Fiscal multiplier in the Russo–Japanese War: A business cycle accounting perspective[1)]

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Abstract

In this paper, we use business cycle accounting, introduced by Chari et al.(2007, Econometrica 75 (3), 781–836), to estimate the fiscal multiplier in Japan during the Russo–Japanese War, 1904–1905. This event is considered to be a natural experiment for the following reasons. 1) The ratio of government spending to GNP was relatively greater than that of the other wars involving Japan. 2) As the battlefields were in Korea and China, the war caused little damage to Japan's physical capital or labor supply. 3) The Russo–Japanese War did not involve any monetary transfer to the Japanese economy. 4) Before the war, people were not convinced that Japan and Russia would go to war. Using business cycle accounting, we estimate the value of the fiscal multiplier to be about 0.2 in the short run and about one

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in the long run. These results are consistent with the previous literature, which estimates the multiplier in different sample periods using econometric models such as structural vector autoregression (VAR) models.

1. Introduction

Although many researchers have estimated the fiscal multipliers of government expenditures, the estimates differ because of differences in the data and estimation methods used. Most government expenditures, however, are planned in the previous fiscal year, and thus they are not unexpected shocks. Economic agents make decisions using published imprecise data about government expenditure, which leads to a miscalculation of the fiscal multiplier.

To avoid such miscalculation, some researchers use military expenditure as unexpected and temporary expenditure. Barro and Redlick (2011) use US data from World War II (WWII), and their reduced-form models of regression analysis estimate that the multiplier of military expenditure lies between 0.4 and 0.7. Using vector autoregression (VAR) models with war dummy variables, Ramey (2011) estimates the fiscal multiplier to be 0.6–1.2. Furthermore, Owyang et al. (2013) use 1890–2010 US historical data and report that the fiscal multiplier of military expenditure is 0.7–0.9. These studies use all wars in their sample period as shocks to government spending. However, some of the wars may have been expected many months before the outbreak of war.

As an example of an unexpected war shock, we focus on the Russo–Japanese War. To our knowledge, there is no structural empirical research for Japan that estimates fiscal multipliers using military expenditure.

Furthermore, as discussed in the next section, using the Russo–Japanese War as a natural experiment has some advantages.

Moreover, to investigate the effects of the government spending during the Russo–Japanese War, this paper uses business cycle accounting (BCA), introduced by Chari et al. (2007).[4] BCA separates factors that affect economic variables (real GNP, consumption, investment, and labor supply) into four wedges: efficiency, labor, investment, and government consumption. These wedges exactly replicate the allocation in the economy. Moreover, if we remove one of these wedges or three wedges, the model provides counterfactual experiments. Since the government consumption wedge consists of government spending and net exports, this method allows us to evaluate the effect of government spending.

When estimating fiscal multipliers, BCA has more advantages than regression analysis and dynamic stochastic general equilibrium (DSGE) models. In regression analysis, several outbreaks of war would be required to estimate fiscal multipliers statistically. It is difficult to obtain sufficient such data for Japan. Furthermore, regression analysis requires appropriate regressors to avoid estimator bias, and VAR analysis requires appropriate structures to obtain efficient estimators, both of which pose problems in this context. Althogh BCA is based on a neoclassical growth model, as shown in Chari et al. (2007) and Sustek (2011), the wedges also can capture the fractions of New Keynesian DSGE models: e.g., sticky prices and sticky wages. This suggests that a fiscal multiplier estimated by BCA is not necessarily small, unlike neoclassical growth models.

Although Braun and McGrattan (1993) and McGrattan and Ohanian (2010) analyze the effects of war using DSGE models, we use BCA to

4) For BCA for the Japanese economy, see Kobayashi and Inaba (2006), Saijo (2008), Otsu (2009), Otsu (2011), Gunji (2013), and Gunji and Miyazaki (2017).

analyze the effects of war. DSGE analysis specifies the structure and shocks of the model, and then compares the simulated and observed data. It is difficult for this approach to replicate the original time series and to estimate the effects of fiscal shocks accurately. If, of course, one introduces a infinite number of frictions into a DSGE, it can capture the actual data. However, it would be not possible. On the other hand, in BCA, wedges estimated from data can replicate the original data series. Therefore, we can estimate the effect of government expenditure controlling for other business cycle factors.

In addition, BCA wedges represent several distortions of business cycles. As proved by Chari et al. (2007), for instance, financial frictions associated with the allocation of intermediate inputs correspond to the efficiency wedge and sticky wages correspond to the labor wedge. Because many types of friction correspond to one or more wedges, we do not have to be concerned about the specification of the model. Furthermore, BCA is conducted by a structural model, which allows us to simulate counterfactuals and identify the effects of government spending and war. In contrast, reduced-form regression analysis does not have these advantages.

This paper makes three contributions. First, to our knowledge, this is the first study to use data for the Russo–Japanese War to estimate the fiscal multiplier. Second, we utilize BCA to estimate the fiscal multiplier. Finally, we propose a new method for calculating the effect of wedges. Although most papers calculate the effect of wedges following Chari et al. (2007), their methodology does not allow for correlations between wedges. Our paper takes such correlations into consideration.

The main conclusion of our paper is that BCA estimates the value of the short-run fiscal multiplier to be 0.20–0.22. We also estimate the long-run multiplier to be 0.98–1.06. In other words, in the short term, the effect of fiscal expenditure on output is not very much, but in terms of long term, the change will be the same as or slightly above the size of fiscal expenditure on output. If fiscal expenditures are financed by current or future taxes and households reduce consumption equal to their present value, the effect on fiscal expenditure should be zero. However, in our simulation the effect is not zero. These results are consistent with the previous literature: e.g., Barro and Redlick (2011) and Owyang et al. (2013). Although Japanese economic growth and/or a wartime boom might bring about a long-run increase in output, we detrend our model, so the figures of the multiplier do not include those effects. From the historical point of view, although Japan's fiscal expenditure during the Russo-Japanese War accompanied various tax increases and finance by foreign bonds, it seems that there was an effect of stimulating the economy. In fact, since the size of fiscal expenditure was the largest before the Second World War, it is suggested that the scale of increase in output was large.

