dollar exchange rate, the call rate, and the federal funds rate, respectively. $Gini_t$ represents market income Gini coefficient. EBP_t is the excess bond premium identified by Gilchrist and Zakrajšek (2012) and extended by Caldara et al. (2016) and it represents financial shocks. This variable is introduced into the model since the sample covers the post-1990 period during which financial shocks play a critical role in generating business cycles.

Now we assume that US economy is exogenous to Korean economy since Korean economy is small relative to US. That is,

$$\begin{bmatrix} Y_t^{KOR} \\ Y_t^{US} \end{bmatrix} = \begin{bmatrix} B_{11}^1 & B_{12}^1 \\ 0 & B_{22}^1 \end{bmatrix} \begin{bmatrix} Y_{t-1}^{KOR} \\ Y_{t-1}^{US} \end{bmatrix} + \cdots + \begin{bmatrix} B_{11}^p & B_{12}^p \\ 0 & B_{22}^p \end{bmatrix} \begin{bmatrix} Y_{t-p}^{KOR} \\ Y_{t-p}^{US} \end{bmatrix} + \begin{bmatrix} u_t^{KOR} \\ u_t^{US} \end{bmatrix} \tag{4.2}$$

where

$$cov\left(\begin{bmatrix} u_t^{KOR} \\ u_t^{US} \end{bmatrix} \right) = \begin{bmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{bmatrix} \tag{4.3}$$

Note that the lower left blocks in each coefficient matrix are zero, which implies that the changes in Y_t^{KOR}, a vector of variables describing Korean economy, do not affect Y_t^{US}, a vector of variables describing US economy. This is the key restriction of a block-exogeneity VAR.

Since the explanatory variables are different across equations, the ordinary least square (OLS) estimation for Equation (4.2) is not efficient. For efficiency, it is estimated by seemingly unrelated regressions (SUR). The estimation period covers from 1991:1Q to 2015:1Q.[11)] The availability of call rate and excess bond premium determines the start and end of the period, respectively. All the variables are logarithmic except for interest rates, excess bond premium, and Gini coefficient which are used in level. A constant term and seasonal dummies are included and the lag length is set as four.

Before estimating Equation (4.2), it is worth to conduct a block-exogeneity test to confirm the validity of block-exogeneity assumption. To do this, we run a regression only for the US block in Equation (4.1)

11) As an anonymous referee suggests, it is possible that the estimation results depend on the sample periods since the economic environments including monetary policy framework in Korea have changed after experiencing 1997 Crisis. For the robustness check, we add the dummy variable taking the value of 1 for the periods until 1998 as an explanatory variable. Some key estimation results are provided in Appendix C. Two differences are noteworthy. First, as shown in Panel (b) of Figure A9, the response of market income Gini coefficient is more persistent. Second, as described in Figure A10, the contribution of monetary policy shocks to income inequliaty becomes smaller. However, overall, these results do not affect our key conclusions.

$$Y_t^{US} = \sum_{i=1}^{4} B_{21}^i \, Y_{t-i}^{KOR} + \sum_{i=1}^{4} B_{22}^i \, Y_{t-i}^{US} + u_t^{US} \tag{4.4}$$

and test the null hypothesis of $B_{21}^i = 0$. The p value is found to be 0.44, which confirms the validity of block-exogeneity assumption.

2. Identification

We need a structural form where the contemporaneous links among the variables are allowed:

$$\begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix} \begin{bmatrix} Y_t^{KOR} \\ Y_t^{US} \end{bmatrix} = \begin{bmatrix} C_{11}^1 & C_{12}^1 \\ 0 & C_{22}^1 \end{bmatrix} \begin{bmatrix} Y_{t-1}^{KOR} \\ Y_{t-1}^{US} \end{bmatrix} + \cdots + \begin{bmatrix} C_{11}^p & C_{12}^p \\ 0 & C_{22}^p \end{bmatrix} \begin{bmatrix} Y_{t-p}^{KOR} \\ Y_{t-p}^{US} \end{bmatrix} + \begin{bmatrix} \epsilon_t^{KOR} \\ \epsilon_t^{US} \end{bmatrix} \tag{4.5}$$

where ϵ_t, the structural errors, are not allowed to be contemporaneously correlated, i.e, $cov\left(\left[\epsilon_t^{KOR}, \epsilon_t^{US}\right]'\right) = I.$

It is possible to recover the structural form from the reduced form by imposing restrictions on matrix A. Specifically, we assume

$$\begin{bmatrix} a_{1,1} & a_{1,2} & a_{1,3} & a_{1,4} & a_{1,5} & a_{1,6} & a_{1,7} & a_{1,8} & a_{1,9} \\ 0 & a_{2,2} & a_{2,3} & a_{2,4} & a_{2,5} & 0 & 0 & 0 & 0 \\ a_{3,1} & 0 & a_{3,3} & a_{3,4} & a_{3,5} & 0 & 0 & 0 & a_{3,9} \\ 0 & 0 & 0 & a_{4,4} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{5,4} & a_{5,5} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{6,6} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{7,6} & a_{7,7} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{8,6} & a_{8,7} & a_{8,8} & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{9,6} & a_{9,7} & a_{9,8} & a_{9,9} \end{bmatrix} \begin{bmatrix} FX_t \\ Gini_t \\ CR_t \\ GDP_t^{KOR} \\ CPI_t^{KOR} \\ EBP_t \\ GDP_t^{US} \\ CPI_t^{US} \\ FFR_t \end{bmatrix} \tag{4.6}$$

These identifying restrictions generally follow Cushman and Zha (1997) and Kim and Roubini (2000) with some modifications. The first equation is the arbitrage equation describing exchange rate market. Since the exchange rate is a forward-looking asset price, all variables are assumed to have contemporaneous effects on the exchange rate. The second equation represents the contemporaneous restrictions on the degree of income inequality. According to the earnings heterogeneity channel, the degree of income inequality is affected by the business fluctuation. To reflect this, we assume that GDP has a contemporaneous effect on the degree of income inequality. Also the savings redistribution channel states that changes in real interest rates can affect the degree of income inequality. So it is assumed that the call rate and CPI contemporaneously affect the degree of income inequality. Since no theories supports that income inequality contemporaneously responds to the exchange rate and foreign variables, we do not assume it. The third one represents the monetary policy rule and implies that the monetary policy instrument, call rate, reacts contemporaneously to the exchange rate, GDP, CPI, and the federal funds rate. The next two equations assume that GDP and CPI simply have the recursive features. Especially, we impose a restriction that GDP and CPI, as slow-moving variables, do not contemporaneously respond to other domestic and foreign variables. Finally, the last four equations imply that the four US variables also have the recursive features with the excess bond premium being most exogenous.

