International Transmission of the US Interest Rate Policy Shocks: Multi-country Model Analysis Using FAVAR

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This study analyzes the international transmission of US interest rate hikes using the factor-augmented autoregression model. To achieve this purpose, this study first identifies the shocks that result from the US interest rate policies and analyzes how these shocks impact the outputs and prices in 22 countries. The shocks from the US interest rate hikes are determined to generally decrease the outputs and prices in the countries analyzed in this study. However, the current study's analysis of the period after the global financial crisis determines that the spillover effect on price is inaccurately measured. Meanwhile, the expenditure-switching effect, which refers to the appreciation of the US dollar following an interest rate hike leading to depreciation in other currencies, thereby improving trade balance, is not considerably large. That is, the income-absorption effect (*i.e.*, decrease in US imports owing to reduced domestic demand) or increase in world interest rate appears stronger than the expenditure-switching effect. Results suggest that the normalization of the US interest rate policy may be a factor that impedes the recovery of the global economy.

Keywords: US monetary policy, Interest rate, International transmission, FAVAR

JEL Classification: E52, F41, F42

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I. Introduction

This study analyzes how the rate hikes in the US central bank affect other countries. The Federal Reserve (Fed) is gradually completing its expansionary monetary policies as the shock from the financial crisis calms and the US economy appears to recover. Following the end of quantitative easing in October 2014, the Federal Open Market Committee (FOMC) meeting held in December 2015 led to the end of the zero interest rate policy that had been maintained for nearly 7 years since December 2008 and raised the federal funds rates (FFR) by 25 bps. The Fed has since raised its policy rates, with the target FFR at 1.5–1.75% as of May 2018. In terms of the policy rate predictions from the participants at the interest rate decision meeting in March 2018,[1] the US policy rate is expected to increase steadily in the future. Furthermore, the Fed has announced that it will gradually reduce its assets, estimated at 4.5 trillion dollars as of September 2017, thereby decreasing its balance sheet to normalize its monetary policy.

As the Fed clarifies its interest rate hike intentions, various countries are keenly aware of the spillover effects of the US rate hike. This awareness is evident from the fact that international financial markets have been generally fluctuating with the share price of emerging market countries declining and exchange rates increasing after the FOMC meeting minutes was released in April 2016. In May 2018, the value of emerging market currencies, such as those of Argentina and Turkey, appeared to be unstable because of concerns with global liquidity contractions caused by the continued US interest rate hikes. Uncertainty over the US interest rate hikes remains one of the major risk factors for global economic growth.[2] As the explanation so for

[1] The dot plot that shows the expected interest rate hikes by the participants of the monetary policy decision meetings indicate three increases of FFR annually from 2018 to 2019.

[2] Market concerns over the US interest rate hikes are also generally owed to previous cases. In 1994, FRB raised interest rates and came out of a period of long-term low interest rates. FFR, which was 3% in September 1992, was increased by 300 bps over 7 hikes from February 1994 and eventually reached 6% in February 1995. The resulting turmoil in the financial markets and outflow of foreign capital led Mexico to receive a bailout from the US and the International Monetary Fund (IMF) (*i.e.*, Tequila Crisis). The ensuing 1995 crisis in Brazil and the 1997 Asian financial crisis were not free from the influence of the US interest

suggests, the US rate hikes can have a profound impact on economies outside the US. Hence, the effects of the US rate hikes should be identified to maintain a steady hand on the economy.

The international transmission of monetary policies has been a long-standing topic in open economy macroeconomics; many studies have been conducted on the international transmission of US interest rate policy.[3, 4] Eichenbaum and Evans (1995) utilize the US monetary policy shock series organized in three methods to show that the US rate hike devalues currencies in major industrialized countries.[5] Kim

rate hikes.

[3] The international transmission of monetary policy is a topic covered by the traditional Mundell–Flemming–Dornbusch (MFD) model and the subsequent sticky price (or "sticky wage") intertemporal model. The MFD model indicates that the monetary tightening policy in one country has the effect of restricting exports because of the appreciation of the home currency that results in an expenditure-switching effect, thereby improving foreign trade balance and increasing income. However, this policy also leads to reduced domestic demand and decrease in imports (*i.e.*, known as the income-absorption effect), thereby exacerbating foreign trade balance and lower income. In the intertemporal model, the monetary tightening policy of a country may improve the foreign trade balance owing to the reduction of savings from consumption smoothing of the home country. This particular policy may also deteriorate a foreign country's trade balance owing to investment reductions by the home country from interest rate hikes. The effects of the expenditure-switching effect (increase in foreign income) and impact of increasing world interest rates (decrease in foreign income) may lead to positive and negative impact on the income of a foreign country. This theoretical ambiguity on the effect of monetary policy on foreign trade balance and income has triggered a subsequent wave of empirical analysis.

[4] After the global financial crisis, substantial research has been conducted on the international transmission of unconventional monetary policies. Refer to Mckinnon and Liu (2013), Lombardi and Zhu (2014), and Chen *et al.* (2014) for the effects of zero interest rate policy; to Chen *et al.* (2011), Glick and Leduc (2012), Chinn (2013), Fratzscher *et al.* (2013), Ahmed and Zlaste (2013), Moore *et al.* (2013), Dahlhaus *et al.* (2014), Rogers *et al.* (2014), Neely (2014), Tillmann (2014), Chen *et al.* (2014), Bauer and Neely (2014), Gilchrist *et al.* (2014), Lim *et al.* (2014), Kawai (2015), Chen *et al.* (2015), Bowman *et al.* (2015), and Noland (2015) for quantitative easing or asset purchase programs; and to Aizenmann *et al.* (2014), Lim *et al.* (2014), Eichengreen and Gupta (2015), and Noland (2015) for QE tapering.

[5] Many studies have been conducted on "delayed overshooting" related to the effects of monetary policy on exchange rates. Refer to Kim and Roubini (2000), Faust and Rogers (2003), Faust *et al.* (2003), and Sholl and Uhlig (2008), among others.

(2001) uses the vector autoregression (VAR) model to analyze the effect of US policy rate cuts on non-US G-6 countries and concludes that the cuts increase outputs in these G-6 countries. However, effects of improvements on trade balance as a transmission channel is minimal. Canova (2005) focuses on the impact of the US monetary policy shock on Latin American countries. He utilizes the sign restriction VAR model for analysis and concludes that the US monetary policy has a significant impact on economic fluctuations in Latin American countries. Miniane and Rogers (2007) review the effects of the US monetary policy on exchange and interest rates using a panel and a two-country VAR model. Unlike the difference between the exchange rate regime and extent of dollarization, they determine that capital control has minimal effect on neutralizing the impact of US monetary policy changes. Mackowiak (2007) estimates the structural VAR models for the emerging market countries in Asia and Latin America. The US monetary policy has a substantial impact on interest rates, exchange rates, prices, and real outputs in these countries.

Furthermore, Ehrmann and Fratzscher (2009) analyze the impact of the US monetary policy shocks on global stock markets. Their analysis indicates that if the Fed increases the policy rate, then the global share price declines, the extent of which is different between countries. Neri and Nobili (2010) conduct a study that focuses on the movement of commodity prices as a transmission channel of the US monetary policy shocks. They construct a two-country VAR model for the US and Eurozone and determine that the increase in FFR results in the activation of the Eurozone economy by lowering the price of raw materials, particularly oil. Edwards (2010) attempts to diversify the literature in terms of data. Panel regression analysis is conducted using high-frequency data from financial markets in emerging countries. The result of the analysis indicates that the change in FFR affects the interest rates in Latin American and Asian countries. Bluedorn and Bowdler (2011) apply the method of Romer and Romer (2004) to analyze the impact of US monetary policy shocks. They determine that the US interest rate hike increases the exchange and interest rates of other countries and decreases outputs.

Kim and Yang (2012) analyze the impact of the US interest rate policy on exchange rates, interest rates, and foreign exchange reserves by focusing on the experiences of nine East Asian economies. The impact of the US monetary policy shock on Asian countries' interest

rates is higher for countries with floating exchange rates but lower for those with fixed exchange rates or capital control. These studies are related to Miniane and Rogers (2007). By contrast, Kazi *et al.* (2013) analyze the possibility that the shock from the US monetary policy has been changed dynamically by using a time varying parameter factor-augmented vector autoregression (TVP-FAVAR) model. Kazi *et al.* (2013) find that the US interest rate hikes have varying effects on the 13 Organisation for Economic Co-operation and Development (OECD) countries' economic growth, and the effects strengthened after 1980s.

Recent studies have also shown interest in identifying factors that may affect the international transmission of the US interest rate policy shocks that are different among countries. Georgiadis (2016) utilizes the global VAR model to estimate the influence of the US monetary policy shock on outputs of other countries as the first stage. In the second stage, the aforementioned study identifies the factors that influence the size of the spillover effect through a cross-section regression analysis. This analysis indicates that the transmission of the US monetary policy shocks is influenced by the level of trade and financial integration, openness of financial markets, exchange rate regime, financial market development, labor market rigidities, industry structure and proportion of manufacturing, and participation in global value chains. Dedola *et al.* (2017) also use a two-stage approach and utilize the Bayesian VAR to identify the US interest rate policy shocks and analyze their effects. However, the aforementioned study concludes that country characteristics, such as GDP size, exchange rate regime, financial market openness, and trade openness, lack a significant correlation with the country-specific spillover effect. Moreover, Kim *et al.* (2016) report that reactions tend to be more responsive to the US monetary policy shocks when the fundamentals of the macroeconomy are considerably weak. In addition, Barakchian (2015) uses a vector error correction model of two countries to show that the responses of major macro variables to the US monetary policy shock are similar in Canada and the US.

Previous studies have shown that the majority of the analyses consider two countries to analyze the international transmission of US interest rate policies from a methodological perspective (refer to Table 1). One type of analysis, such as that of Kim (2001), involves setting the VAR models on the US economy, identifying the monetary policy shock based on the model, and analyzing by adding one foreign variable at a

TABLE 1

LITERATURE ON THE INTERNATIONAL TRANSMISSION OF US INTEREST RATE POLICY

Researchers	Impacted Countries	Impacted Indexes	Methodologies
Eichenbaum and Evans (1995)	Japan, Germany, Italy, France, the UK	exchange rate	two-stage approach[1)]
Kim (2001)	non-US, G-6	trade balance, output, exchange rate, prices, terms of trade, interest rate	two country SVAR
Canova (2005)	8 Latin American countries	output, prices, interest rate	sign restriction VAR (two-country)
Miniane and Rogers (2007)	26 countries	exchange rate, interest rate	panel / two-country VAR
Mackowiak (2007)	Hong Kong, South Korea, Malaysia, the Philippines, Singapore, Thailand, Chile, Mexico	output, prices, exchange rate, interest rate	two-country SVAR
Ehrmann and Fratzscher (2009)	50 countries	equity price	regression analysis
Neri and Nobili (2010)	Eurozone	exchange rate, trade balance, commodity price, interest rate	sign restriction VAR (two-country)
Edwards (2010)	Brazil, Chile, Mexico, Colombia, the Philippines, South Korea, Malaysia, Indonesia	interest rate	panel regression
Bluedorn and Bowdler (2011)	Canada, France, Germany, Italy, Japan, the UK	exchange rate, interest rate, output	two-country SVAR
Kim and Yang (2012)	9 East Asian countries	exchange rate, interest rate	two-country SVAR
Kazi *et al.* (2013)	14 OECD countries	output, equity, interest rate, trade	time-varying parameter FAVAR
Georgiadis (2016)	61 advanced and non-advanced countries	output	GVAR
Barakchian (2015)	Canada	output, prices, interest rate	two-country VECX model
Kim *et al.* (2016)	10 emerging economies	equity price, exchange rate, interest rate	VAR-X model
Dedola *et al.* (2017)	36 advanced and emerging countries	exchange rate, equity, interest rate, output, prices, trade balance	two-stage approach using BVAR

Note: 1) In the first stage, the US interest rate policy shock is identified using the basic model. In the second stage, the impact of the US interest rate policy shock on the economic variables of individual countries are analyzed using the autoregressive distributed lag (ARDL) model and regression method, among others.

time.[6] Others form one VAR model by combining the variable vectors of the US economy and foreign economies, as seen in Kim and Yang (2012); or identify the US monetary policy shocks first and add it to the models explaining foreign economies as an explanatory variable, as per Dedola *et al.* (2017). Exceptions include Kazi *et al.* (2013), which utilize (time varying) FAVAR, and Georgiadis (2016), which utilizes global VAR.

However, given the significant expansion of international trade and financial transactions, the analysis of international transmission based on a two-country model is restrictive because such assessment makes the consideration of interactions between countries difficult. Accordingly, the current study adopts the FAVAR model as the analysis method. FAVAR has been deemed suitable for constructing a multi-country model that reflects the interactions between countries without degrees-of-freedom problems associated with large amounts of data.[7,8] Kazi *et al.* (2013) also use FAVAR as an analysis method but with certain differences. First, Kazi *et al.* (2013) do not directly address the need for a multi-country model.[9] Instead, the constraints on the central bank's information set and the omitted variable bias are cited as the reasons for using the FAVAR model. Moreover, their research utilizes only 20 sets of data that reflect the US economy. However, the current study seeks to use additional data to enhance the precision of identifying monetary policy shocks. Furthermore, Kazi *et al.* (2013) focus on the international transmission of the US interest rate policy on 13 OECD countries, whereas the current study covers 22 countries, including non-OECD countries, thereby covering a considerably wide range. The former uses quarterly data, whereas the present study uses monthly data.