The structure of the paper is as follows. Section 2 gives a brief history of the Russo–Japanese War and demonstrates why using this war as natural experiments has some advantages. Section 3 provides a description of BCA. In Section 4, we explain how to calculate fiscal multipliers using our framework. Section 5 describes our data, Section 6 presents our estimation results, and Section 7 concludes. In two appendices, we provide details about estimating the spillover effects of the government wedge and constructing labor force data.

2. The Russo–Japanese War

In this section, we describe a brief history of the Russo-Japanese War, and then discuss some advantages of this war for estimating the government multipliers.

The Russo–Japanese War was fought between the Russian Empire and the Empire of Japan from 1904 to 1905. Much of fighting took place in northeastern China (the Liaodong Peninsula and Mukden in Southern Manchuria) and the seas around Korea (Sea of Japan).

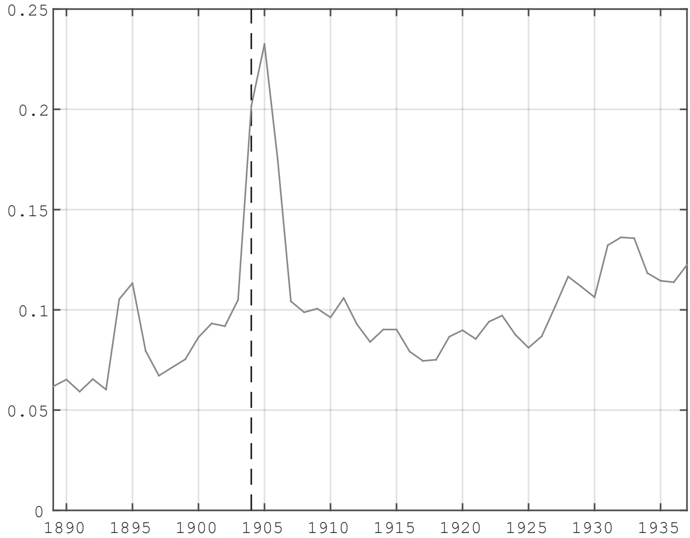
In the Sino–Japanese War of 1894-1895, Japan eliminated Chinese power in Korea and won control over the Liaotung Peninsula in Manchuria. An alliance of Russia, France and Germany, however, pressured Japan to give back the peninsula in return for increased reparations. In 1898 Russia had pressured China into granting it a lease for the strategically important port of Port Arthur, at the tip of the Liaodong Peninsula, in southern Manchuria. In 1902, Japan signed a treaty with Britain that secured British intervention should any country join Russia in a war against Japan, effectively removing the threat of other European powers' involvement if hostilities happened. Japan offered to recognize Russian dominance in Manchuria in exchange for recognizing Japanese dominance in Korea. Russia refused and demanded Korea north of the 39th parallel to be a neutral buffer zone between Russia and Japan. After negotiations broke down in 1904, the Japanese Navy gave a sudden attack against the Russian Eastern Fleet at Port Arthur, China.

From the end of July 1904, Japanese forces besieged Port Arthur's fortress town, accepting the surrender of the garrison in January 1905. In the meantime, in 1904 Japanese divisions had advanced into Manchuria, driving back the much larger Russian army. The final battle of the land war was fought at Mukden in late February and early March 1905. The battle cost both sides almost a third of their forces as Japanese troops outflanked Russian ones and took the town. The final large-scale encounter of the war was the Battle of Tsushima. The Japanese engaged the Russians in the Tsushima Straits on 27–28 May 1905, and the Russian fleet was virtually annihilated. This decisive naval victory at Tsushima, together with increasing internal political unrest throughout Russia, brought the Russian government to the peace table.

Although Japan had won the war decisively, Japan was by this time financially exhausted. As a result, Japan did not have the negotiating power many expected. Under the terms of the treaty, which was signed by both parties on September 5, 1905, Russia turned over Port Arthur to the Japanese, while retaining the northern half of Sakhalin Island, which lies off its Pacific coast. The Russians also agreed to leave Manchuria and recognize Japanese control of the Korean peninsula. However, Russia refused to pay indemnities to Japan. Japan's total war expenditure was 2,150 million yen, of which 38%, or 820 million yen, was raised overseas. The amount of financing was so huge that the debts still remained after World War I.

Using the Russo–Japanese War as a natural experiment has some advantages. First, the ratio of government spending to GNP was relatively greater than that for other wars involving Japan. Japan experienced three great wars that required enormous government expenditure: the Sino–Japanese War, 1894–1895; the Russo–Japanese War, 1904–1905; and WWII, 1941–1945. The Sino–Japanese War was the first war in which the Japanese military was modernized. Figure 1 shows the ratio of government expenditure to output from 1889 to 1937. The ratio in the Sino–Japanese war is the greatest in Japan before WWII. Moreover, military expenditure accounted for 50 percent of total government expenditure in the Sino–Japanese War and 58 percent in WWII. In contrast, it accounted for 74 percent in the Russo–Japanese War.[5)]

Figure 1: The ratio of government expenditure to output



Second, in the Russo–Japanese War, as for the US in WWII, Japan was at war with Russia on foreign soil, and therefore fewer Japanese civilians were killed. The Japanese labor force totaled about 25 million workers at that time. While the number of dead was 85,000 (0.34% of the labor force), the number of injured was 150,000 (0.61% of the labor force). These figures are lower relative to not only other wars involving Japan, but also to other wars in general. Moreover, unlike the Sino–Japanese War, it is feasible to estimate data on hours worked during the Russo–Japanese War.

Third, Japan gained only the southern half of Sakhalin and control of Korea, but did not receive any monetary compensation in the Treaty of Portsmouth in 1905. This implies that the Russo–Japanese War did not involve any monetary transfer to the Japanese economy, while requiring a

5) See Ohkawa et al. (1974, p. 22).

vast amount of government spending.

Fourth, the outbreak of this war was largely unexpected. According to Itaya (2012), Japanese bonds had been stable and priced at around 76 yen prior to the start of the war; however, the price dropped to 67 yen two days after the outbreak. Sussman and Yafeh (2000) point out that because it was generally believed that Japan would lose the war, a large risk premium was attached to Japanese bonds.[6] Therefore, using government expenditure in this period is suitable for estimating the fiscal multiplier.