Maximum likelihood estimates of A11 and A12 are obtained using Ω.[12] The p value of likelihood ratio test for the over-identifying restrictions is 0.323. Thus our identifying restrictions are not rejected at conventional significance levels.

3. Evaluation of Estimated Monetary Policy Shocks

Before we examine the effects of monetary policy on income inequality, it is worth to evaluate the estimated monetary policy shocks $\hat{\epsilon}_t^{CR, KOR}$, the

12) See the Appendix B for details and results.

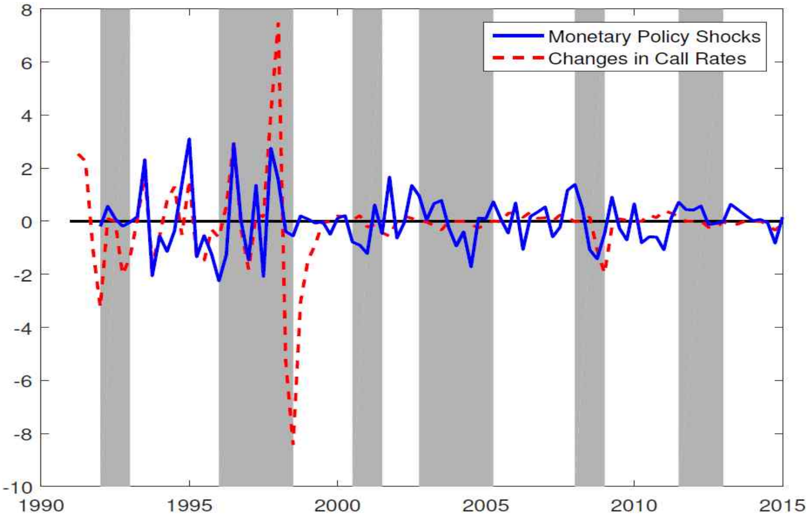
third component of $\hat{\epsilon}_t^{KOR}$. The estimated shocks and changes in call rates are described in Figure 4. Several findings are as follows. First, two series show different patterns, implying that a substantial portion of changes in call rates is due to endogenous responses of monetary policy and so that changes in call rates cannot be used as monetary policy shocks. Also note that monetary policy shocks became less volatile after around 1998 when the Bank of Korea started to target the call rates. Finally, Korean economy has experienced four recessions after 1998 and the monetary policy shocks were generally contractionary right before the start of recession periods. Especially, the last two results are consistent with general common sense and support the validity of estimated monetary shocks.

Another way to evaluate the validity of estimated monetary shocks is to examine the predictability of them as in Cloyne and Hürtgen (2016). In principle, the estimated monetary policy shocks are exogenous in a sense that they are unpredictable. To confirm this, we regress the estimated shocks on a set of lagged macroeconomic variables including GDP growth rate, CPI inflation rate, and the unemployment rate

$$\hat{\epsilon}_t^{CR,\,KOR} = c + \sum_{i=1}^{I} \beta_i x_{t-i} + \epsilon_t \tag{4.7}$$

and test the null hypothesis that β_i for all $i = 1, \cdots, I$ are equal to zero to examine whether they are predictable. The results in the case of $I = 4$ are shown in Table 3. We cannot statistically reject the hypothesis of unpredictability of the shock series. The lack of predictability suggests that it is suitable to use the shocks to estimate the effects of monetary policy shocks.

Figure 4: Estimated Monetary Policy Shocks



Note: The shaded areas represent economic recessions.

Table 3: Predictability of Monetary Policy Shocks

Regressor	F–statistics	p–values
GDP Growth	0.27	0.90
CPI Inflation	0.73	0.58
Unemployment Rate	1.76	0.15

Note: The table reports F-statistics and p-values for the null hypothesis that all coefficients β_i are equal to zero.

V. Results

This section reports the response of income inequality to monetary policy shocks, the contribution of monetary policy shocks to income inequality, the relative importance of each channel through which monetary policy shocks affect income inequality, and the impact of monetary easing on income inequality since global financial crisis.

1. Response of Income Inequality to Monetary Policy Shocks

Figure 5 describes the impulse responses to a one-standard deviation contractionary monetary policy shock.[13][14] One-standard error bands are obtained by bootstrapping methods using 300 replications. After a shock, the call rates significantly increase during one year, reaching its peak to 0.65%p as seen in Panel (c). GDP in Panel (d) decreases for two years, having a peak decline of 0.48%. In Panel (e), CPI responds slowly, starting to decrease after one and half years, and has a peak decline of 0.15%. Note that there is no price puzzle. Overall, these responses of macro variables are consistent with common sense and previous literature qualitatively.[15] On the other hand, there are the exchange rate puzzle as shown in Panel (a): a positive shock to call rates should result in the depreciation, not appreciation, of Korean Won. However, in case of Korea the ratio of foreign capital is larger in stock market than in bond market and so a contractionary monetary policy shock, by decreasing the stock price, might result in the depreciation of Korean Won. Since previous studies also do not provide consistent results for the relationship between interest and exchange rates in Korea, we reserve out judgement on this issue.

