Essays on the macroeconomic effects of fiscal policy in Japan

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Abstract

This thesis provides new empirical evidence and analyses on the macroeconomic effects of tax and government spending shocks in Japan within a vector autoregressive (VAR) framework. To achieve identification, three different approaches were employed. The first technique is the recursive VAR approach, which is relied on the Cholesky decomposition of the variance-covariance matrix of the VAR disturbances and imposed assumptions about the contemporaneous links between the endogenous variables. Second, following the study of Blanchard and Perotti (2002), the study used the structural VAR approach that based on institutional information about tax and transfer systems to estimate the automatic responses of tax revenues and government spending to economic activity. The third approach, proposed by Uhlig (2005) and Mountford and Uhlig (2009), identified fiscal shocks via sign restrictions on the impulse responses. The analyses also focused on the impacts of fiscal policy under various economic circumstances in Japan. First, these effects under fixed exchange rate regime and under floating exchange rate regimes were compared. Second, the study investigated whether the impacts of fiscal policy were enhanced or reduced during the zero lower bound (ZLB) period. The main findings are as follows. Drawing on the full sample over the 1960-2018 period, the study showed that an unexpected increase in taxes lead to a decrease in output while a similar shock to government spending has positive impacts on output. Surprisingly, interest rates and prices decreased in response to a positive spending shock. With respect to the role of exchange rate regime, the empirical evidences demonstrated that fiscal policy was not necessarily more effective under fixed exchange rates as predicted by conventional wisdom. In addition, the findings revealed that the expansionary impacts of government spending shocks on output were stronger in the ZLB period. An increase in government spending during this ZLB period could even lead to higher inflation, although with a lag. These findings may suggest important policy implications for Japan.

Keywords: Fiscal policy shocks, Sign restrictions, Structural VAR, Recursive VAR, Exchange rate regime, Zero lower bound, Japan.
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CHAPTER I

Introduction

1.1 Background

What are the impacts of fiscal policy on economic activity? Further, do these effects depend on different economic conditions? These matters have been put at the center of debates in economic circles since decades, and even more after the recent global financial crisis and world recession. This is due to the weakness of traditional monetary transmission mechanism, especially when the interest rate nearly reaches the zero lower bound, with no more room to decrease central bank interest rate further. The monetary policy alone seems unable to counter the huge contraction of demand, which forced the governments in many developed economies to implement changes in fiscal policy, such as fiscal stimulus packages. However, to date, our knowledge of fiscal effectiveness is still limited in both theoretical and empirical aspects and there have been a lot of controversial arguments on this topic. Japan is a typical example where the efficacy of fiscal policy has been hotly debated. Unlike most of the other developed countries in which the expansionary fiscal policies were used after the 2008 financial crisis, the Japanese government had regularly implemented fiscal stimulus packages including changes in public investment and taxes for a long time before, especially during the so-called "lost decade" period. However, despite these efforts, Japan has been still in a slump for many years after the collapse of asset-price bubble in the early 1990s. The country was considered as the most serious economic slowdown experienced by any major industrial economy since 1950s (Bayoumi, 2001). GDP growth rate averaged only approximately 0.3% per annum over this period (Figure 1.1). Furthermore, output gap was at around 4 percent point in the early 1990 but it decreased sharply and remained to be negative most of the time afterward (Figure 1.2). Meanwhile, the fiscal deficit of Japan has grown significantly during this time (Figure 1.3). Therefore, there have been a number of economists believed that fiscal policy in Japan was ineffective. They argued that expansionary effect of fiscal policy was not enough to push up the economy and therefore, unlimited increase in government expenditure simply made the fiscal crisis worsen. For instance, Milton Friedman wrote in the Wall Street Journal in 2001: "Does fiscal stimulus stimulate? Japan's experience in the 90s is dramatic evidence to the contrary. Japan resorted repeatedly to large doses of fiscal stimulus in the form of extra government spending. The result: stagnation at best, depression at worst, for most the past decade". Moreover,
from the empirical viewpoint, most of the existing studies support this argument. Bayoumi (2001), Ihori et al. (2003), Miyazaki (2009) found that fiscal policy generated limited effects on output in Japan.

**Figure 1.1 GDP Growth Rate in Some Developed Countries 1962Q1-2018Q4 (Compared to Previous Quarter)**

*Source: OECD*

**Figure 1.2 Output Gap as Percentage of Potential Output in Some Developed Countries 1985-2018**

*Source: OECD*
However, was it actually the case for fiscal policy in Japan? In fact, there is still another hypothesis that fiscal policy had significant expansionary effects on output and without fiscal stimuli, the recessions would have even worsened. From theoretical viewpoint, Krugman (1999) indicated that fiscal expansion might play an important role in getting Japan out of cyclical slumps. With respect to empirical evidences, Kuttner and Posen (2002)'s paper is one of only few studies revealed that expansion fiscal policy in Japan had significant stimulative effects.

The above debates imply that there remains a great deal of uncertainty related to the effectiveness of fiscal policy in Japan. One possible explanation for this uncertainty, which has been discussed in recent literature, is that the effects of fiscal policy may depend on time-variant factors, such as the state of the economy, the exchange rate regime or the monetary policy accommodation (Christiano et al. 2011, Eggertsson 2011, Woodford 2011, Auerbach and Gorodnichenko 2012, Baum et.al. 2012 and Ilzetzki et al. 2013). To examine this hypothesis, Japan is again an appropriate subject to study. This is because the Japanese economy has witnessed several distinct periods of macroeconomic activity in recent decades, leading to significant changes in behaviors of many macroeconomic variables over time. For example, with respect to exchange rate regime, Japan has switched from fixed exchange rate regime to floating exchange rate regime since 1973. Furthermore, among the developed countries, Japan has experienced the longest zero interest rate episode (from 1995 to present). As a result, it is possible to compare the impacts of fiscal policy in Japan under different economic circumstances.
1.2 Objectives

This study aimed to provide new empirical evidences and shed some new light on the effectiveness of fiscal policy in Japan by employing three different identification approaches to investigate the impacts of tax and government spending shocks on macroeconomic variables.

In addition, the research compared these above effects between fixed exchange rate regime period and floating exchange rate regime period; and between the normal time and the ZLB time.

To examine whether the state-dependency hypothesis of fiscal policy is true for other economies, the thesis analyzed and compared the effects of fiscal shocks during and outside the ZLB in Japan and three developed countries including Canada, the United Kingdom and the United State.

1.3 Related literature

In recent years, empirical studies have presented various model frameworks to analyze the economic effects of fiscal policy. These studies focus on two main areas: one concentrate on different econometric methodologies that can be used to examine the impacts of fiscal policy while the other attempts to compare the findings under various economic circumstances.

1.3.1 Overview of the estimation techniques

Regarding the econometric methodology, the VAR based model and Dynamic Stochastic General Equilibrium (DSGE) model are the two most popular techniques to estimate the impacts of fiscal policy shocks on the economic activity. With respect to DSGE models, the main idea of this technique is to base on a predetermined theoretical construction to study the effects of fiscal policy. There have been several different econometric methodologies applied in the literature, for example, the threshold VAR models (Baum and Koester, 2011, for Germany, Baum et al., 2012), time-varying parameter VAR models with stochastic volatility (Kirchner et al., 2010) and Smooth Transition Vector Autoregressive models (Auerbach and Gorodnichenko 2012).

As compared to the DSGE models, VAR-based specifications have the advantage of being not constrained by a predetermined theoretical construction. Particularly, the estimated results in DSGE models depend largely on a number of factors, such as the forward looking features of the models, the assumptions on the utility function of the individuals, the production function of the firms, the monetary policy reaction function (Perrotti 2007, Christiano et al. 2011). On the other hand, the VAR based model may face the problem of omitting important structural features of the economy, which can be addressed by the DSGE models. Another fundamental difference between these two methods is the nature of the fiscal shock, which has significant influence on the estimated effects of
these shocks. In particular, while the VAR models typically rely on specific temporary fiscal shocks, the DSGE models allow for policy evaluations based on both temporary and permanent shocks (Karagyozova-Markova et al. 2013). Therefore, it may not be appropriate to compare the empirical results of these two techniques.

Within the VAR framework, to date, there are four main identification approaches that have been widely applied. The first approach is so-called "Recursive VAR approach" which was originally proposed by Sims (1980) and later applied in the studies of Fatas and Mihov (2001), Favero (2002), Caldara and Kamps (2008) and many others. This technique is relied on the Cholesky decomposition of the variance-covariance matrix of the VAR disturbances and imposed assumptions about the contemporaneous links between the endogenous variables to achieve identification. The recursive VAR approach is considered as a simple empirical tool for the purpose of making an easy understandable econometric analysis. However, the estimated results of VAR system depend largely on the ordering of the endogenous variables (Stock and Watson, 2001).

Another methodology to identify the fiscal policy effect is the structural VAR approach introduced by Blanchard and Perotti (2002). This approach is one of the most widely used identification strategies in recent empirical papers. It is based on institutional information about tax and transfer systems to estimate the automatic responses of tax revenues and government spending to economic activity.

The third approach is the event-study approach (or narrative approach) proposed by Ramey and Shapiro (1998) and further applied by Burnside et al. (2004), Ramey (2011) and Caldara and Kamps (2008). This approach accesses the effects on output resulting from large unexpected increases in government spending. For instance, in the study of Ramey and Shapiro (1998) who employed data for the United State, these large increases were associated with the Vietnam War, the Korean War and the Reagan military build-up. It is argued that the narrative approach may provide valuable analysis on the impact of fiscal policy shocks, but employing this approach requires information on the exogenous spending shocks with long data series. As a consequence, most of the existing studies using this approach were limited to be applied for the case of the US economy.

The fourth approach identifies fiscal shocks via sign restrictions on the impulse response. This approach was introduced by Uhlig (2005) and then extended in Mountford and Uhlig (2009). Unlike the recursive approach and the Blanchard-Perotti technique that make assumptions on the contemporaneous relations between reduced-form and structural residuals, the sign restrictions approach directly imposes constraints on the impulse response functions.
1.3.2 Effects of fiscal policy under different economic conditions

It is argued that the impacts of fiscal shocks on output may be diverse under different economic conditions such as the state of the economy, the exchange rate regime or the monetary policy accommodations (Christiano et al. 2011, Eggertsson 2011, Woodford 2011, Auerbach and Gorodnichenko 2012, Baum et.al. 2012 and Ilzetzki et al. 2013). Even if the effects of fiscal shocks could be perfectly identified, linear time series models would still provide average estimations across possibly distinct circumstances. Furthermore, comparing these impacts under different conditions might yield important policy implications. This study focused on two factors that possibly affect the effectiveness of fiscal policy but have not been yet widely studied in the previous works: the exchange rate regime and the zero lower bound constraint.

Regarding the former factor, the idea that fiscal policy is more effective under a fixed than under a flexible exchange rate regime, is one of the most popular pieces of wisdom in economic policy. According to the textbook Mundell-Fleming model, under the floating exchange rate regime, a fiscal expansion has positive effects on output, but it also increases demand for money and thus, raises the interest rate. A higher domestic interest rate would then attract foreign capital flows into the economy, which results in appreciation of the domestic currency. As a consequence, imports will be encouraged while exports will be reduced, offsetting the effects of the fiscal expansionary. In contrast, under a fixed exchange rate regime, a similar fiscal expansion also increases output but it will lead to a growth in money supply in order to maintain the fixed exchange rate parity. Thus, the effects of fiscal shocks in a peg are believed to be larger than that in a float. There have been several empirical evidences supporting this point of view. For instance, controlling explicitly for the exchange rate regime, Corsetti et al. (2012) and Born et al. (2013) investigated the effects of fiscal shocks in OECD countries. They found that fiscal policy tends to be more effective within a fixed than a flexible exchange rate regime. In addition, Ilzetzki et al. (2013) who employed a recursive panel VAR model showed that the fiscal multipliers in economies applying the pegged exchange rate regime are above one, but in countries under a float, the multipliers close to zero or even negative. On the other hand, Corsetti et al. (2011) used a standard New Keynesian model of small open economy to investigate the transmission of government spending shock under the two regimes and found that fiscal policy was not necessarily more effective under fixed exchange rates as predicted in the Mundell-Fleming model.

Another recent strand of the literature concentrates on the effects of fiscal shocks when the ZLB on nominal interest rates is binding. It is argued that the impacts of fiscal policy depend on whether the ZLB period is caused by a fundamental shock or by a confidence (non-fundamental) shock
(Mertens and Ravn, 2014). In the former environment, an increase in government purchases is inflationary, which results in crowding in of private consumption and a lower real interest rate. Therefore, the effects of government spending expansionary would be enhanced. Several empirical studies supported this argument. For instance, Christiano et al. (2011), Eggertsson (2011) and Woodford (2011) found that spending multiplier during the ZLB could be substantially larger than one in a standard New Keynesian model for the case of the US. With respect to the effect of tax shocks in this environment, a fall in the marginal labor tax rate has deflationary effects, which crowds out private consumption and increases the real interest rate (Mertens and Ravn, 2014). Therefore, tax cuts have smaller effects in the ZLB period than in the normal period. This argument was supported by Eggertsson (2011) who found that the effects of tax cuts that stimulate aggregate supply, for example a cut in the labor tax, switch the signs from being positive to negative at the ZLB. If the ZLB period, however, is caused by a non-fundamental shock, a temporary increase in government spending is deflationary whereas tax cuts are inflationary and thus, the former would have limited expansionary effects while the latter become more expansionary. Mertens and Ravn (2014) found that the ZLB spending multiplier was less than 0.2 compared to approximately 0.6 outside of the ZLB. On the other hand, the ZLB tax multiplier was around 0.8, more than twice as large as the ZLB does not bind.

1.3.3 Studies on the effects of fiscal policy in Japan

There have been a large number of empirical studies that analyzed the macroeconomic effects of fiscal policy in Japan. The literature can be separated into two conflicting strands. The first point of view believes that fiscal policy generated limited effects in stimulating the economy. Bayoumi (2001) used a VAR to find the explanations for the extended slump in Japan over the 1990s and showed that the absence of bold and consistent fiscal stimulus was one of the main reasons. The author indicated that the expansionary effects of fiscal policy were small except in the wake of September 1995 stimulus package. Ihori et al. (2003) applied a non-structural VAR model to analyze the efficacy of fiscal policy and found that the Keynesian fiscal policy was not effective in the 1990s. Another study by Miyazaki (2009) who used a mixed VAR - event study approach showed that the negative effects of fiscal policy dominated the positive impacts in terms of size and persistence in the late 1990s. Perri (2001) developed a DSGE model in which fiscal policy may have both expansionary and contraditionary effects. Adopting this model for the case of Japanese economy, he found that the net expansionary effects were quantitatively small. Fueki, Fukunaga and Saito (2011) used two DSGE models to study the effects of fiscal policy in Japan. They found that, in both models, the effect of a positive government consumption shock on real GDP was
substantially small when the government targets a fiscal surplus by raising tax rates. Iwata (2009) estimated a medium-scale DSGE model of Japanese economy and found a positive effect of government spending on output in the first period but this effect was relatively short-lived. On the other hand, the second strand of the literature supports the hypothesis that fiscal policy had significant expansionary effects on macroeconomic activity in Japan. Based on the structural VAR model and a dataset over the period 1976-1999, Kuttner and Posen (2002) showed that both tax cuts and government spending increases resulted in higher real GDP with the output multipliers being 2.5 and 2.0 (measured at a four-year horizon), respectively.

With respect to the state-dependency of fiscal policy in Japan, most of the existing studies have been focus on the differences between the effects when the economy was in recessions and in expansions. To do that, some studies divided the entire sample into two periods - before and after a specific point of time (normally the early and mid 1990s). For example, Ihori et al. (2003) indicated that the impacts of tax on private consumption in the 1990s were smaller than those before the 1990s. In the study of Miyazaki (2009), the sample period was split at 1997 quarter 2 when the consumption tax rate rose to 5%. The research showed that permanent tax cuts in the former part of the 1990s had more sustainable and more persistent stimulative effects than those in the late 1990s. Auerbach and Gorodnichenko (2017) revealed that the effects of government purchase on output were weaker in the post-1985 sample than in the full sample. On the other hand, some studies adopted other VAR techniques including the threshold VAR model (Kameda 2014) and Markov-switching VAR model (Ko and Morita 2018). These studies found that the effects of fiscal policy were weaker in recessions.