[6] These methods are referred to as the "marginal method." (Kim 2001).

[7] When variables are added to the VAR model, the number of parameters that need estimation increases substantially, thereby reducing the degree of freedom. This case is referred to as the degrees-of-freedom problem, which FAVAR resolves by summarizing information using factors.

[8] Kim (2001) emphasizes the need for a large-scale model that can reflect multi-country structures. Georgiadis (2016) also explicitly mentions the necessity of a multi-country model in addition to the current study.

[9] The reason why the analytical method of this study is referred to as the multi-country model is the simultaneous analysis of data from multiple countries to reflect international interactions. The reason is not that this study reflects all economic data from the countries concerned.

The results of this paper are summarized as follows. First, the impact of the US rate hike shock lowers industrial production in the majority of the 22 countries. This result suggests that the US interest rate policies may be one of the factors that will cause the co-movement of economies on an international level. Moreover, the response to the US interest rate hike shocks occurs over a long period. Second, the consumer price index also decreases in the majority of countries. With the exception of Brazil, the extent of price decline widens over time for the entire group. This finding could be interpreted that the impact of the US interest rate hike is likely to sustain the global trend of low inflation. However, note that the link between the US interest rate policy shocks and their spillover effects on foreign countries' prices may have been weakened because of shifts in inflation dynamics. Lastly, the income-absorption effect or increase in world interest rate appears stronger than the expenditure-switching effect. After the impact of the US rate hike shocks, the currencies of each country depreciate. However, the accuracy of these estimates is low. In addition, the effect of high foreign exchange rates that lead to improvement in trade balance is even more uncertain. The majority of the countries experience worsened trade balance or minimal changes to it.

The remainder of this paper is organized as follows. Section II describes the model and data. Section III presents the analysis results. Lastly, Section IV provides the summary of the analysis results and the conclusion.

II. Econometric Methodology

A. Model

This study is based on the FAVAR model proposed by Bernanke, Boivin, and Eliasz (2005). FAVAR is advantageous because it facilitates the analysis of large data sets by reducing information through common factors, thereby solving the degrees-of-freedom problem.

The FAVAR model comprises two equations. The first equation expresses the dynamics of the model as follows:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \upsilon_t, \tag{1}$$

where Y_t is an $M \times 1$ vector of observable economic variables, F_t is a $K \times 1$ vector of unobservable factors, $\Phi(L)$ is a lag polynomial with a finite order, and v_t is a disturbance term with mean of 0 and variance–covariance matrix of Q. If all terms of $\Phi(L)$ that relate Y_t to F_{t-1} are 0, then equation (1) is no different from a standard VAR. That is, FAVAR is a generalized version of the standard VAR.

The second equation shows the relationship between observable informational time series and factors as follows:

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t, \tag{2}$$

where X_t is an $N \times 1$ vector of an observable informational time series. Although F_t is unobservable, the assumption is that the related information can be extracted from X_t. Λ^f is an $N \times K$ factor loading matrix, while Λ^y is an $N \times M$ matrix. e_t refers to an error term with expected value of 0. The classification of observable variables into Y_t or X_t depends on the purpose of the analysis. Typically, the variable of interest, the impact of which should be known, is included in equation (1) as Y_t, while the other information variables are included in equation (2) to be used in factor extraction. The current study uses FFR as Y_t, while other data are used as X_t.

Two methods are used in estimating the FAVAR model. The first method is a two-step procedure, while the other is maximum likelihood estimation. To explain the two-step method, the first step is to utilize principal component analysis to extract the K factors from X_t. Y_t is excluded when extracting the factors. Thereafter, F_t is replaced with $\hat{F}_t$, which is extracted in the first stage, and equation (1) is routinely estimated. The error bands of the impulse response functions are generally obtained using the bootstrap procedure of Kilian (1998). The maximum likelihood estimation method simultaneously estimates equations (1) and (2). Bernanke, Boivin, and Eliasz (2005) estimate equations (1) and (2) simultaneously using likelihood-based Gibbs sampling.

The two-stage estimation and maximum likelihood estimation methods have their respective characteristics. In general, the two-stage estimation method is simple to calculate and is known to relatively outperform the maximum likelihood estimation method in terms of uncertainty of estimates (Bernanke *et al.* 2005). The current study uses these considerations as bases to utilize the two-step estimation method.

B. Model

This study uses 132 macroeconomic time series for the US and 88 time series for the remaining 22 countries. All data are on a monthly basis. The 22 countries are Japan, Germany, the UK, France, Brazil, Italy, India, Canada, South Korea, Spain, Mexico, the Netherlands, Sweden, Belgium, Norway, Austria, Denmark, Malaysia, Finland, Ireland, Greece, and Portugal (in order of nominal GDP). As of 2014, these 22 countries account for 51.9% of the world GDP (based on the IMF World Economic Outlook Database).

The US data are obtained from the Federal Reserve Bank of St. Louis. Accordingly, finding large economic indicators to use in FAVAR may be difficult and effort-intensive. However, the Federal Reserve Bank of St. Louis recently built a database to provide easy access to factor analysis, such as FAVAR (McCracken and Ng 2015). The database provided by the Federal Reserve Bank of St. Louis[10] comprises 135 series of data. This study excludes four series of data, the time series of which has ended or is no longer timely, but utilizes the shadow FFR data[11] from Wu and Xia (2016), thereby forming a collection of 132 US economic indicators.

Industrial production, consumer price index, net exports, and exchange rate data are obtained for the 22 countries. The exchange rate refers to the monthly average exchange rate against the US dollar. The sources are based on the monthly economic indicator (MEI) of the OECD economic database. When data are unavailable, this study refers to the international financial statistics (IFS) of the International Monetary Fund (IMF).

The data span the period from January 1974 to June 2015. All data are seasonally adjusted. If the source provides seasonally adjusted data, then the data are used as provided. However, if raw data are provided, then they are seasonally adjusted using Census X-12 in Eviews. Appendix 2 provides additional information on the data used in this study.

[10] http://research.stlouisfed.org/econ/mccracken/fred-md/

[11] Refer to https://www.frbatlanta.org/cqer/research/shadow_rate.aspx?panel=1. Shadow FFR refers to an index developed to analyze the stance of monetary policies during financial crises, such as zero interest rates and quantitative easing policies, and assess their impact on the economy.

III. Empirical Results

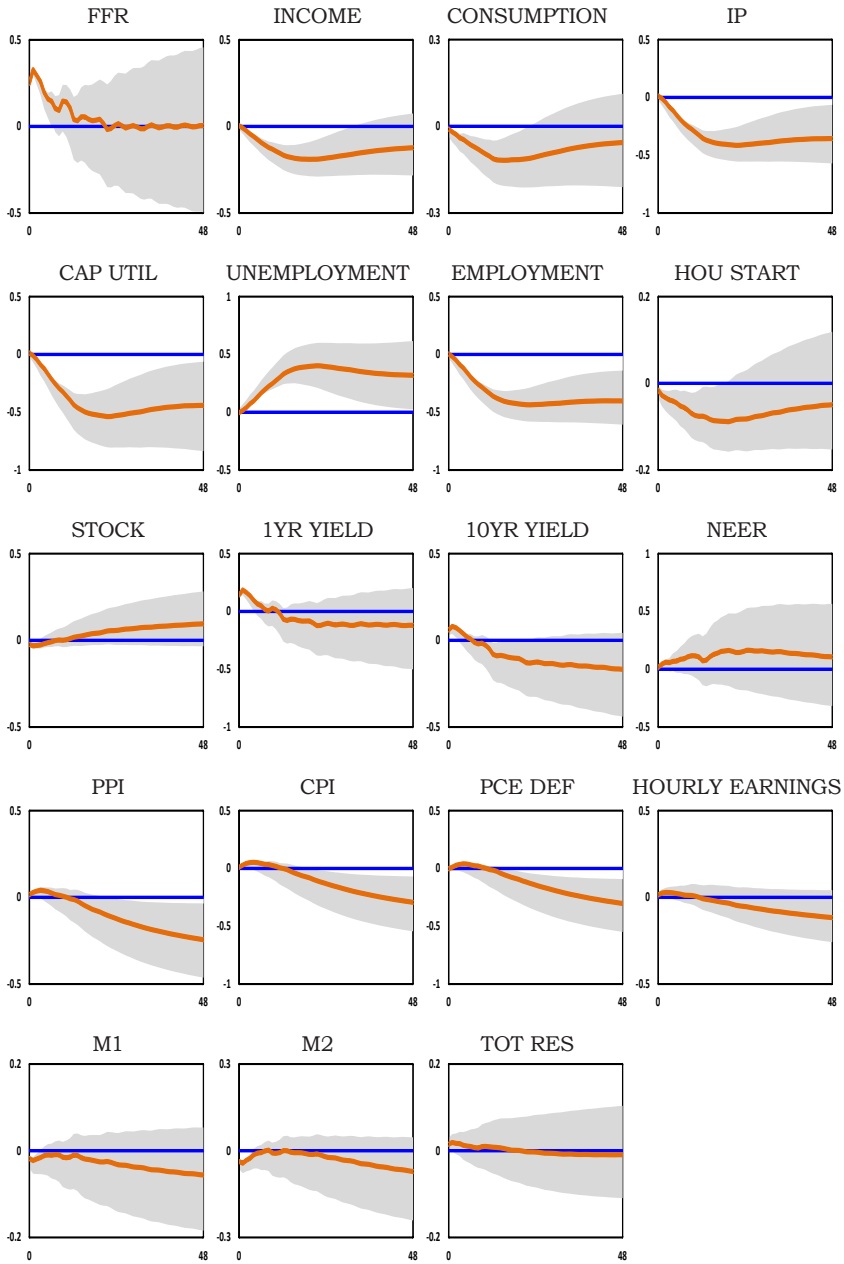
A. Identification of the US Interest Rate Policy Shocks

To analyze the international transmission of the US interest rate policies, the US interest rate policy shock should be identified first. Given that the main interest of this study is international transmission of the US interest rate policy, the current approach taken focuses on the accuracy of the results rather than on the theoretical criteria[12] of the US monetary policy identification. In this regard, various options for the specification of the model are set to maximize the accuracy of identification.

First, the same identification restriction used by Bernanke, Boivin, and Eliasz (2005) is placed on the VAR equation. Bernanke, Boivin, and Eliasz (2005) impose recursive contemporaneous restrictions on the FAVAR model similar to those applied by Sims (1980), to identify monetary policy shocks. That is, the information variables are classified into slow-moving and fast-moving variables. A slow-moving variable refers to variables on which FFR changes do not impact in the same period, whereas a fast-moving variable refers to variables that show response to changes in FFR contemporaneously. Bernanke, Boivin, and Eliasz (2005) classify financial indicators, such as interest and exchange rates, as fast-moving variables, while the real economy-related indicators, such as production, prices, and employment as slow-moving variables. The current study follows this approach. Appendix 2 provides detailed information on the classification into slow- or fast-moving variables.

The next issue is the number of information variables used for the US economy. This study attempts to use various models. Figure 1 shows the impulse response functions when 131 variables are used (called "big model" or "benchmark model"), while Appendix Figure 1 in Appendix 1 shows the functions when 21 variables are used (called "small model"). The analysis period is from January 1974 to June 2008. All variables are converted to stationary series. Appendix 2 includes the details of the variable transformation. In all figures, the dark orange line is a point estimate of the impulse response function, while the gray

[12] Bai and Ng (2002) suggest a method for determining the optimal number of factors based on information criteria. However, the robustness of this method is not known to be high.



Note: Gray areas are the 68% error bands.