3. The Model

BCA requires a neoclassical growth model, called a prototype economy, with four wedges: efficiency, labor, investment, and government consumption. Using the framework of a real business cycle model, these four wedges correspond to total factor productivity, taxes on labor income, taxes on investment, and the residual calculated by subtracting consumption and investment from output.

Chari et al. (2007) show that the allocations of many DSGE models are the same as those provided by a prototype economy under certain conditions on the wedges. In other words, the wedges in BCA can represent any type of friction in DSGE models. Furthermore, the wedges are estimated to reproduce the actual data, so BCA allows us to simulate counterfactual situations, for instance, an economy that has only an efficiency wedge. If the wedges that are most important for replicating the actual data were known, the frictions equivalent to these wedges would be

6) There are some studies that investigate financial markets' awareness of the beginning of wars. For instance, Suzuki (2012) shows that the stock markets of the countries damaged during WWII did not predict the beginning of the war.

the major candidates for causes of business cycles.

Before showing the prototype economy, we briefly explain the technical structure of BCA. In ordinary DSGE simulation, exogenous shock s_t changes endogenous variable Y_t, that is, $Y_t = f(s_t)$. For example, production, consumption expenditure, labor, etc. are used as endogenous variables. Since s_t is an artificial value, Y_t obtained by simulation does not necessarily agree with the actual value. On the other hand, in the BCA method, we substitute actual values for Y_t and use the inverse function to estimate the wedge $\hat{s}_t = f^{-1}(Y_t)$. Therefore, substituting $\hat{s}_t$ into $Y_t = f(\hat{s}_t)$ gives the actual value again. Analyzing the estimated wedge allows us to know when and how the wedge changed. This is a feature not found in ordinary DSGE. Moreover, by setting the wedge(s) to a value different from the reality, it is also possible to perform an counterfactual experiment which simulates how internal variables diverge from the reality. Although it is possible to know the extent of the impact of shock by historical decomposition in DSGE, BCA also has an advantage that it can be simulated without imposing strong assumptions about model structure and wedge.

The model used in this paper is as follows. The representative household in the prototype economy maximizes its lifetime utility as follows:

$$E_0 = \sum_{t=0}^{\infty} U(c_t, l_t) N_t, \tag{1}$$

subject to the budget constraint,

$$c_t + (1 + \tau_{xt}) x_t = (1 - \tau_{lt}) w_t l_t + r_t k_t + T_t, \tag{2}$$

and the law of motion for capital,

$$(1 + \gamma_n) k_{t+1} = (1 - \delta) k_t + x_t, \tag{3}$$

where c_t is consumption expenditure per capita, l_t is labor supply per capita, N_t is population, x_t is investment expenditure per capita, k_t is capital stock per capita, T_t is government transfers per capita, w_t is the wage rate, r_t is the rental rate, τ_{lt} is the labor wedge, τ_{xt} is the investment wedge, β is the subjective discount rate, γ_n is the rate of population growth, δ is the rate of depreciation, and $U(\cdot,\cdot)$ is instantaneous utility.

Firms maximize

$$A_tF(k_t,\ (1+\gamma_A)^t l_t)-r_tk_t-w_tl_t,$$

where A_t is the efficiency wedge, $F(\cdot,\cdot)$ is technology in terms of labor and capital, and γ_A is the labor-augmenting technological progress rate.

The equilibrium of this prototype economy is summarized by the resource constraint

$$c_t+x_t+g_t=y_t,$$

and the following conditions:

$$y_t=A_tF(k_t,\ (1+\gamma_A)^t l_t),$$

$$-\frac{U_{lt}}{U_{ct}}=(1-\tau_{lt})A_t(1+\gamma_A)^t F_{lt},$$

$$U_{ct}(1+\tau_{xt})=\beta E_t(U_{c,t+1}[A_{t+1}F_{k,t+1}+(1-\delta)(1+\tau_{x,t+1})]),$$

and (3), where g_t is the government consumption wedge.

Following Chari et al. (2007), we assume the instantaneous utility function $u(c_t,1-l_t\ )=\mathrm{In}\ c_t+\phi\ \mathrm{In}(1-l_t)$ and the production technology $F(k_t,(1+\gamma_A)^t l_t\ )=k_t^{\alpha}((1+\gamma_A)^t l_t\ )^{1-\alpha}$. To remove the effect of long-run economic growth, we detrend the time series. Denoting $\hat{z}_t \equiv Z_t/((1+\gamma_A)^t N_t)$, we obtain

$$\hat{y}_t = A_t \hat{k}_t^{\alpha} l_t^{1-\alpha}, \tag{4}$$

$$\hat{y}_t = \hat{c}_t + \hat{x}_t + \hat{g}_t, \tag{5}$$

$$\frac{\phi \hat{c}_t}{1-l_t} = (1-\tau_{lt})(1-\alpha)\frac{\hat{y}_t}{l_t}, \tag{6}$$

$$\frac{(1+\gamma_A)(1+\tau_{xt})}{\hat{c}_t} = \beta E_t \left[\frac{\alpha \hat{y}_{t+1}/\hat{k}_{t+1}(1+\tau_{x,t+1})(1-\delta)}{\hat{c}_{t+1}} \right], \tag{7}$$

$$(1+\gamma_A)(1+\gamma_n)\hat{k}_{t+1} = (1-\delta)\hat{k}_t + \hat{x}_t. \tag{8}$$

We also assume that the state at time t is $s_t = (g_t, A_t, \tau_{lt}, \tau_{xt})'$ and the log-linearized s_t follows a first-order VAR(1) process

$$\tilde{s}_t = P\tilde{s}_{t-1} + \varepsilon_t, \tag{9}$$

where ε_t is a normally distributed error term with mean zero and covariance matrix V. Unlike the earlier papers on BCA, we set the government consumption wedge g_t to be the first variable in the state vector s_t, because we use a Cholesky decomposition to conduct a counterfactual experiment in Section 5. The artificial shock on g_t is provided only for 1904, so the decomposition does not affect the other periods.