However, the existing literature on the role of other factors, such as the exchange rate regime and the stance of monetary policy, in driving the effectiveness of fiscal policy in Japan has been still limited. To date, there have been only few studies that compared the effects of fiscal policy under different exchange rate regimes and explored the role of the ZLB constraint. With respect to exchange rate regime, Japan maintained a fixed exchange rate against the dollar from the early postwar years to the early 1970s. Under the Breton Woods System of exchange rates, Japan benefited from a fixed and undervalued currency that made exports extremely competitive. In addition, thank to this stable exchange rate combined with a young and skilled workforce, the country witnessed a high growth during that period (Hoshi and Kashyap 2011). However, the collapse of the Breton Woods regime in the early 1970s put an end to this story. After March 1973, the Yen was on a fluctuating exchange rate standard and generally rates were freely fluctuating in Japan (Quirk 1977; Meltzer 1986; Green, 1990). The important question is whether or not the fiscal policy was more effective under a fixed exchange rate regime. However, empirical evidences have
been still limited. A work by World Economic Model Group (1986) using EPA world economic model and found that the effect of a fiscal expansion under the floating exchange rate regime is considerably greater than under the fixed rate regime in Japan. Based on a new Keynesian model, Miyamoto et al. (2017) found that the fiscal multiplier can be larger than 1 during the 1960s and 1970s when the Japanese economy was under the fixed exchange rate regime while it was below unity after the collapse of the fixed exchange rate regime. Regarding the ZLB constraint, there has been also a lack of empirical studies on the effects of fiscal policy during the ZLB period in Japan. Miyamoto et al. (2018) examined the effects of government expenditure shocks on output when the nominal interest rate is near zero. They found that the output multiplier in Japan is above one under the ZLB and larger than that in the normal time. Kato et al. (2018) used the narrative approach to study the impact of tax changes on macroeconomic variable during and outside the ZLB and concluded that there was little difference in reaction of output across these two periods in Japan.

1.4 Research contributions

This study improves upon the preceding works in various ways. First, while most of these previous studies used a single VAR identification approach, this research employed three different methodologies including the recursive VAR, the structural VAR and the sign restriction approaches to achieve identification. In addition, these approaches were applied to four different VAR systems with various endogenous variables and in four sample periods (a full sample and three sub-samples). Second, as stated in the previous section, there have been only a few studies that investigate the role of ZLB constraint and exchange rate regime in driving the effectiveness of fiscal policy in Japan. With respect to the former factor, Miyamoto et al. (2018) and Kato et al. (2018) only considered the effects of single fiscal variable (i.e. either tax side or government spending side) on output. Unlike these studies, this thesis takes into account the macroeconomic impacts of both tax and government spending shocks during and outside the ZLB period. Furthermore, regarding exchange rate regime factor, to the best of author's knowledge, this research is one of the very first studies exploring the differences between the impacts of fiscal policy under fixed exchange rate regime period and those under floating exchange rate regime period in Japan. For these purposes, the thesis employed a rich fiscal data set over the 1960-2018 period, which covered both the fixed and floating exchange rate periods and also the presence of the ZLB.

1.5 Outline of the thesis

Following this introduction, Chapter 2 of this thesis explains the identification problem, the empirical VAR model and presents the recursive VAR and structural VAR to explore the effects of
fiscal policy in Japan. Based on a similar VAR framework and dataset, Chapter 3 introduces the identification and discusses the results obtained by using the sign restriction approach. Chapter 4 compared the effects of fiscal shocks on output during and outside the ZLB period in four developed countries including Japan, Canada, the UK and the US. Chapter 5 summaries the results, some policy implications and limitations of the thesis and makes some suggestions for further research.
CHAPTER II

Analysis on the macroeconomic effects of fiscal policy shocks in Japan: The recursive VAR and structural VAR approach

2.1 Introduction

This chapter will investigate the effects of fiscal policy shocks including tax and government spending shocks on macroeconomic activity in Japan by using the recursive VAR approach introduced by Sim (1980) and the structural VAR approach proposed by Blanchard and Perotti (2002). The first section of the chapter presents a simple three-variable VAR model and explains the identification problem for this model. To achieve the identification, in the second section, the recursive VAR and the structural VAR approaches will be introduced. Next, the three-variable VAR model will be expanded by incorporating more endogenous variable to the system. Finally, the results on the macroeconomic effects of fiscal shocks obtained by using the two approaches and different VAR models will be discussed. The full sample will be then split into three different subsamples: 1960Q1-1972Q4, 1973Q1-1995Q2 and 1995Q3-2018Q4 to compare the impacts of fiscal policy between fixed exchange rate regime and floating exchange rate regime; and between normal period and ZLB period of the interest rate.

2.2 Identification problem

To explain the identification problem, the study starts with a simple three variable VAR model, which is similar to that of Blanchard and Perotti (2002) and Kuttner and Posen (2002). Accordingly, the reduced form of basic VAR specification can be expressed as:

(1) \[ Y_t = C_1 Y_{t-1} + C_2 Y_{t-2} + \ldots + C_p Y_{t-p} + u_t \]

where \( Y_t = [T_t \ G_t \ X_t]' \) is the three-dimensional vector of the logarithms of endogenous variables including tax revenues, government expenditure and GDP. \( u_t = [u_t^T \ u_t^G \ u_t^X]' \) is the corresponding three-dimensional vector of reduced-form residuals and \( E(u_t) = 0 \).

The variance-covariance matrix of the system is denoted as \( \Omega_u: \Omega_u = E[u_t u_t'] \).

With \( L \) being the lag operator, equation (1) can also be written as:

(2) \[ C(L)Y_t = u_t \]
(with $C(L) = I - C_1 L - C_2 L^2 - \ldots - C_p L^p$)

As pointed out in Blanchard and Perotti (2002), although the reduced-form VAR in (1) is estimable, the obtained residuals have little economic significance. This is because the reduced-form disturbances are, in general, contemporaneously correlated across equations. As a consequence, these residuals from the equations for tax revenues and government spending cannot be interpreted as exogenous shocks. Hence, it is necessary to transform the reduced-form residuals into the structural shocks.

Assuming that the relationship between the reduced-form residuals and the structural disturbances can be described as:

\[
\begin{align*}
 u_t &= F
\end{align*}
\]

where $\varepsilon_t = [\varepsilon^T_t, \varepsilon^G_t, \varepsilon^X_t]'$ is the three-dimensional vector of the structural shocks that we want to identify with $E(\varepsilon_t) = 0$. The structural shocks $\varepsilon^T_t$, $\varepsilon^G_t$ and $\varepsilon^X_t$ are assumed to be uncorrelated with each other and hence, they can be economically interpreted.

Substituting (3) into (2) delivered the structural-form VAR:

\[
C(L)Y_t = F\varepsilon_t
\]

or

\[
F^{-1}C(L)Y_t = \varepsilon_t \quad \text{(Assuming that F is invertible)}
\]

The variance-covariance matrix of the system then become $\Sigma_{\varepsilon}$ and the link between $\Sigma_{\varepsilon}$ and the reduced-form variance-covariance matrix $\Omega_u$ can be written as:

\[
\begin{align*}
\Omega_u &= E[u_t u_t'] = E[(F\varepsilon_t)(F\varepsilon_t)'] = FE[\varepsilon_t\varepsilon_t']F' = F\Sigma_{\varepsilon}F'
\end{align*}
\]

Furthermore, since $\varepsilon^T_t$, $\varepsilon^G_t$ and $\varepsilon^X_t$ are assumed to be uncorrelated with each other, the off-diagonal elements of matrix $\Sigma_{\varepsilon}$ are all zero:

\[
\Sigma_{\varepsilon} = E[\varepsilon_t\varepsilon_t'] = \begin{bmatrix}
\sigma^2_t & 0 & 0 \\
0 & \sigma^2_G & 0 \\
0 & 0 & \sigma^2_X
\end{bmatrix}
\]
The structural moving average representation of the endogenous variables $Y_t$ can also be delivered from equation (4):

(7) \[ Y_t = D(L)\epsilon_t \]
(with $D(L) = FC(L)^{-1}$)

In equation (7), $Y_t$ is expressed as current and past values of the structural shocks $\epsilon_t$.

The identification problem is to recover the structural shocks $\epsilon_t$ that affect the endogenous variables. In other words, we need to identify the parameters in equation (4) or in equation (7). Since $C(L)$ and $\Omega_u$ can be estimated from the reduced-form VAR in equation (1), identification is achieved if $F$ and $\Sigma_e$ are known. As pointed out in chapter 1, the existing studies have used different strategies to identify the fiscal shocks. In this chapter, the recursive VAR and the structural VAR approaches, which imposed assumptions on the contemporaneous relations between reduced-form and structural residuals (matrix $F$) in equation (3), were applied.

2.3 The identification approaches

For the identification of the recursive VAR and the structural VAR approaches, it is more convenient to assume that the relationship between reduced-form and structural residuals in equation (3) can be expressed by some matrix $A$ and matrix $B$ as follows:

(3a) \[ Au_t = B\epsilon_t \]

or in matrix-form as:

(3b) \[
\begin{bmatrix}
    a_{tt} & a_{tg} & a_{tx} \\
    a_{gt} & a_{gg} & a_{gx} \\
    a_{xt} & a_{xg} & a_{xx}
\end{bmatrix}
\begin{bmatrix}
    u_t^T \\
    u_c^T \\
    u_x^T
\end{bmatrix}
= \begin{bmatrix}
    b_{tt} & b_{tg} & b_{tx} \\
    b_{gt} & b_{gg} & b_{gx} \\
    b_{xt} & b_{xg} & b_{xx}
\end{bmatrix}
\begin{bmatrix}
    \epsilon_t^T \\
    \epsilon_c^T \\
    \epsilon_x^T
\end{bmatrix}
\]

where $a_{ij}$ is element of matrix $A$ and represents the contemporaneous respond of variable $i$ to a shock in variable $j$. $b_{ij}$ is element of matrix $B$ and implies how the variable $i$ is affected by a structural shock in variable $j$.

This representation of structural form VAR is known as the AB model (see, e.g., Lukepohl, 2005). Making assumptions on matrix $F$ is then proportional to imposing restrictions to matrix $A$ and matrix $B$. 

13
2.3.1 The recursive VAR approach

The recursive approach was originally suggested by Sim (1980) and developed by Fatas and Mihov (2001) to study the impacts of fiscal policy shocks on output. According to this approach, matrix A is restricted to a 3x3 lower triangular matrix with unit diagonal (allowing a Cholesky decomposition) and matrix B is restricted to a three-dimensional identity matrix.

Another point that need to be considered is the order of the endogenous variables since this approach allows one variable to affect contemporaneously other variables following it in the ordering, but has no contemporaneous impact on those preceding it. In this study, the order of endogenous variables followed the studies of Fatas and Mihov (2001), Caldara and Kamps (2008). Accordingly, government expenditure is ordered first, output is placed second and the last is tax revenue.

With these above imposed restrictions, equation (3b) became:

\[
\begin{bmatrix}
1 & 0 & 0 \\
axg & 1 & 0 \\
axg & axg & 1 \\
\end{bmatrix}
\begin{bmatrix}
u_G^t \\
u_T^t \\
u_T^T \\
\end{bmatrix}
= 
\begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1 \\
\end{bmatrix}
\begin{bmatrix}
e_G^t \\
e_T^t \\
e_T^T \\
\end{bmatrix}
\]

The above ordering of the endogenous variables has an economic meaning and can be interpreted as follows:

(i) Government expenditure is ordered first and does not respond contemporaneously to shocks to GDP and tax revenues.

(ii) Output is ordered second and does not respond contemporaneously to shocks to tax revenues but is affected by government expenditure shocks.

(iii) Tax revenues are ordered last and contemporaneously affected by shocks to government expenditure and output.

Another assumption imposed in equation (8) is that the off-diagonal elements of matrix B are all zero, which indicates that structural shocks are restricted not to be mutually correlated. It is worth noting that these above assumptions are held only for the first period, while later all variables in the system are allowed to interact freely. Furthermore, the explanations for selecting this ordering have been discussed in the recent literature. Caldara and Kamps (2008) argued that unlike movements in tax receipts, movements in government expenditure are largely unrelated to the business cycle. In addition, when the government observes major shocks affecting the economy, they may implement
systematic countercyclical policies but there is no automatic stabilizer among the components of government spending. Therefore, it is plausible to assume that it may take one period before the government can realize the shock and react to it, or in other words, the government expenditure should be ordered first in the system. The reasons for ordering GDP before tax revenues can be explained by the fact that shocks to output may immediately affect the tax base and, thus, have a contemporaneous impact on tax receipts. In addition, automatic stabilizers in the tax system are numerous, thus, it is not realistic to assume that taxes do not respond contemporaneously to shocks to output. As a consequence, GDP is ordered second and tax revenues are placed third in the system.

2.3.2 The structural VAR approach

Another identification approach is the structural VAR model based on the methodology of Blanchard and Perotti (2002). From equation (3b), it is theoretically accepted in the literature that output cannot be affected by structural shocks to taxes and government expenditure within one quarter and vice versa. This makes the coefficients $b_{xt}$, $b_{xg}$, $b_{tx}$ and $b_{gx}$ all equal to zero.

Another important assumption, following the study of Blanchard and Perotti (2002), is that output is allowed to have a contemporaneous effect on tax revenues, but not on government expenditure. In other words, the elasticity of government expenditure is assumed to equal to zero ($a_{gx} = 0$).

The model also assumed that taxes do not respond contemporaneously to a shock to expenditure (or vice versa). That makes the coefficients $a_{tg} = 0$ and $a_{gt} = 0$.

However, structural shocks to taxes/expenditure are allowed to influence expenditure/taxes within one period. Thus, it is necessary to determine whether taxes respond to the increase in expenditure or the reverse when the government raises both of them at the same time. In this study, it was assumed that spending decision comes first, so that $b_{gt} = 0$.

Finally, following Blanchard and Perotti (2002) and Kuttner and Posen (2002), the diagonal elements of matrix A and B are assumed to be equal to 1. With the imposed assumptions above, equation (3b) can be written as:

$$
\begin{bmatrix}
1 & 0 & a_{tx} \\
0 & 1 & 0 \\
1 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
u_1^T \\
u_2^T \\
u_3^T
\end{bmatrix}
= 
\begin{bmatrix}
1 & b_{tg} & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\varepsilon_1^T \\
\varepsilon_2^T \\
\varepsilon_3^T
\end{bmatrix}
$$

or in the form of system of equations:

$$
u_1^T = -a_{tx}u_2^T + b_{tg}\varepsilon_1^T + \varepsilon_1^T$$

$$
u_2^T = b_{tg}u_1^T + \varepsilon_2^T$$

$$
u_3^T = a_{tx}u_2^T + b_{tg}\varepsilon_2^T + \varepsilon_3^T$$
\[ u_t^G = \varepsilon_t^G \]
\[ u_t^X = -a_{xt}u_t^T - a_{xg}u_t^F + \varepsilon_t^X \]

The economic implication in equation (10) can be interpreted as follows:

(i) Unexpected movements in taxes \( u_t^T \) depend on the contemporaneous respond of taxes to a shock to GDP (captured by \(-a_{xt}u_t^X\)); the respond of taxes to structural shocks to spending (captured by \( b_{tg}\varepsilon_t^F \)) and to taxes (captured by \( \varepsilon_t^T \)).

(ii) Unexpected movements in government expenditure \( u_t^G \) depend on the respond of expenditure to structural shocks to spending (captured by \( \varepsilon_t^F \)).

(iii) Unexpected movements in output \( u_t^X \) depend on the contemporaneous respond of GDP to a shock to taxes (captured by \(-a_{xt}u_t^T\)); the contemporaneous respond of GDP to a shock to government expenditure (captured by \(-a_{xg}u_t^F\)); and the respond of GDP to structural shocks to GDP (captured by \( \varepsilon_t^X \)).

Equation (9) shows that there are 4 unknown elements to identify in matrix A and matrix B. In addition, in equation (6), the variance-covariance matrix of the structural form VAR (\( \Sigma_\varepsilon \)) is diagonal, which makes 3 more unknown elements to estimate. Consequently, we have 7 unknown parameters in total to estimate. However, we only know 6 unique elements of the covariance matrix of reduced-form VAR residuals \( \Omega_u \) by estimating equation (1). Therefore, one more assumption needs to be imposed into matrix A or matrix B so that the model is just-identified. Following Blanchard and Perotti (2002) approach, the institutional information on the elasticity of taxes on output (i.e., \( a_{tx} \)) is used to identify the model. Based on the working paper of Giorno et al. (1995) that calculate output elasticities of tax receipts for OECD countries and the study of Kuttner and Posen (2002), this parameter was set to be equal to -1.25. The model is then exactly-identified.