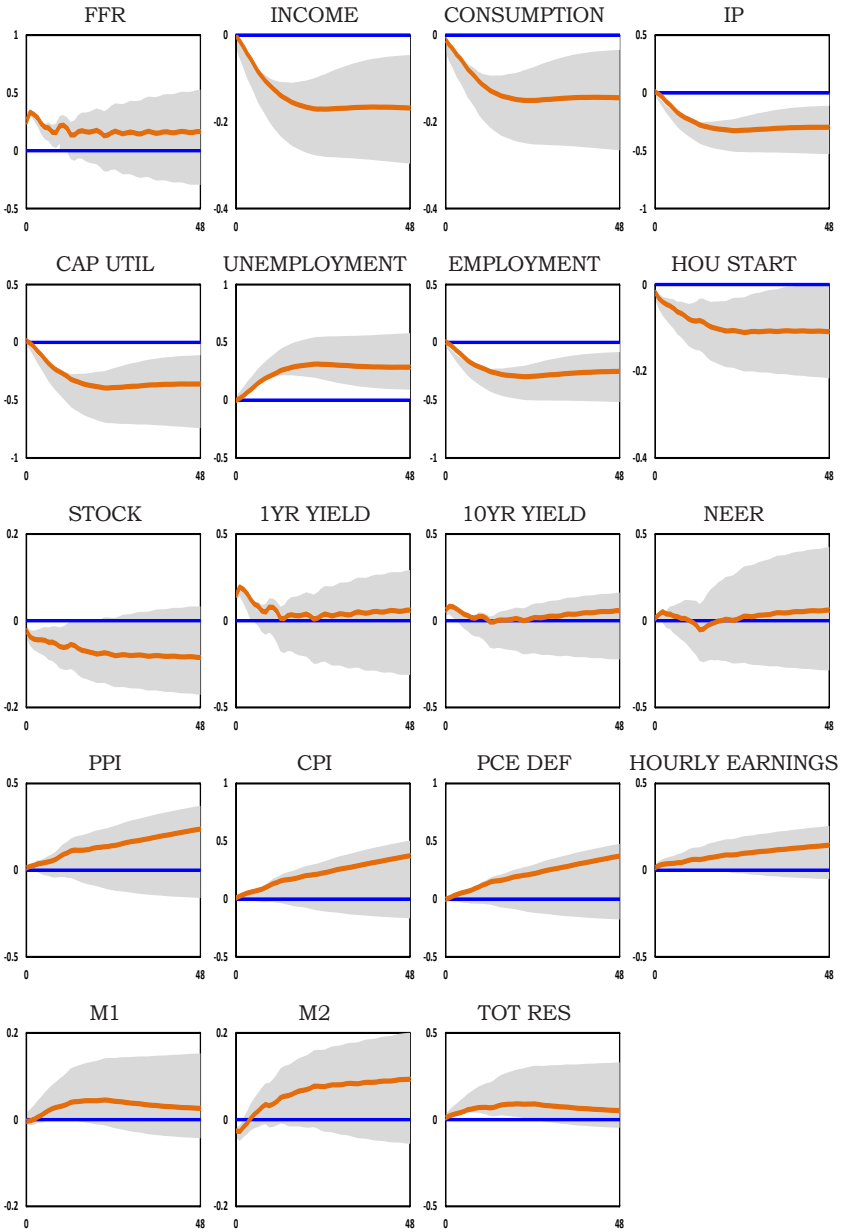
FIGURE 1
IDENTIFICATION OF THE US INTEREST RATE POLICY SHOCK (BENCHMARK MODEL)

area represents the corresponding 68% error band.[13] INCOME refers to the real personal income excluding transfers, CONSUMPTION is the real personal consumption expenditure, IP refers to the industrial production, CAP UTIL is the capacity utilization rate, UNEMPLOYMENT refers to the unemployment rate, STOCK refers to the S&P500 stock price index, EMPLOYMENT refers to the employment, HOU START refers to the housing starts, M1 refers to M1 money stock, M2 refers to M2 money stock, TOT RES refers to the total reserves, 1YR YIELD refers to the 1-year government bond yields, 10YR YIELD refers to the 10-year government bond yields, NEER refers to the nominal effective exchange rate, PPI refers to the producer price index, CPI refers to the consumer price index, PCE DEF refers to the personal consumption expenditure deflator, and HOURLY EARNINGS refers to the average hourly earnings. Figure 1 and Appendix Figure 1 show that the increase of FFR by 25 bps leads to a reduction of income, consumption, and employment, as well as the decline of prices and increase of interest rates. From a qualitative standpoint, no significant differences exist between the two. However, in terms of model accuracy as expressed by the width of the error band, the larger model evidently shows superior results than the smaller model. These differences appear to be caused by the fact that the Fed uses a variety of information variables in determining the direction of monetary policy.

The next issue is determining the analysis period. The accurate identification of the Fed's monetary policy stance during the financial crisis is known to be difficult because of unprecedented policies, such as zero-interest rate policy and quantitative easing (Wu and Xia 2016).

Accordingly, this study divides the analysis period from January 1974 to June 2008 and from January 1974 to June 2015. Figure 2 shows the impulse response functions that correspond to the latter period. Moreover, comparing Figures 1 and 2 shows that when the financial crisis period is included in the analysis, the accuracy of the real variables, such as income, consumption, and employment, improves. However, prices change direction and increase during contractionary

[13] Kim and Roubini (2000), Primiceri (2005), and Uhlig (2005) use an error band of 68% because of the degree of freedom. The error band and interpretation of this study are based on these examples. However, other error bands, such as 90%, are often used. Hence, the analysis results of this study should be interpreted conservatively.



Note: Gray areas are the 68% error bands.

FIGURE 2

IDENTIFICATION OF THE US INTEREST RATE POLICY SHOCK (1974–2015)

monetary policy. That is, a price puzzle appears. These results are similar even if FFR is replaced with the shadow FFR from Wu and Xia (2016) (see Appendix Figure 2). The emergence of a price puzzle appears to be caused by the inflation rate not increasing despite the Fed operating an extremely expansionary monetary policy in coping with the financial crisis. The US inflation rate remained at an average annual rate of 1.4% from 2009 to 2015.

This study also attempts to use the level variables instead of the stationary time series to plot the impulse response functions (see Appendix Figure 3). This step considers the previous studies that analyze effects of monetary policy shocks often utilizing the level variables (*i.e.*, Christiano *et al.* 1996). When using the level variables, the accuracy of the impulse response functions improves. However, a price puzzle emerges, followed by a liquidity puzzle, where the monetary indicators, such as total reserve, increase. Lastly, the number of factors extracted from the information variables is set to 3, while the number of lags in equation (1) is set to 13. Several numbers of factors and lags are tried but the results are most satisfactory when the number of factors is 3, while and the number of lags is 13.[14] This study determines that as the number of factors increases, the error bands of the impulse response functions of several variables also increase (Appendix Figure 4). The use of only a few lags does not make any substantial difference in the results (Appendix Figure 5). A few studies, such as Bernanke, Boivin, and Eliasz (2005) and Dedola *et al.* (2017), which use monthly data apply 13 lags.

The current study uses the preceding analysis to identify the shocks from the US interest rate hikes based on the large model, analysis period between January 1974 to June 2008, stationary time series, 3 factors and 13 lags, and sets the shock as the benchmark case (see Figure 1). The impulse responses of the major US economic indicators are generally consistent with the theories. Income, consumption, employment, output, and prices decline, while interest rates, external value of currency, and unemployment rate increase. The accuracy

[14] In relation to the number of lags, SC proposes 2 and HQ proposes 3 as the optimal number of lags. However, LR, FPE, and AIC present 13. The results of applying the model determining factor numbers in Bai and Ng (2002) indicate that the optimal number of factors for IC is 6–7 and for PC is 7–8. However, the optimal number for AIC is 3.

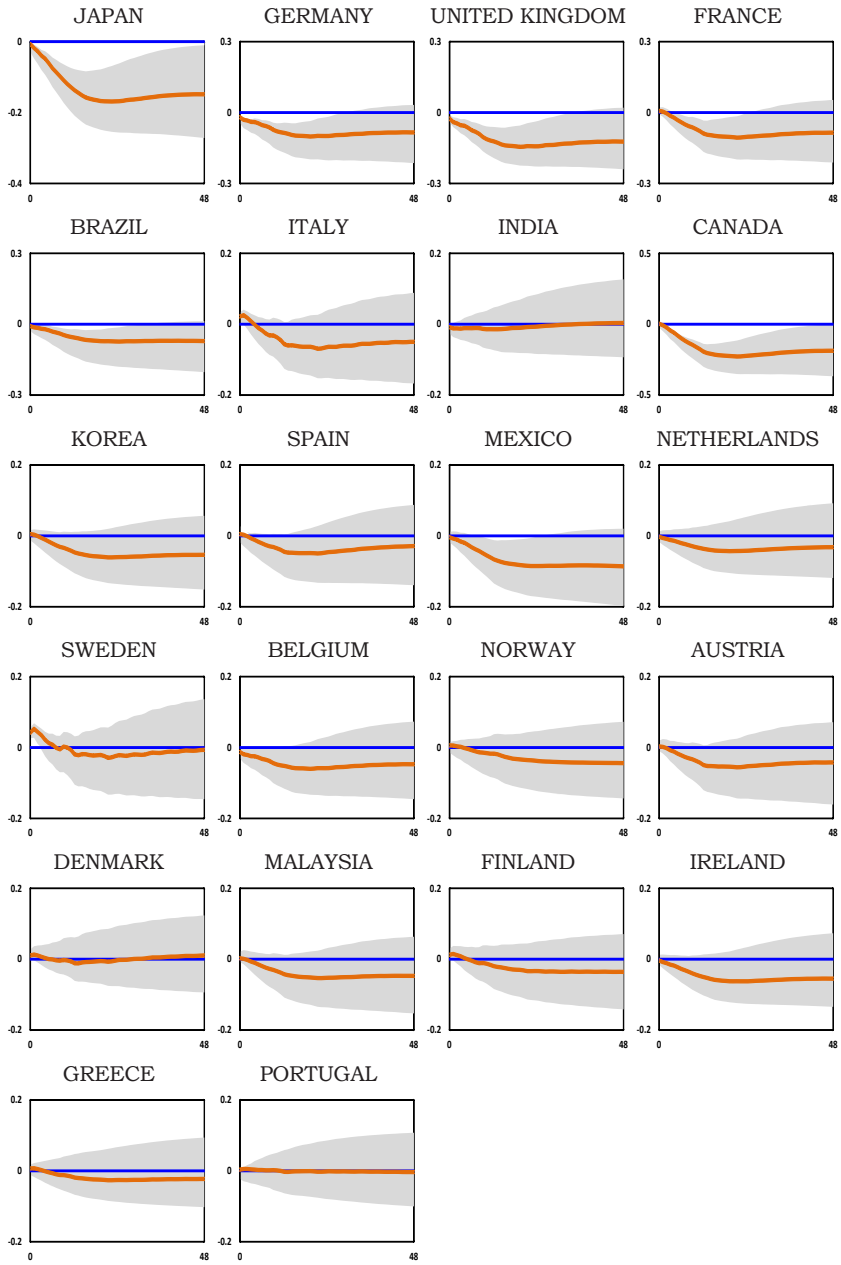
of the estimates is relatively high. The next section analyzes the international transmission of such identified interest rate hike shocks.

B. Effects on Outputs

Figure 3 shows the impact of the US interest rate hikes on industrial production in 22 other countries. First, the impact of the US rate hike shocks lowers the industrial production in the majority of the 22 countries.[15] In particular, Japan, Germany, the UK, France, Brazil, Canada, Mexico, and Belgium experience substantial decreases. The only countries with minimal or no change in industrial production are India, Denmark, and Portugal. As an exception, Italy, Sweden, and Finland show a slight increase in industrial production but only at the beginning of the shocks. These results suggest that the US interest rate policies may be one of the factors that will cause the co-movement of economies on an international level. Moreover, the responses to the US interest rate hike shocks occur over a long period. The majority of the countries failed to completely recover from the negative impact even four years after the shock. Only India, Sweden, and Denmark returned to equilibrium within four years.

This study analyzes the size of the largest impulse response, the point at which such response occurs, and four-year cumulative impulse response by country to determine the country that experiences the largest and earliest of shocks. Table 2 shows the results. First, the differences in the months of maximum impact between countries are not significant. In numerous countries, the maximum shock occurs at a point of time near the two-year mark. India and Denmark have earlier shocks compared with other countries. Mexico, Norway, Finland, and

[15] These results are consistent with the analysis of Kim (2001), which concludes that the expansionary US monetary policy leads to an increase in GDP and industrial production in six developed countries, including France and Germany. Bluedorn and Bowdler (2011), Georgiadas (2016), and Dedola *et al.* (2017) report the same results. However, these results contradict that of Kazi *et al.* (2013), which conclude that the contractionary US monetary policy leads to high GDP in France, Germany, Italy, the UK, Austria, Spain, and Finland. Kazi *et al.* (2013) propose the causes of increasing GDP as the decrease in raw material prices and increase in US import demand owing to the strengthening of the US dollar. Similar to Kazi *et al.* (2013), Canova (2005) reports an increase in output to the contractionary US monetary shocks in Latin American economies.



Note: Gray areas are the 68% error bands.

FIGURE 3

IRFS OF THE INDUSTRIAL PRODUCTION INDEXES

Table 2
Statistics of IRFs of the Industrial Production Indexes

Countries	Max impact	Month of max impact	Cumulative impact
Japan	−0.16885	23	−6.46954
Germany	−0.10149	20	−3.91795
The UK	−0.14531	20	−5.63532
France	−0.10613	22	−3.82186
Brazil	−0.07336	25	−2.88493
Italy	−0.06932	22	−2.22455
India	−0.01429	13	−0.27596
Canada	−0.22788	22	−8.45591
South Korea	−0.06078	23	−2.23643
Spain	−0.04965	22	−1.64982
Mexico	−0.08608	48	−3.32927
The Netherlands	−0.04314	20	−1.58179
Sweden	−0.02931	22	−0.41838
Belgium	−0.06020	20	−2.29008
Norway	−0.04408	48	−1.43358
Austria	−0.05584	22	−1.96766
Denmark	−0.01202	14	0.04881
Malaysia	−0.05337	23	−1.97403
Finland	−0.03586	48	−1.20143
Ireland	−0.06250	23	−2.39618
Greece	−0.02659	22	−0.92320
Portugal	−0.00352	48	−0.04696
Mean	−0.06953	25.9	−2.50391

Portugal show the largest shocks near the four-year mark.

Canada has the largest impact size and largest response after 22 months, reaching −0.228, which is over three times the average of −0.070 for 22 countries. Other countries, such as Japan, the UK, France, Germany, Mexico, and Brazil have large impact, while Greece, India, Denmark, and Portugal have relatively small impact.

The feature of the cumulative impulse responses is nearly similar to that of the maximum impact responses. Canada experiences the largest impact (−8.456), which is well above three times the average (−2.504), followed by Japan, the UK, Germany, France, Mexico, and Brazil.

The size of the cumulative impact in India, Portugal, and Denmark is considerably smaller compared with those in other countries.