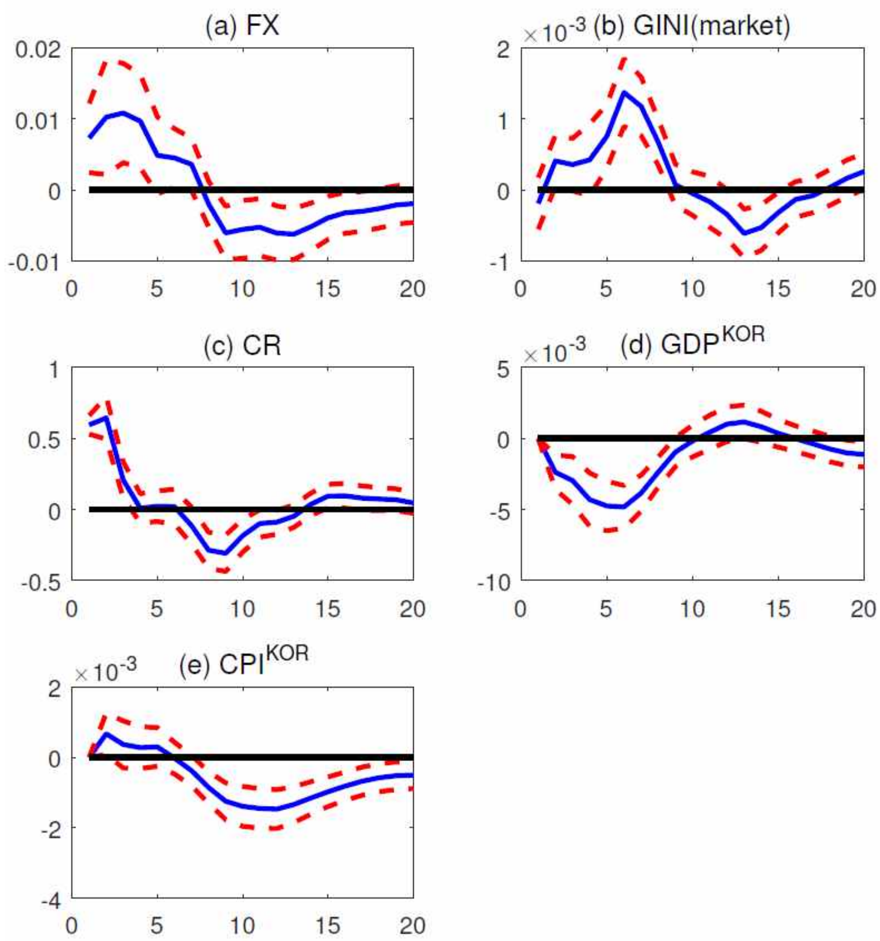
Panel (b) describes one of the key results in this paper. Following a one-standard deviation contractionary (expansionary) monetary policy shock, market income Gini coefficient increases (decreases) significantly after one year, reaching its peak to 0.0014 (0.14%p). The estimation result that contractionary monetary policy shocks worsen income inequality is consistent with other studies such as Coibion et al. (2017) for US,

13) The standard deviation of estimated monetary policy shock is 1.00.

14) Due to the block-exogeneity restriction, US variables do not respond to Korean monetary policy shocks and so their responses are not shown.

15) In terms of magnitudes, the responses of output and price are small compared to previous literature. One reason for these weak responses is that the response of the call rates to a 100 bp monetary policy shock is less than 100 bp due to the contemporaneous response of other variables. Also the number of variables and structural shocks in our model is relatively large and so the effect of each shock cannot be large. Finally, under the block-exogeneity restriction, the effect of domestic shocks would be small.

Figure 5: Responses to Monetary Policy Shocks



Note: The solid lines describe the impulse responses to a one-standard deviation contractionary monetary policy shock. The dash lines represent one-standard error bands obtained by bootstrapping methods using 300 replications.

Mumtaz and Theophilopoulou (2017) for UK, and Furceri et al. (2016) for the panel data of 32 countries even though the magnitude of response is small compared to them.[16)]

16) For instance, Coibion et al. (2017) document that a 100 bp contractionary monetary policy shock increases the income Gini coefficient by 0.01.

2. Contribution of Monetary Policy Shocks to Income Inequality

The contributions of monetary policy shocks to income inequality can be evaluated in two ways. First, we can examine the portion of the variance of the forecast error in predicting market income Gini coefficient due to the monetary policy shocks. The second way is to examine the portion of the historical movement of market income Gini coefficient due to the monetary policy shocks.

Panel (a) in Figure 6 shows the forecast error variance of market income Gini coefficient due to monetary policy shocks. Monetary policy shocks help forecast only 5% of the variance of the forecast error in predicting market income Gini coefficient at a horizon of one and half years or more. Even considering that our model includes nine shocks and so that the contribution of each shock cannot be large in absolute terms, the contribution of monetary policy shocks is small.[17)]

Panel (b) describes the historical contribution to market income Gini coefficient of monetary policy and all shocks. Note that, consistent with the result of forecast error variance decomposition, the portion of the historical movement of market income Gini coefficient due to the monetary policy shocks is small and, even sometimes, the monetary policy shocks contribute to market income Gini coefficient in the opposite direction.

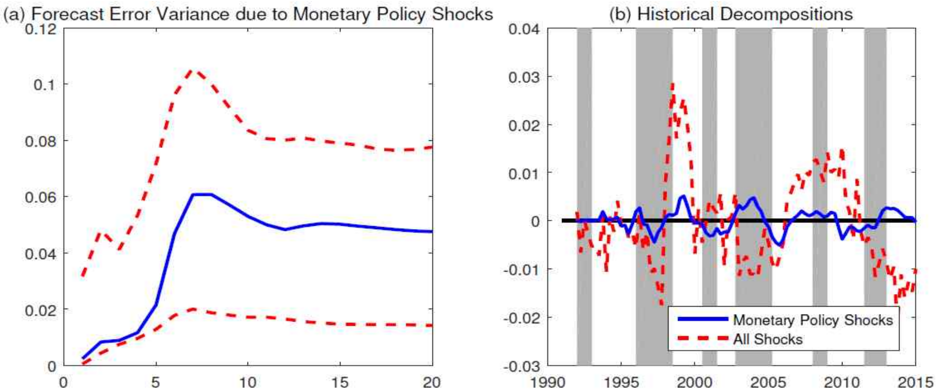
To sum up, the contribution of monetary policy shocks to income inequality measured by market income Gini coefficient is small in Korea.

3. Relative Importance of Each Channel

We examine the relative importance of each channel through which monetary policy shocks affect income inequality by decomposing the gap between the change rates in the market income of high-income and

17) Since there are nine shocks, the contribution of each shock would be about 11% if each shock equally contributes to market income Gini coefficient.

Figure 6: Contribution of Monetary Policy Shocks to Income Inequality



Note: Panel (a) shows the forecast error variance of market income Gini coefficient due to monetary policy shocks. The dash lines represent one-standard error bands obtained by bootstrapping methods using 300 replications. In Panel (b), the solid and dashed lines describe the historical contribution to market income Gini coefficient of monetary policy and all shocks, respectively. The shaded areas represent economic recessions.

low-income earners as seen in Equation (2.2):[18]

$$
\begin{aligned}
\frac{\triangle Y^H}{Y^H}-\frac{\triangle Y^L}{Y^L} = & \underbrace{\frac{r_w^H+r_w^L}{2}\left(\frac{\triangle W^H}{W^H}-\frac{\triangle W^L}{W^L}\right)+\frac{r_b^H+r_b^L}{2}\left(\frac{\triangle B^H}{B^H}-\frac{\triangle B^L}{B^L}\right)}_{Earnings\ \ heterogeneity\ \ channel} \\
& +\underbrace{\frac{r_f^H+r_f^L}{2}\left(\frac{\triangle F^H}{F^H}-\frac{\triangle F^L}{F^L}\right)}_{Saving\ \ redistribution\ \ channel}+\underbrace{\frac{r_o^H+r_o^L}{2}\left(\frac{\triangle O^H}{O^H}-\frac{\triangle O^L}{O^L}\right)}_{Transfers\ \ heterogeneity\ \ channel} \\
& +\underbrace{(r_w^H-r_w^L)\frac{\frac{\triangle W^H}{W^H}+\frac{\triangle W^L}{W^L}}{2}+(r_b^H-r_b^L)\frac{\frac{\triangle B^H}{B^H}+\frac{\triangle B^L}{B^L}}{2}}_{Income\ \ composition\ \ channel}
\end{aligned}
$$