It is also necessary to note that instead of estimating directly the two parameters \( a_{xt} \) and \( a_{xg} \) in (10), Blanchard and Perotti used the cyclically-adjusted reduced-form tax and spending residuals as instrumental variables to identify these parameters. This study utilized the same technique to estimate \( a_{xt} \) and \( a_{xg} \). In particular, the cyclically-adjusted reduced form tax and spending residuals can be described as:

\[ u_{t,.CA}^T = u_t^T - (-a_{tx}u_t^X) = u_t^T + a_{tx}u_t^X \]
where \( u^T_{t,CA} \) and \( u^G_{t,CA} \) are cyclically-adjusted reduced-form tax and spending residuals, respectively. Because \( u^T_{t,CA} \) and \( u^G_{t,CA} \) are uncorrelated with the structural shocks to GDP \( \epsilon^X_t \), they can be used as instruments to estimate \( a_{xt} \) and \( a_{xg} \) in a regression of \( u^X_t \) against \( u^T_t \) and \( u^G_t \).

### 2.4 Models with other endogenous variables

In order to fully understand the transmission mechanism of fiscal policy shocks, it is essential to take into account the reacts of macroeconomic variables other than output. Hence, beside the above three variable specification (thereafter named model (1)), various macroeconomic factors will be imposed to the model in the following.

**Model with private consumption - Model (2)**

First, it is crucial to examine the effects of fiscal shocks on output components, such as private consumption, to sort out the relative merits of alternative theories. For instance, Blanchard and Perotti (2002) noted that although both standard neoclassical and Keynesian models predicted a positive impact of government spending on output, the former implied a negative effect on private consumption while an opposite sign was expected in the latter model. Therefore, private consumption was added to model (1) as an endogenous variable.

**The recursive VAR approach**

Following Blanchard and Perotti (2002), it is assumed that the additional variable private consumption was ordered last in the VAR system. Accordingly, equation (8) becomes:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
\alpha_{xg} & 1 & 0 & 0 \\
\alpha_{tg} & \alpha_{tx} & 1 & 0 \\
\alpha_{cg} & \alpha_{cx} & \alpha_{ct} & 1
\end{bmatrix}
\begin{bmatrix}
u^G_t \\
u^X_t \\
u^T_t \\
u^C_t
\end{bmatrix} =
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\epsilon^G_t \\
\epsilon^X_t \\
\epsilon^T_t \\
\epsilon^C_t
\end{bmatrix}
\]

where \( u^C_t \) and \( \epsilon^C_t \) are reduced-formed and structural-form residuals, respectively, in the equation of the fourth endogenous variable - private consumption \( (C_t) \).

**The structural VAR approach**

Within the structural VAR approach, the private consumption variable was also ordered last in the system. Moreover, the relation between residuals followed the specification of Blanchard and Perotti (2002) in the case of four-variable VAR as follows:
The model assumes that private consumption does not respond contemporaneously to a shock to output (and vice versa). That makes the coefficients $\alpha_{cx} = 0$ and $\alpha_{xc} = 0$. In addition, private consumption was required not to have contemporaneous effect on taxes and government spending. This implies that $\alpha_{tc} = 0$ and $\alpha_{gc} = 0$.

**Model with import - Model (3)**

Second, since the study attempt to compare the effects of fiscal policy under fixed exchange rate regime and floating exchange rate regime, variations in variables like import and export might be a key to understand the differences between these two regimes. Hence, model (3) including import as an addition fourth variable was examined in this research.

**The recursive VAR approach**

Theoretically, higher output stimulated by fiscal policy shocks may lead to higher import but with a lag. Hence, it is reasonable to assume that imports cannot contemporaneously react to shocks to taxes, government spending and output (Deskar-skrobic and Simovic, 2017). Accordingly, within the recursive VAR, import was ordered first in the system:

\[
\begin{bmatrix}
1 & 0 & a_{tx} & 0 \\
0 & 1 & 0 & 0 \\
\alpha_{xt} & \alpha_{xg} & 1 & 0 \\
\alpha_{ct} & \alpha_{cg} & 0 & 1
\end{bmatrix}
\begin{bmatrix}
u_t^T \\
u_t^G \\
u_t^X \\
u_t^I
\end{bmatrix}
= 
\begin{bmatrix}
1 & b_{tg} & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\varepsilon_t^T \\
\varepsilon_t^G \\
\varepsilon_t^X \\
\varepsilon_t^I
\end{bmatrix}
\]

where $u_t^I$ and $\varepsilon_t^I$ are reduced-form and structural-form residuals, respectively, in the equation of the additional endogenous variable: import ($I_t$).

**The structural VAR approach**

With an additional fourth variable import, the VAR system in the structural VAR approach can be written as follows:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
\alpha_{gi} & 1 & 0 & 0 \\
\alpha_{xi} & \alpha_{xg} & 1 & 0 \\
\alpha_{ti} & \alpha_{tg} & \alpha_{tx} & 1
\end{bmatrix}
\begin{bmatrix}
u_t^T \\
u_t^G \\
u_t^X \\
u_t^I
\end{bmatrix}
= 
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\varepsilon_t^I \\
\varepsilon_t^G \\
\varepsilon_t^X \\
\varepsilon_t^T
\end{bmatrix}
\]
Similar to the recursive approach, import was assumed not to respond contemporaneously to fiscal shocks and shocks to output. That makes $a_{it} = a_{ig} = a_{tx} = 0$. However, this variable was allowed to affect taxes, government spending and GDP (Deskar-skrbic and Simovic, 2017).

**Model with interest rate and inflation - Model (4)**

Third, this research also investigates whether the impacts of fiscal policy in Japan were enhanced or reduced during the ZLB period. As a result, it is reasonable to include some proxies for monetary policy to be in the vector of endogenous variables. Following the study of Perotti (2004), model (4) was constructed by adding two variables: interest rate and inflation to the baseline model.

**The recursive VAR approach**

The ordering of the recursive VAR system with two more variables including interest rate and inflation followed the study of Boiciuc (2015) and other previous studies. Accordingly, equation (8) became:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
\alpha_{tg} & 1 & 0 & 0 & 0 \\
\alpha_{tg} & \alpha_{tx} & 1 & 0 & 0 \\
\alpha_{tg} & \alpha_{tx} & \alpha_{rr} & \alpha_{rt} & 1 \\
\end{bmatrix}
\begin{bmatrix}
u_t^G \\ u_t^x \\ u_t^n \\ u_t^r \\ u_t^R \\ \end{bmatrix} =
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\begin{bmatrix}
\epsilon_t^G \\ \epsilon_t^x \\ \epsilon_t^n \\ \epsilon_t^r \\ \epsilon_t^R \\ \end{bmatrix}
\]

where $u_t^P$ and $\epsilon_t^P$ are reduced-formed and structural-form residuals, respectively, in the equation of the fourth endogenous variable - inflation ($\Pi_t$) and $u_t^R$ and $\epsilon_t^R$ are reduced-formed and structural-form residuals, respectively, in the equation of the fifth endogenous variable - interest rate ($R_t$).

In equation (8c), inflation was assumed to be contemporaneously influenced by shocks to government spending and output, and not affected by the tax and interest rate shocks. Furthermore, interest rate was allowed to respond to shocks to all other variables in the system.

**The structural VAR approach**

Following the study of Perotti (2004), the relationship between reduced form residual and structural form disturbances in a five-variable VAR system can be written as follow:

\[
\begin{bmatrix}
1 & 0 & \alpha_{tx} & \alpha_{tp} & \alpha_{tr} \\
0 & 1 & 0 & \alpha_{tp} & \alpha_{tr} \\
\alpha_{tx} & \alpha_{sx} & 1 & 0 & 0 \\
\alpha_{tx} & \alpha_{sx} & \alpha_{sx} & 1 & 0 \\
\alpha_{tx} & \alpha_{sx} & \alpha_{sx} & \alpha_{sx} & 1 \\
\end{bmatrix}
\begin{bmatrix}
u_t^P \\ u_t^x \\ u_t^n \\ u_t^r \\ u_t^R \\ \end{bmatrix} =
\begin{bmatrix}
1 & b_{tg} & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\begin{bmatrix}
\epsilon_t^P \\ \epsilon_t^x \\ \epsilon_t^n \\ \epsilon_t^r \\ \epsilon_t^R \\ \end{bmatrix}
\]

Adding two more variables to the system made 14 more unknown elements in matrix A. Furthermore, in equation (6), there were also 2 more unknowns to estimate. As a consequence, we
have 16 more parameters in total to estimate. On the other hand, we only know 15 unique elements of \( \Omega \) by estimating equation (1) with five-variable VAR model. Compared to the three-variable VAR system (in which 6 elements of \( \Omega \) can be estimated), there were 9 more identified parameters in the new model. Therefore, we need \((16 - 9) = 7\) more assumptions to be imposed so that the model is exactly identified. This study applied a similar technique to Perotti (2004)'s. The imposed assumptions are as follows:

First, the model assumed that shocks to interest rate do not contemporaneously affect other variables. This makes \( \alpha_{tr} = \alpha_{gr} = \alpha_{xt} = \alpha_{pr} = 0 \).

Second, inflation was assumed not to contemporaneously influence output (i.e. \( \alpha_{\pi x} = 0 \)).

Regarding the elasticity of spending to inflation, Perotti (2004) noted that computing this elasticity is complicated since some components of spending may effectively indexed to the price level within one quarter while some others may not. Following the study of Boiciuc (2015) among the others, I assumed that \( \alpha_{gr} = 0 \). For the effects of price level on taxes, the elasticities \( \alpha_{tx} \) can be computed from tax revenues components including income taxes on individuals, corporate income taxes and indirect taxes. Perotti (2004) assumed that the elasticity of corporate income taxes and indirect taxes to the inflation are all zero. On the other hand, the elasticities of income taxes on individuals to the price level, holding unchanged employment, output and wage, can be calculated by subtracting 1 from the elasticity of tax revenues per person to earnings. Price, Dang and Botev (2015) provided an estimate of 1.88 of the elasticity of taxes to earnings for Japan. Hence, the parameter \( \alpha_{tx} \) was set to be -0.88.

With respect to the elasticity of tax to output, I still set \( \alpha_{tx} = -1.25 \) as in the baseline model. It is also important to note that the cyclically-adjusted reduced form tax and spending residuals were still used to estimate the two parameters \( \alpha_{xt} \) and \( \alpha_{xg} \), as in the baseline model. However, with two more variables added, equation (11) and (12) become:

\[
(11a) \quad u^T_{t,CA} = u_t^T - (-a_{tx}u_t^X - a_{tx}u_t^X - a_{tx}u_t^X - a_{tx}u_t^X) = u_t^T + a_{tx}u_t^X + a_{tx}u_t^X
\]

\[
(12a) \quad u^G_{t,CA} = u_t^G - (-a_{gx}u_t^X - a_{gx}u_t^X - a_{gx}u_t^X - a_{gx}u_t^X) = u_t^G
\]

2.5 Computing fiscal multipliers

After the estimation of the VAR models discussed above, the impulse responses of output and other endogenous variables to fiscal (tax and government spending) shocks were obtained. They
indicated how the macroeconomic factors react to a positively unexpected increase in taxes and government spending by one percent.

On the other hand, these effects of tax and spending shocks were easier to interpret and comparable between different fiscal scenarios when put in Yen term. Hence, the thesis also calculated the fiscal multipliers that have been widely applied in the literature. It is measured as the ratio of the response of output at a given horizon to an initial movement of the fiscal variable (Blanchard and Perotti, 2002; Canova and Pappa, 2007; Mountford and Uhlig, 2009). Following these studies, the fiscal multipliers in this study were calculated as follows:

\[
\text{Multiplier for GDP at horizon } k = \frac{\text{GDP response at horizon } k}{\text{Average fiscal variable share of GDP}}
\]

The median responses were used in all cases. This multiplier measured the impact in Japanese Yens of one Yen increase in tax/spending at the first quarter. Following Blanchard and Perotti (2002), the peak responses of output to a given fiscal shock were also focused in this study.

2.6 Data

The data source of the study was collected from Organization Economic Cooperation and Development (OECD)’s Economic Outlook Projections database. The baseline VAR model (model (1)) consists of three endogenous variables: tax revenues, government expenditure, GDP, and a constant. Following Blanchard and Perotti (2002) and Kuttner and Posen (2002), the revenue variable is defined as the total tax revenues including direct and indirect taxes less social security contributions while the expenditure variable is defined as the total government expenditure less net interest payments. In addition, as specified in the previous section, model (2) included the private consumption variable while model (3) added imports to the baseline model. In model (4), two monetary policy variables: interest rate and inflation, were incorporated. The interest rate variable is defined as the short-term nominal interest rate while GDP deflator is a proxy for inflation variable. All these variables are expressed in logarithm, per capita and real terms, except for interest rate and GDP deflator. The quarterly dataset was used and hence, a lag length of four quarter was chosen for all models. Furthermore, the data cover the period 1960Q1-2018Q4, which included both the fixed and floating exchange rate periods and the presence of the ZLB. Since data for the short-term interest rate was not available before the 1970s, the research period for model (4) was 1973Q1-2018Q4.
In order to analyze the effects of fiscal policy shocks under different economic conditions, it is important to identify the time when there was a change in the regime. First, with respect to the exchange rate regime, Japan has switched from fixed to floating exchange rate regime since February 1973 (Quirk 1977; Green, 1990). Regarding the ZLB, this research defines ZLB periods as those episodes when the short-term nominal interest rate is less than 1 percent, following the studies of Bonam et al. (2017) and Klein and Winkler (2018). Accordingly, the nominal interest rate in Japan has been near zero from 1995Q3 to 2018Q4 (Figure 2.1).

![Figure 2.1. Japan Short-Term Nominal Interest Rate](source: OECD)

To filter out the effects of the exchange rate regime and the ZLB constraint on each other, the full sample 1960Q1-2018Q4 was divided into three sub-samples: 1960Q1-1972Q4, 1973Q1-1995Q2 and 1995Q3-2018Q4 (Table 2.1). The first sub-sample represents the period in which the Japanese economy is characterized by fixed exchange rate regime and normal interest rates (i.e. not constrained by the ZLB). The second sub-sample 1973-1995Q2 corresponds to the episode with floating exchange rate regime and normal interest rates. The third sub-sample 1995Q3-2018Q4 also cover floating exchange rate regime period but the interest rate was at the ZLB. Hence, to examine whether exchange rate regime affect the effects of fiscal policy, the responses of macroeconomic variables to fiscal shocks were compared using sub-sample (A) 1960Q1-1972Q4 and sub-sample (B) 1973Q1-1995Q2. Similarly, to investigate whether the impacts of fiscal shocks were enhanced...
or reduced during the ZLB period, sub-sample (B) 1973Q1-1995Q2 and sub-sample (C) 1995Q3-2018Q4 were employed.

<table>
<thead>
<tr>
<th>Sub-sample</th>
<th>Exchange rate regime</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) 1960Q1-1972Q4</td>
<td>Fixed</td>
<td>Normal</td>
</tr>
<tr>
<td>(B) 1973Q1-1995Q2</td>
<td>Float</td>
<td>Normal</td>
</tr>
<tr>
<td>(C) 1995Q3-2018Q4</td>
<td>Float</td>
<td>ZLB</td>
</tr>
</tbody>
</table>

2.7 Results

This section discusses the impulse responses of macroeconomic variables including output, private consumption, import, inflation and interest rate to fiscal shocks and the fiscal multipliers derived from four different VAR specifications by using two identification approaches: the recursive VAR and the structural VAR. The estimates for different sample periods were then presented to explore the role of the exchange rate regime and the ZLB constraint in driving the effects of fiscal policy shocks. In the case of using the full sample, all four models: (1), (2), (3) and (4) were employed. To compare the effects under a peg and a float, only three models: model (1), model (2) and model (3) were used because the data for interest rate variable was not available before the 1970s. Finally, to examine the impacts during and outside the ZLB, all four models were utilized.

In all figures, the dashed lines represent two-standard deviation bands, which were computed by Monte Carlo simulations based on 400 replications. The units on the vertical axis were percent while the horizontal axis represented the number of quarters following the initial shocks.

2.7.1 Results for the effect of fiscal shocks using full sample

The tax shock

Figure 2.2 and Figure 2.3 plot the impulse responses of output and other macroeconomic variables to tax shocks by using the recursive VAR approach and the structural VAR approach. They display the dynamic effects of an unanticipated positive increase by one percent in taxes for a five-year time horizon.
**Figure 2.2.** Responses of macroeconomic variables to tax shock (full sample) - the recursive approach
The responses of output to a positive tax shock by using the recursive VAR approach were positive but insignificant in all four models. By construction of this approach, the responses at the first period were zero. After increasing slightly in 3 quarters, these responses followed a trend line of around 0.5%. In contrast, the results computed by the structural VAR approach showed that

FIGURE 2.3. RESPONSES OF MACROECONOMIC VARIABLES TO TAX SHOCK (FULL SAMPLE)- THE STRUCTURAL VAR APPROACH
output responded negatively and significantly to an unanticipated increase in taxes in model (1), (2) and (3). In model (4), the output responses were statistically insignificant at almost time horizons. The on-impact point estimates of the responses in the first three model were consistent at around -0.5% and that in model (4) was -0.01%. This indicated that output decreases by about 0.5% as a result of a one percent increase in taxes. Furthermore, the estimated effects of tax shocks were relatively persistent in the first three models.