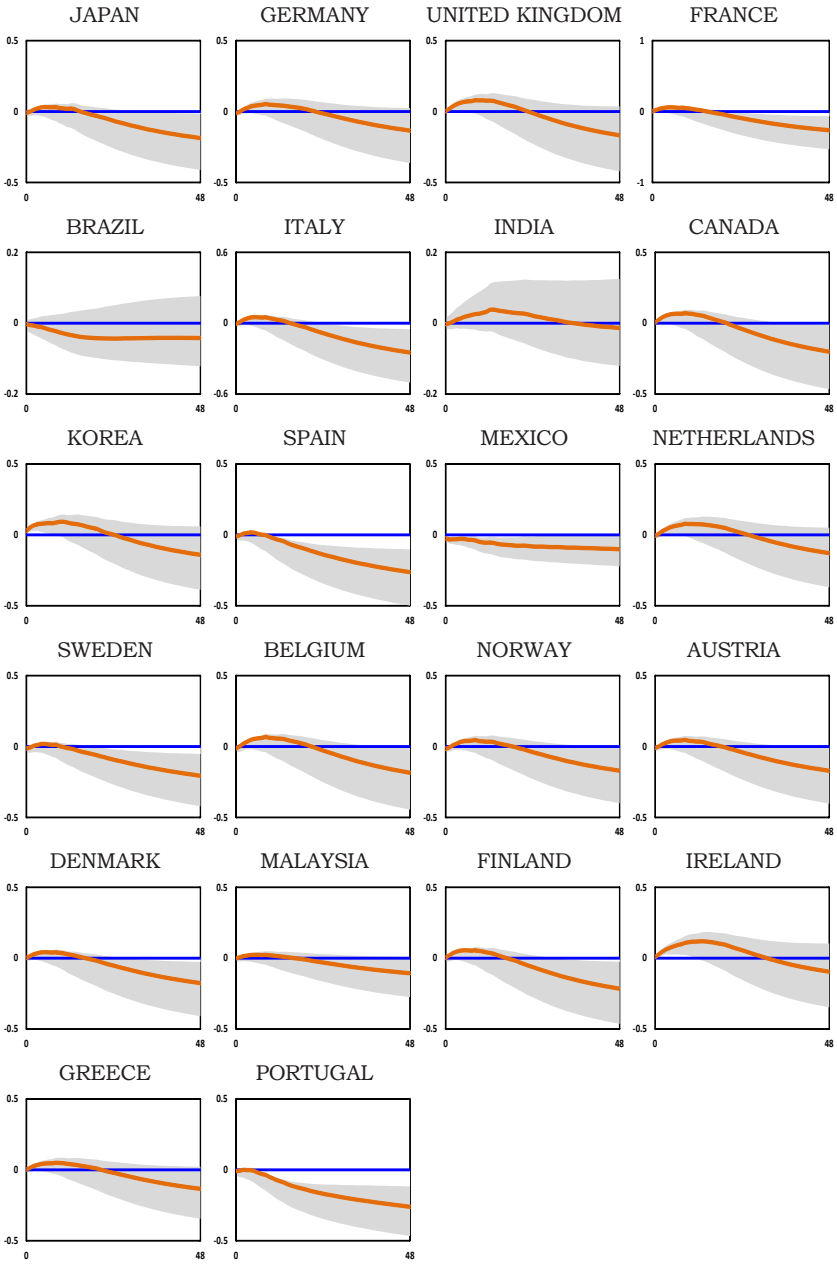
C. Effects on Prices

Figure 4 shows the impulse response functions of the consumer price index (CPI). CPI also decreases in the majority of the countries, which is similar to the results of industrial production.[16] Except for Brazil, deflation accelerates over time for the majority of the countries. In four years, prices decrease significantly in 16 countries, including Japan, France, Italy, Canada, Spain, and Mexico. Figure 4 shows that the impact of the US rate hike is likely to sustain low inflation globally. In addition, the simultaneous decline in industrial production and prices means that the impact of the US rate hike will act as a demand shock to other countries.

This study summarizes various statistics to determine which countries have the most severe decline and which have the earliest impact. However, unlike in the case of industrial production, this study analyzes the month when a decrease occurs, the impact after 48 months, and the cumulative impact after 48 months, noting that the extent of price decline expands gradually over time. Table 3 presents the results.

A total of 14 countries, including Japan, Germany, Brazil, and Italy, show a decrease in prices at the end of the first month after the shock. Only Brazil and Mexico among these 14 countries experience a continued decline in prices. The prices in other countries increase and decrease again thereafter. From the price decline after the increase, the average timing of the price decline occurs at the 18.5-month mark. That is, the decrease in prices starts on a significant basis after one year and six months after the US rate hike. The timing of the price decline is in the order of Brazil, Mexico, Portugal, and Spain for countries experiencing it the earliest. India, Ireland, the Netherlands, France, the

[16] Contrary to the current research, a few studies, such as Canova (2005) and Mackowiak (2007), show that contractionary US monetary policy shocks incur an increase in prices in a group of developing countries. They focus on the role of capital inflows or currency depreciation. Dedola *et al.* (2017) show a similar result to the current study. They show that inflation decreases in the majority of the countries to the US interest rate hike shocks although the effects are not precisely estimated.



Note: Gray areas are the 68% error bands.

FIGURE 4

IRFS OF THE CONSUMER PRICE INDEXES

TABLE 3
STATISTICS OF IRFS OF THE CONSUMER PRICES INDEXES

Countries	Month when a decrease occurs[1)]	Impact after 48 months	Cumulative impact
Japan	1 (16)	−0.18707	−3.24370
Germany	1 (23)	−0.13463	−1.32071
The UK	24 (24)	−0.16778	−1.27177
France	16 (16)	−0.26434	−4.42025
Brazil	1 (1)	−0.04189	−1.68615
Italy	1 (16)	−0.24873	−4.15878
India	1 (36)	−0.01347	0.58306
Canada	21 (21)	−0.20138	−2.39876
South Korea	25 (25)	−0.14081	−0.47580
Spain	1 (9)	−0.26337	−6.09922
Mexico	1 (1)	−0.10124	−3.48097
The Netherlands	1 (27)	−0.12914	−0.39697
Sweden	1 (11)	−0.20639	−4.31939
Belgium	1 (22)	−0.18509	−2.06965
Norway	1 (20)	−0.17075	−2.39627
Austria	1 (19)	−0.17104	−2.38747
Denmark	17 (17)	−0.17598	−2.68759
Malaysia	1 (17)	−0.10639	−1.63449
Finland	18 (18)	−0.21562	−3.19812
Ireland	32 (32)	−0.09540	1.34139
Greece	22 (22)	−0.13414	−1.43711
Portugal	1 (4)	−0.26078	−7.09932
Mean	8.6 (18.5)	−0.16434	−2.46627

Note: 1) Months when the first decreases occur. The numbers inside the parentheses are the months when the impulse responses start to decrease again after increases.

UK, and Germany (in the same order) are the slowest to experience price declines.

France is the country with the highest decrease in prices four years after the shock. The average impact is −0.164, while that of France is −0.264. After France, the highest price decreases are in Spain, Portugal, Italy, Finland, Sweden, and Canada. The Netherlands, Malaysia, Mexico,

Ireland, Brazil, and India are among the group of countries with small price decreases.

The cumulative impulse responses are similar. Portugal (−7.099) is the country with the highest decrease in the cumulative price decline, with Spain, France, Sweden, and Italy among the most significant losers. Germany, the UK, South Korea, the Netherlands, India, and Ireland are among the countries experiencing small cumulative impact from the US interest rate hikes. In particular, India and Ireland experience increasing cumulative prices.

D. Transmission Mechanism

A country's contractionary monetary policy would reduce income in other countries when the income-absorption effect overwhelms the expenditure-switching effect in the MFD model and the increase in world interest rate effect overturns the expenditure-switching effect in the intertemporal model. Such movement is based on theories on the international transmission of monetary policy.[17] That is, a country's contractionary monetary policy leads to increasing income in other countries when both models show sufficient expenditure-switching effects. Therefore, the empirical analysis on the reduction of industrial production in other countries (as discussed in Section B) can be considered evidence that when the Fed increases its policy rates, the income-absorption effect or increase in the world interest rate will overpower the expenditure-switching effects.[18, 19]

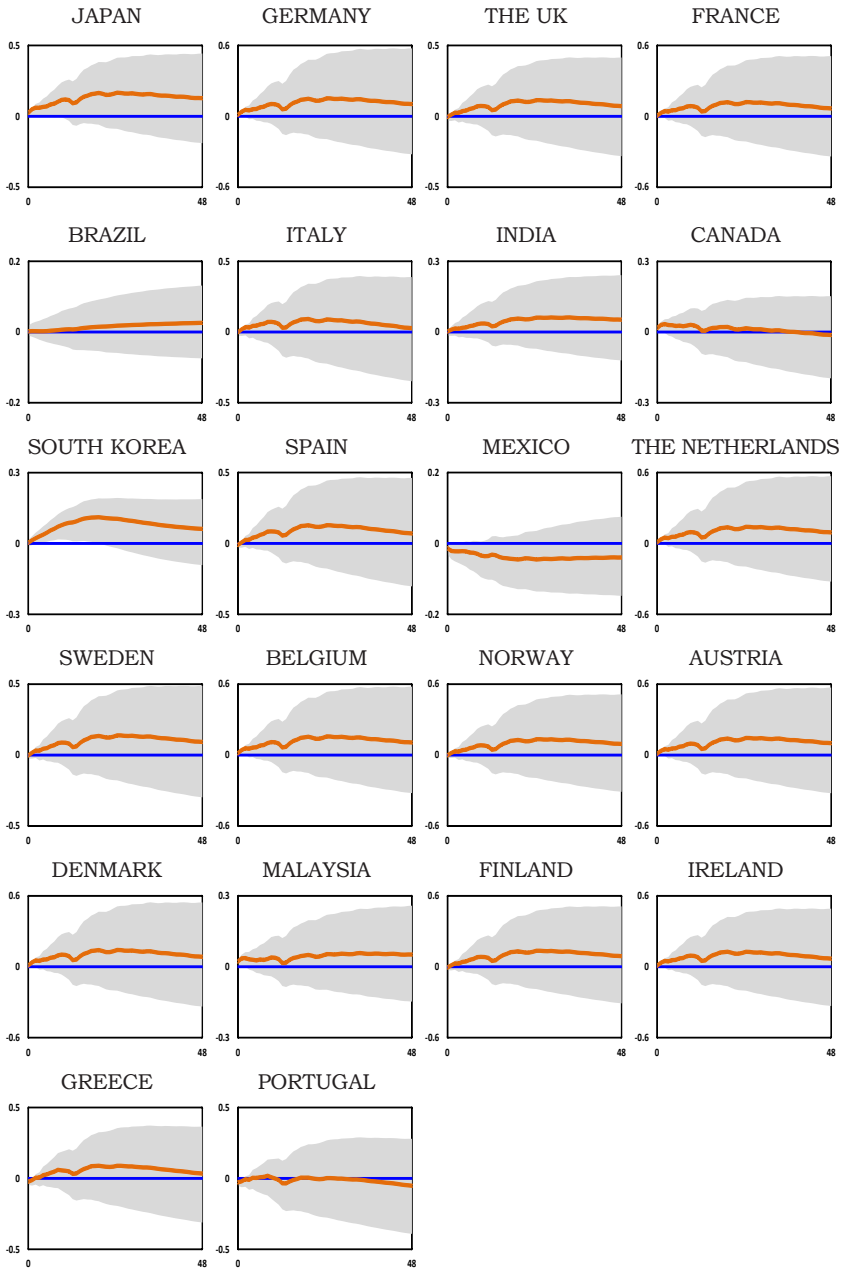
These possibilities can be reconfirmed in Figures 5 and 6. Figure 5 shows the impact of the US interest rate hike on the exchange rates against the US dollars for each country, while Figure 6 shows the impact on the trade balance (net exports).

First, the exchange rates increase in 21 countries (except Mexico) after the impact of the US interest rate hike, thereby implying that

[17] Refer to footnote (1) for a detailed description of the international transmission mechanism of each model.