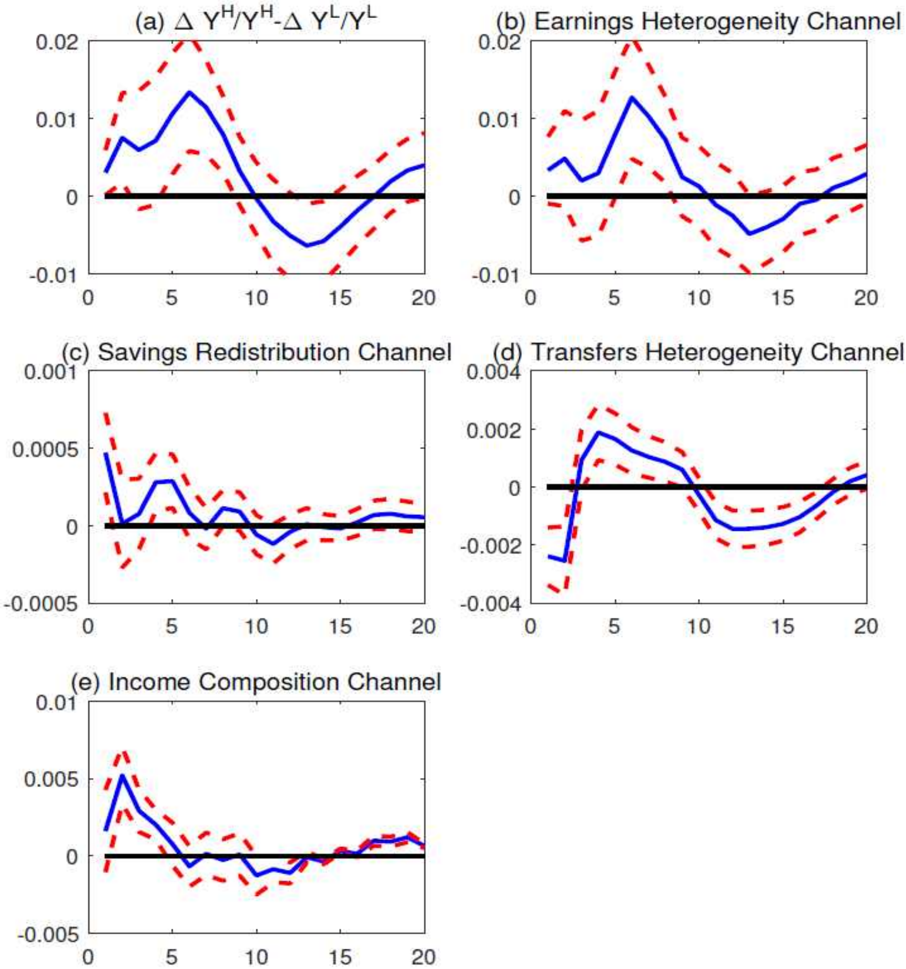
18) We use the gap between the change rates in the market income as a measure for the degree of inequality since it is harder to decompose market income Gini coefficients. As seen below, the response of the gap between the change rates in the market income is similar to that of market income Gini coefficient.

$$\underbrace{+(r_f^H - r_f^L)\frac{\dfrac{\triangle F^H}{F^H}+\dfrac{\triangle F^L}{F^L}}{2}+(r_o^H - r_o^L)\frac{\dfrac{\triangle O^H}{O^H}+\dfrac{\triangle O^L}{O^L}}{2}}_{Income\ \ composition\ \ channel} \quad (5.1)$$

We first compute the left-hand side of Equation (5.1) using the responses of market incomes for the top 20% and bottom 20% earners to a one-standard deviation contractionary monetary policy shock. In order to obtain the earnings heterogeneity channel, we use the responses of wage and business incomes for the top 20% and bottom 20% market income earners and use the ratios of wage and business incomes for each of two groups during sample periods. Similarly, we compute the effects of savings redistribution and transfers heterogeneity channels from the responses and ratios of financial and private transfer incomes for each of two groups. Finally, the effect of income composition channel is obtained by subtracting the effects of three channel computed above from the left-hand side of Equation (5.1).

Figure 7 describes the results. Panel (a) shows that, after a one-standard deviation contractionary monetary policy shock, the gap between the market incomes for the top 20% and bottom 20% earners increases by 1.33%p at the peak. Note that the response of the gap between the market incomes for two groups is very similar to the response of market income Gini coefficient shown in Panel (b) in Figure 5. Panel (b) shows the earnings heterogeneity channel which, as expected, worsens the degree of income inequality. Note that the response of earnings heterogeneity channel has the pattern similar to that of the gap between the market incomes in Panel (a). In addition, the size of two responses is similar and both of them significantly increase from about one year after the shock. This means that the earnings heterogeneity channel is most important in explaining the response of income inequality. This result is consistent with Coibion et al. (2017), Mumtaz and Theophilopoulou (2017), and Inui and Yamada (2017), all of which provide the evidence for the existence of earnings heterogeneity channel and stress the importance of the channel.

Figure 7: Responses of Each Channel



Note: This figure shows the impulse responses to a one-standard deviation contractionary monetary policy shock of the gap between the market incomes of high income and low-income earners (Panel (a)) and each channel (other panels). The dash lines represent one-standard error bands obtained by bootstrapping methods using 300 replications.