An explanation for the differences between the above results obtained from the recursive VAR and the structural VAR is the assumption on the responses of output to tax shock for the first period. While the structural VAR approach computed an elasticity of taxes to output, the recursive VAR assumed this elasticity equal to zero. This zero relationship is a quite strong assumption that may affect the reacts of output to a tax shock in the following quarters.

With respect to the responses of other variables, there were also some differences between these two approaches. First, reacting to an unexpected positive tax shock, consumption increased significantly for five quarters with the immediate impact of 0.27% in the recursive approach. On the other hand, the responses of consumption within the structural VAR approach were insignificant. Second, the responses of import to tax shock followed a similar pattern in the two approaches. It increased significantly for the first 4-5 quarters before turning to be insignificant. Third, regarding the reacts of monetary policy variables, the recursive approach indicated that prices and interest rates increased in response to a rise in taxes while the structural VAR showed the opposites. These differences in the results again were due to the assumptions imposed into the models by the two approaches as discussed in section 2.4.

**The government spending shock**

Figure 2.4 and Figure 2.5 showed the impulse responses of macroeconomic variables to a one percent increase in government spending, using the recursive VAR approach and the structural VAR approach.

In general, the results of responses to spending shocks were relatively consistent across four models and between the two approaches. Output rose in response to an unexpected increase in spending with the on-impact point estimated ranged between 0.13% and 0.19 % within the recursive VAR approach, and between 0.11% and 0.13% within the structural VAR approach. However, the effects of spending shocks were relatively transitory.

Private consumption and import also reacted positively to shocks to spending, although these responses were statistically insignificant at almost time horizons. With respect to monetary policy
factors, it was revealed that prices and interest rates were decreased but the effects were relatively small.

<table>
<thead>
<tr>
<th>Model (1)</th>
<th>Model (2)</th>
<th>Model (3)</th>
<th>Model (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Import</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP deflator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest rate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.4. Responses of Macroeconomic Variables to Spending Shock (Full Sample)- The Recursive VAR Approach**
The fiscal multipliers

According to Kuttner and Posen (2002), the effects of tax and spending shocks were easier to interpret and comparable between different fiscal scenarios when put in Yen term. As discussed in
section 2.5, the fiscal multipliers were calculated by scaling the output responses by the inverse of share of fiscal variable in GDP. This multiplier measured the impact in Japanese Yens of one Yen increase in tax/spending at the first quarter.

Table 2.2 reported the tax and spending multipliers for the whole sample 1960Q1-2018Q4. Regarding the tax multiplier, the obtained multipliers by the recursive VAR were positive while those by the structural VAR were negative. As discussed above, this was due to different assumptions imposed by the two approaches. The assumptions in the structural VAR approach seems to be more realistic than that in the recursive VAR since it did not assume a zero elasticity of taxes to output. Thus, for tax multipliers, the analyses focused on the structural VAR approach. Table 2.2 showed that output in the structural VAR approach fell on impact by 3.09 to 3.22 Yen in model (1), (2) and (3) and 0.03 in model (4). Furthermore, the multipliers in the first three models were not very different over time.

In terms of spending multipliers, the results were consistent between the two approaches and across different models. It was shown that spending shocks caused an effect of 0.56 to 0.59 Yen (the recursive VAR) and 0.49 to 0.55 Yen (the structural VAR) in the first quarter. The effect reached a peak between 1 to 2 years following the shocks.

<table>
<thead>
<tr>
<th>Tax multipliers</th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>The recursive VAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0</td>
<td>2.20</td>
<td>2.26</td>
<td>2.20</td>
<td>2.06</td>
<td>2.28</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0</td>
<td>2.85</td>
<td>2.74</td>
<td>2.61</td>
<td>2.73</td>
<td>3.03</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0</td>
<td>2.39</td>
<td>2.24</td>
<td>1.99</td>
<td>2.00</td>
<td>2.43</td>
</tr>
<tr>
<td>Model (4)</td>
<td>0</td>
<td>3.06</td>
<td>3.17</td>
<td>3.51</td>
<td>4.20</td>
<td>4.21</td>
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<tr>
<td>The structural</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAR approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>-3.09</td>
<td>-2.95</td>
<td>-3.02</td>
<td>-3.01</td>
<td>-2.88</td>
<td>-3.09</td>
</tr>
<tr>
<td>Model (2)</td>
<td>-3.22</td>
<td>-2.79</td>
<td>-2.56</td>
<td>-2.37</td>
<td>-1.86</td>
<td>-3.22</td>
</tr>
<tr>
<td>Model (3)</td>
<td>-3.09</td>
<td>-3.13</td>
<td>-3.45</td>
<td>-3.51</td>
<td>-3.32</td>
<td>-3.52</td>
</tr>
<tr>
<td>Model (4)</td>
<td>-0.03</td>
<td>2.40</td>
<td>2.13</td>
<td>0.91</td>
<td>-0.50</td>
<td>-0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spending multipliers</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The recursive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAR approach</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0.56</td>
<td>0.60</td>
<td>0.57</td>
<td>0.47</td>
<td>0.35</td>
<td>0.64</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0.58</td>
<td>0.58</td>
<td>0.44</td>
<td>0.24</td>
<td>0.05</td>
<td>0.59</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0.52</td>
<td>0.63</td>
<td>0.66</td>
<td>0.55</td>
<td>0.38</td>
<td>0.69</td>
</tr>
<tr>
<td>Model (4)</td>
<td>0.69</td>
<td>0.92</td>
<td>1.03</td>
<td>0.97</td>
<td>0.86</td>
<td>1.03</td>
</tr>
<tr>
<td>The structural</td>
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<tr>
<td>VAR approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0.55</td>
<td>0.59</td>
<td>0.56</td>
<td>0.46</td>
<td>0.34</td>
<td>0.63</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0.56</td>
<td>0.56</td>
<td>0.43</td>
<td>0.22</td>
<td>0.04</td>
<td>0.58</td>
</tr>
</tbody>
</table>
### Table 2.3: On-impact Estimates

<table>
<thead>
<tr>
<th>Model (3)</th>
<th>0.52</th>
<th>0.60</th>
<th>0.61</th>
<th>0.49</th>
<th>0.31</th>
<th>0.65 (qtr 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model (4)</td>
<td>0.49</td>
<td>0.82</td>
<td>0.96</td>
<td>0.92</td>
<td>0.84</td>
<td>0.96 (qtr 8)</td>
</tr>
</tbody>
</table>

#### 2.7.2 The effect of fiscal shocks under fixed exchange rate regime and under floating exchange rate regime

This section compared the macroeconomic effects of fiscal policy shocks under fixed exchange rate regime and under floating exchange rate regime. For this purpose, two sub-samples 1960Q1-1972Q4 and 1973Q1-1995Q2 were used. Since the data for interest rate variable was not available before the 1970s, model (4) was excluded in this section.

**The tax shock**

Figure 2.6 plotted the impulse response function of output after a one percent increase in tax under fixed exchange rate and floating exchange rate regimes and table 2.3 reported the corresponding tax multipliers. As discussed in the previous section, regarding the effects of tax shock on output, the study focused on the results obtained by using structural VAR approach. Panel B of Figure 2.6 indicated that, under both regimes, a positive tax shock caused a fall in output and the effect was significant in some first quarters. Moreover, there were insignificant differences between output reacts under a peg and a float. The on-impact estimates under fixed exchange rates were between -0.50% and -0.56% across the three models while these numbers under a float were between -0.44% and -0.48%. The corresponding tax multipliers in the first quarter ranged between -2.66 and -3.12 under both regimes and most of these were also the peak multipliers over the five-year horizon (Table 2.3).
**Panel A. Output Responses to Tax Shock - The Recursive VAR Approach**

Model (1)  
Model (2)  
Model (3)  

**Panel B. Output Responses to Tax Shock - The Structural VAR Approach**

Model (1)  
Model (2)  
Model (3)  

**Figure 2.6. Estimated Impulse Responses of Output to a Positive Tax Shock Under Fixed and Floating Exchange Rate Regimes**
**Table 2.3—Tax Multipliers: Fixed Exchange Rate Regime and Floating Exchange Rate Regime**

<table>
<thead>
<tr>
<th>The recursive VAR approach</th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed exchange rate regime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0</td>
<td>2.79</td>
<td>0.13</td>
<td>-0.57</td>
<td>0.40</td>
<td>3.42</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0</td>
<td>5.65</td>
<td>1.70</td>
<td>0.15</td>
<td>0.60</td>
<td>5.86</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0</td>
<td>2.56</td>
<td>-0.78</td>
<td>-0.56</td>
<td>-1.15</td>
<td>3.08</td>
</tr>
<tr>
<td>Floating exchange rate regime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0</td>
<td>1.88</td>
<td>4.27</td>
<td>6.13</td>
<td>7.01</td>
<td>7.01</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0</td>
<td>1.16</td>
<td>2.69</td>
<td>3.85</td>
<td>5.07</td>
<td>5.07</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0</td>
<td>1.98</td>
<td>4.18</td>
<td>6.12</td>
<td>7.51</td>
<td>7.51</td>
</tr>
</tbody>
</table>

With regards to the reactivity of other macroeconomic variables, Figure 2.7 showed the responses of private consumption and imports to a positive tax shock. It was indicated that private consumption was nearly not affected by a tax shock under a peg as the responses were close to zero at all horizons while the impacts under a float were slightly higher. On the other hand, the effects of tax shock on imports tend to be higher under floating exchange rate regime (Figure 2.7). To be more specific, under fixed exchange rate regime, the responses of import were insignificant at almost all horizons while under a float, imports responded positively in the first quarters.

**Panel A. Responses to Tax Shock - The Recursive VAR Approach**

![Graphs showing responses to tax shock](image)

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The government spending shock

Figure 2.8 showed the output responses to a one percent positive shock in taxes under a peg and a float, and table 2.4 presented the corresponding spending multipliers. Generally, output responded positively to an unexpected increase in government spending across three models and two approaches. Furthermore, there was no significant difference in the responses of output under fixed exchange rate regime and under floating exchange rate regime (Figure 2.8). The immediate impacts ranged from 0.06% to 0.16% under a peg and from 0.19% to 0.21% under a float. The corresponding multipliers implied that output rose on impact by 0.22-0.75 Yen under a peg and 0.88-0.97 Yen in response to a 1 Yen increase in government spending (Table 2.4).
PANEL A. OUTPUT RESPONSES TO SPENDING SHOCK- THE RECURSIVE VAR APPROACH

Model (1)  
Model (2)  
Model (3)  

Fixed exchange rate  
Floating exchange

PANEL B. OUTPUT RESPONSES TO SPENDING SHOCK- THE STRUCTURAL VAR APPROACH

Model (1)  
Model (2)  
Model (3)  

Fixed exchange rate  
Floating exchange

Figure 2.8. Estimated impulse responses of output to a positive spending shock under fixed and floating exchange rate regimes

Table 2.4—Spending multipliers: fixed exchange rate regime and floating exchange rate regime

<table>
<thead>
<tr>
<th>The recursive VAR approach</th>
<th>Fixed exchange rate regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model (1)</td>
<td>1 qtr</td>
</tr>
<tr>
<td></td>
<td>0.48</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0.22</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0.70</td>
</tr>
</tbody>
</table>
With respect to responses of private consumption, it was showed that shocks to spending have positive effects on this variable in both approaches (Figure 2.9). These results were in line with those obtained from full sample estimation. However, there were no considerable differences between the responses under a peg and those under a float. In addition, the result showed insignificant reacts of imports to a spending shock under both regimes (Figure 2.9).

**Panel A. Responses to Spending Shock - The Recursive VAR Approach**
2.7.3 The effect of fiscal shocks during and outside the ZLB

This section examined whether the effects of fiscal policy shocks were enhanced or reduced during the ZLB period. To do that, the impulse responses of macroeconomic variables in two sub-samples 1973Q1-1995Q2 and 1995Q3-2018Q4 were compared. In this section, all four models were employed.

The tax shock

Figure 2.10 presented the impulse responses of output to a one percent increase in tax during and outside the ZLB period and table 2.3 reported the corresponding tax multipliers. Similar to the discussions in the previous sections, for the effects of tax shocks on output, the study analyzed the results obtained by using the structural VAR approach. In general, results were mixed across different models. It was shown that an unanticipated increase in tax had negative impacts on output in model (1), (2) and (3) under both regimes (Panel B-Figure 2.10). However, the effects in the ZLB period tend to be slightly larger and more persistent than those in the normal period. In contrast, model (4) showed that the effects in the ZLB were transitory as compared to those in the normal time (Panel B-Figure 2.10). Table 2.5 showed a similar pattern in which the on-impact multipliers estimated by model (1), (2) and (3) at the ZLB (between -3.87 and -4.58 Yen) were larger than that...
outside the ZLB (between -2.66 and -2.88). In model (4), the multipliers under both regimes were relatively small (-0.02 and -0.03) but the trough multiplier in the normal time was larger than that in the ZLB (-5.32 against -4.44).

**Panel A. Output Responses to Tax Shock - The Recursive VAR Approach**

Model (1) | Model (2) | Model (3) | Model (4)
---|---|---|---
ZLB period

Normal period

**Panel B. Output Responses to Tax Shock - The Structural VAR Approach**

Model (1) | Model (2) | Model (3) | Model (4)
---|---|---|---
ZLB period

Normal period

**Figure 2.10. Estimated Impulse Responses of Output to a Positive Tax Shock During and Outside the ZLB**
Turning to the effects of tax shocks on other variables, private consumption responded positively to an increase in taxes in the ZLB period but these effects were short-lived. On the other hand, the responses of private consumption were insignificant in the normal time. The react of import were relatively similar during and outside the ZLB period as it increased in response to a rise of taxes. Regarding the monetary policy proxies, prices rose significantly in the ZLB period while it was not affected during the normal time. In contrast, shocks to taxes did not influence the interest rate in the ZLB period but caused an increase of this variable in the normal time.