As we cannot solve the prototype model explicitly like other DSGE models, we log-linearize the model and apply the Uhlig (1995) method to derive the policy functions.[7]

7) The code is available from the authors upon request.

4. Fiscal Multipliers

In this section, we explain how to calculate the fiscal multipliers using BCA. We divide the government consumption wedge into military expenditure, ge_t, and others, that is, government consumption plus net export minus military expenditure, nx_t. Log-linearizing the equation, we have

$$\tilde{g}_t = \frac{g^e}{g}\tilde{g^e}_t + \frac{nx}{g}\tilde{nx}_t, \tag{10}$$

where the variables without time subscripts, t, denote steady state values. We set military expenditure to be in a steady state, that is, $\tilde{ge}_{1904}=0$, and compare the simulated and actual GNP to identify the effect of government expenditure. Denoting the simulated GNP in 1904 as $y_t(\tilde{ge}_{1904}=0)$, we have the fiscal multiplier

$$FM^s = \frac{y_{1904} - y_{1904}(\tilde{g^e}_{1904}=0)}{g_{1904} - g_{1904}(\tilde{g^e}_{1904}=0)}$$

$$= \frac{y[\exp(\tilde{y}_{1904}) - \exp(\tilde{y}_{1904}(\tilde{g^e}_{1904}=0))]}{g[\exp(\tilde{g}_{1904}) - \exp(\tilde{g}_{1904}(\tilde{g^e}_{1904}=0))]}.$$

This is a short-run fiscal multiplier. Moreover, the cumulative effect from 1904 is defined as

$$FM^L = \frac{y\sum_{s=0}^{T}[\exp(\tilde{y}_{1904+s}) - \exp(\tilde{y}_{1904+s}(\tilde{g^e}_{1904}=0))]}{g\sum_{s=0}^{T}[\exp(\tilde{g}_{1904+s}) - \exp(\tilde{g}_{1904}(\tilde{g^e}_{1904}=0))]},$$

which is called a long-run fiscal multiplier.

We conduct simulations that set the deviation of a component of government expenditure, that is, only military expenditure, from the steady state equal to zero. We employ two types of counterfactuals. The first method uses the counterfactual government consumption wedge and three other actual wedges for 1904, so there is no spillover effect of the counterfactual to the other three wedges. Put differently, we use $\{(nx/g)\tilde{nx}_{1904}, \tilde{A}_{1904}, \tilde{\tau}_{l,1904}, \tilde{\tau}_{x,1904}\}$ instead of $\{\tilde{g}_{1904}, \tilde{A}_{1904}, \tilde{\tau}_{l,1904}, \tilde{\tau}_{x,1904}\}$. This method is different from that of Chari et al. (2007), which sets one of the wedges to be zero over the simulation period. This method investigates the *direct* effect of the government consumption wedge and ignores the *indirect* effect of the government consumption wedge on the other wedges.

The second method substitutes the counterfactual government consumption wedge into the data-generating process of the wedges (9) to obtain the wedges over subsequent periods. In this case, the shock on the innovation of the government consumption wedge for 1904 first affects those of the other wedges, and thereafter affects them through the coefficient vector of the VAR. Therefore, we estimate two channels of the spillover effect. At $t=1904$, we use $s^c_{1904}=\{(nx/g)\tilde{nx}_{1904}, \tilde{A}_{1904}, \tilde{\tau}_{l,1904}, \tilde{\tau}_{x,1904}\}$ and the structural error $\hat{\varepsilon}^C_{1904}$. For the estimation method of $\hat{\varepsilon}^C_{1904}$, see Appendix 1. At $t>1904$, we use the wedges simulated from the VAR

$$s^c_t=Ps^c_{t-1}+\hat{\varepsilon}_t,$$

where $\hat{\varepsilon}_t$ is the residual from the actual data. After that, we estimate the wedges recursively. In this case, there is an indirect effect of the government consumption wedge, that is, all wedges vary from the actual wedge at $t>1904$.

The sample period is short, so we constrain the parameter matrix, P, and covariance matrix, V, to estimate (9) efficiently. As for P, we assume that the government consumption wedge affects the other three wedges in the next period, but the converse is not true; that is,

$$P=\begin{bmatrix} p_{11} & 0 & 0 & 0 \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ p_{41} & p_{42} & p_{43} & p_{44} \end{bmatrix}.$$

Chari et al. (2007) and Saijo (2008) also assume $p_{21} = p_{31} = p_{41} = 0$. However, we do not use this restriction because we allow for a spillover effect from the government consumption wedge because military expenditure was the major component of government expenditure in this period; however, the economic condition does not necessarily affect the change in government expenditure. As for V, following Chari et al. (2007) and Saijo (2008), we assume

$$V=\begin{bmatrix} \sigma_{11} & \sigma_{21} & \sigma_{31} & \sigma_{41} \\ \sigma_{21} & \sigma_{22} & 0 & 0 \\ \sigma_{31} & 0 & \sigma_{33} & 0 \\ \sigma_{41} & 0 & 0 & \sigma_{44} \end{bmatrix}.$$

That is, errors of the government consumption wedge might have a correlation with those of the other three wedges, but errors of the other three wedges are uncorrelated with each other.

5. Data

Here, we discuss the data used in the paper and the parameters of the model. The time period is 1889 to 1937 because of data availability limitations. Y_t, C_t, and X_t are gross national expenditure, consumption expenditure, and gross domestic fixed capital formation, respectively, measured using fixed prices from Ohkawa et al. (1974) (hereafter, LTES 1). K_t is gross capital stock measured using fixed prices from Ohkawa and Shinohara (1979).

Since hours worked are not available during the sample period, we estimate them from several earlier studies. The estimated hours worked are quite stable, so the accuracy would not affect the result below. For details regarding labor supply, l_t, see Appendix 2. We divide the variables by the number of those in the population who are over 10 years of age, N_t, to obtain per capita variables, y_t, c_t, x_t, and k. We also detrend the variables by dividing them by $(1+\gamma_A)^t$. To obtain the deviation from the steady state, we use a Hodrick–Prescott (HP) filter with annual parameter $\lambda=100$.