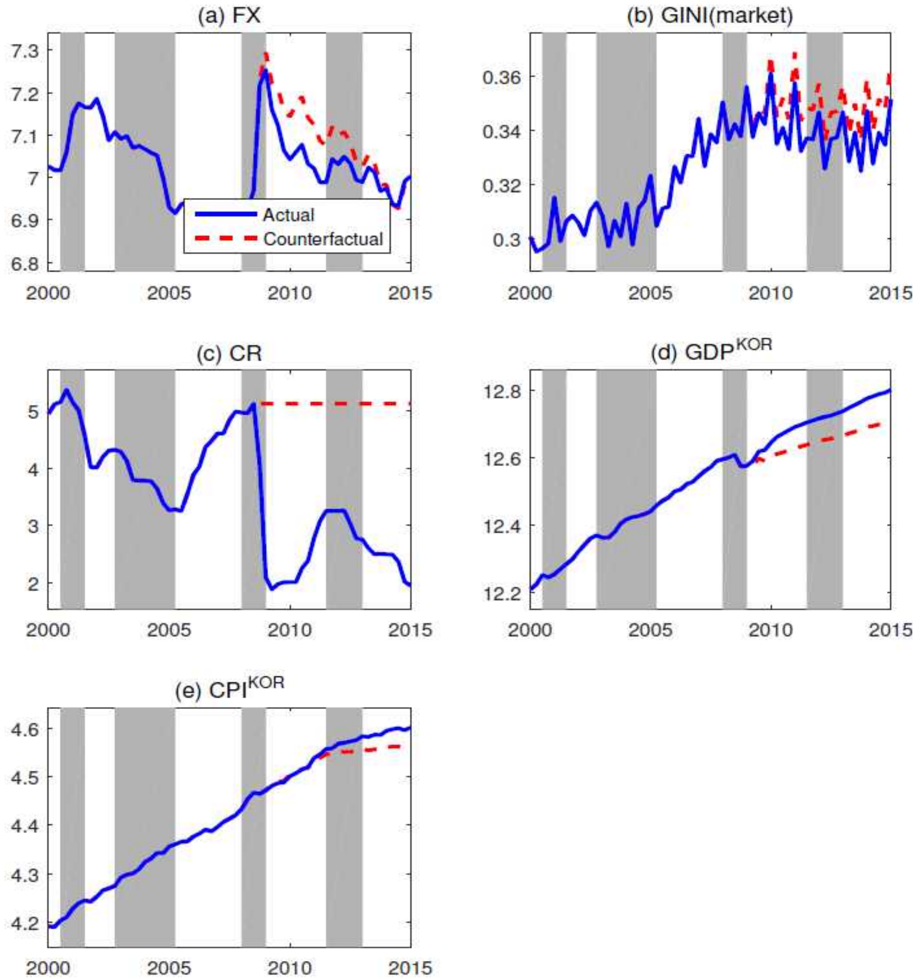
Panel (c) shows that the savings redistribution channel also works in worsening the income inequality even though the contribution is small relative to the earnings heterogeneity channel. Panel (d) shows that, as expected, the transfers heterogeneity channel improves the income inequality. The effect of transfers heterogeneity channel is bigger than that of savings redistribution channel but smaller than that of earnings heterogeneity channel. Finally, Panel (e) shows that the income composition channel worsens the income inequality, which is contrary to a theoretical prediction. One reason for this inconsistency is that a theoretical prediction mentioned in Section 2 assumes that the ratio of business income is higher for high-income earners while it is not in the data as described in Table 1. If the true ratio of business income is positively correlated with the amount of income, the income composition channel could work in a way to improve income inequality and so the true response of market income inequality should be weaker than those in Panel (a) in Figure 5 and Figure 7.

4. Impact of Monetary Easing on Income Inequality since Financial Crisis

So far we analyze the effect of monetary policy shocks on income inequality. In this subsection, we tackle the second question of how monetary policy affected income inequality in Korea since global financial crisis. More specifically, we examine how income inequality would be if Bank of Korea had left the call rate unchanged despite the global financial crisis. To answer this question, we implement a counterfactual analysis following Bernanke et al. (1997) and Kilian and Lewis (2011). The main idea is to compute the sequence of monetary policy shocks to hold the call rate constant from a given time, to compute the responses of economy to the counterfactual shocks, and to compare the counterfactual economy with the actual one.

Figure 8 shows the result. We assume that instead of lowering the rate drastically since 2008:Q4, Bank of Korea held the call rate constant at 5.13% from 2008:Q3 and thereafter, as described in Panel (c). Since the sequence of contractionary monetary policy shocks is required to keep the interest rate high, GDP and CPI would be lower as shown in Panels (d) and (e) while the exchange rate would increase as displayed in Panel

Figure 5: Counterfactual Analysis



Note: The solid and dashed lines describe the actual and counterfactual series, respectively. The counterfactual series are obtained by holding the call rate at 5.13% from 2008:Q3 and thereafter.

(a). Finally, Panel (b) shows that the counterfactual market income Gini coefficient. The actual average of the Gini coefficient during 2008:Q4 - 2015:Q1 is 0.340 while the counterfactual counterpart is 0.349 which is higher by 0.009 (0.9%p). Therefore, it would not worsen the income inequality to lower interest rate since the global financial crisis. Instead, by boosting the economy it could help reducing income inequality, which is consistent with Bivens (2015).

However, we need to be conservative in interpreting the results of counterfactual analysis since constructing any counterfactual is subject to the Lucas critique. Generally, economic agents would expect the central bank to deal with economic recessions by lowering the policy rate. So if the bank holds the rate constant, not lowering it, a contractionary monetary policy shock occurs. That is, it causes a sequence of contractionary monetary policy shocks to maintain the call rate unchanged despite an economic downturn. Then the rational economic agents would think that the monetary policy rule is changed and adjust their expectations on the rule. So the effects of the sequence of contractionary monetary policy shocks would become muted. Thus, it is possible that the average of market income Gini coefficient could be less than 0.349 in the counterfactual situation where the bank holds the rate constant. The counterfactual Gini coefficient 0.349 needs to be considered as the maximum value attained under the assumption of static expectations.

Ⅵ. Conclusion

In this paper, we analyze the relationships between monetary policy and income inequality in Korea. The main findings are as follows. First, the market income Gini coefficient has an upward trend, increasing from 0.296 in 1990:Q1 to 0.349 in 2017:Q2. The Gini coefficient also has seasonality and tends to increase during recessions. Second, the estimation results show that following a one-standard deviation contractionary (expansionary) monetary policy shock, market income Gini coefficient increases (decreases) significantly one year after a shock, reaching its peak to 0.0014 (0.14%p) while GDP and CPI decrease (increase) significantly by 0.48% and 0.15%, respectively. Third, the contributions of monetary policy shocks to income inequality are found to be small as shown by forecast error variance and historical decompositions. Fourth, earnings heterogeneity channel is most important among various channels through which monetary policy affects income inequality. Finally, a counterfactual analysis implies that if Bank of Korea held the call rate constant at 5.13% from 2008:Q3 and thereafter, the market income Gini coefficient would be higher by 0.009 (2.64%) on average during 2008:Q4 - 2015:Q1. Overall, our results suggest that while monetary policy shocks affect the degree of income inequality significantly the effects are limited in terms of magnitude. Rather, various institutional factors such as economic structure, labor market, systems for education, tax, welfare still seem the main drivers of income inequality.