### PANEL A. RESPONSES TO TAX SHOCK- THE RECURSIVE VAR APPROACH

<table>
<thead>
<tr>
<th></th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
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<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0.00</td>
<td>1.88</td>
<td>4.27</td>
<td>6.13</td>
<td>7.01</td>
<td>7.01 (qtr 20)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0.00</td>
<td>1.16</td>
<td>2.69</td>
<td>3.85</td>
<td>5.07</td>
<td>5.07 (qtr 20)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0.00</td>
<td>1.98</td>
<td>4.18</td>
<td>6.12</td>
<td>7.51</td>
<td>7.51 (qtr 20)</td>
</tr>
<tr>
<td>Model (4)</td>
<td>0.00</td>
<td>0.13</td>
<td>1.15</td>
<td>2.04</td>
<td>3.34</td>
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<td><strong>ZLB period</strong></td>
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<tr>
<td>The recursive VAR approach</td>
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<tr>
<td>Model (1)</td>
<td>3.87</td>
<td>-0.86</td>
<td>-1.02</td>
<td>-1.52</td>
<td>-1.84</td>
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<tr>
<td>Model (2)</td>
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<td>-2.91</td>
<td>-1.96</td>
<td>-1.07</td>
<td>-0.62</td>
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<td>-1.74</td>
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<td>-3.99 (qtr 1)</td>
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<td>Model (4)</td>
<td>0.02</td>
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<td>0.96</td>
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<td>5.45</td>
<td>-4.44 (qtr 4)</td>
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<tr>
<td>The structural VAR approach</td>
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<td></td>
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</tr>
<tr>
<td>Model (1)</td>
<td>-2.88</td>
<td>-2.38</td>
<td>-0.81</td>
<td>0.42</td>
<td>1.24</td>
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<td>-1.12</td>
<td>1.19</td>
<td>2.86</td>
<td>4.58</td>
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<td>-2.66</td>
<td>-2.10</td>
<td>-0.21</td>
<td>0.91</td>
<td>1.66</td>
<td>-2.66 (qtr 1)</td>
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<tr>
<td>Model (4)</td>
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<td>-0.33</td>
<td>-1.83</td>
<td>-3.48</td>
<td>-5.32</td>
<td>-5.32 (qtr 20)</td>
</tr>
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</table>

### TABLE 2.5—TAX MULTIPLIERS: NORMAL PERIOD AND ZLB PERIOD
**The normal period**

**PANEL B. RESPONSES TO TAX SHOCK - THE STRUCTURAL VAR APPROACH**

Private consumption - Model (2)  
Import - Model (3)  
GDP deflator - Model (4)  
Interest rate - Model (4)

**FIGURE 2.11. ESTIMATED IMPULSE RESPONSES OF OTHER MACROECONOMIC VARIABLES TO A POSITIVE TAX SHOCK DURING AND OUTSIDE THE ZLB**

**The government spending shock**

Figure 2.12 presented the output responses to a one percent increase in government spending when the interest rate were at and not at the ZLB, and table 2.6 reported the corresponding spending multipliers. Generally, all models indicated that the impacts during the ZLB period were larger than those in the normal time, although with a lag (Figure 2.12). In the ZLB period, the peak spending multipliers were between 0.92 and 2.23 Yen while the estimates during the normal time were between 0.65 and 1.15 Yen (Table 2.6).
FIGURE 2.12. ESTIMATED IMPULSE RESPONSES OF OUTPUT TO A POSITIVE SPENDING SHOCK DURING AND OUTSIDE THE ZLB PERIOD

<table>
<thead>
<tr>
<th>Table 2.6—Spending multipliers: normal period and ZLB period</th>
</tr>
</thead>
<tbody>
<tr>
<td>The recursive VAR period</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Model (1)</td>
</tr>
<tr>
<td>Model (2)</td>
</tr>
<tr>
<td>Model (3)</td>
</tr>
</tbody>
</table>
With respect to the reacts of other variables, private consumption increased in response to spending shocks and the effects were quite similar in the two regimes (Figure 2.13). The effects on import variable were found to be positive and stronger during the ZLB. On the contrary, inflation was nearly not affected by a unexpected shock to spending in both regimes, but it should be noted that in long term, the effects during the ZLB was slightly larger. Meanwhile, the interest rates were not influenced during the ZLB but it responded negatively to a spending shock in the normal time, although this effect was short-lived.
2.8 Conclusion

This chapter explores the macroeconomic effects of fiscal policy shocks by using the recursive VAR approach and the structural VAR approach. For this purpose, four VAR models with different endogenous variables were introduced. In addition, the full sample was split into three sub-samples to investigate the impacts of fiscal shocks in different economic conditions. In general, the results obtained by the two approaches were relatively consistent, except for the effects of tax shocks on output. This was due to the different assumptions employed by the two approaches, in which the assumption in the structural VAR framework was considered to be more convincing. The main findings of this chapter were as follows.

First, based on the full sample dataset, the recursive VAR approach indicated that output responded positively to a tax shock while the structural VAR showed the opposite. In terms of
spending shocks, all models confirmed a positive effect of spending shocks on output, although these effects were short-lived. Private consumption and import also increased in response to a rise in spending while prices and interest rates were nearly not affected.

Second, the chapter also compared findings under fixed exchange rate regime and under floating exchange rate regime and revealed that fiscal policy might not necessary more effective under a peg.

Third, with respect to the ZLB constraint, while the results for tax shocks were mixed, all models supported the hypothesis that the effects of spending shocks were enhanced in the ZLB period. In addition, it should be noted that the interest rates did not respond to an unexpected rise in spending in the ZLB period while it immediately decreased in the normal time, although the effect was short-lived. Prices were nearly not affected by a positive spending shock but in long-term, the impacts on this variable tend to be larger in the ZLB period.
CHAPTER III

Analysis on the macroeconomic effects of fiscal policy shocks in Japan: The sign restriction approach

3.1 Introduction

It is argued that the two approaches discussed in chapter 2 rely on assumption about the sluggish reaction of relevant variables to macroeconomic shocks, and thus, they may not provide analyses based on a purely VAR framework (Mountford and Uhlig, 2009). In this chapter, an alternative approach namely the sign restriction approach was introduced. Unlike the recursive VAR and the structural VAR approach that make assumptions on the contemporaneous relations between reduced-form and structural residuals (matrix F), the sign restriction approach imposes restriction directly on the impulse responses $D(L)$. This chapter introduces the sign restriction approach to investigate the effects of tax and government spending shocks on macroeconomic activity in Japan. First, the chapter presents the identification of this approach based on a similar VAR framework introduced in chapter 2. Next, drawing on the same data in the previous chapter, the results using different sample periods and VAR models will be discussed.

3.2 Identification for the three-variable case

This section presents the sign restriction approach for the three-variable VAR system. To achieve identification, the approach imposes restriction into the impulse response function $D(L)$.

3.2.1 Computing the estimate of $D(L)$

Turning back to the identification problem explained in section 2.2 of chapter 2, it is important to note that the key to identify the structural shocks is to estimate matrix F. Beside the methodologies that make assumptions on this matrix, there is another approach that imposes inequality sign restrictions directly to the impulse response functions. In general, the inequality restrictions approach on the structural impulse responses functions aims to provide set, but not point, estimates (Stock and Watson 2016). Hence, the econometric problem here is how to estimate and perform inference about F given that it is set-identified.

The sign restriction approach used in this study followed the methodology proposed by Uhlig (2005) and Mountford and Uhlig (2009). The idea behind this methodology is to use the Bayesian VAR in order to compute the posterior distribution of the structural impulse responses functions.
To do that, a prior distribution for \( D(L) \) is required. Since \( D(L) = FC(L)^{-1} \) (equation (7)), developing a prior for \( D(L) \) is equivalent to developing a prior for \( F \) and \( C(L) \).

Uhlig (2005) and Mountford and Uhlig (2009) assumed that the vector of structural shock \( \varepsilon \) is normalized to be of variance 1, that is \( \Sigma_\varepsilon = E[\varepsilon \varepsilon'\varepsilon] = I \). Then from equation (5), we have:

\[
\Omega_u = F \Sigma_\varepsilon \ F' = FF'
\]

This equation implied that matrix \( F \) provides an exact factorization of \( \Omega_u \) and hence, any matrix \( F \) can be expressed as:

\[
F = \tilde{A}Q
\]

where \( \tilde{A} \) is the lower-triangular Cholesky factor of \( \Omega_u \) (i.e. \( \tilde{A}\tilde{A}' = \Omega_u \)) and \( Q \) is an orthogonal square matrix (i.e. \( QQ' = I \)).

Substituting (14) into the expression of \( D(L) \), we have:

\[
D(L) = FC(L)^{-1} = \tilde{A}QC(L)^{-1}
\]

Since \( C(L) \) and \( \Omega_u \) are reduced-form parameters which have conjugate priors under standard assumption of normally distributed errors (Stock and Watson, 2016), the only non-standard part of the prior for \( D(L) \) in (15) is \( Q \). Thus, by assuming a prior distribution \( \pi(Q) \) for \( Q \), the posterior distribution of \( D(L) \) can be computed. As \( Q \) is an orthogonal matrix, in the 2-dimensional case, it can be written as:

\[
Q = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}
\]

(Since \( \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}' = 1 \))

Hence, drawing from \( \pi(Q) \) reduced to drawing from a prior over \( \theta, -\pi \leq \theta \leq \pi \) (Uhlig, 2005; Stock and Watson, 2016). The impulse responses \( D(L) \) can be then expressed in terms of \( \theta \) and the elements of covariance matrix \( \Omega_u \) and thus, its posterior distribution is identified. The analytics of the simple 2-variable case was provided in Appendix 3A.

Based on the idea discussed above, the sign restriction approach can be described by the following algorithm:

- **Step 1:** Estimate the reduced-form VAR in equation (1) and (2) to obtain the coefficient matrix \( C(L) \) and the variance-covariance matrix \( \Omega_u \).
• **Step 2**: Based on the estimated \( \hat{C}(L) \) and \( \hat{\Omega}_u \) in step 1, random draws of \( C(L) \) and \( \Omega_u \) were taken. Following Uhlig (2005) and Mountford and Uhlig (2009), this study used a conjugate Normal-Wishart prior for \( C(L) \) and \( \Omega_u \).

• **Step 3**: For each draw \( (C(L), \Omega_u) \) in step 2, randomly take a draw of \( Q \) from a prior distribution \( \pi(Q) \), and then compute the structural impulse response functions \( D(L) = \tilde{A}QC(L)^{-1} \) from (15).

• **Step 4**: Check if the calculated \( D(L) \) in step (3) satisfies the criterion. If they do, they are candidates for valid impulse responses and are reserved otherwise they are discarded.

• **Step 5**: Repeat step 2 through step 4 until obtaining a certain number of valid cases. Finally, the confidence bands of 16th, 50th and 84th quantiles based on this sample for the impulse responses were plotted.

The method described in step 4 to select valid \( D(L) \) is known as the pure sign restriction approach (or rejection method) proposed by Uhlig (2005). However, Caldara and Kamps (2012) argued that the sets of pure sign restriction solutions are very large in fiscal VAR and this approach alone cannot pin down the sign of impact tax and spending multipliers. To address this limitation, this study utilized an alternative approach that identifies the shocks by minimizing some penalty function.

From Uhlig (2005) and Mountford and Uhlig (2009), the penalty function is defined as follows:

\[
f(x) = \begin{cases} x & \text{if } x \leq 0 \\ 100x & \text{if } x \geq 0 \end{cases}
\]

which heavily penalize positive response and reward negative responses at a slope 100 times smaller than the slope for penalties on the positive side.

Let \( D_j(k) \) be the three dimensional responses to column \( j \) of matrix \( F \) at horizon \( k \) where \( k = 0,1,\ldots,K \) and \( \sigma_i \) be the standard deviation of variable \( i \). Let \( l_{s+} \) represents the variables for which the impulse responses are constrained to be positive and \( l_{s-} \) be the set of variables for which the responses are required to be negative. The criterion function to be minimized can thus be given by:

\[
\psi = \sum_{i \in l_{s+}} \sum_{k=0}^{K} f \left( -\frac{D_{ij}(k)}{\sigma_i} \right) + \sum_{i \in l_{s-}} \sum_{k=0}^{K} f \left( \frac{D_{ij}(k)}{\sigma} \right)
\]

In equation (16), the impulse responses were re-scaled by the term \( \sigma_i \) so that the deviations across
different responses were comparable to each other (Uhlig, 2005). To implement this minimization, a combination of simplex and genetic algorithms was used in this study.

3.2.2 The identifying assumptions of the fiscal shocks

Following Mountford and Uhlig (2009), this study considered two types of shocks in the model: fiscal shocks and non-fiscal shocks. With respect to fiscal shock, a positive reaction of tax revenues and government spending for four quarters following the shock was imposed. Regarding non-fiscal shock, it is assumed that the tax shock and the government spending shock are orthogonal to two non-fiscal shocks including the business cycle shock and the monetary policy shock. It is also important to note that the two fiscal shocks were not required to be mutually orthogonal.

The sign restrictions on the impulse response functions are described in Table 3.1. To specify, a business cycle shock is identified as a shock that raises output, private consumption and taxes for four quarters following the shock. A monetary policy shock moves interest rates up and prices down for four quarters after the shock. On the other hand, the fiscal shocks are identified with tax revenues and government spending responding positively to tax and spending shocks, respectively, for four quarters following the shocks. In addition, these two fiscal shocks are required to be orthogonal to the business cycle shock and the monetary policy shock identified in the first step. In other words, the business cycle shock and the monetary shock come first while the two fiscal shocks are second in order.

**Table 3.1—Identifying Sign Restrictions**

<table>
<thead>
<tr>
<th></th>
<th>Business cycle shock</th>
<th>Monetary policy shock</th>
<th>Tax shock</th>
<th>Government spending shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax revenues</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Government spending</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private consumption</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Import</td>
<td></td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest rate</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

It is important to note that the different models specified in the previous chapter employ different types of shocks. In particular, only model (4) imposed all four shocks: the business cycle shock, the monetary policy shock, the tax shock and the government spending shock. On the other hand, in model (1), (2) and (3), monetary shock is assumed not to affect the endogenous variables.
Therefore, in these models, only three shocks were identified: the business cycle shock, the tax shock and the government spending shock.

The restriction that tax and spending shocks be orthogonal to the business cycle shock is to filter out the effect of business cycle on the fiscal variables. To illustrate, an increase in tax revenues may due to a business cycle upturn and this upturn is possibly caused by a change in tax policy. Assuming the business cycle shock to be causally prior to the fiscal policy shocks brings about that when taxes and output move in the same direction, this must be due to a change in business cycle leading to the increase in taxes not the other way around (Mountford and Uhlig, 2009). Furthermore, this assumption implies that output movements are mostly explained by business cycle shocks, whereas the remaining effects are considered as estimates of the impact of fiscal policy.

3.3 Data

In this chapter, a similar dataset as in the previous chapter was used. Furthermore, the sample was divided into three sub-samples as in chapter 2 to investigate the differences in the effects of fiscal shocks under fixed exchange rate regime and floating exchange rate regime, and during and outside the ZLB period.

3.4 Results

This section analyzes the effects of fiscal shocks on macroeconomic variables including output, private consumption, import, inflation and interest rates through the impulse responses functions and the fiscal multipliers derived from the sign restriction approach. First, the estimates using full sample data are presented. Next, the results for different sample periods are then discussed to investigate the role of the exchange rate regime and the ZLB period in driving the effects of fiscal shocks. In the case of using the full sample, all four models: (1), (2), (3) and (4) were used. To compare the effects under a peg and a float, only three models: model (1), model (2) and model (3) were employed because the data for interest rate variable was not available before 1970. Finally, to examine the impacts during and outside the ZLB, all four models were utilized.

In all figures, solid lines are impulse responses that are 50th quantiles of 1000 valid draws while dashed lines are 16th and 84th quantiles. The units on the vertical axis were percent while the horizontal axis represented the number of quarters following the initial shocks.
3.4.1 Results for the effect of fiscal shocks using full sample

**The tax shock**

Figure 3.1 showed the responses of output a positive unexpected increase in taxes and government spending by one percent for the whole sample 1960Q1-2018Q4. It was indicated that the responses of output to a positive tax shock were negative and significant in all models with the on-impact point estimates being between 0.57-0.75%. These estimates were slightly higher than those of around 0.5% obtained from the structural VAR approach. In addition, given that there was no restriction imposed to these responses after four periods, the output responses to tax shock were persistent (Figure 3.1).

Regarding responses of other variables, the sign restriction approach indicated that private consumption responded negatively and significantly to a positive tax shock. Similar to output responses, the reacts of private consumption were relatively persistent. On the other hand, the responses of imports in the sign restriction approach were quite similar to those in the other two approaches. Import rose in response to a unexpected increase in taxes. The reacts of GDP deflator and interest rates were consistent with those in the recursive VAR approach as both variables increased after a positive tax shock (Figure 3.1). To be more specific, the immediate responses of GDP deflator and interest rates were 0.06% and 0.19%, respectively.
Table 3.2 reported the corresponding tax multipliers for the whole sample 1960Q1-2018Q4. It was shown that, in the case of a positive tax shock, output fell on impact by between 3.43 and 4.54 Yen (Table 3.2). Similar to the results of the structural VAR approach, trough multipliers was found in the first quarter in most of the models.

The government spending shock

Figure 3.2 showed the impulse responses of macroeconomic variables to a one percent increase in government spending, using the sign restriction approach. It was indicated that an unexpected increase in government spending had expansionary effects on output and the immediate impacts
ranged between 0.16-0.20 %. These effects were consistent with those of the recursive VAR approach (between 0.13 and 0.19 %) and the structural VAR approach (between 0.11 and 0.13%). In addition, these results were in line with the estimate of 0.16 percent in the study of Kuttner and Posen (2002) for the case of Japan. It was also important to note that the impacts of spending shocks were relatively less persistent than those of tax shocks (Figure 3.1 and Figure 3.2).

The responses of other variables were also consistent with those of the recursive VAR and structural VAR approaches. Indeed, private consumption and imports responded positively to spending shocks while GDP deflator and interest rates reacted negatively. The effects on GDP deflator and interest rates were more recognizable than those in other two approaches with the on-impact estimates being -0.03% and -0.28%, respectively.
Table 3.3 presented the corresponding spending multipliers computed in four models for the full sample 1960Q1-2018Q4. Spending shocks caused an effect of 0.70 to 0.88 Yen on output in the first quarter. Moreover, compared to the tax multipliers in table 3.2, it was suggested that spending shocks had a much smaller effect on output than those of taxes.