The parameters are calibrated as follows. To estimate the labor-augmenting technological progress rate, γ_A, we use

$$\text{In}\frac{y_t}{k_t^{\alpha}l_t^{1-\alpha}}=\text{In }A_t+[\text{In}(1+\gamma_A)](1-\alpha)t$$

from the production function. The coefficient of t from the ordinary least squares (OLS) estimation, $\hat{b}$, yields $\gamma_A=\exp(\hat{b}/(1-\alpha))-1=0.0234$. Following Hayashi and Prescott (2008), the capital share, α, is 1/3, the subjective discount rate, β, is 0.96, and the depreciation rate, δ, is 0.038146, which is the average from 1889 to 1937. The population growth rate, γ_n, is 0.0117, which is the average growth rate of N_t.

The time-allocation parameter, ϕ, is calibrated from the intratemporal optimal condition. Prior to this, however, it is necessary to obtain the labor wedge. We set the target of the minimum value of the labor wedge to be 3%, which is the ceiling of the labor income tax rates. In this period, the labor income tax rates were quite low relative to the present rates: they ranged from 1% for 300–1,000 yen of annual income up to 3% for 30,000 yen. Additionally, the number of hours worked was high: the average number of weekly hours worked in the nonagricultural sector in our sample period is 68 hours. These facts suggest that the labor wedges are not very high. Therefore, we set the target of the labor wedge to be 3% and obtain

$\phi = 0.9351$.

The government consumption wedge g_t consists of government spending ge_t and net export nx_t. If nx_t is negative and g_t is negative, we cannot log-linearize the prototype model. To obtain positive value of the variables, we divide the government consumption wedge into

$$g_t = ge_t + ex_t - im_t,$$

where ex_t is exports and im_t is imports. Log-linearizing this equation, we have

$$\tilde{g}_t = \frac{g^e}{g} \tilde{g}^e{}_t + \frac{ex}{g} \tilde{ex}_t - \frac{im}{g} \tilde{im}_t.$$

As ge_t, ex_t, and im_t are positive, we can use the HP filtered data for the variables signified with a tilde and the sample averages for the steady states to obtain $\tilde{g}_t$.

The counterfactual is that the deviation of government expenditure from the steady state in 1904, $\tilde{ge}_{1904}$, is zero. We employ the following four assumptions related to government expenditure.

The first counterfactual is that military expenditure equals zero in 1904. The military and war-related expenditures are available from Emi and Shionoya (1966) (LTES 7). However, LTES 1 excludes government fixed capital formation from general government consumption expenditure and adds it to domestic fixed capital formation, so it is interpreted as military capital formation. Therefore, subtracting items related to fixed capital formation from military and war-related expenditures, we use expenditure related to conscription, war expenses (extraordinary military special account and ministries other than army and navy), and war-related expenses (military allowances in the form of aid, annuities, and pensions). We also remove duplications in the extraordinary military special account and other accounts. Furthermore, we should remove fixed capital formation from the extraordinary military special account, but these data are not available. Instead, we multiply the extraordinary military special account by the share of the sum of personnel expenses, consumption good expenses, provision and fodder, clothing, and transportation and communication to obtain military consumption expenditure. We call this broad military expenditure:

$$\text{Broad military expenditure} = ME \times \zeta_1,$$

where

ME = expenditure related to conscription + war expenses + war-related expenses − duplications,

ζ_1 = (personnel expenses + consumption goods + provision and fodder + clothing transportation and communication)/ extraordinary military special account.

The second counterfactual is that military expenditure is defined in a narrower sense: broad military expenditure minus expenditure abroad for requisition; that is, expenditure related to provision and fodder and to transportation and communications. Ikeyama (2001) suggests that the Japanese army requisitioned provisions, e.g., rice, wheat, and soy sauce, from many domestic areas at low prices. However, because the Japanese government had a military currency on issue since the Sino–Japanese war in 1894–1895, it is unlikely that all provisions and fodders were requisitioned within Japan. Therefore, we also estimate the fiscal multiplier using narrow military expenditure:

$$\text{Narrow military expenditure} = ME \times \zeta_2,$$

where

ζ_2 = (personnel expenses + consumption goods + clothing) /extraordinary military special account.

For comparison, we employ two more counterfactuals. The third counterfactual is that the government consumption wedge equals zero in 1904. This means that the change in the government consumption wedge in 1904 is entirely the result of the war. This is the same assumption that was used in the simulations in earlier studies on BCA. The fourth counterfactual is that government expenditure equals zero in 1904. The government consumption wedge consists of government expenditure and net exports, so the latter is assumed to be influenced only by the war.

As discussed in the introduction, military expenditure can be considered as unexpected or temporary shocks, so the third or fourth assumption is preferable in the sense of calculating the fiscal multiplier.

6. Results

In this section, we present our estimation results. However, we first estimate the parameters of VAR(1). Table 1 presents the parameters of VAR(1) estimated using the maximum likelihood method. We use these parameters to estimate the wedges.

The estimated wedges are shown in Figure 2. All the wedges rise dramatically for 1904, but they are not strongly correlated in the other period. The outbreak of war is a political issue, so most of the movement in the government consumption wedge in 1904 is exogenous. On the other hand, the other three wedges increase in the same way, so the movements are caused by the government consumption wedge.