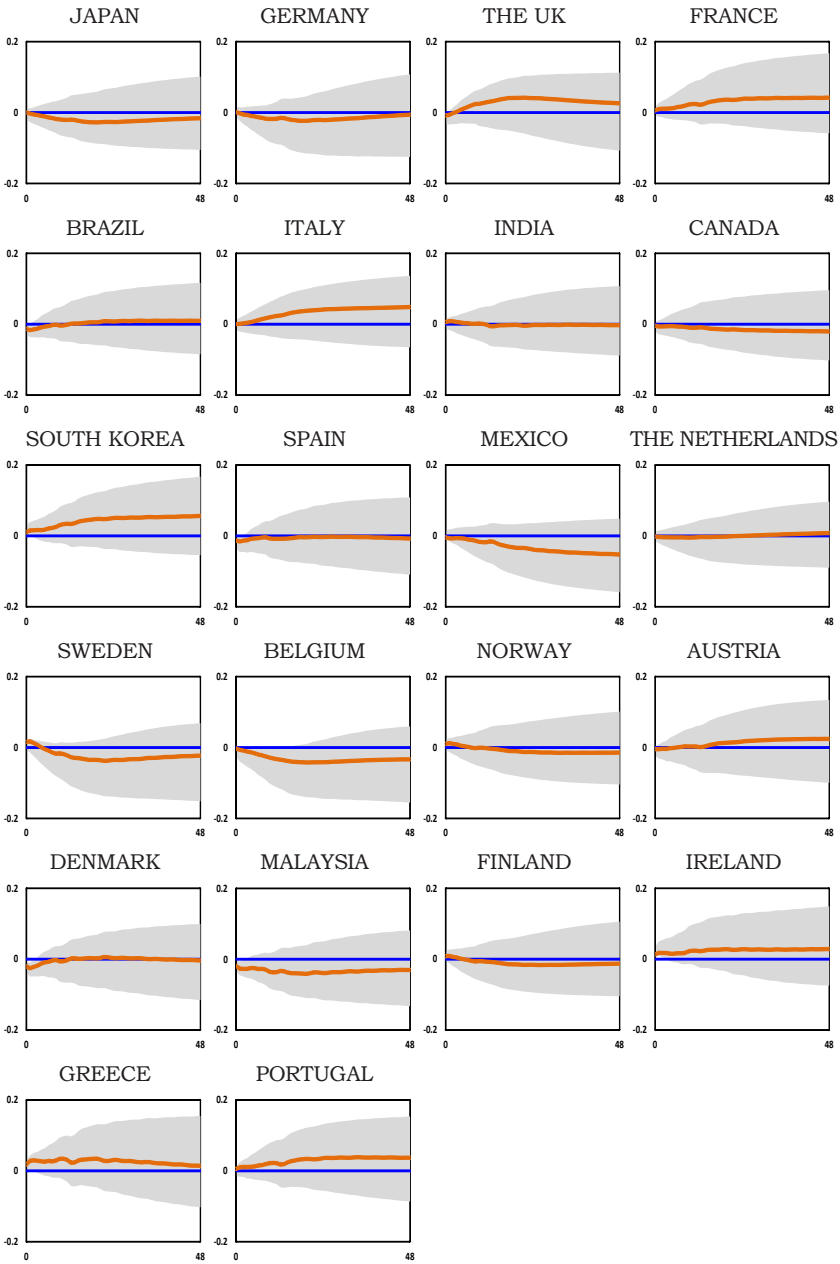
[18] The interest rate data should be incorporated into the model to verify that the channel of increasing global interest rates functions properly. However, this study could not include the interest rate variable owing to limited data.

[19] Kim (2001) argues that the role of trade balance is limited as an international transmission channel of the US monetary policy.



Note: Grey areas are the 68% error bands.

FIGURE 5
IRFS OF THE EXCHANGE RATES



Note: Grey areas are the 68% error bands.

FIGURE 6
IRFs OF THE NET EXPORTS

the currencies of these countries are devalued.[20] This result is in response to the appreciation of the US dollar (see Figure 1). However, the accuracy of the estimation is low. No significant increases are observed in the exchange rates in 19 countries except for Japan, South Korea, and Malaysia. Even in cases where the exchange rates increase substantially, the durations of such increase for Japan and Malaysia are the first five and three months, respectively. As an exception, only South Korea shows a substantial increase in exchange rate during months 4 to 20, which is relatively a long period.

Furthermore, the effect of currency depreciation on the improvements of trade balance is considerably uncertain. Figure 6 shows that despite the increasing exchange rates, the majority of the countries experience worsening trade balances (*e.g.*, Japan, Germany, Canada, Mexico, and Sweden) or experience insignificant changes (Brazil, India, and the Netherlands). Even for countries with improved trade balances (the UK, France, and Italy), the error band includes 0, thereby making the estimation results insignificant.

Given that Kang (2016) analyzed that the effect of exchange rates on exports has declined substantially, expecting the expenditure-switching effect to function despite continued interest rate hikes by the US is considerably difficult.

E. Analysis that Includes the Period After the Global Financial Crisis

To date, the discussion has focused on the features of the international transmission when the US monetary policy shocks are identified. This section analyzes the changes in the international transmission when the global financial crisis period is considered. If the period after the global financial crisis is included in the analysis period, the US interest rate policy shock is not properly identified because of such reasons as the emergence of a price puzzle (see Figure 2 and Appendix Figure 2). This result may be caused by changes in the inflation dynamics after the global financial crisis. At the time of the global financial crisis, the limited decline in inflation for developed countries, such as the US, compared with the size of the financial crisis

[20] These results are consistent with those of many previous studies, including Eichenbaum and Evans (1995), Miniane and Rogers (2007), and Dedola *et al.* (2017), although the estimates are relatively imprecise.

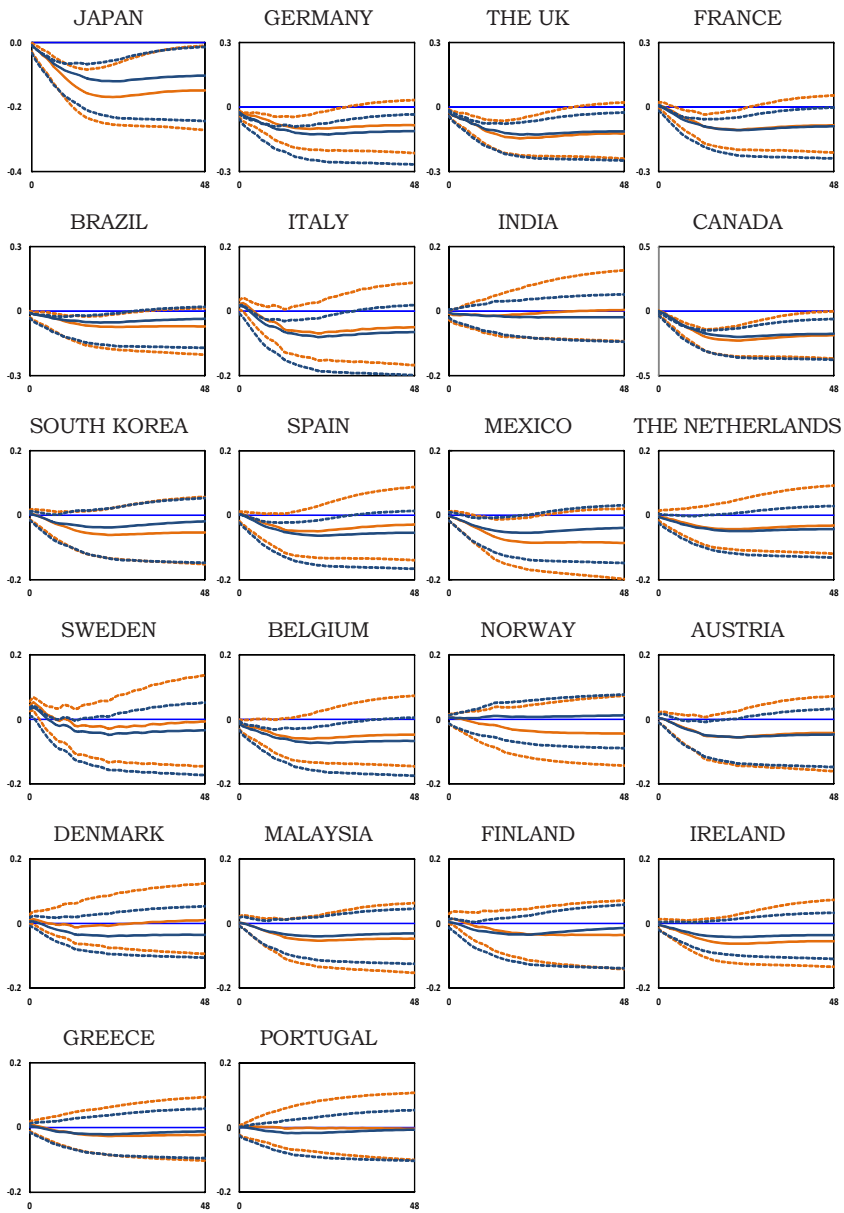
is referred to as the "missing inflation" puzzle; the rate of inflation not reaching the inflation target despite highly expansionary monetary and fiscal policies is called the "excessive disinflation" puzzle (Constâncio 2015). This area has generated heightened research interest, particularly on the causes and links with changes in economic structures.

Figures 7 to 10 illustrate the impulse response functions when the period after the global financial crisis is considered and overlapped with the impulse response functions when the period after the financial crisis is not considered. The dark blue lines in the figure correspond to the impulse response functions when the period after the global financial crisis is considered, while the lines marked with orange color correspond to the impulse response functions when the financial crisis is not considered. First, no significant difference exists in the industrial production whether the period after the global financial crisis is considered (see Figure 7). Only Norway experiences a turnaround from decline to increase. However, all other countries see production decline. The UK, France, Canada, the Netherlands, Austria, and Greece have extremely similar impulse response functions. No evident differences are observed in the significance of the responses.

Figure 9 shows no substantial change in the response of the exchange rates. In particular, the exchange rates against the US dollar temporarily decline shortly after the rate hike shock but eventually turn upwards in the long run. The accuracy of the estimation is low, which is similar to the case when the period after the financial crisis is not considered. Malaysia is the only country in which the exchange rate responds significantly and this period lasts only approximately three months in the beginning. The expenditure-switching effect does not function even when considering the period after the global financial crisis. The responses of the trade balances are also insignificant in many countries and similar to cases when only the pre-financial crisis period is included (Figure 10).

However, consumer prices show a distinctively different response (Figure 8). The emergence of a price puzzle from including the period after the financial crisis leads to increases in prices in many countries. Inflationary reaction has no exception, although the uncertainty of the price movements increases substantially. Only the UK, South Korea, the Netherlands, and Ireland show relatively considerable responses.

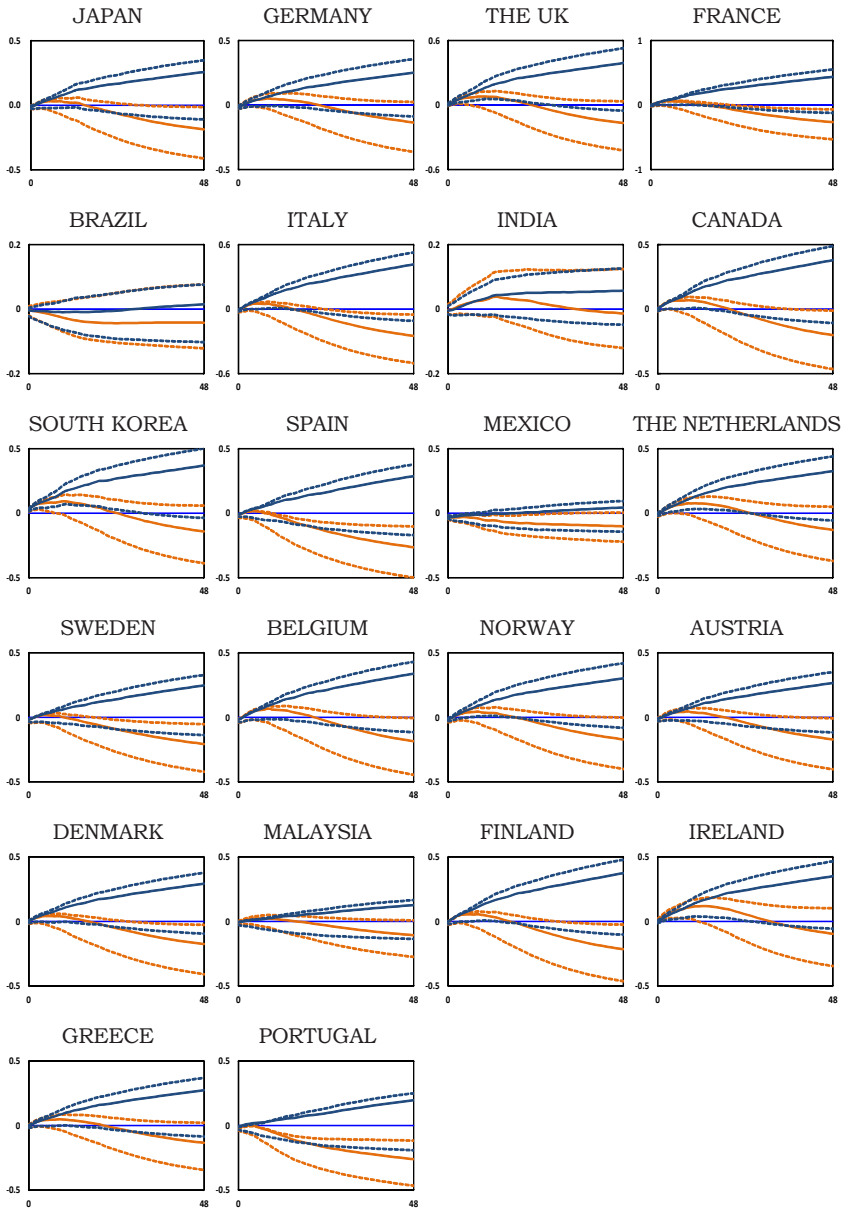
The preceding results remain unchanged even if the monetary policy indicator is changed from FFR to the shadow FFR from Wu and Xia



Note: Dark blue lines are impulse response functions when the analysis period is 1974–2015. Orange lines are impulse response functions when the analysis period is 1974–2008.