As far as we know, this is the first paper which examines the effects of monetary policies on income inequality in Korea. Despite these contributions, there are several issues that have not been addressed in the this paper. First, the effective number of samples used for estimation, 93, is rather small and so the reliability of estimation results could be doubted. To obtain monthly observations for income inequality all these series, some interpolation will be required. Second, it would be meaningful to use and analyze income tax data instead of survey data since the former is more reliable than the latter. But income tax data is available only annually and so, again, some interpolation will be required. Lastly, it would be interesting to analyze whether the responses of income inequality to monetary policy shocks depend on the phase of the business cycle. We leave these issues for future research.

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Appendix

A. Characteristic of Samples

Table A1 shows some characteristics of samples used in this paper.

Table A1: Characteristics of Sample

	1990–1995	1996–2000	2001–2005	2006–2010	2011–2017.Q2
Initial Samples	6,377	6,569	6,847	7,949	7,048
Rural Households	0	0	838	1,608	1,482
Remaining Samples	6,377	6,569	6,009	6,341	5,566
Family Size	3.87	3.61	3.44	2.90	2.72
Per Household					
Wage Income	1,740,730	1,986,284	2,273,015	2,273,438	2,425,517
Business Income	835,194	959,759	950,231	767,007	734,495
Financial Income	32,002	45,360	30,059	18,810	14,655
Private Income	116,997	160,091	181,987	202,218	197,984
Market Income	2,724,923	3,151,494	3,435,291	3,261,474	3,372,648
Public Transfers	−86,556	−128,107	−166,723	−140,437	−120,406
Disposable Income	2,638,367	3,023,386	3,268,568	3,121,036	3,252,242
Per Person					
Wage Income	895,359	1,057,322	1,249,806	1,421,672	1,594,559
Business Income	439,046	522,033	527,846	479,836	475,724
Financial Income	16,319	23,552	15,392	10,414	8,237
Private Income	54,514	77,665	90,426	104,860	108,944
Market Income	1,405,238	1,680,571	1,883,470	2,016,782	2,187,464
Public Transfers	−45,632	−70,000	−94,975	−96,533	−98,223
Disposable Income	1,359,606	1,610,571	1,788,496	1,920,250	2,089,241

Note: The sample sizes represent the average of households surveyed every quarter during each periods and the family sizes represent the average of household members of those households. The income values means the average of monthly incomes during each periods.

B. Estimation of a Block-exogeneity VAR Model

In this appendix, we show the likelihood function for a block-exogeneity VAR model to estimate A_{11} and A_{12}. For convenience's sake, Equation (4.5) is repeated here:

$$\begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix} \begin{bmatrix} Y_t^{KOR} \\ Y_t^{US} \end{bmatrix} = \begin{bmatrix} C_{11}^1 & C_{12}^1 \\ 0 & C_{22}^1 \end{bmatrix} \begin{bmatrix} Y_{t-1}^{KOR} \\ Y_{t-1}^{US} \end{bmatrix} + \cdots + \begin{bmatrix} C_{11}^p & C_{12}^p \\ 0 & C_{22}^p \end{bmatrix} \begin{bmatrix} Y_{t-p}^{KOR} \\ Y_{t-p}^{US} \end{bmatrix} + \begin{bmatrix} \epsilon_t^{KOR} \\ \epsilon_t^{US} \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} Y_t^{KOR} \\ Y_t^{US} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}^{-1} \begin{bmatrix} C_{11}^1 & C_{12}^1 \\ 0 & C_{22}^1 \end{bmatrix} \begin{bmatrix} Y_{t-1}^{KOR} \\ Y_{t-1}^{US} \end{bmatrix} + \cdots$$

$$+ \begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}^{-1} \begin{bmatrix} C_{11}^p & C_{12}^p \\ 0 & C_{22}^p \end{bmatrix} \begin{bmatrix} Y_{t-p}^{KOR} \\ Y_{t-p}^{US} \end{bmatrix} + \begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}^{-1} \begin{bmatrix} \epsilon_t^{KOR} \\ \epsilon_t^{US} \end{bmatrix} \qquad \text{(A1)}$$

where $cov\left(\left[\epsilon_t^{KOR}, \epsilon_t^{US}\right]'\right) = I$. Let

$$\begin{bmatrix} u_t^{KOR} \\ u_t^{US} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}^{-1} \begin{bmatrix} \epsilon_t^{KOR} \\ \epsilon_t^{US} \end{bmatrix}$$

$$= \begin{bmatrix} A_{11}^{-1}\epsilon_t^{KOR} - A_{11}^{-1}A_{12}A_{22}^{-1}\epsilon_t^{US} \\ A_{22}^{-1}\epsilon_t^{US} \end{bmatrix} \qquad \text{(A2)}$$

Then

$$cov\left(\begin{bmatrix} u_t^{KOR} \\ u_t^{US} \end{bmatrix}\right) = \begin{bmatrix} A_{11}^{-1}A_{11}^{-1'} + A_{11}^{-1}A_{12}A_{22}^{-1}A_{22}^{-1'}A'_{12}A_{11}^{-1'} & -A_{11}^{-1}A_{12}A_{22}^{-1}A_{22}^{-1'} \\ -(A_{11}^{-1}A_{12}A_{22}^{-1}A_{22}^{-1'})' & A_{22}^{-1}A_{22}^{-1'} \end{bmatrix}$$

$$= \begin{bmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{bmatrix} \qquad \text{(A3)}$$

Denoting $Y_t = [Y_t^{KOR}, Y_t^{US}]'$ and $X_t = [X_t^{KOR}, X_t^{US}]'$ where $X_t^{KOR} = [Y_{t-1}^{KOR}, \cdots, Y_{t-p}^{KOR}]'$ and $X_t^{US} = [Y_{t-1}^{US}, \cdots, Y_{t-p}^{US}]'$, the log likelihood function can be written as

$$\mathcal{L}(\theta) = \sum_{t=1}^{T} \log f(Y_t | X_t; \theta)$$

$$= \sum_{t=1}^{T} \log f(Y_t^{KOR} | Y_t^{US}, X_t|; \theta) + \sum_{t=1}^{T} \log f(Y_t^{US} | X_t; \theta) \qquad \text{(A4)}$$