Following the earlier studies, e.g., Chari et al. (2007), we first simulate the model with only one wedge, that is, without three wedges over time. Figure 3 depicts the simulation results of the effect of each wedge on real GNP. The broken line is log-linearized output around the steady state, and the solid line is output without each wedge. As output without the

Table 1: Parameters of the VAR(1) Process

Coefficient matrix P on lagged states

$$\begin{bmatrix} 0.8037 & 0 & 0 & 0 \\ 0.0003 & 0.9215 & -0.1122 & 0.0882 \\ 0.0092 & -0.0128 & 0.0528 & 1.2323 \\ -0.0010 & -0.8282 & 0.0910 & 0.1906 \end{bmatrix}$$

Variance–covariance matrix V

$$\begin{bmatrix} 29.2931 & 0.1314 & -0.2093 & -0.0585 \\ 0.1314 & 0.0018 & 0 & 0 \\ -0.2093 & 0 & 0.0187 & 0 \\ -0.0585 & 0 & 0 & 0.0014 \end{bmatrix}$$

Coefficient matrix Q, where $V = QQ'$

$$\begin{bmatrix} 5.4123 & 0 & 0 & 0 \\ 0.0243 & 0.0342 & 0 & 0 \\ -0.0387 & 0.0275 & 0.1283 & 0 \\ -0.0108 & 0.0077 & -0.0049 & 0.0344 \end{bmatrix}$$

Figure 2: Estimated wedges

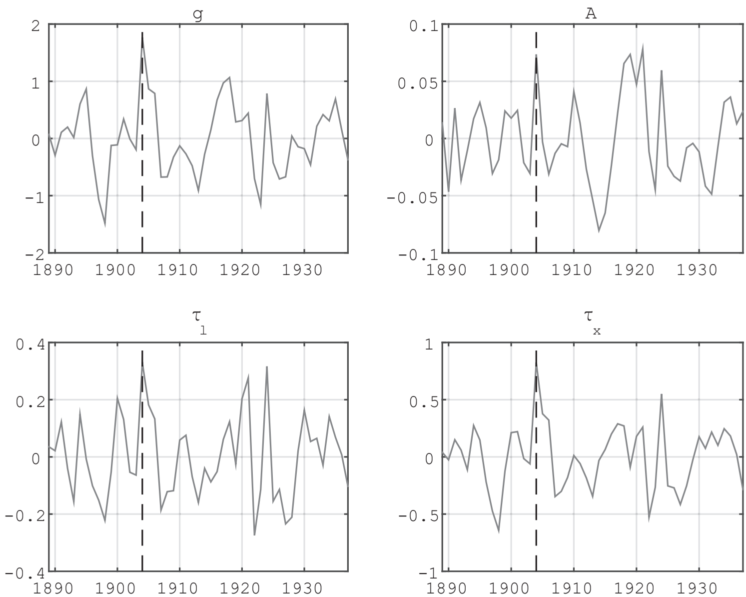
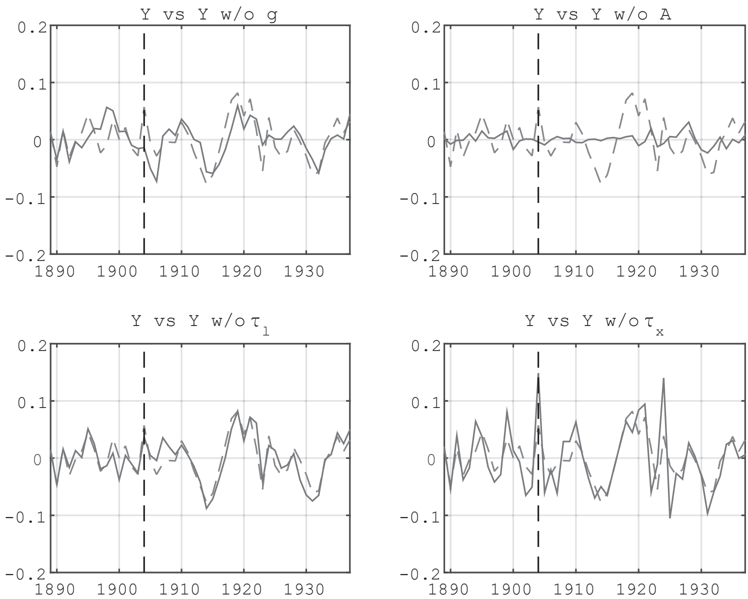


Figure 3: Output data and predictions of the models with just one wedge



efficiency wedge is virtually unchanged, the efficiency wedge would be the most important factor for output. This is consistent with earlier studies. The labor and investment wedges affect output during the war to some extent. However, the latter is slightly volatile. By contrast, output without the government consumption wedge is different from actual output over time. While earlier studies rarely considered the effect of the government consumption wedge, our analysis implies that it plays an important role in this period.

Next, Table 2 presents the estimates of the fiscal multipliers. The first row shows the short-run fiscal multipliers without the spillover effects among wedges. The multipliers of the government consumption wedge and total government expenditure are 0.28 and 0.23, respectively. In the second row, the multipliers with the spillover effects are 0.30 and 0.25.

Table 2: Fiscal multiplier

Estimation method	Government consumption wedge	Total government expenditure	Broad military expenditure	Narrow military expenditure
Short-run				
w/o spillover	0.2825	0.2296	0.1994	0.1802
w/ spillover	0.3067	0.2498	**0.2170**	**0.1962**
Long-run				
w/o spillover	0.0720	0.4409	0.3816	0.3441
w/ spillover	0.4012	1.1770	**1.0561**	**0.9763**

The multipliers of broad and narrow military expenditures are 0.22 and 0.20, respectively, which are relatively small. They are all less than one, as are the fiscal multipliers calculated from normal DSGEs. As shown in Woodford (2011), this is because government expenditure increases not only output but also the disutility of labor supply, causing a fall in output. Therefore, each of the military expenditures does not have a large effect on output in the short run.

However, the long-run multipliers produce different results. This is because a temporary change in government expenditure can affect the capital stock after the shock and thereby change output. For the multiplier without spillovers, which does not consider the dynamic effects among the wedges, the fiscal multipliers of the government consumption wedge and government expenditure are 0.07 and 0.44, and those of broad and narrow military expenditures are 0.38 and 0.34, respectively. Although the multipliers without spillover effects are small in the short run, they are around double their short-run values in the long run. For the multiplier with spillovers, which allows the spillover effect after the shock of the government consumption wedge in 1904, the fiscal multipliers are larger than those from the multiplier without spillovers, but they are around one. As military expenditure is more suitable as an unexpected shock of government consumption, we conclude that the fiscal multiplier in the long run is 0.98–1.06.