FIGURE 7

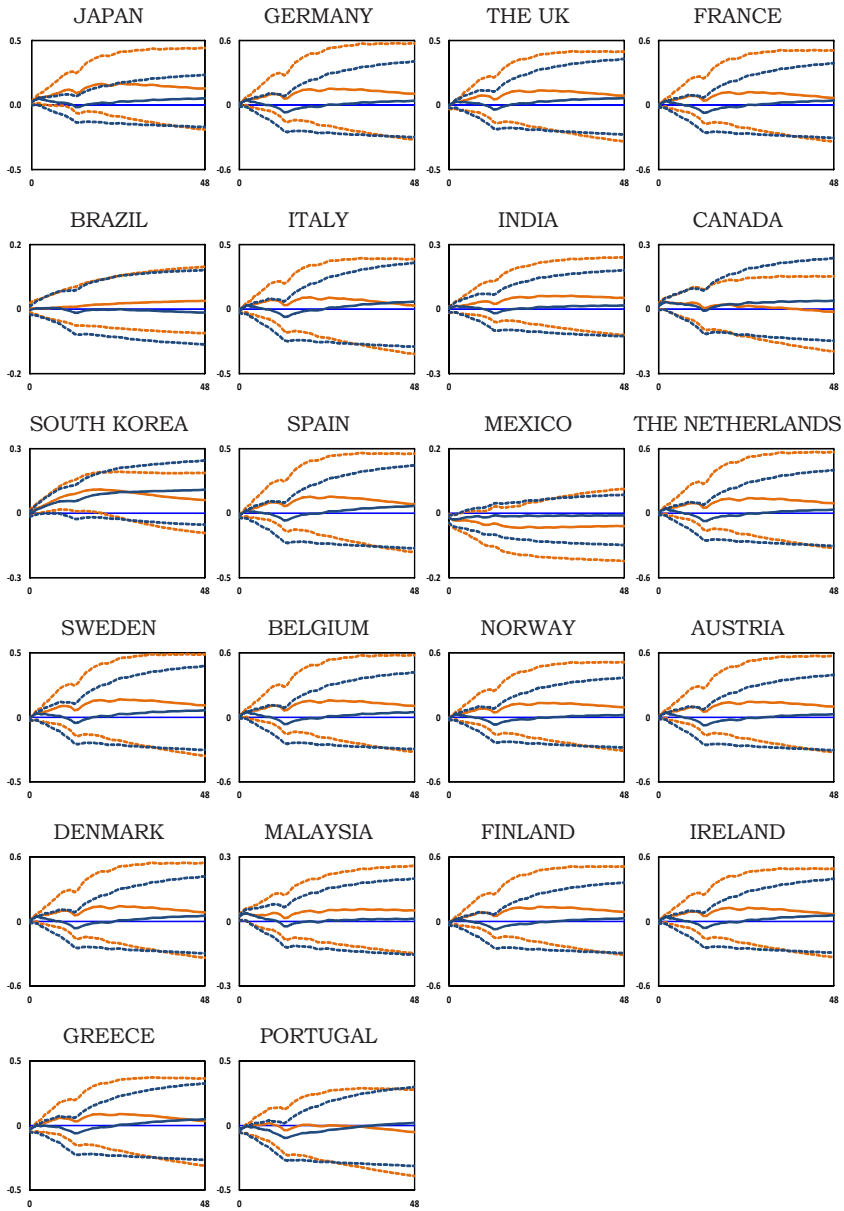
IRFS OF THE INDUSTRIAL PRODUCTION INDEXES (1974–2015)



Note: Dark blue lines are impulse response functions when the analysis period is 1974–2015. Orange lines are impulse response functions when the analysis period is 1974–2008.

FIGURE 8

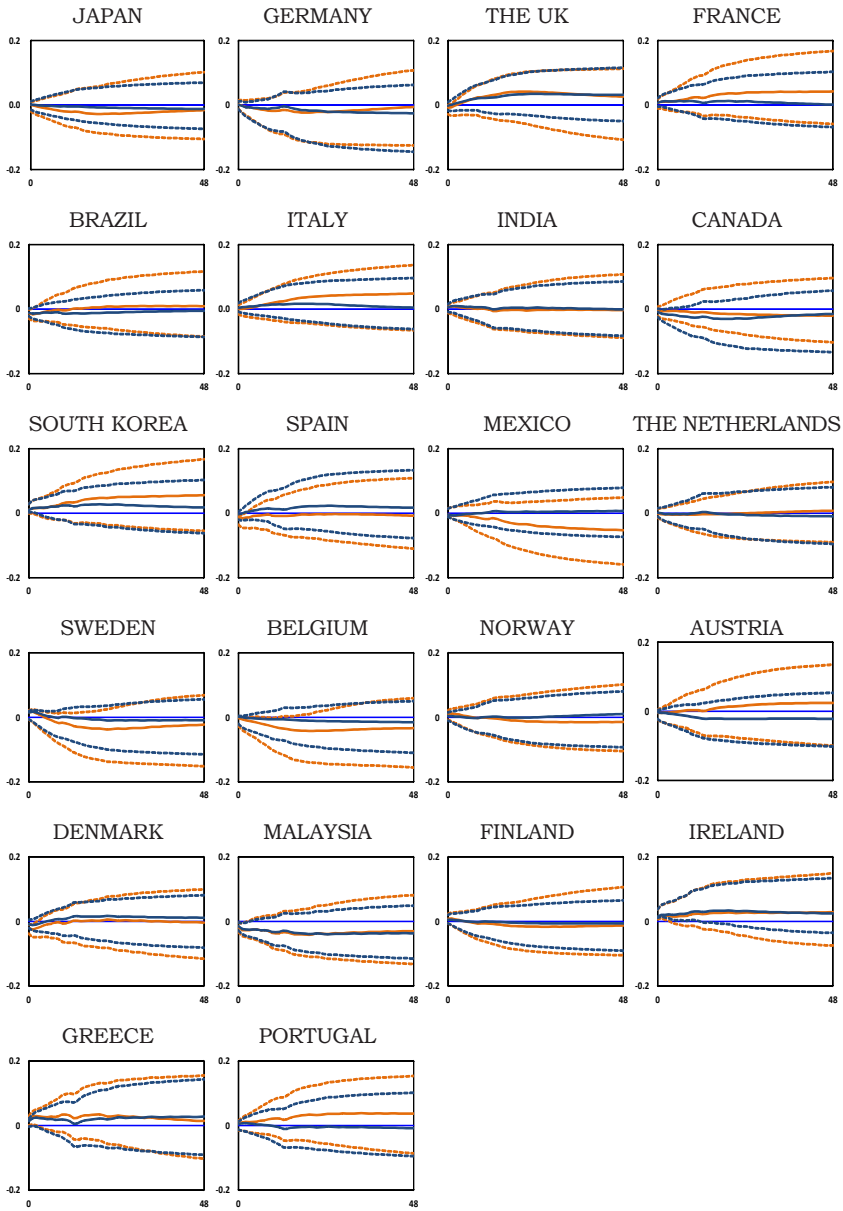
IRFS OF THE CONSUMER PRICE INDEXES (1974–2015)



Note: Dark blue lines are impulse response functions when the analysis period is 1974–2015. Orange lines are impulse response functions when the analysis period is 1974–2008.

FIGURE 9

IRFS OF THE EXCHANGE RATES (1974–2015)



Note: Dark blue lines are impulse response functions when the analysis period is 1974–2015. Orange lines are impulse response functions when the analysis period is 1974–2008.

FIGURE 10

IRFS OF THE NET EXPORTS (1974–2015)

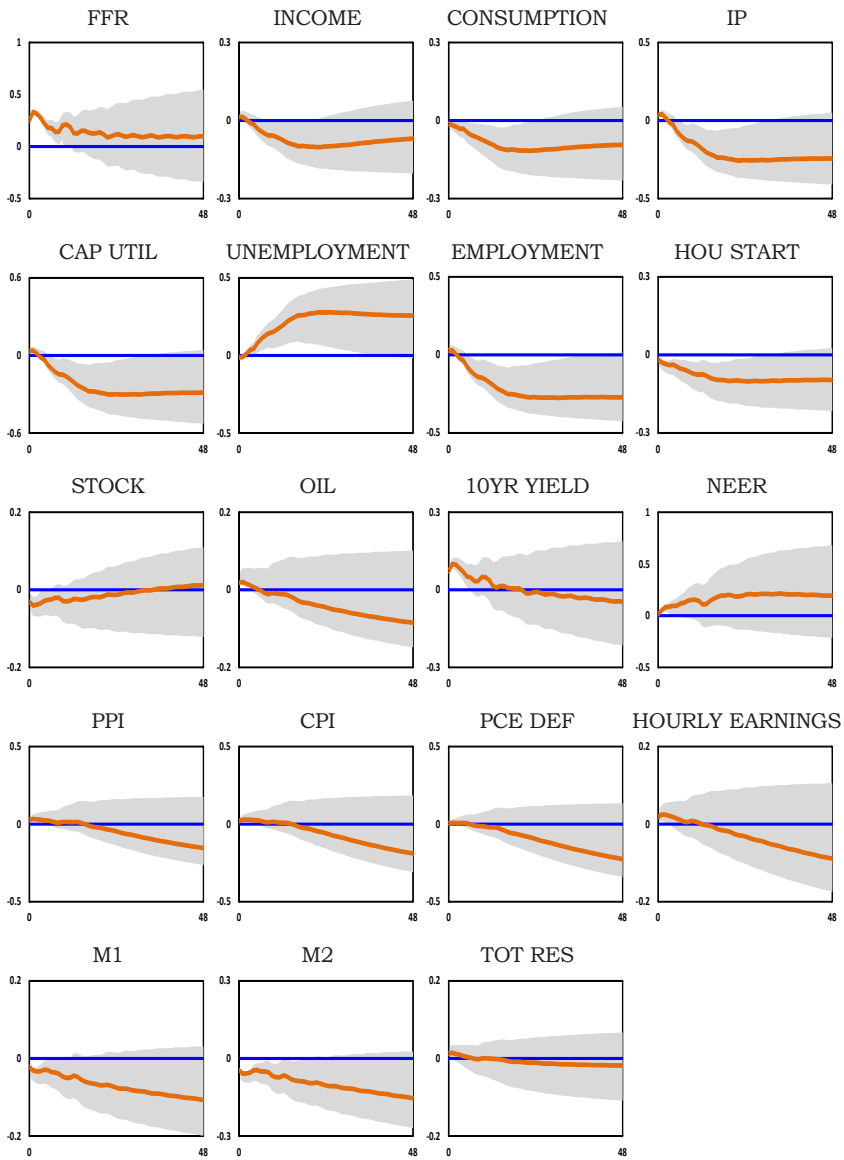
(2016).

IV. Conclusion

This study analyzes the international transmission of the US interest rate hikes using the FAVAR model. The current study first identifies the shocks of the US interest rate policy and analyzes the impact of such shocks on outputs and prices in 22 other countries. The impact of the US interest rate hike generally leads to decline in the outputs and prices in these countries. However, this study determines that the spillover effect on price is inaccurately measured when analyzing the period after the global financial crisis. Meanwhile, the effect of the appreciation of the US dollar from high interest rates that lead to the improvement of the trade balances of other countries is not extremely large. These results suggest that the normalization of the US interest rate policy may be a factor that impedes the recovery of the global economy.

Therefore, each country should prepare measures to cope with the impact of the US interest rate hikes. Since the global financial crisis, various countries have suffered from long economic downturns. Since 2009, the average annual growth rate in Japan has remained at 0%, while growth in Europe has also stagnated. The growth of emerging market countries, which is led by China as a key pillar of economic growth, has slowed down. Some researchers also raise the possibility of secular stagnation (Summers 2016). The price situation also resonates with such conditions, with the inflation rates of major countries falling below targets. Under these circumstances, countries should strengthen their foundation for growth by creating new growth engines, improve the efficiency of the economy through structural reforms, and promote the soundness of financial markets by reorganizing the systems to cope with the impact of the US interest rate hikes. In addition, the timely and effective operation of macroeconomic policies is extremely important given the limited space of monetary and fiscal policies in each country.

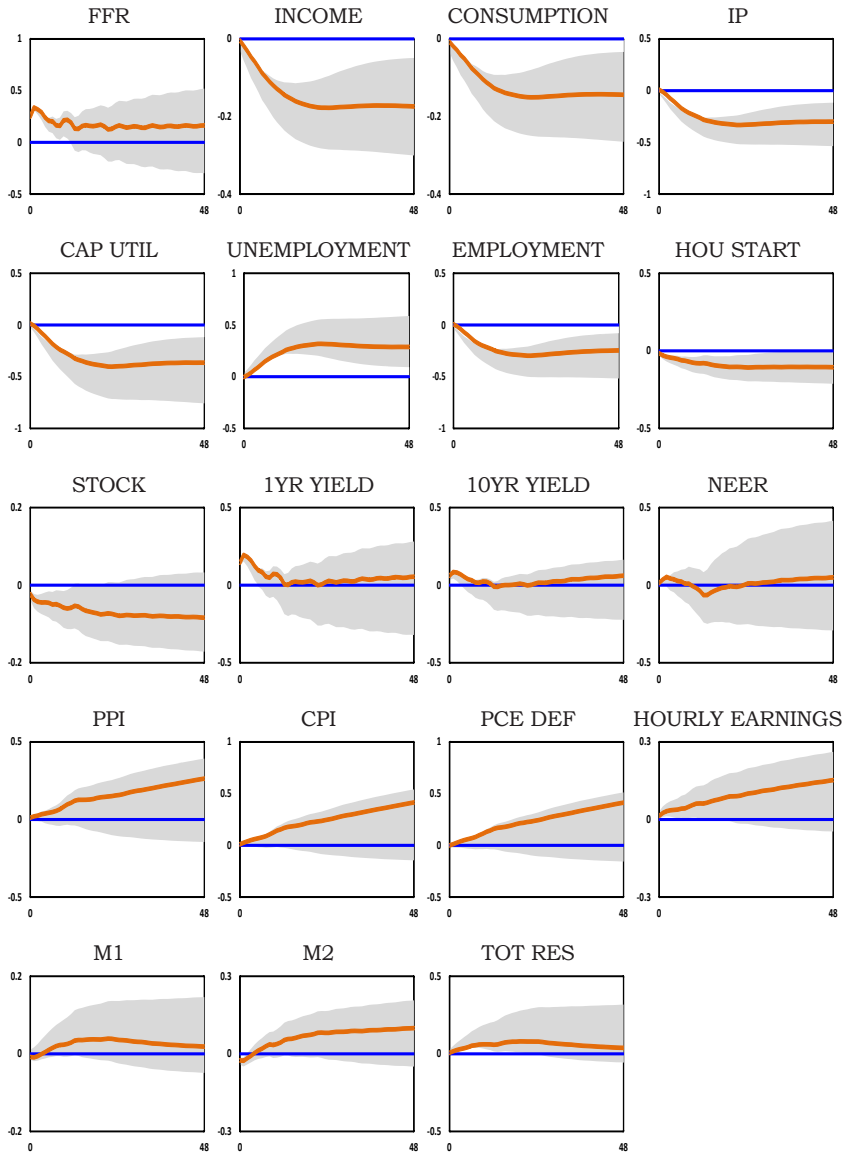
Appendix 1
Identification of the US Interest Rate Policy Shock



Note: Gray areas are the 68% error bands.

