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The Public Investment Multipliers: Evidence from Stock Returns of Narrowly Defined Industry in Japan

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Abstract

This paper provides an evidence on the macroeconomic impacts of public investment. I extract public investment news shocks from the excess return of narrowly defined road pavement firms in Japan and use them as an instrument for future government spending. I found that the extracted news shocks predict the future government spending through changes in future public investment. The result shows that the public investment multiplier is 1.64 a year after the shock and about 5 after four years, which is considerably larger than fiscal multipliers estimated in previous studies. The findings highlight the importance of the *types* of government spending, in addition to the *amount* of the spending, in determining the overall effects of countercyclical fiscal policies.

Keywords: Fiscal multiplier; Stock returns; Public Investment; Infrastructure Investment.

JEL Classification: E32;E62;H54.

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1 Introduction

What are the macroeconomic impacts of public investment? Despite that public investment typically constitutes a large part of countercyclical fiscal packages, research on its impacts is relatively limited. Much of the current literature, instead, focuses on the defence spending variation to estimate the effects of government spending. In this regard, there is a gap between the state of knowledge about the effects of government spending, which is mostly learned from defence or total government spending, and the estimate needed to assess the fiscal policies today, which is the effects of the public investment that are frequently used for countercyclical stimulus packages. The distinction between the two types of spending could be significant; while the government spending is usually treated as a waste in macroeconomic models, the public investment is likely to improve productivity as reported by Fernald (1999). The goal of this paper is to fill this gap by estimating the public investment multipliers by exploiting the variation in public investment news shocks, which is extracted from the excess return of road pavement firms in Japan.

The challenge in estimating the public investment multipliers stems from the two common characteristics of this type of spending. First is the long implementation lag, which makes the spending highly predictable. As emphasized by Ramey (2011b) and Leeper, Walker, and Yang (2013), when government spending is anticipated long before the actual outlays, failure to control for the anticipation effects leads to incorrect inference. Since infrastructure construction takes years to complete, the anticipation effects associated with estimating its impacts is likely to be substantial. On a related note, Ramey (2016) highlighted the difficulty of controlling for the anticipation effects in the US by pointing out that "most of the spending on the U.S. highway system was anticipated once the highway bill was passed in 1956." The infrastructure investment in Japan, on the other hand, has been driven by a sequence of long-term plans, which are frequently revised and renewed, providing unexpected variations in how much infrastructure investment was to be conducted in the near future.[1] Together with this variation in the infrastructure investment, I overcome the problem of anticipation effects using the excess return of the road pavement firms in Japan following Fisher and Peters (2010). As per the efficient market hypothesis,

[1]Public investment = infrastructure investment + public inventory investment. Sine infrastructure investment accounts for the majority of the public investment, I will use public investment and infrastructure investment interchangeably.

any movement in the stock prices reflects unexpected shocks to the beliefs about future profits of the firms. If the profitability of the selected road pavement firms depend heavily on public road investments, the shocks to their excess returns can be interpreted as a surprise public road investment news shock. Moreover, since the road investment constitutes the largest fraction of public investment, the public road investment news shocks could generally be interpreted as public investment news shocks. The use of excess return of road pavement firms makes it possible to extract the public investment news shocks that are less likely to suffer from the problem of anticipation effects.

The second challenge is related to the endogenous nature of the infrastructure investment. Even though the public infrastructure spending is mainly motivated by the long-term goal of developing a stock of infrastructure, the spending is often used for countercyclical stimulus purposes. This makes simply estimating the multipliers using the excess return of the road pavement firms inappropriate. For this reason, I extract a purified measure of excess returns by regressing the excess return on a number of contemporaneous and lagged economic and financial variables. The residuals from the regression is my measure of excess return that should be orthogonal to other shocks that affects current and future output.[2] I verify that the extracted news measure is orthogonal to the current state of economy by conducting a series of robustness checks.