Table 3.3 —SPENDING MULTIPLIERS- FULL SAMPLE (1960Q1-2018Q4)- THE SIGN RESTRICTION APPROACH

| Model (1) | 0.76 | 0.67 | 0.61 | 0.45 | 0.26 | 0.77 (qtr 5) |
| Model (2) | 0.75 | 0.60 | 0.33 | -0.01 | -0.34 | 0.75 (qtr 1) |
| Model (3) | 0.70 | 0.76 | 0.71 | 0.51 | 0.19 | 0.83 (qtr 5) |
| Model (4) | 0.88 | 1.46 | 1.72 | 1.58 | 1.34 | 1.72 (qtr 8) |

3.4.2 Results for the effect of fiscal shocks under fixed exchange rate regime and floating exchange rate regime

This section compared the macroeconomic effects of fiscal policy shocks under fixed exchange rate regime and under floating exchange rate regime. For this purpose, two sub-samples 1960Q1-1972Q4 and 1973Q1-1995Q2 were used. Model (4) was excluded in this section, as the data for interest rate variable was not available before the 1970s.

The tax shock

Figure 3.3 showed the impulse response function of output after a one percent increase in taxes under fixed and floating exchange rate regimes and table 3.4 reported the corresponding tax multipliers. With respect to the effect of a positive tax shock, the responses of output in three models were negative under both regimes (Figure 3.3). In addition, there was no significant difference in the size of these effects under a peg and a float although the impacts under fixed exchange rates tend to be more persistent. The tax multipliers reported in table 3.4 showed the same
picture in which the on-impact tax multipliers under fixed exchange rates (ranged between -4.06 and -2.38) were slightly higher than those under floating exchange rates (ranged between -4.67 and -3.46).

**Figure 3.3. Estimated impulse responses of output to a positive tax shock under fixed and floating exchange rate regimes - the sign restriction approach.**

**Table 3.4—Tax multipliers: fixed exchange rate regime and floating exchange rate regime - the sign restriction approach.**

<table>
<thead>
<tr>
<th></th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed exchange rate regime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>-3.80</td>
<td>-2.72</td>
<td>-3.85</td>
<td>-3.60</td>
<td>-2.04</td>
<td>-3.85</td>
</tr>
<tr>
<td>Model (2)</td>
<td>-2.38</td>
<td>-0.31</td>
<td>-2.66</td>
<td>-3.29</td>
<td>-2.00</td>
<td>-3.49</td>
</tr>
<tr>
<td>Model (3)</td>
<td>-4.06</td>
<td>-4.15</td>
<td>-6.64</td>
<td>-4.51</td>
<td>-4.60</td>
<td>-6.64</td>
</tr>
<tr>
<td><strong>Floating exchange rate regime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>-4.67</td>
<td>-3.98</td>
<td>-2.33</td>
<td>-0.89</td>
<td>0.004</td>
<td>-4.67</td>
</tr>
<tr>
<td>Model (2)</td>
<td>-3.46</td>
<td>-3.33</td>
<td>-1.97</td>
<td>-0.73</td>
<td>0.51</td>
<td>-3.66</td>
</tr>
<tr>
<td>Model (3)</td>
<td>-4.41</td>
<td>-4.49</td>
<td>-3.07</td>
<td>-1.90</td>
<td>-1.12</td>
<td>-4.49</td>
</tr>
</tbody>
</table>

Private consumption significantly decreased in response to a rise in taxes and these effects were similar under the two regimes. On the contrary, imports increased in both regimes but the impacts under a float were substantially larger.
The government spending shock

Turning to the effect of government spending shock, Figure 3.5 and Table 3.5 showed the estimated impulse responses and the corresponding multiplier under the two regimes. It was indicated that the effects under fixed exchange rates were slightly larger than those under a float, but these differences were insignificant. The peak multipliers under a peg ranged from 2.06 and 3.01 while those under a float were between 1.44 and 2.31 across different models.
Figure 3.5. Estimated impulse responses of output to a positive spending shock under fixed and floating exchange rate regimes - the sign restriction approach.

Table 3.5—Spending multipliers: fixed exchange rate regime and floating exchange rate regime- the sign restriction approach.

<table>
<thead>
<tr>
<th></th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed exchange rate regime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>-0.63</td>
<td>0.83</td>
<td>2.13</td>
<td>2.39</td>
<td>1.91</td>
<td>2.49 (qtr 13)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>-1.28</td>
<td>-0.19</td>
<td>1.23</td>
<td>1.72</td>
<td>1.59</td>
<td>2.06 (qtr 15)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0.02</td>
<td>1.24</td>
<td>3.01</td>
<td>2.12</td>
<td>2.69</td>
<td>3.01 (qtr 8)</td>
</tr>
<tr>
<td><strong>Floating exchange rate regime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>1.96</td>
<td>1.57</td>
<td>1.79</td>
<td>1.77</td>
<td>1.79</td>
<td>1.96 (qtr 1)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>1.44</td>
<td>1.24</td>
<td>1.04</td>
<td>0.76</td>
<td>0.48</td>
<td>1.44 (qtr 1)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>1.99</td>
<td>1.89</td>
<td>2.31</td>
<td>2.10</td>
<td>2.12</td>
<td>2.31 (qtr 8)</td>
</tr>
</tbody>
</table>

Figure 3.6 showed the responses of private consumption and imports to a positive spending shock. The findings for these two variables were consistent with the results obtained from the recursive VAR approach and the structural VAR approach. Indeed, private consumption increased in both regimes but the differences in the size of the responses were trivial. Meanwhile, imports were not significantly affected by spending shocks in both regimes.
3.4.3 Results for the effect of fiscal shocks during and outside the ZLB

This section examined the effects of fiscal policy shocks during and outside the ZLB. To do that, the responses of macroeconomic variables in two sub-samples 1973Q1-1995Q2 and 1995Q3-2018Q4 were compared. In this section, all four models were used.

The tax shock

Figure 3.7 presented the output responses to one percent increase in taxes in the normal time and in the ZLB time and table 3.6 showed the impact multipliers for these two periods.

It was revealed that the responses of output in the normal time were significantly larger, but less persistent, than that in the ZLB period (Figure 3.7). The immediate responses of output ranged from 0.56-0.67% in the ZLB period and 0.58-0.78% in the normal time. The corresponding spending multipliers were between -3.99 and -3.35 Yen and between -4.67 and -3.46 Yen, respectively (Table 3.6).
The normal period

Figure 3.7. Estimated impulse responses of output to a positive tax shock during and outside the ZLB period—The sign restriction approach

Table 3.6—Tax multipliers: normal period and ZLB period—The sign restriction approach

<table>
<thead>
<tr>
<th></th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The ZLB period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>-3.92</td>
<td>-1.86</td>
<td>-2.85</td>
<td>-3.25</td>
<td>-3.07</td>
<td>-3.92 (qtr 1)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>-3.38</td>
<td>-0.23</td>
<td>-1.37</td>
<td>-2.03</td>
<td>-1.94</td>
<td>-3.38 (qtr 1)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>-3.99</td>
<td>-1.97</td>
<td>-3.13</td>
<td>-3.51</td>
<td>-2.77</td>
<td>-3.99 (qtr 1)</td>
</tr>
<tr>
<td>Model (4)</td>
<td>-3.35</td>
<td>-0.16</td>
<td>-1.19</td>
<td>-1.88</td>
<td>-1.17</td>
<td>-3.35 (qtr 1)</td>
</tr>
<tr>
<td><strong>The normal period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>-4.67</td>
<td>-3.98</td>
<td>-2.33</td>
<td>-0.89</td>
<td>0.00</td>
<td>-4.67 (qtr 1)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>-3.46</td>
<td>-3.33</td>
<td>-1.97</td>
<td>-0.73</td>
<td>0.51</td>
<td>-3.66 (qtr 3)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>-4.41</td>
<td>-4.49</td>
<td>-3.07</td>
<td>-1.90</td>
<td>-1.12</td>
<td>-4.49 (qtr 4)</td>
</tr>
<tr>
<td>Model (4)</td>
<td>-4.37</td>
<td>-4.37</td>
<td>-3.24</td>
<td>-2.09</td>
<td>-0.69</td>
<td>-4.37 (qtr 1)</td>
</tr>
</tbody>
</table>

With respect to the effects on other variables, private consumption responded negatively to a positive tax shock in both periods. Although there was no significant difference in the size of these impacts, the responses of private consumption in the ZLB were more persistent. Regarding the reacts of imports in the two periods, it was shown that shocks to taxes had negative impacts on this variable during the ZLB while the opposite was true for the normal periods. The results for GDP deflator were also mixed as it increased in the ZLB period and decreased in the normal time. In addition, it was not surprising that tax shocks did not have any effect on interest rate in the ZLB time while it positively and significantly affected this factor during the normal period (Figure 3.8).

57
The government spending shock

It was relatively clear that the effects of spending shocks on output were larger during the ZLB period, although with a lag (Figure 3.9). The results in Table 3.7 also support this point, as the peak multipliers ranged between 1.53 and 2.93 in the ZLB period and between 1.44 and 2.31 in the normal time.

Figure 3.8. Estimated impulse responses of other macroeconomic variables to a positive tax shock during and outside the ZLB period - the sign restriction approach

Figure 3.9. Estimated impulse responses of output to a positive spending shock during and outside the ZLB period - the sign restriction approach
Table 3.7—Spending Multipliers: Normal period and ZLB period - The Sign Restriction Approach

<table>
<thead>
<tr>
<th></th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ZLB period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>0.29</td>
<td>1.20</td>
<td>2.69</td>
<td>2.66</td>
<td>1.83</td>
<td>2.76 (qtr 9)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>0.43</td>
<td>1.02</td>
<td>2.07</td>
<td>1.90</td>
<td>1.08</td>
<td>2.07 (qtr 8)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>0.36</td>
<td>1.37</td>
<td>2.79</td>
<td>2.80</td>
<td>2.07</td>
<td>2.93 (qtr 9)</td>
</tr>
<tr>
<td>Model (4)</td>
<td>0.57</td>
<td>0.17</td>
<td>0.35</td>
<td>1.29</td>
<td>1.53</td>
<td>1.53 (qtr 20)</td>
</tr>
<tr>
<td>The normal period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model (1)</td>
<td>1.96</td>
<td>1.57</td>
<td>1.79</td>
<td>1.77</td>
<td>1.79</td>
<td>1.96 (qtr 1)</td>
</tr>
<tr>
<td>Model (2)</td>
<td>1.44</td>
<td>1.24</td>
<td>1.04</td>
<td>0.76</td>
<td>0.48</td>
<td>1.44 (qtr 1)</td>
</tr>
<tr>
<td>Model (3)</td>
<td>1.99</td>
<td>1.89</td>
<td>2.31</td>
<td>2.10</td>
<td>2.12</td>
<td>2.31 (qtr 8)</td>
</tr>
<tr>
<td>Model (4)</td>
<td>1.79</td>
<td>1.46</td>
<td>0.73</td>
<td>0.17</td>
<td>-0.96</td>
<td>1.79 (qtr 1)</td>
</tr>
</tbody>
</table>

The behaviors of other macro variables in response to a spending shock were consistent with the findings of the recursive VAR and structural VAR approaches. There was almost no difference in the responses of private consumption between two periods. In addition, the impacts on imports were slightly higher during the ZLB. With respect to inflation, the effects of spending shock on this variable were trivial in short-term under both regimes, but in long-term, the prices might increase under a ZLB environment (Figure 3.10). Similar to the responses to a tax shock, it was indicated that spending shocks did not have any impact on interest rate during the ZLB period. However, an increase in government spending might reduce the interest rates in the normal time, although the effect was transitory.
3.5 Robustness checks

In this section, several robustness checks will be performed. It is argued that the compositions of spending and taxes have changed during the last 2-3 decades in Japan and that changes may affect the impact of fiscal policy because different components of taxes and spending may have different macroeconomic effects. With respect to taxes, there have been significant changes in the structure of revenue during the research period 1960-2018 (Figure 3.11). To be more specific, the proportion of indirect taxes has been declined from 50% of total taxes in 1960 to around 33% in the late 1980s but after that, it grew sharply and reached a value of approximately 45% in the recent years. The increase in indirect taxes since the 1990s were largely due to the consumption taxes raising from 3% to 5% in 1997 and from 5% to 8% 2014. In contrast, the proportion of direct taxes on corporate followed a downward trend from about 35% of total taxes in the early 1960s to an average of 24% over the past decade. With respect to direct taxes on household, the proportion of this tax increased dramatically from around 14% in 1960 to 37% in the early 1990s but after that, it followed a downward trend and remained stable at around 25-30% of total taxes in recent years.
It is argued that the changes in different type of taxes may have different effects on macroeconomic variables. For instance, Tenhofen, Wolff and Heppke-Falk (2010) found that, in Germany, direct taxes lowered output significantly, while indirect tax revenue shocks had little effects. Gil et al. (2019) revealed that the effect of an increase in direct taxes had smaller negative impacts on output than that of indirect taxes in Spain. Therefore, I split the total taxes into three components: Indirect taxes, Direct taxes on household and Direct taxes on business and investigate the effects of each of these components on macroeconomic variables, using the similar framework discussed in the main text. The results of output responses to shocks to different categories of taxes and based on full sample data, were shown in Figure 3B.1, Appendix 3B. In general, there was no significant difference between the effects of tax shock on output estimated with three components of taxes and that of total taxes. To specify, output responses in the cases of indirect taxes were slightly larger than those of direct taxes on household and direct taxes on business with the on-impact estimates being -0.57% to -0.75%, -0.31% to -0.47%, -0.26% to -0.54%, respectively. Those estimates were consistent with that of 0.57 to 0.75% in the case of total taxes. The above results indicated that output was more sensitive to a change in indirect taxes than changes in direct taxes.

Similarly, there is argument that changes in different types of government expenditure have different effects on macroeconomic variables. For instance, the effect of unexpected increase in social security expenditure and that of public work expenditure may differ. In Japan, the fact is that...
the sizes of social security expenditure out of the total expenditure have increased in recent years, whereas the proportion of other policy expenses, such as public works, education and science, and national defense, has decreased during the same period (Japanese public finance fact sheet, Ministry of Finance 2017). Figure 3.12 showed the percentage of social security expenditure in total expenditure over the period 1960-2018. It was indicated that there was a rapid increase in social security paid by the government from around 12% in 1960 to approximately 33% in 2018. In the main text of the dissertation, following the study of Kuttner and Posen (2002), the social security expenditure and net interest payment were excluded from the total government spending to study the effects of other policy expenses. However, it is essential to take into account the effects of social security expenditure in Japan and hence, in this section this components was included in the definition of government spending and to check for the robustness of the models. The results were shown in Appendix 3B. It was indicated that the results using new definition of government expenditure were consistent with those in the previous section. To specify, drawing on the full sample data, the immediate effects of a new defined spending shock on output range from 0.15% to 0.35%, which was close to the estimates of 0.16-0.20% in the case of government spending not including social security expenditure.

Figure 3.12. Japanese social security expenditure as percentage of total expenditure 1960Q1-2018Q4

Source: OECD and Author's calculations

3.6 Conclusion

Drawing on the same dataset used chapter 2, this chapter explored the macroeconomic effects of
fiscal policy shocks in Japan by using the sign restriction approach. The approach has some advantages compared to the approaches proposed in chapter 2, as it does not rely on strong assumptions about the contemporaneous relationship between macroeconomic variables. Therefore, the sign restriction approach might provide a more convincing result. In general, the findings obtained by this approach were quite consistent with those in the recursive VAR approach and the structural VAR approach.

First, the full sample estimation implied a significant negative effect of an unexpected increase in taxes on output while a similar rise in government spending positively affected output. The effects of tax shocks were larger and more persistent than those of spending shocks. With respect to the responses of other macroeconomic variables, private consumption significantly decreased while imports, GDP deflator and interest rates increase in response to a rise in taxes. In the case of a positive spending shock, private consumption and imports reacted positively whilst prices and interest rates responded negatively.

Second, the effects of fiscal policy shocks under fixed exchange rate regime and floating exchange rate regime were compared. The results indicated that there was no significant difference in the effects of fiscal shocks under the two regimes.

Third, the chapter investigated whether the impacts of fiscal policy shocks were enhanced or reduced during the ZLB period. The empirical evidences showed that the effects of tax shocks on output were decreased during the ZLB period. In this case, imports were reduced while prices increased. On the other hand, the results implied a stronger effect of spending shock on output during the ZLB time. Prices increased more than it did in the normal time, although with a lag. It was also important to note that, in both cases, the interest rates were not affected by tax and government spending shocks during the ZLB periods but it responded to these shocks in normal time (positively to a tax shocks and negatively to a spending shock).