Appendix Figure 1

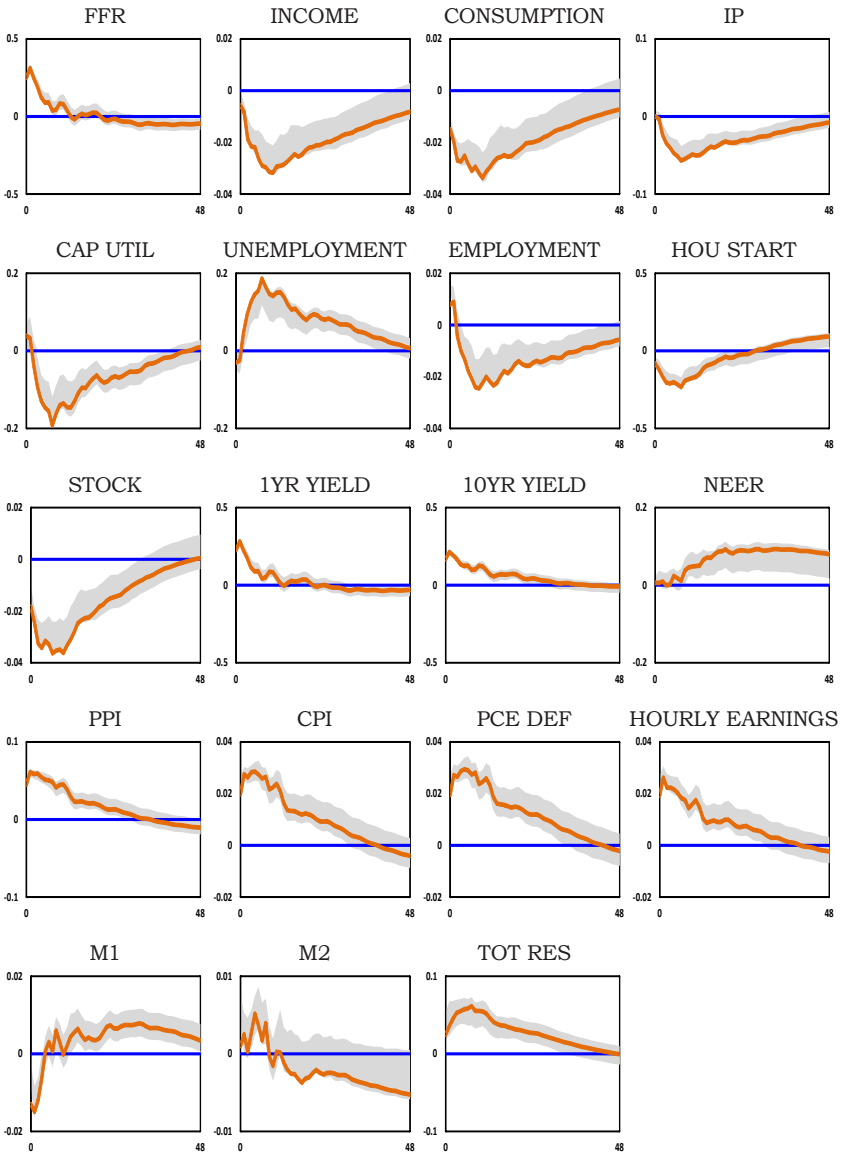
Identification of the US Interest Rate Policy Shock (Small Model)



Note: Gray areas are the 68% error bands.

APPENDIX FIGURE 2

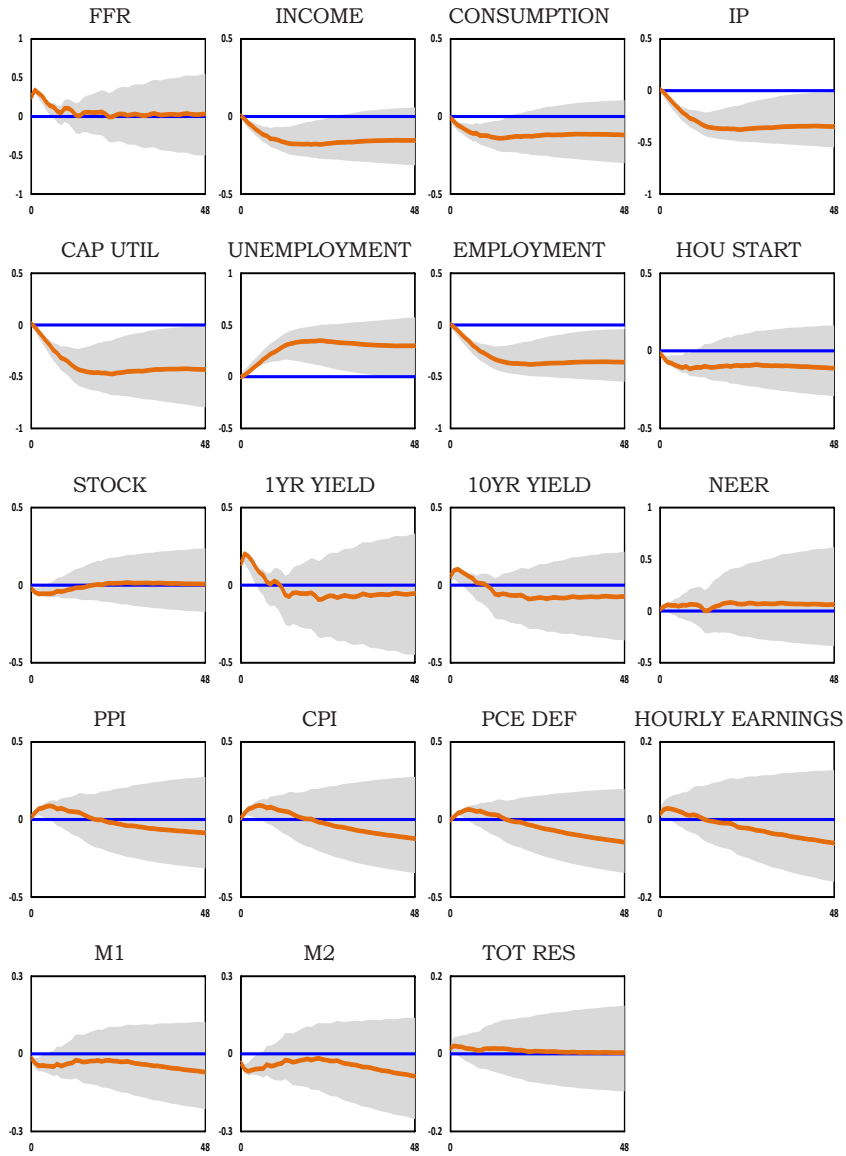
IDENTIFICATION OF THE US INTEREST RATE POLICY SHOCK (SHADOW FFR)



Note: Gray areas are the 68% error bands.

Appendix Figure 3

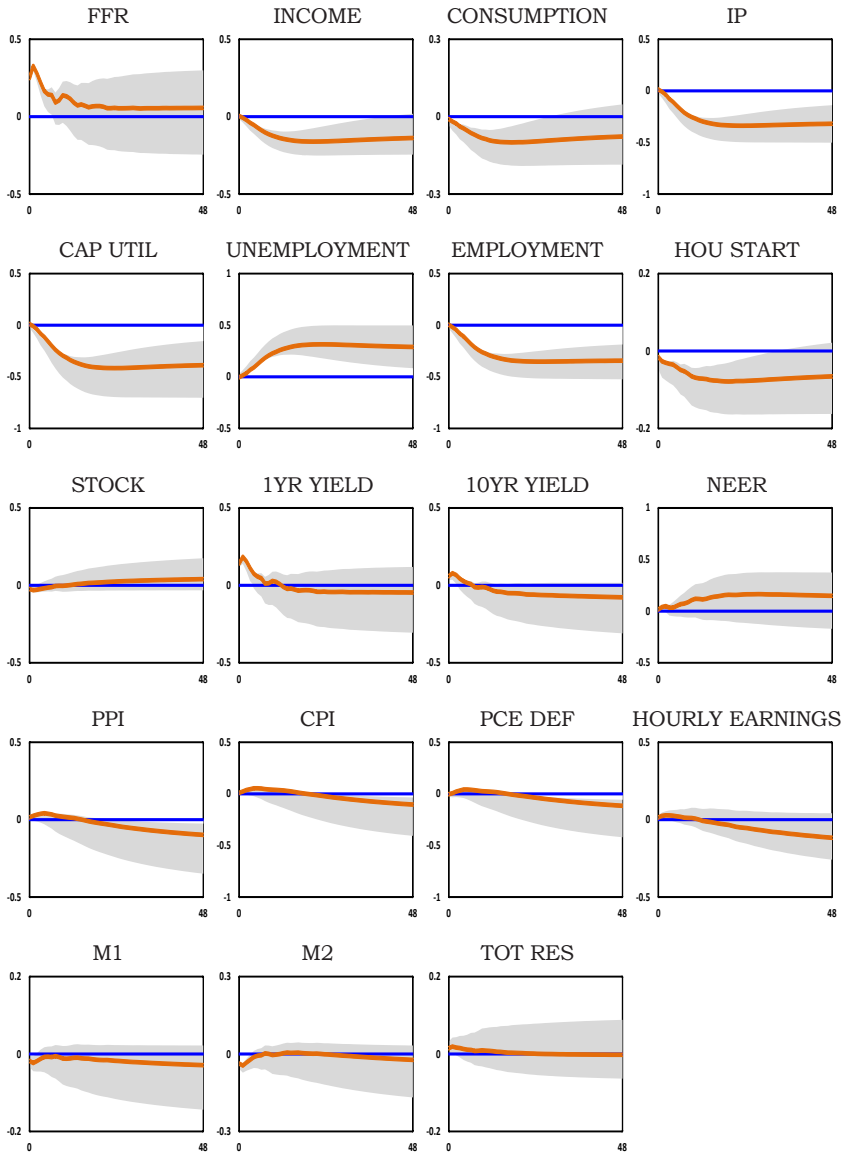
Identification of the US Interest Rate Policy Shock (Level Variables)



Note: Gray areas are the 68% error bands.

APPENDIX FIGURE 4

IDENTIFICATION OF THE US INTEREST RATE POLICY SHOCK (FACTORS = 4, LAGS = 13)



Note: Gray areas are the 68% error bands.

Appendix Figure 5

Identification of the US Interest Rate Policy Shock (Factors = 3, Lags = 8)

Appendix 2
Information on Data

The description of the data used in the analysis is as follows. The data between January 1974 and June 2015 are used in the analysis. The code for converting to the stationary time-series is as follows: 1 is no transformation, 2 is first difference, 4 is logarithm, and 5 is the first difference of logarithm. Slow-moving variables are denoted by S, while fast-moving variable are denoted by F. The variables used for the big and small models are marked with *. The last column is the source of the data.