Since US block is assumed to be recursive, it is just identified and so the second term in Equation (A4) is a constant. Thus, the maximum likelihood estimates can be obtained by maximizing the first term on the right hand side in Equation (A4). The first term is (ignoring a constant term)

$$\sum_{t=1}^{T} \log f(Y_t^{KOR} | Y_t^{US}, X_t; \theta) = -\frac{T}{2} log|var(Y_t^{KOR} | Y_t^{US}, X_t)| - \frac{1}{2} \sum_{t=1}^{T} [Y_t^{KOR}$$

$$- E(Y_t^{KOR} | Y_t^{US}, X_t)]' [var(Y_t^{KOR} | Y_t^{US}, X_t]^{-1} [Y_t^{KOR} - E(Y_t^{KOR} | Y_t^{US}, X_t)] \qquad \text{(A5)}$$

Now we want to show

$$\sum_{t=1}^{T} \log f(Y_t^{KOR} | Y_t^{US}, X_t, \theta) = -T \log|A_{11}| - \frac{T}{2} trace(A_{11}[\Omega_{11}$$

$$- \Omega_{12}(-A_{11}^{-1}A_{12}) - (-A_{11}^{-1}A_{12})'\Omega_{21} + (-A_{11}^{-1}A_{12})'\Omega_{22}(-A_{11}^{-1}A_{12})]A'_{11}) \qquad \text{(A6)}$$

First, note that

$$var(Y_t^{KOR} | Y_t^{US}, X_t) = \Omega_{11} - \Omega_{12}\Omega_{22}^{-1}\Omega_{21}$$

$$= A_{11}^{-1} A_{11}^{-1'} \qquad \text{(A7)}$$

implying that the first term on the right hand side in Equation (A5) is equivalent to

$$-\frac{T}{2}log|var(Y_t^{KOR}|Y_t^{US},X_t) = -T\log|A_{11}| \tag{A8}$$

Second, let $\hat{v}_t = Y_t^{KOR} - E(Y_t^{KOR}|Y_t^{US},X_t)$ and then the second term on the right hand side in Equation (A5) is

$$\sum_{t=1}^{T}[Y_t^{KOR} - E(Y_t^{KOR}|Y_t^{US},X_t)]'[var(Y_t^{KOR}|Y_t^{US},X_t)]^{-1}[Y_t^{KOR} - E(Y_t^{KOR}|Y_t^{US},X_t)]$$

$$= \sum_{t=1}^{T}\hat{v}'_t(A_{11}^{-1}A_{11}^{-1\prime})^{-1}\hat{v}_t$$

$$= T\times trace(A_{11}\frac{\hat{v}_t\hat{v}'_t}{T}A'_{11}) \tag{A9}$$

where

$$\frac{\hat{v}_t\hat{v}'_t}{T} = \frac{1}{T}(Y_t^{KOR} - \hat{d} - \hat{D}'_0Y_t^{US} - \hat{D}'_1X_t^{KOR} - \hat{D}'_2X_t^{US})$$

$$(Y_t^{KOR\prime} - \hat{d}' - Y_t^{US\prime}\hat{D}_0 - X_t^{KOR\prime}\hat{D}_1 - X_t^{US}\hat{D}_2)$$

$$= \Omega_{11} - \Omega_{12}\hat{D}_0 - \hat{D}'_0\Omega_{21} + \hat{D}'_0\Omega_{22}\hat{D}_0 \tag{A10}$$

and

$$\hat{D}_0 = \hat{\Omega}_{12}\hat{\Omega}_{22}^{-1}$$

$$= -A_{11}^{-1}A_{12} \tag{A11}$$

Table A2 shows the estimation results.

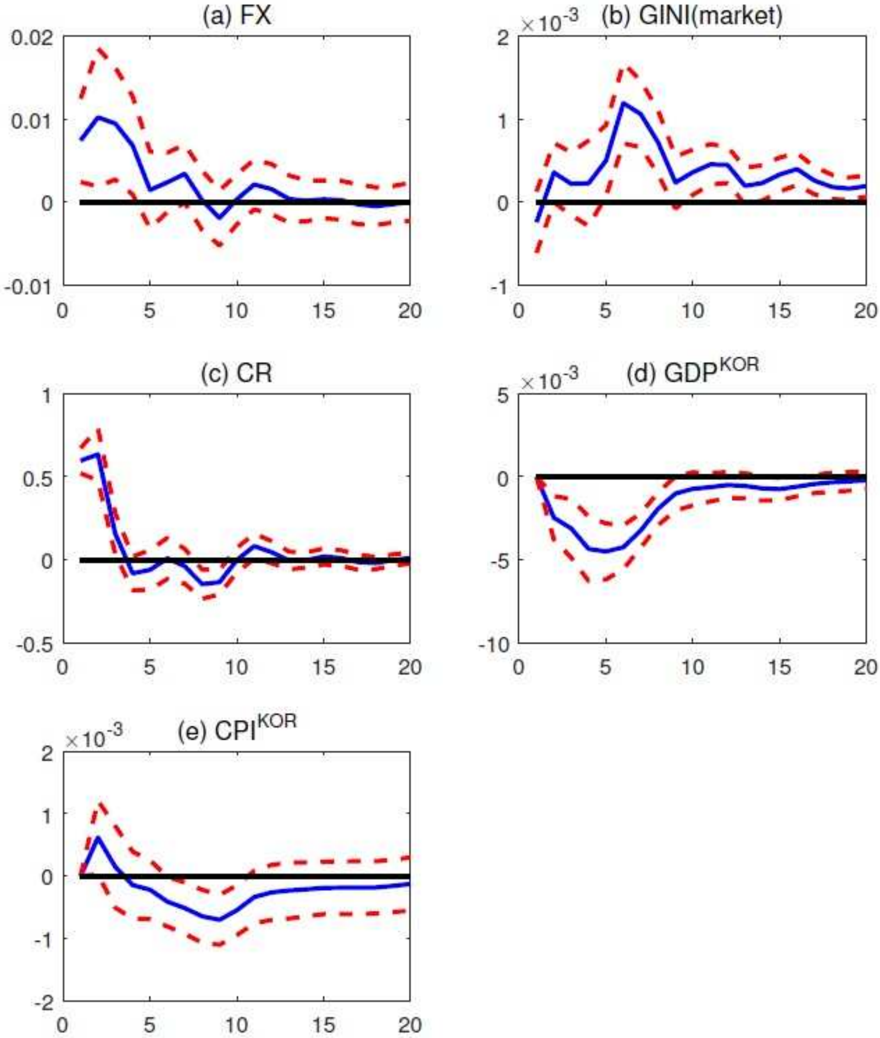
Table A2: Estimation Results for Impact Matrix