To see this intuitively, we plot the change in output for each simulation. Figure 4 shows the change in output for the multiplier without spillovers. The shock to each variable increases output in 1904, but the effect disappears quickly. Figure 5 depicts the same simulation for the multiplier with spillovers. In this case, the shock in 1904 affects all wedges and the capital stock through the law of motion for capital, (3), and the VAR, (9). These effects increase output from 1904 to 1915, but they seem to disappear from 1916 onward. The reason why the fiscal multipliers with

Figure 4: Output data and predictions of the models without government expenditure in 1904, w/o spillover

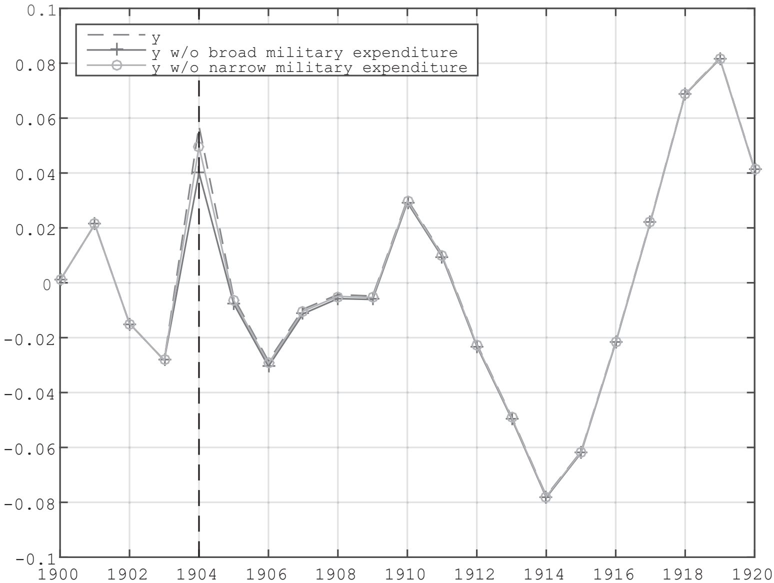
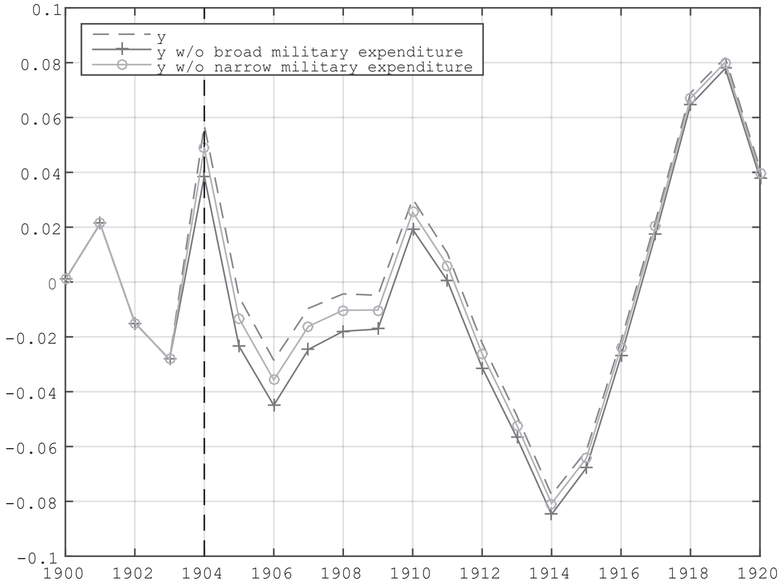


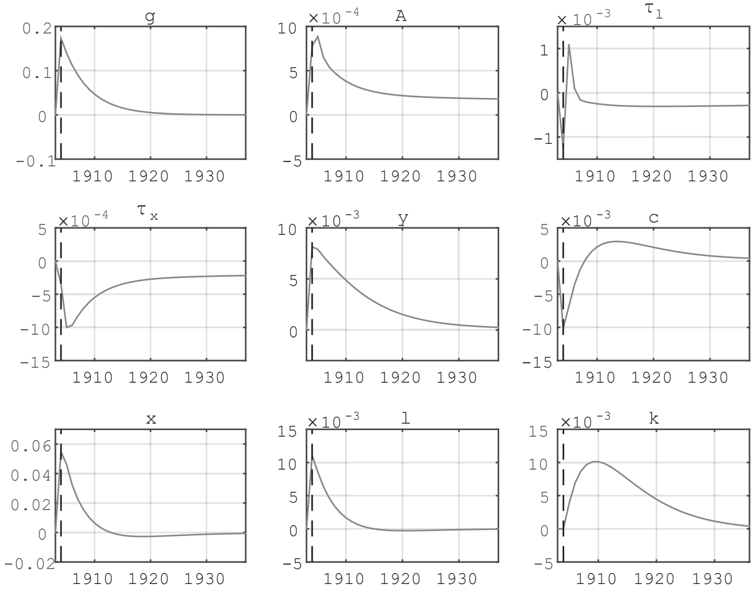
Figure 5: Output data and predictions of the models without government expenditure in 1904, w/ spillover



spillovers are larger than those without spillovers is that the government consumption wedge in the multiplier with spillovers does not shrink after 1904 because of the dynamic effect of the VAR. As the difference between the actual government consumption wedge and the simulated wedge in the multiplier without spillovers arises only in 1904, the effect of the government spending is limited.

We next show the impulse-response functions for a shock in narrow military expenditure in 1904, which is the most reliable data for the government spending shock of the Russo–Japanese War. Figure 6 shows the results. The change in the government consumption wedge in 1904 increases the other three wedges: the impacts are about 0.1 percent. The increases in the labor and investment wedges decrease output in 1904,

Figure 6: Impulse-response functions to narrow military expenditure in 1904



while the increase in the efficiency wedge increases output and the fiscal multiplier. Interestingly, consumption expenditure decreases temporarily in 1904, but increases afterward. This is partly because the labor wedge also increases after 1905. In standard macroeconomics, government expenditure crowds out consumption. However, our counterfactual experiment increases consumption.

In summary, we found that the fiscal multiplier for the shock in 1904 is 0.20–0.22 in the short run and 0.98–1.06 in the long run. These findings are consistent with earlier studies, as discussed in the introduction.