**APPENDIX 3A: The analytics of the sign restriction approach for the simplest case: bivariate VAR model**

This section presented the identification of the sign restriction approach for bivariate VAR models. Analyzing such simple baseline can help clarifying the intuition behind this approach.

In the following, a model with two variables $X_1$ and $X_2$ was considered. To illustrate, $X_1$ could be output (a non-policy variable) and $X_2$ could be taxes (a policy variable). In addition, it is assumed that the model has one lag. Following the model presented in the main text, the 2-variable reduced form VAR can be expressed as follows:
or we can use the lag operator to rewrite (17) as:

\[
C(L)X_t = u_t \quad \text{(with } C(L) = \begin{bmatrix} 1 - C_{11}L & -C_{12}L \\ -C_{21}L & 1 - C_{22}L \end{bmatrix})
\]

To keep the example simple, suppose that output does not depend on lagged values of taxes and also taxes do not correlated with lagged values of output (i.e. \( C_{12} = C_{21} = 0 \)), so that:

\[
C(L) = \begin{bmatrix} 1 - C_{11}L & 0 \\ 0 & 1 - C_{22}L \end{bmatrix}
\]

From equation (4) and (7) in the main text, the structural VAR and structural moving average VAR in this case are then expressed as follows:

\[
F^{-1}C(L)X_t = \epsilon_t \quad \text{(Structural VAR)}
\]

\[
X_t = D(L)\epsilon_t \quad \text{(Structural MA)}
\]

(with \( D(L) = FC(L)^{-1} \))

To achieve identification of the system, the sign restriction approach make assumptions on \( D(L) \). Thus, it is necessary to compute matrix \( D(L) \).

Substituting \( C(L) \) in equation (14) into \( D(L) \), we have:

\[
D(L) = F \left[ \frac{1}{1 - C_{11}L} \right]^{-1} \begin{bmatrix} 1 - C_{11}L & 0 \\ 0 & 1 - C_{22}L \end{bmatrix}
\]

\[
D(L) = \frac{1}{(1 - C_{11}L)(1 - C_{22}L)} \begin{bmatrix} 1 - C_{11}L & 0 \\ 0 & 1 - C_{22}L \end{bmatrix}
\]

\[
D(L) = F \left[ \frac{1}{(1 - C_{11}L)(1 - C_{22}L)} \right]^{-1} \begin{bmatrix} 1 - C_{11}L & 0 \\ 0 & 1 - C_{22}L \end{bmatrix}
\]

Hence, to compute \( D(L) \), we need to know matrix \( F \). From equation (14), any matrix \( F \) can be expressed as:
\[ F = \bar{A}Q \]

where \( \bar{A} \) is the lower-triangular Cholesky factor of \( \Omega_u \) (i.e. \( \bar{A}\bar{A}' = \Omega_u \)) and \( Q \) is an orthogonal square matrix (i.e. \( QQ' = I \)).

Matrix \( \bar{A} \) can be derive from \( \Omega_u \)- the variance-covariance matrix of the system. In the two variable case, \( \Omega_u \) can be written as:

\[
\Omega_u = \begin{bmatrix}
\sigma_1^2 & \text{cov}(X_1, X_2)\\
\text{cov}(X_2, X_1) & \sigma_2^2
\end{bmatrix}
\]

By definition, \( \text{cov}(X_1, X_2) = \text{cov}(X_2, X_1) = \sigma_1 \sigma_2 \rho_{12} \) where \( \rho_{12} \) is the correlation coefficient between the two variables. Therefore, \( \Omega_u \) can be rewritten as follows:

\[
(21) \quad \Omega_u = \begin{bmatrix}
\sigma_1^2 & \sigma_1 \sigma_2 \rho_{12} \\
\sigma_1 \sigma_2 \rho_{12} & \sigma_2^2
\end{bmatrix}
\]

Since \( \Omega_u = \bar{A}\bar{A}' \), we can use the Cholesky-Banachiewicz and Cholesky-Crout algorithms to derive the elements of \( \bar{A} \) from (21) as follows:

\[
(22) \quad \bar{A} = \begin{bmatrix}
\sigma_1 & 0 \\
\sigma_2 \rho_{12} & \sigma_2 \sqrt{1 - \rho_{12}^2}
\end{bmatrix}
\]

Since \( \rho_{12} \in (-1,1) \) and equation (22) has the term \( \sqrt{1 - \rho_{12}^2} \), it is possible to express \( \rho_{12} \) in terms of some angle \( \beta \).

Let \( \beta = \arccos(\rho_{12}) \) or \( \cos(\beta) = \rho_{12} \) with \( \beta \in (0, \pi) \) (since \( -1 \leq \rho_{12} \leq 1 \)). Then, we have:

\[ \sqrt{1 - \rho_{12}^2} = \sqrt{1 - \cos(\beta)^2} = \sin(\beta) \]. Substituting into (22) delivered \( \bar{A} \) in terms of \( \sigma_1, \sigma_2 \) and \( \beta \):

\[
(23) \quad \bar{A} = \begin{bmatrix}
\sigma_1 & 0 \\
\sigma_2 \cos(\beta) & \sigma_2 \sin(\beta)
\end{bmatrix} \quad \beta \in (0,\pi)
\]

Regarding matrix \( Q \), since \( Q \) is an orthogonal matrix (i.e. \( QQ' = I \)), any matrix \( Q \) can be expressed as functions of some angle \( \theta \) as follows:

\[
(24) \quad Q = \begin{bmatrix}
\cos(\theta) & -\sin(\theta) \\
\sin(\theta) & \cos(\theta)
\end{bmatrix} \quad \theta \in (-\pi, \pi)
\]

(This is because \( \begin{bmatrix}
\cos(\theta) & -\sin(\theta) \\
\sin(\theta) & \cos(\theta)
\end{bmatrix} \begin{bmatrix}
\cos(\theta) & -\sin(\theta) \\
\sin(\theta) & \cos(\theta)
\end{bmatrix} = I \))
Substituting (23) and (24) into (14) to obtain matrix $F$:

$$F = \tilde{A}Q$$

$$F = \begin{bmatrix}
\sigma_1 & 0 \\
\sigma_2 \cos(\beta) & \sigma_2 \sin(\beta)
\end{bmatrix}
\begin{bmatrix}
\cos(\theta) & -\sin(\theta) \\
\sin(\theta) & \cos(\theta)
\end{bmatrix}$$

$$F = \begin{bmatrix}
\sigma_1 \cos(\theta) & -\sin(\theta) \\
\sigma_2 \cos(\theta + \beta) + \sigma_2 \sin(\theta) & -\sigma_2 \cos(\theta) + \sigma_2 \sin(\theta) \cos(\theta)
\end{bmatrix}$$

(25)

Substituting (25) into (20), we have:

$$D(L) = \begin{bmatrix}
\sigma_1 \cos(\theta) & -\sin(\theta) \\
\sigma_2 \cos(\theta - \beta) & -\sigma_2 \sin(\theta - \beta)
\end{bmatrix}
\begin{bmatrix}
(1 - C_{11} L)^{-1} & 0 \\
0 & (1 - C_{22} L)^{-1}
\end{bmatrix}$$

(26)

$$D(L) = \begin{bmatrix}
\sigma_1 \cos(\theta)(1 - C_{11} L)^{-1} & -\sin(\theta)(1 - C_{22} L)^{-1} \\
\sigma_2 \cos(\theta - \beta)(1 - C_{11} L)^{-1} & -\sigma_2 \sin(\theta - \beta)(1 - C_{22} L)^{-1}
\end{bmatrix} = \begin{bmatrix}D_{11} & D_{12} \\
D_{21} & D_{22}\end{bmatrix}$$

In (26), $D_{ij}$ represent response of variable $i$ to a shock to variable $j$. To identify the shocks, sign restrictions were imposed into the elements of matrix $D(L)$. To illustrate, if a tax shock is defined as a shock that raise taxes for at least one period following the shock, then this shock is identified when:

(27)

$$D_{22} > 0$$

$$\Leftrightarrow -\sigma_2 \sin(\theta - \beta)(1 - C_{22} L)^{-1} > 0$$

$$\Leftrightarrow \sin(\theta - \beta) < 0$$

(Assuming that $C_{22} > 0$ so that $(1 - C_{22} L)^{-1} > 0$)

$$\Leftrightarrow -\pi + \beta < \theta < \beta$$

Therefore, the pure sign restriction approach for the bivariate case with a tax shock can be described by the following algorithm:
• **Step 1:** Estimate the reduced-form VAR in equation (12) to obtain the coefficient matrix $C(L)$ and the variance-covariance matrix $\Omega_u$ and hence, $\sigma_1, \sigma_2$ and $\beta$ are known

• **Step 2:** Draw random value of $\theta$ ($\theta \in (-\pi, \pi)$) from a prior distribution $\pi(\theta)$

• **Step 3:** Compute $D(L)$ from $\theta, \sigma_1, \sigma_2$ and $\beta$

• **Step 4:** Check if $-\pi + \beta < \theta < \beta$. If $\theta$ satisfies then keep $\theta$, otherwise discard $\theta$

• **Step 5:** Repeat step 2 through step 4 until obtaining a certain number of valid cases.

Finally reporting the summary statistics

However, as discussed in the main text, the above method to select valid $\theta$ in step 4 had some drawbacks. Thus, the penalty function approach was used in this study. This approach aims to minimize a function of the impulse responses. To specify, in the 2-variable case with a tax shock that need to be identified, the restriction (22) was replaced by minimizing the following criterion function:

\begin{equation}
\psi = f \left( \frac{-D_{22}}{\sigma_2} \right)
\end{equation}

where $f(x) = \begin{cases} x & \text{if } x \leq 0 \\ 100x & \text{if } x \geq 0 \end{cases}$

Equation (28) is a simple case of equation (16). Substituting the element $D_{22}$ obtained from (26) into (28), we have:

\begin{equation}
\psi = f \left( \frac{-\sigma_2 \sin(\theta - \beta)(1 - C_{22}L)^{-1}}{\sigma_2} \right)
\end{equation}

\begin{equation}
\psi = f(\sin(\theta - \beta)(1 - C_{22}L)^{-1})
\end{equation}

In this case, it was simply showed that $\psi$ is minimized when $\sin(\theta - \beta) = -1$ or $\theta = \beta - \frac{\pi}{2}$.

Unlike the pure sign restriction approach, the penalty function method exactly identifies the best response out of all those satisfying the sign restrictions and hence, reduces the uncertainty of identification procedures.
APPENDIX 3B

Figure 3B.1 Estimated impulse responses of output to shocks to different categories of taxes (full sample)
**Figure 3B.2. Responses of Macroeconomic Variables to Spending Shock (Full Sample)-Social Security Expenditure Included**
CHAPTER IV

The macroeconomic effects of fiscal policy shocks: Evidences from other developed countries

4.1 Introduction

The results from chapter II and chapter III suggested that there was no strong evidence that the effects of fiscal policy shocks differ between fixed exchange rate regime and floating exchange rate regime while these impacts significantly changed during the ZLB period in Japan. Therefore, in this chapter, the thesis will examine whether these differences during ZLB period are true for other developed countries including: Canada, the UK and the US. The output responses to fiscal policy shocks and fiscal multipliers in these countries will be also compared with those of Japan. For this purposes, the chapter employed the sign restriction approach to identify the VAR model.

4.2 Methodology and data

To investigate the effects of fiscal policy shocks in four developed countries, this chapter used the same methodology that proposed in chapter 3. To specify, the sign restriction approach was employed to identify the VAR model. However, in this chapter, only the baseline model (model (1)) was considered. This was because the samples for the ZLB periods in countries such as Canada and the US, were relatively short and hence, adding more variables and restrictions into the baseline model would make the confident bands of the impulse responses become very large and difficult to interpret.

There were four countries included in the sample: Canada, Japan, the UK and the US. The data source for Canada, Japan and the UK was collected from OECD’s Economic Outlook Projections database while the US data was obtained from US Bureau of Economic Analysis. The variables for the Canada, the UK and the US were generated similarly to those of Japan in the previous chapters.

The main purpose of this chapter was to investigate the effects of fiscal policy during and outside the ZLB in the four countries. Therefore, it was important to identify the ZLB period in these countries. In the case of Canada, the UK and the US, this chapter applied a similar definition of the ZLB periods as proposed in chapter 2. To be more specific, the ZLB periods were defined as those episodes when the short-term nominal interest rate is less than 1 percent. The details of the ZLB periods in four countries were reported in table 4.1. It should be note that the short-term nominal interest rates in Canada from 2010Q4 to 2014Q4 were just slightly higher than 1% (approximately
1.1% during this period). Moreover, the rates during this period did not change significantly. Therefore, it might be still reasonable to treat this period as a low interest rate period in the case of Canada. Table 4.1 also indicated that the ZLB period in Japan was considerably longer than those in the three other countries.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Normal period</th>
<th>ZLB period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1973Q1-2009Q1</td>
<td>2009Q2-2017Q2</td>
</tr>
<tr>
<td>Japan</td>
<td>1973Q1-1995Q2</td>
<td>1995Q3-2018Q4</td>
</tr>
<tr>
<td>UK</td>
<td>1973Q1-2009Q2</td>
<td>2009Q3-2018Q4</td>
</tr>
<tr>
<td>US</td>
<td>1973Q1-2009Q2</td>
<td>2009Q3-2016Q4</td>
</tr>
</tbody>
</table>

### 4.3 Results

This section discusses the impulse responses of output to tax and government spending shocks and the fiscal multipliers during and outside the ZLB by using the sign restriction approach.

In all figures, red lines represent impulse responses in the normal period and blue lines are impulse responses in the ZLB period. Solid lines are responses that are 50th quantiles of 1000 valid draws while dashed lines are 16th and 84th quantiles. The units on the vertical axis were percent while the horizontal axis represented the number of quarters following the initial shocks. It should be noted that the confidence intervals of impulse responses in the ZLB period of Canada and the US were relatively large since the sample for the ZLB in these two countries were short.

**The tax shock**

Figure 4.1 showed the impulse response function of output after a one percent increase in taxes during and outside the ZLB and table 4.2 reported the corresponding tax multipliers. First, the results indicated that tax shocks had negative and significant effects on output in all four countries and in both the normal time and the ZLB time. Second, the impacts of tax shocks differed between the normal period and the ZLB period in terms of size and persistence. To specify, the effects of tax shocks were significantly larger in the normal period compared with those in the ZLB period in all four countries. In the first two quarters following the shocks, the differences between the two regimes were not large (except the UK) but after that, became statistically significant. With respect to the persistence, the results showed that impacts of tax shocks during the ZLB period were more
transitory with an exception of Japan. Furthermore, in the normal time, the effects were long-lived in the US and the UK but in the ZLB period, the effects in Japan were more persistent than those in the other three countries.

Table 4.2 showed the tax multipliers in four countries in the normal time and in the ZLB time. The tax multipliers in Japan were generally stronger than those in the other countries during both periods with the trough responses being \(-3.92\) in the ZLB period and \(-4.67\) in the normal time. The numbers for the case of the US were also notable with a peak of \(-4.91\) in normal time, but much smaller with a peak of \(-0.98\) in the ZLB.
Table 4.2—Tax multipliers: normal period and ZLB period - Four countries

<table>
<thead>
<tr>
<th>Country</th>
<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ZLB period</td>
<td>-0.38</td>
<td>-0.35</td>
<td>0.51</td>
<td>1.29</td>
<td>0.76</td>
<td>-1.03 (qtr 2)</td>
</tr>
<tr>
<td>The normal period</td>
<td>-0.60</td>
<td>-2.13</td>
<td>-1.62</td>
<td>-0.99</td>
<td>-0.03</td>
<td>-2.13 (qtr 4)</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ZLB period</td>
<td>-3.92</td>
<td>-1.86</td>
<td>-2.85</td>
<td>-3.25</td>
<td>-3.07</td>
<td>-3.92 (qtr 1)</td>
</tr>
<tr>
<td>The normal period</td>
<td>-4.67</td>
<td>-3.98</td>
<td>-2.33</td>
<td>-0.89</td>
<td>0.00</td>
<td>-4.67 (qtr 1)</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ZLB period</td>
<td>-2.24</td>
<td>-0.55</td>
<td>-0.74</td>
<td>-0.81</td>
<td>-0.63</td>
<td>-0.81 (qtr 12)</td>
</tr>
<tr>
<td>The normal period</td>
<td>-1.18</td>
<td>-2.32</td>
<td>-2.44</td>
<td>-2.32</td>
<td>-2.21</td>
<td>-2.46 (qtr 6)</td>
</tr>
<tr>
<td>US</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>The ZLB period</td>
<td>-0.98</td>
<td>-0.07</td>
<td>0.02</td>
<td>0.45</td>
<td>0.87</td>
<td>-0.98 (qtr 1)</td>
</tr>
<tr>
<td>The normal period</td>
<td>-1.21</td>
<td>-2.85</td>
<td>-4.03</td>
<td>-4.66</td>
<td>-4.74</td>
<td>-4.91 (qtr 16)</td>
</tr>
</tbody>
</table>

The spending shock

Figure 4.2 presented the output responses to a one percent positive spending shock in the normal time and in the ZLB time and table 4.3 reported the corresponding spending multipliers. The results were generally less conclusive. It was shown that Japan exhibited the largest expansionary effects in both regimes. In Canada, the impacts in the first several quarters were small but after that, spending shocks may increase the output. Meanwhile, in the US, the effects of spending shocks were relatively short-lived as output only rose for around 2-3 quarters following the initial shock. The impacts in the UK were negative in both regimes and at almost all time horizons. This may suggest that an increase in government spending in the UK did not have expansionary effects on output. Comparing the effects during and outside the ZLB, it was revealed that spending shocks had stronger impacts on output during the ZLB in Canada and Japan but with a lag. On the other hand, there was no significant difference between effects under the two regimes in the case of the US.
Figure 4.2. Responses of output to spending shock in four developed countries

Table 4.3 reported the spending multipliers during and outside the ZLB in the four countries. Similar to the case of a tax shock, the spending multipliers in Japan were largest among the countries, with the peak responses of 2.76 and 1.96 in the ZLB and in the normal time, respectively.