Coefficient	Estimate	p–value
$a_{1,1}$	−46.616	0.000
$a_{1,2}$	−55.945	0.051
$a_{1,3}$	0.522	0.060
$a_{1,4}$	−62..288	0.000
$a_{1,5}$	201.933	0.000
$a_{1,6}$	0.545	0.289
$a_{1,7}$	−40.605	0.002
$a_{1,8}$	−206.673	0.000
$a_{1,9}$	−0.938	0.105
$a_{2,2}$	273.609	0.000
$a_{2,3}$	0.089	0.551
$a_{2,4}$	−8.934	0.551
$a_{2,5}$	−114.217	0.000
$a_{3,1}$	−13.014	0.022
$a_{3,3}$	1.839	0.000
$a_{3,4}$	43.050	0.024
$a_{3,5}$	−119.403	0.000
$a_{3,9}$	−2.175	0.000
$a_{4,4}$	138.800	0.000
$a_{5,4}$	48.722	0.000
$a_{5,5}$	261.733	0.000
$a_{6,6}$	4.500	0.000
$a_{7,6}$	−1.348	0.003
$a_{7,7}$	−249.327	0.000
$a_{8,6}$	−0.936	0.044
$a_{8,7}$	10.139	0.000
$a_{8,8}$	−260.024	0.000
$a_{9,6}$	0.938	0.059
$a_{9,7}$	45.121	0.066
$a_{9,8}$	49.032	0.049
$a_{9,9}$	−4.221	0.000

C. Estimation of Results with Dummy Variable for pre-1997 Crisis

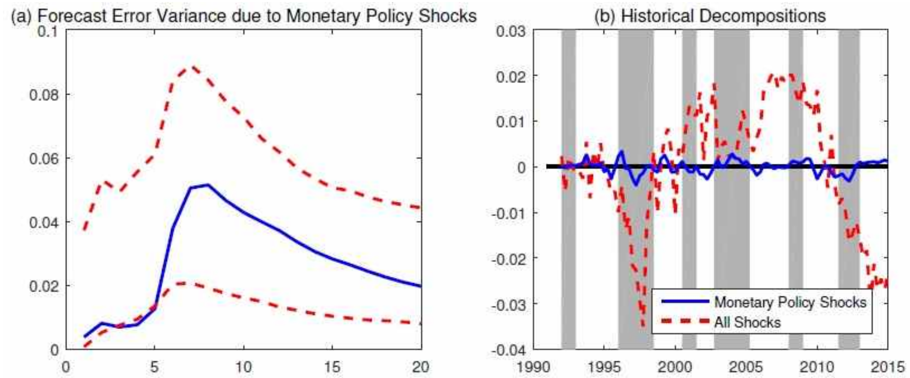
In this appendix, we show some key estimation results with dummy variable for pre-1997 Crisis: impulse responses to monetary policy shocks in Figure A9, contribution of monetary policy shocks to income inequality in Figure A10, and estimation results for impact matrix in Table A3.

Figure A9: Responses to Monetary Policy Shocks
(with Dummy Variable for pre-1997 Crisis)



Note: The solid lines describe the impulse responses to a one-standard deviation contractionary monetary policy shock. The dash lines represent one-standard error bands obtained by bootstrapping methods using 300 replications.

Figure A10: Contribution of Monetary Policy Shocks to Income Inequality (with Dummy Variable for pre-1997 Crisis)



Note: Panel (a) shows the forecast error variance of market income Gini coefficient due to monetary policy shocks. The dash lines represent one-standard error bands obtained by bootstrapping methods using 300 replications. In Panel (b), the solid and dashed lines describe the historical contribution to market income Gini coefficient of monetary policy and all shocks, respectively. The shaded areas represent economic recessions.

Table A3: Estimation Results for Impact Matrix (with Dummy Variable for pre-1997 Crisis)

Coefficient	Estimate	*p*–value
$a_{1,1}$	−46.942	0.000
$a_{1,2}$	−56.320	0.046
$a_{1,3}$	0.560	0.079
$a_{1,4}$	−64.706	0.000
$a_{1,5}$	197.421	0.000
$a_{1,6}$	0.485	0.354
$a_{1,7}$	−43.891	0.000
$a_{1,8}$	−208.578	0.000
$a_{1,9}$	−1.043	0.071
$a_{2,2}$	273.609	0.000
$a_{2,3}$	0.113	0.479
$a_{2,4}$	−6.765	0.666
$a_{2,5}$	−112.922	0.000
$a_{3,1}$	−12.366	0.040
$a_{3,3}$	1.830	0.000
$a_{3,4}$	45.602	0.023
$a_{3,5}$	−116.270	0.000
$a_{3,9}$	−1.949	0.000
$a_{4,4}$	138.954	0.000
$a_{5,4}$	51.575	0.000
$a_{5,5}$	268.375	0.000
$a_{6,6}$	4.503	0.000
$a_{7,6}$	−1.340	0.003
$a_{7,7}$	−249.939	0.000
$a_{8,6}$	−0.935	0.038
$a_{8,7}$	8.129	0.033
$a_{8,8}$	−261.859	0.000
$a_{9,6}$	0.939	0.050
$a_{9,7}$	43.504	0.070
$a_{9,8}$	45.735	0.075
$a_{9,9}$	−4.250	0.000

〈Abstract in Korean〉

통화정책과 소득불평등

박종욱*

본고는 우리나라에서의 통화정책과 소득불평등 간의 관계를 분석하였다. 통계청의 가계동향조사 자료를 이용하여 다양한 소득범위에 대하여 지니계수를 시산한 뒤 우리나라와 미국 경제로 구성된 블록외생성(block-exogeneity) VAR모형을 추정하여 통화정책이 소득불평등에 미치는 영향을 살펴보았다. 충격반응분석 결과 한 단위 표준편차 크기의 긴축적(완화적) 통화정책 충격은 GDP와 CPI를 각각 최대 0.48%와 0.15% 만큼 감소시키는 한편 1년 후 시장소득 지니계수를 최대 0.0014(0.14%p) 만큼 유의하게 증가시키는 것으로 나타났다. 그러나 분산분해 및 역사분해 분석결과 통화정책 충격이 소득불평등에 미치는 기여도는 작은 것으로 나타났다. 또한 통화정책이 소득불평등에 미치는 여러 경로 중 이질적 소득 경로(earnings heterogeneity channel)가 가장 중요한 것으로 나타났다. 마지막으로 반사실적(counterfactual) 분석 결과 한국은행이 2008.4분기~2015.1분기 동안 콜금리를 2008년 3분기 수준인 5.13%로 유지하였다면 정태적 기대 가정하에서 시장소득지니계수는 실제보다 평균적으로 0.009 (0.9%p) 만큼 높았을 것으로 추정되었다.

핵심 주제어: 통화정책, 소득불평등, 블록외생성(block-exogeneity) VAR

JEL Classification: E5, E4, C1

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