7. Concluding Remarks

In this paper, we utilized BCA to estimate the fiscal multiplier during the Russo–Japanese War. BCA decomposes the frictions of many DSGEs into four wedges, which replicate exactly the actual endogenous variables. These features allow us to avoid the model misspecification that can occur in DSGE and VAR models.

For estimating fiscal multipliers, data for the Russo–Japanese War period have the advantage that the war was unexpected and involved little damage to the capital stock or the labor force. We employed a government consumption wedge, total government expenditure, broad military expenditure, and narrow military expenditure as measures of government expenditure for the calculation of the multipliers.

Using the BCA approach, we conclude that the short-run multiplier is 0.20–0.22, and the long-run multiplier is 0.98–1.06. This is consistent with the results estimated using other methods in earlier studies.

Large-scale fiscal expenditure seems to cause households and firms to expect future tax increases and reduce consumption expenditures by the same size. This is the result seen with a simple neoclassical model assuming rational agents and a frictionless economy. However, the results of this paper suggest that the prediction obtained from such a simple model does not hold. On the other hand, simulation by BCA alone can not know what route this result was derived. This point may be the limit of BCA. On the other hand, we can not analyze what kind of channel this result was derived by BCA simulation alone. This point may be the limit of this paper.

Furthermore, our conclusion is drawn using a BCA approach, in which the prototype model is essentially a one-sector growth model with four stochastic wedges. On the other hand, Hayashi and Prescott (2008) and

Golosov et al. (2017) propose a two-sector model for macroeconomic analysis before WWII. Developing a two-sector model for BCA is left for future research.

Appendix 1: Estimation of simultaneous spillover effects

The estimation method of the spillover effect of the government consumption wedge in 1904, $\hat{\varepsilon}^{C}_{1904}$, is as follows. As we would like to set military expenditure $\tilde{ge}_t$ equal to zero only at $t=1904$ from (10), we seek a structural shock $v_{1,1904}$ so that the government consumption wedge is $(nx/g)\tilde{nx}_{1904}$. First, we use the estimated coefficient matrix P to obtain the residual:

$$\hat{\varepsilon}_t = s_t - P s_{t-1}.$$

Next, we implement a Cholesky decomposition on the variance-covariance matrix $V=QQ'$ and obtain the structural shock:

$$\hat{v}_t = Q^{-1}\hat{\varepsilon}_t.$$

This allows us to transform the error term ε_t into the idiosyncratic shock v_t, in which each factor is not correlated with each other. Moreover, the first equation in (9) is an AR(1) process by assumption, so we would like to obtain the government consumption wedge $\tilde{g}_{1904} = p_{11} g_{1903} + \hat{\varepsilon}_{1,1904} = (nx/g)\tilde{nx}_t$. Using $\hat{\varepsilon}_{1,t} = q_{11}\hat{v}_{1,t}$, we solve this equation to obtain the idiosyncratic shock of government military expenditure:

$$\hat{v}^{C}_{1,1904} = \frac{\bar{g}_{1904} - p_{11} q_{1903}}{q_{11}}.$$

Finally, we replace the actual residual of the government consumption wedge with $\hat{v}^{C}_{1,1904}$:

$$\hat{\varepsilon}_{1904}^{C}=Q[\hat{v}_{1,1904}^{C} \quad \hat{v}_{2,1904} \quad \hat{v}_{3,1904} \quad \hat{v}_{4,1904}]' .$$

This is the simultaneous spillover effect. After this period, we calculate the wedges using (10).

Appendix 2: Construction of labor force data

In this appendix, we provide details about the construction of labor force data. We could not find suitable aggregate labor force data for the prewar period for Japan. There are no aggregate data of hours worked in prewar Japan. In this appendix, we describe how we estimated the number of hours worked. For the agricultural sector only, we can utilize the number of employees, E_t^a, and weekly hours worked, h_t^a, estimated by Shintani (1981) and Hayashi and Prescott (2008).

For the nonagricultural sector, we use the number of gainful workers aged 10 years and older from Umemura et al. (1988) (LTES 2) as E_t^n. To our knowledge, there are no time series data of hours worked in the nonagricultural sector. Therefore, we use average daily hours worked in the cotton spinning industry from Fujino et al. (1979) (LTES 11, p.27). As the employees in this industry work on a two-shift system, we divide the data by two. The period average value is 10.82 hours.

As it is implausible to assume that this industry was representative of all industries during the sample period, we further use the following three statistics to estimate a more accurate time series. First, Odaka (1990) investigates factory-level data from *Aichi-ken Shokko Chosa*, which surveys 100 factories in six industries in 1894 in Aichi prefecture, and finds that the average daily number of hours worked is 11.9.[8] Second, *Shokko Jijo*, published by the Ministry of Agriculture and Commerce (revised by

Inumaru (1998)) surveys 16 industries in 1901 and finds that the average daily number of hours worked is 11.75.[9] Third, Rodo Undo Shiryo Kanko Iinkai (1959) estimates the average daily number of hours worked to be 11 from 1908 to 1918. We calculate the average number of hours worked in the nonagricultural sector, h_t^n, as the average of these four averages, $((11.9+11.75+11+10.82)/4=11.3675)$. That is, we multiply the daily number of hours worked in the cotton spinning industry by $11.3675/10.82=1.05$ to obtain h_t^n.

To estimate the aggregate labor force data, we take the weighted average of the agricultural and nonagricultural sectors,

$$l_t=\frac{E_t^a}{N_t}\frac{h_t^a}{16\times 6}+\frac{E_t^n}{N_t}\frac{h_t^n(6/7)}{16},$$

where N_t is the population aged 10 and over from Umemura et al. (1988) (LTES 2). In this formula, assuming eight hours of sleep nightly, we divide h_t^a by 16×6, which is the possible number of working hours (24 minus 8 hours) multiplied by weekly days of work (6 days). In addition, we multiply h_t^n by $6/7$ because h_t^n is calculated in terms of working days, that is, $h_t^n=$hours worked during working days/6, and we divide this by the possible number of working hours (24 minus 8 hours).

8) The industries comprise textiles, metal refining and processing, machinery and equipment, ceramics, chemicals, food, and others.

9) The industries comprise textiles, silk, fabrics, iron, glass, cement, matches, tobacco, printing, and others.

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