<table>
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<th>1 qtr</th>
<th>4 qtr</th>
<th>8 qtr</th>
<th>12 qtr</th>
<th>20 qtr</th>
<th>Peak</th>
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<td><strong>Canada</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ZLB period</td>
<td>-0.21</td>
<td>-0.23</td>
<td>0.70</td>
<td>1.43</td>
<td>0.98</td>
<td>1.46</td>
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<td>The normal period</td>
<td>0.01</td>
<td>0.15</td>
<td>0.51</td>
<td>0.50</td>
<td>0.51</td>
<td>0.54</td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The ZLB period</td>
<td>0.29</td>
<td>1.20</td>
<td>2.69</td>
<td>2.66</td>
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<tr>
<td>The normal period</td>
<td>1.96</td>
<td>1.57</td>
<td>1.79</td>
<td>1.77</td>
<td>1.79</td>
<td>1.96</td>
</tr>
</tbody>
</table>
### 4.4 Conclusion

In this chapter, the effects of fiscal policy shocks in the ZLB period and in the normal time were compared, using data from four developed countries including: Canada, Japan, the UK and the US. The results showed a significant and stronger effect of tax shocks on output during the ZLB period in all four countries. The findings were less conclusive in the case of a government spending shock, as only in Canada and Japan, the effect of an increase in spending on output was stronger in the ZLB and with a lag. The empirical evidences also demonstrate that the tax and spending multipliers in Japan were relatively larger than those in other developed countries.
CHAPTER V

Conclusions

5.1 Introduction

This chapter presents the summary of the thesis and draws conclusion about the macroeconomic effects of fiscal policy in Japan. Section 5.2 will summarize the whole study. Next, the main results in the previous chapters and policy implications of these findings will be discussed in section 5.3. Finally, section 5.4 will point out some limitations of the research and provide suggestions for further studies.

5.2 Summary of the thesis

There exist controversial arguments on the effectiveness of fiscal policy in Japan. The aim of this study was to investigate the macroeconomic effects of fiscal policy on economic activity in Japan. To do that, the thesis relied on the VAR framework, which include both fiscal and non-fiscal factors as endogenous variables. The effects of structural fiscal shocks on the non-fiscal variables were then recovered. In other words, the study attempted to answer the question that how an unexpected change in fiscal variables affect the other macroeconomic factors. Regarding fiscal policy variables, the study took into account the effects of both tax and government spending sides. In addition, to examine the impact on key macroeconomic variables, the thesis introduced four different models. The baseline model (model (1)) included three variables: tax revenues, government spending and output. Model (2) incorporated private consumption in the baseline model while model (3) added imports variable. In order to account for the presence of monetary policy, two variables: GDP deflator and interest rates were included in model (4). After estimating these VAR models, the impulse responses of macroeconomic variables and fiscal multipliers for tax and government spending shocks were analyzed.

The second purpose of the thesis was to examine the state-dependency of fiscal policy shocks in Japan. Two important factors that may affect the effectiveness of fiscal policy were focused in this study: the exchange rate regime and the ZLB constraint. For this purpose, the full sample data (1960Q1-2018Q4) was split into three different sub-samples (A) 1960Q1-1972Q4, (B) 1973Q1-1995Q2 and (C) 1995Q3-2018Q4. The study compared the effects of fiscal policy between fixed exchange rate period and floating exchange rate period by adopting the VAR model in sub-sample
(A) and sub-sample (B). Furthermore, to examine whether the effects differ between the ZLB period and the normal period, the research employed sub-sample (B) and sub-sample (C).

To identify the above VAR models, the thesis employed three different identification approaches that have been widely applied in the literature. Chapter II presented the identification problem and introduced the recursive VAR and the structural VAR approaches. These approaches achieved identification by making assumptions on the contemporaneous relations between reduced-form and structural residuals. Chapter III proposed the sign restriction approach to identify the VAR systems. Unlike the two approaches above, this technique did not rely on sluggish reaction of relevant variables to macroeconomic shocks. It imposed restriction directly on the impulse response functions and thus, might provide more convincing results.

In chapter IV, the thesis adopted the sign restriction approach to compare the effects of fiscal policy during and outside the ZLB period in Japan and three other developed countries including Canada, the UK and the US.

### 5.2 General discussions of the main findings

This section will discuss the results of the study and draw some policy implications. First, the empirical findings in chapter II and III will be analyzed. Chapter II employed the recursive VAR and structural VAR approaches while chapter III used the sign restriction technique to investigate the effects of fiscal policy shocks on macroeconomic variables. In both chapters, a full sample and three sub-samples were used.

With respect to the results using the full sample, the findings for the effects of spending shock on output were consistent across the three approaches whereas the results for tax shock were mixed. To be more specific, while the structural VAR and the sign restriction approach implied a negative impact of an increase in taxes on output, the recursive approach showed a reversed react. As discussed in chapter II, this was due to different assumptions imposed into the VAR system in which the assumption that output does not respond to shocks to taxes seems to be a relatively strong assumption. As a consequence, in term of tax shock, the study focused on the results of the structural VAR and the sign restriction approach. It was shown that output responded negatively and significantly to a positive tax shock with the on-impact estimates being around -0.5% in the structural VAR approach and between 0.57%-0.75% within the sign restriction approach. Compared to the previous studies for Japanese economy, this effect was lower than the estimate of 1.2 percent in the study of Kato et al. (2018) but much higher than the 0.03 percent impact estimated by Kuttner and Posen (2002). The findings also showed that tax multipliers ranged from -3.22 to -3.09 in the structural VAR approach and from -4.54 to -3.43 in the sign restriction approach. These multipliers
were also considerably higher than the estimate of -0.16 Yen in the study of Kuttner and Posen (2002).

Turning to the effect of government spending shocks within the full sample estimation, all three approaches indicated positive impacts of an unanticipated increase in government spending on output with the immediate responses of 0.13-0.19%, 0.11-0.13% and 0.16-0.20% in the recursive VAR, the structural VAR and the sign restriction approach, respectively. These results were consistent with the estimate of 0.16 percent in the study of Kuttner and Posen (2002) for the case of Japan. The corresponding spending multipliers 0.56-0.59 Yen, 0.49-0.55 Yen, 0.70-0.88 Yen, respectively, in the three approaches. Generally speaking, these above findings were in line with the results of Kuttner and Posen (2002) who claimed that tax cuts and increases in government spending had expansionary effects on output. This was an interesting result because most of the existing studies found that fiscal policy generated limited effects on output in Japan.

The next concern was the behaviors of other macroeconomic variables and which theoretical models that the results supported because they may lead to different policy implications. On the theoretical front, so far there were several controversial views. The standard Keynesian theory, for instance the IS-LM model, predicted that aggregate demand could be stimulated by tax cuts or increase in government spending. When there is a rise in government spending, for example, the IS curve shift upward and hence, the interest rate increases. As a result, output and consumption increase while investments fall. On the other hand, the neoclassical model predicts that increases in government spending will eventually require the taxes on households to rise, which decline their permanent income and therefore, reduce their consumption. The New Keynesian models, which added distortions, such as price stickiness and adjustment cost of investment, to the neoclassical framework, could produce results consistent with those of the two models above depending on the values of parameters or the functional forms assumed.

In this study, the empirical results showed a significant and positive response of private consumption to an increase in government spending. These results were consistent across the three identification approaches. However, both GDP deflator and interest rates fell in response to positive spending shock.

With respect to a positive tax shock, while the structural VAR found an insignificant react of private consumption, the sign restriction approach showed that private consumption responded negatively to an increase in taxes. GDP deflator and interest rates rose in the sign restriction approach and the recursive VAR approach. In contrast, the two variables fell in model (4) by using the structural VAR approach (however, it should be noted that output did not fall in this model).
Taken together, these findings were difficult to reconcile with either the traditional Keynesian model or the neoclassical model. Although the private consumption increase in response to a rise in government spending but this was not caused by a rise in interest rates. Moreover, Keynesian economics also predicts that an increase in government spending will induce an increase in prices because it causes a shift to the right of the AD curve. However, in this case, the empirical evidences showed that prices decreased. It is also important to note that the negative responses of GDP deflator and interest rates to a rise in government spending was a counter-intuitive finding but this negative association has been found in other studies such as Canova and Pappa (2007) and Mountford and Uhlig (2009). Otsubo (2018) also found that expansionary fiscal policy significantly lowered prices for the case of Japan.

The second stage of the thesis was to investigate the effect of fiscal policy shocks in different economic conditions. First, the study compared the results of responses of macroeconomic variables to fiscal shocks under fixed exchange rate regime and floating exchange rate regime. General speaking, fiscal policy was not necessarily more effective under fixed exchange rates as predicted in the Mundell-Fleming model. The results obtained from all three approaches showed that there was no significant difference in the responses of output to fiscal shocks under these two regimes. Furthermore, the responses of imports to a positive tax shock in floating exchange rate regime were even positive and larger than those under a peg.

Second, the study examined whether the impacts of fiscal policy shocks were enhanced or reduced during the ZLB period. With respect to the effects of tax shocks, the results were mixed. While the structural VAR approach showed that the impacts on output in the ZLB period tend to be slightly larger and more persistent than those in the normal period, the sign restriction approach found the opposite. It should be noted that prices decrease in the former approach and increased in the latter approach. The opposite findings above were, to some extent, in line with those of Kato et al. (2018) who did not find convincing evidence on the differences of output response to tax shocks across monetary policy regimes. On the other hand, the findings for spending shock were consistent across the three approaches and four models. It was indicated that the effects of spending shocks on output were larger during the ZLB period, although with a lag. In the context of Japan, the results were in line with the findings of Miyamoto et al. (2018) who found that spending multiplier in the ZLB period was larger than the multiplier in the normal period. With respect to the responses of other variables, it was not surprising that interest rates were not affected by a positive spending shock during the ZLB period. This was supported the view that the central bank is not responsive to an unexpected increase in government spending during the ZLB period. However, in the normal time, it was notably found that interest rate fall, although the effects were short-lived. Meanwhile,
the effects of spending shock on GDP deflator were relatively small in short-term under both regimes with the responses in normal time being negative for several quarters, but in long-term, the prices might increase in the ZLB period. Combining with the result that interest rates did not move due to a spending shock during the ZLB, this means that the real interest rate might drop in the ZLB period.

From the theoretical viewpoint, the differences in responses of output to fiscal policy shock can be explained by a standard New Keynesian model. It was argued that, for instance, an increase in government spending would cause a rise in firms' marginal costs of production and therefore, increase the inflation. With respect to the interest rates, it was suggested that the real interest rate would go down in the ZLB period since the central bank does not change the nominal interest rate. On the contrary, in the normal time, the real interest rates would rise because of intensive central bank response. The results of this study as discussed above had some evidences that support this theory. It might, therefore, yield some important policy implications. Expansionary fiscal policy by increasing government spending is effective in stimulating GDP and it even more effective during the ZLB period. Furthermore, in the ZLB time, an increase in government spending may also help the government to reach the inflation target but this process will take time.

However, there exist a lot of controversial arguments on how the government finances the spending increase in the context of Japan. It is commonly known that government spending can be paid for in one of three directions: (1) raising revenue via taxes, (2) borrowing money (by issuing government bonds) and engaging in deficit spending, or (3) printing money. Of which, the first two options are the more standard methods for governments, especially those in developed countries, to finance their spending (Sumner and Horan 2019). On the other hand, recent literature has paid attention on the modern monetary theory (MMT), which provided a different view regarding how to finance the government spending. The central macroeconomic policy claim of this theory is that monetarily sovereign countries, such as Canada, Japan, the UK and the US, are not operationally constrained by revenues when it comes to federal government spending. To be more specific, an increase in government spending still has expansionary effects but now there is no need for the government to raise taxes to support that spending increase (see for example Wray (1998), Wray (2012)). The theory claims that spending and deficits as needed can be financed by having the central bank ‘print’ (i.e., create by keystroke) money. In addition, such a government is the monopoly issuers of the currency, and hence, it will not default on its bonds because it has the power to issue as much money as needed to pay off the public debt. Japan has been considered as the clearest case that the may validate the ideas of MMT. The reason is that Japan has borrowed deeply since the country’s boom ended in the early 1990s with a high debt-to-GDP ratio of around
240% (OECD National Accounts Statistics) and big fiscal deficit (as shown in figure 1.3). However, both Japanese inflation and interest rates have been still remained low. Advocates of MMT argued that there is no need to raise taxes to finance government spending. To date, there has been no reliable counterfactual and empirical evidence on this issues and it is undoubted that there is a difference between the theory and its practice. The findings of this study showed that an increase in taxes had less negative effects on output during the ZLB period (the sign restriction approach). Furthermore, that tax shock may immediately decrease the government spending while it may increase the prices in the ZLB. These results suggest that, if government pursues the inflation target, then a tax hike could be combined with government spending increase to achieve this target. On the other hand, if government spending is targeted as argued in the MMT, then increase in taxes should not be combined because it may have negative effects on both output and government spending.

5.3 Limitations and suggestion for further researches

Although the findings of this study yielded some important policy implications and contribute to the fiscal policy analysis literature in Japan, there were still some limitations to this research. First, in practice, fiscal policy measures are often announced in advance of their implementation. Thus, the possibility is that people are aware of change in stance with respect to future fiscal policy and they can immediately react. However, in our VAR-based models, we assumed that fiscal shocks are unanticipated, which might be misspecified. Morita (2017) showed that anticipated spending shocks play an important role in the dynamics of Japanese GDP compared with unanticipated spending shocks. Second, in the structural VAR approach, a fixed elasticity of tax to output was used across different samples due to the lack of data availability on different types of tax revenues while in fact, it should be a time-variant parameter. Third, in order to fully understand the transmission mechanism of fiscal policy, the empirical setting could be extended to study the effects of fiscal shocks on other important macroeconomic variables, for example private investments, real wages and expected inflation. Fourth, the results from this study showed that standard neoclassical model and traditional Keynesian model cannot deliver the empirical predictions that fiscal policy is more effective when monetary policy is inactive or constraint. It was suggested that there is a need for a more sensible structural general equilibrium model that allow us to analyze all the consequences of policy experiment. Fifth, there have been structural changes in Japanese economy during last several decades and those changes may affect effectiveness of fiscal policy in Japan. Urasawa (2018) showed that the Japan has experienced massive structural changes since the end of the 1990s. These changes included a decade of deflation, a reduction in working-age population, an
growth in non-regular labors which has almost doubled since the early 1990s and caused a large decline in wage costs and rapid advances in globalization. Ko and Morita (2018) and found that the structural changes occurred in the mid-1970s, the early 1990s, and the late 1990s. The authors constructed four regimes based on the above three structural changes and examined the effect of fiscal policy in these corresponding period. The results showed that the sizes and multiplier effects were relatively different among regimes. In other words, there were evidences that structural changes may affect the impacts of fiscal policy and it is essential to include these structural changes in the VAR model. However, in practice, the timing of structural changes is often exogenously imposed and that may lead to misspecification, especially for the sign restriction approach (Uhlig 2005). Therefore, an important question is how to endogenously permit the structural changes in the empirical model. A potential solution is to employ a Markov-switching VAR model, which can be implemented in further stages of this research path.
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