Appendix Table 1
List of Data Used in the FAVAR Analysis

US Economic Indicators					
1	Real Personal Income	5	S		FRB St. Louis
2	RPI ex. Transfers	5	S	*	FRB St. Louis
3	Real PCE	5	S	*	FRB St. Louis
4	Real M&T Sales	5	S		FRB St. Louis
5	Retail and Food Services Sales	5	S		FRB St. Louis
6	Industrial Production Index	5	S	*	FRB St. Louis
7	IP: Final Products and Supplies	5	S		FRB St. Louis
8	IP: Final Products	5	S		FRB St. Louis
9	IP: Consumer Goods	5	S		FRB St. Louis
10	IP: Durable Consumer Goods	5	S		FRB St. Louis
11	IP: Nondurable Consumer Goods	5	S		FRB St. Louis
12	IP: Business Equipment	5	S		FRB St. Louis
13	IP: Materials	5	S		FRB St. Louis
14	IP: Durable Materials	5	S		FRB St. Louis
15	IP: Nondurable Materials	5	S		FRB St. Louis
16	IP: Manufacturing	5	S		FRB St. Louis
17	IP: Residential Utilities	5	S		FRB St. Louis
18	IP: Fuels	5	S		FRB St. Louis
19	ISM Manufacturing: Production	1	S		FRB St. Louis
20	Capacity Utilization: Manufacturing	2	S	*	FRB St. Louis
21	Civilian Labor Force	5	S		FRB St. Louis
22	Civilian Employment	5	S		FRB St. Louis

23	Civilian Unemployment Rate	2	S	*	FRB St. Louis
24	Average Duration of Unemployment	2	S		FRB St. Louis
25	Civilians Unemployed <5 Weeks	5	S		FRB St. Louis
26	Civilians Unemployed 5-14 Weeks	5	S		FRB St. Louis
27	Civilians Unemployed >15 Weeks	5	S		FRB St. Louis
28	Civilians Unemployed 15-26 Weeks	5	S		FRB St. Louis
29	Civilians Unemployed >27 Weeks	5	S		FRB St. Louis
30	Initial Claims	5	S		FRB St. Louis
31	All Employees: Total nonfarm	5	S	*	FRB St. Louis
32	All Employees: Goods-Producing	5	S		FRB St. Louis
33	All Employees: Mining and Logging	5	S		FRB St. Louis
34	All Employees: Construction	5	S		FRB St. Louis
35	All Employees: Manufacturing	5	S		FRB St. Louis
36	All Employees: Durable goods	5	S		FRB St. Louis
37	All Employees: Nondurable goods	5	S		FRB St. Louis
38	All Employees: Service Industries	5	S		FRB St. Louis
39	All Employees: TT&U	5	S		FRB St. Louis
40	All Employees: Wholesale Trade	4	S		FRB St. Louis
41	All Employees: Retail Trade	5	S		FRB St. Louis
42	All Employees: Financial Activities	5	S		FRB St. Louis
43	All Employees: Government	5	S		FRB St. Louis
44	Hours: Goods-Producing	2	S		FRB St. Louis
45	Overtime Hours: Manufacturing	2	S		FRB St. Louis
46	Hours: Manufacturing	2	S		FRB St. Louis
47	ISM Manufacturing: Employment	1	S		FRB St. Louis
48	Housing Starts: Total	5	F	*	FRB St. Louis
49	Housing Starts: Northeast	5			FRB St. Louis
50	Housing Starts: Midwest	5			FRB St. Louis
51	Housing Starts: South	5			FRB St. Louis
52	Housing Starts: West	5			FRB St. Louis
53	Housing Permits	5			FRB St. Louis
54	Housing Permits: Northeast	5			FRB St. Louis
55	Housing Permits: Midwest	5			FRB St. Louis
56	Housing Permits: South	5			FRB St. Louis
57	Housing Permits: West	5			FRB St. Louis
58	ISM: PMI Composite Index	1			FRB St. Louis
59	ISM: New Orders Index	1			FRB St. Louis

60	ISM: Supplier Deliveries Index	1			FRB St. Louis
61	ISM: Inventories Index	1			FRB St. Louis
62	Orders: Durable Goods	5	F		FRB St. Louis
63	Orders: Nondefense Capital Goods	5	F		FRB St. Louis
64	Unfilled Orders: Durable Goods	5	F		FRB St. Louis
65	Total Business Inventories	5	F		FRB St. Louis
66	Inventories to Sales Ratio	2	F		FRB St. Louis
67	M1 Money Stock	5	F	*	FRB St. Louis
68	M2 Money Stock	5	F	*	FRB St. Louis
69	Real M2 Money Stock	5	F		FRB St. Louis
70	St. Louis Adjusted Monetary Base	5	F		FRB St. Louis
71	Total Reserves	5	F	*	FRB St. Louis
72	Non-borrowed Reserves	5	F	*	FRB St. Louis
73	Commercial and Industrial Loans	5	F		FRB St. Louis
74	Real Estate Loans	2	F		FRB St. Louis
75	Total Non-revolving Credit	5	F		FRB St. Louis
76	Credit to PI ratio	2	F		FRB St. Louis
77	S&P: Composite	5	F	*	FRB St. Louis
78	S&P: Industrials	5	F		FRB St. Louis
79	S&P: Dividend Yield	2	F		FRB St. Louis
80	S&P: Price-Earnings Ratio	4	F		FRB St. Louis
81	Effective Federal Funds Rate	2	F	*	FRB St. Louis
82	Shadow Federal Funds Rate	2	F		Wu and Xia (2016)
83	3-Month AA Commercial Paper Rate	2	F		FRB St. Louis
84	3-Month Treasury-bill	2	F		FRB St. Louis
85	6-Month Treasury-bill	2	F		FRB St. Louis
86	1-Year Treasury-bond	2	F		FRB St. Louis
87	5-Year Treasury-bond	2	F		FRB St. Louis
88	10-Year Treasury-bond	2	F	*	FRB St. Louis
89	Aaa Corporate Bond Yield	2	F		FRB St. Louis
90	Baa Corporate Bond Yield	2	F		FRB St. Louis
91	CP - FFR spread	1	F		FRB St. Louis
92	3 Month - FFR spread	1	F		FRB St. Louis
93	6 Month - FFR spread	1	F		FRB St. Louis
94	1 year - FFR spread	1	F		FRB St. Louis
95	5 year - FFR spread	1	F		FRB St. Louis
96	10 year - FFR spread	2	F		FRB St. Louis

97	Aaa - FFR spread	2	F		FRB St. Louis
98	Baa - FFR spread	2	F		FRB St. Louis
99	Trade Weighted US FX Rate	5	F	*	FRB St. Louis
100	Switzerland / US FX Rate	5	F		FRB St. Louis
101	Japan / US FX Rate	5	F		FRB St. Louis
102	U.S. / UK FX Rate	5	F		FRB St. Louis
103	Canada / US FX Rate	5	F		FRB St. Louis
104	Producer Price Index: Finished Goods	5	S	*	FRB St. Louis
105	PPI: Finished Consumer Goods	5	S		FRB St. Louis
106	PPI: Intermediate Materials	5	S	*	FRB St. Louis
107	PPI: Crude Materials	5	S	*	FRB St. Louis
108	Crude Oil Prices: WTI	5	F	*	FRB St. Louis
109	PPI: Commodities	5	S		FRB St. Louis
110	ISM Manufacturing: Prices	1	S		FRB St. Louis
111	Consumer Price Index: All Items	5	S	*	FRB St. Louis
112	CPI: Apparel	5	S		FRB St. Louis
113	CPI: Transportation	5	S		FRB St. Louis
114	CPI: Medical Care	5	S		FRB St. Louis
115	CPI: Commodities	5	S		FRB St. Louis
116	CPI: Durables	5	S		FRB St. Louis
117	CPI: Services	5	S		FRB St. Louis
118	CPI: All Items Less Food	5	S		FRB St. Louis
119	CPI: All items less shelter	5	S		FRB St. Louis
120	CPI: All items less medical care	5	S		FRB St. Louis
121	PCE: Chain-type Price Index	5	S	*	FRB St. Louis
122	PCE: Durable goods	5	S		FRB St. Louis
123	PCE: Nondurable goods	5	S		FRB St. Louis
124	PCE: Services	5	S		FRB St. Louis
125	Average Hourly Earnings: Goods	4	S		FRB St. Louis
126	Average Hourly Earnings: Construction	5	S		FRB St. Louis
127	Average Hourly Earnings: Manufacturing	5	S	*	FRB St. Louis
128	MZM Money Stock	5	F		FRB St. Louis
129	Consumer Motor Vehicle Loans	5	F		FRB St. Louis
130	Total Consumer Loans and Leases	5	F		FRB St. Louis
131	Securities in Bank Credit	5	F		FRB St. Louis
132	CBOE S&P 100 Volatility Index	1	F		FRB St. Louis

Indicators of Non-US Economies					
Industrial Production					
1	Japan Industrial Production	5	S	*	OECD MEI
2	Germany Industrial Production	5	S	*	OECD MEI
3	UK Industrial Production	5	S	*	OECD MEI
4	France Industrial Production	5	S	*	OECD MEI
5	Brazil Industrial Production	5	S	*	IMF IFS
6	Italy Industrial Production	5	S	*	OECD MEI
7	India Industrial Production	5	S	*	IMF IFS
8	Canada Industrial Production	5	S	*	OECD MEI
9	South Korea Industrial Production	5	S	*	OECD MEI
10	Spain Industrial Production	5	S	*	OECD MEI
11	Mexico Industrial Production	5	S	*	IMF IFS
12	The Netherlands Industrial Production	5	S	*	OECD MEI
13	Sweden Industrial Production	5	S	*	OECD MEI
14	Belgium Industrial Production	5	S	*	OECD MEI
15	Norway Industrial Production	5	S	*	OECD MEI
16	Austria Industrial Production	5	S	*	OECD MEI
17	Denmark Industrial Production	5	S	*	OECD MEI
18	Malaysia Industrial Production	5	S	*	IMF IFS
19	Finland Industrial Production	5	S	*	OECD MEI
20	Ireland Industrial Production	5	S	*	OECD MEI
21	Greece Industrial Production	5	S	*	OECD MEI
22	Portugal Industrial Production	5	S	*	OECD MEI
Consumer Price Index					
23	Japan Consumer Price Index	5	S	*	OECD MEI
24	Germany Consumer Price Index	5	S	*	OECD MEI
25	The UK Consumer Price Index	5	S	*	OECD MEI
26	France Consumer Price Index	5	S	*	OECD MEI
27	Brazil Consumer Price Index	5	S	*	OECD MEI
28	Italy Consumer Price Index	5	S	*	OECD MEI
29	India Consumer Price Index	5	S	*	OECD MEI
30	Canada Consumer Price Index	5	S	*	OECD MEI
31	South Korea Consumer Price Index	5	S	*	OECD MEI
32	Spain Consumer Price Index	5	S	*	OECD MEI
33	Mexico Consumer Price Index	5	S	*	OECD MEI
34	The Netherlands Consumer Price Index	5	S	*	OECD MEI

35	Sweden Consumer Price Index	5	S	*	OECD MEI
36	Belgium Consumer Price Index	5	S	*	OECD MEI
37	Norway Consumer Price Index	5	S	*	OECD MEI
38	Austria Consumer Price Index	5	S	*	OECD MEI
39	Denmark Consumer Price Index	5	S	*	OECD MEI
40	Malaysia Consumer Price Index	5	S	*	IMF IFS
41	Finland Consumer Price Index	5	S	*	OECD MEI
42	Ireland Consumer Price Index	5	S	*	OECD MEI
43	Greece Consumer Price Index	5	S	*	OECD MEI
44	Portugal Consumer Price Index	5	S	*	OECD MEI
Net Export[1)]					
45	Japan Net Export	2	S	*	OECD MEI
46	Germany Net Export	2	S	*	OECD MEI
47	The UK Net Export	2	S	*	OECD MEI
48	France Net Export	2	S	*	OECD MEI
49	Brazil Net Export	2	S	*	IMF IFS
50	Italy Net Export	2	S	*	OECD MEI
51	India Net Export	2	S	*	IMF IFS
52	Canada Net Export	2	S	*	OECD MEI
53	South Korea Net Export	2	S	*	OECD MEI
54	Spain Net Export	2	S	*	OECD MEI
55	Mexico Net Export	2	S	*	IMF IFS
56	The Netherlands Net Export	2	S	*	OECD MEI
57	Sweden Net Export	2	S	*	OECD MEI
58	Belgium Net Export	2	S	*	OECD MEI
59	Norway Net Export	2	S	*	OECD MEI
60	Austria Net Export	2	S	*	OECD MEI
61	Denmark Net Export	2	S	*	OECD MEI
62	Malaysia Net Export	2	S	*	IMF IFS
63	Finland Net Export	2	S	*	OECD MEI
64	Ireland Net Export	2	S	*	OECD MEI
65	Greece Net Export	2	S	*	OECD MEI
66	Portugal Net Export	2	S	*	OECD MEI
Exchange Rate[2)]					
67	Japan Exchange Rate	5	F	*	OECD MEI
68	Germany Exchange Rate	5	F	*	OECD MEI
69	The UK Exchange Rate	5	F	*	OECD MEI

70	France Exchange Rate	5	F	*	OECD MEI
71	Brazil Exchange Rate	2	F	*	OECD MEI
72	Italy Exchange Rate	5	F	*	OECD MEI
73	India Exchange Rate	5	F	*	OECD MEI
74	Canada Exchange Rate	5	F	*	OECD MEI
75	South Korea Exchange Rate	5	F	*	OECD MEI
76	Spain Exchange Rate	5	F	*	OECD MEI
77	Mexico Exchange Rate	5	F	*	OECD MEI
78	The Netherlands Exchange Rate	5	F	*	OECD MEI
79	Sweden Exchange Rate	5	F	*	OECD MEI
80	Belgium Exchange Rate	5	F	*	OECD MEI
81	Norway Exchange Rate	5	F	*	OECD MEI
82	Austria Exchange Rate	5	F	*	OECD MEI
83	Denmark Exchange Rate	5	F	*	OECD MEI
84	Malaysia Exchange Rate	5	F	*	IMF IFS
85	Finland Exchange Rate	5	F	*	OECD MEI
86	Ireland Exchange Rate	5	F	*	OECD MEI
87	Greece Exchange Rate	5	F	*	OECD MEI
88	Portugal Exchange Rate	5	F	*	OECD MEI

Notes: 1) The amount of net export is divided by the industrial production index for normalization.
2) Exchange rate is measured in terms of the national currency per USD. Monthly average rates are used.

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