The extracted excess return shocks are noisy measures of news shocks about future infrastructure spending. To this end, I employ the local projection-IV method using the extracted measure of the excess return shocks as an instrument variable and estimate the macroeconomic impacts of the public investment. The use of the IV alleviates the problem of measurement errors likely contained in the excess return news shocks because it uses only the variation in the excess return shocks that are associated with the variation in the total government spending. As with the IV identification strategy in the microeconomic literature, my identification strategy relies on two crucial assumptions, which are that my instrument variable 1) captures news about the future public investment (relevance condition) and 2) affects output only through the government spending (exclusion restriction). The exclusion restriction is dealt with by regressing the excess return on current and lagged macroeconomic/financial variables as described above. The relevance condition is directly

[2]This is same as placing the excess return at the last in the causal ordering of VAR behind macro/financial variables.

testable. I show that the residual variation of excess returns predicts both the future government spending as well as future public investment in a statistically significant manner. Importantly. the residual variation does not predict the future government consumption, suggesting that my measure of news shocks predicts total government spending only though the public investment component of the spending.

Following Ramey and Zubairy (2016), I estimate the cumulative public investment multipliers of output. I found the road investment multiplier of about 1.64 a year after the news shock and about 5 after four years. The estimated multipliers are considerably larger than conventional estimates of fiscal multipliers. These results, however, are in line with other studies that estimated a large public investment multiplier at the state-level in the US as reported in Leduc and Wilson (2013). The estimated public investment multipliers are robust to different specifications. Furthermore, the study found that the public investment crowds in consumption and investment, and the multipliers associated with them are both considerably larger than multipliers in previous studies. Additionally, the public investment multipliers for tax rate and interest rate are found to be positive and statistically significant, suggesting that the large public investment multiplier cannot be explained by passive tax or interest rate policies. Finally, I show some evidence that is consistent with a declining multiplier of output over time. The evidence suggest that the public investment multipliers on the current stock of infrastructure might be smaller than the multipliers 30 years ago.

1.1 Related Literature

There is an extensive literature that studied the effects of government spending on macroeconomy. As summarized by Ramey (2011a), two popular identification strategies are 1) military spending news shocks pioneered by Ramey and Shapiro (1998) and 2) Blanchard and Perotti (2002)'s identification strategy (BP method hereafter) that imposes an assumption that the government spending does not react to the current economic conditions on a VAR estimation. Using the identification scheme such as these, the literature typically estimates the government spending multipliers by exploiting the variation in defence or total government spending. Surveying the large body of work, Ramey (2011a) concluded that the reliable estimates of fiscal multipliers are between 0.8 - 1.5.[3] In contrast to much of the existing studies, I provide

[3]Ramey (2011a) also emphasized that any reasonable person can claim the multipliers between 0.6 - 2.0.

the estimate of fiscal multipliers using the variation in the public investment and find that the public investment multipliers are considerably larger than the conventional estimates of fiscal multipliers.

One of the few studies that explored the effects of public investment is Leduc and Wilson (2013). They estimated the effects of road investment at the state-level by identifying the highway spending news shocks at the local state. Their estimates suggest infrastructure spending multipliers of 3 on impact and even larger multiplier 6-8 years out. Their estimates of local multipliers are considerably greater than the conventional estimates of fiscal multipliers, which suggests that the infrastructure spending might have significantly higher multipliers even at the national level. Pereira (2000) investigated the effects of highway spending using the BP method and the US macroeconomic data from 1956 to 1997. He found a multiplier of about 2, but his estimates are likely contaminated by the anticipation effects because the study does not control for the changes in expectation.[4] Chandra and Thompson (2000) used the US county data and compare the local earnings before and after the completion of a new highway at the local county. They found that earnings are higher during the periods of highway construction (1-5 years before completion) compared to when the highway is completed and that earnings after completion grows over many years. Leigh and Neill (2011) exploited the institutional setting unique to Australia and estimated local effects of highway construction. Noticing that local government spending in Australia is dispensed largely based on discretionary earmarks rather than formulas, they used political power of localities as an instrument variable for funds dispersed to communities. They found that local highway funds decreases local unemployment rates. The current paper contributes to the literature by providing the direct estimates of the macroeconomic impacts of public investment after controlling for the anticipation effects.

A number of researchers estimated the fiscal multipliers in Japan. Recently, Miyamoto, Nguyen, and Sergeyev (2017) estimated the fiscal multipliers in Japan under the normal periods as well as under the zero lower bound (zlb) periods using the BP methods after controlling for the chages in expectation. They found the fiscal multipliers of 0.6 under the normal periods and 1.5 under the zlb periods. Kuttner and Posen (2002) used the BP method to find the government expenditure multipliers well in excess of one. Bayoumi (2001) also employed the BP methods and reported

[4] As emphasized by Ramey (2011b), the government spending shocks extracted from the BP method is highly likely to be anticipated

the multiplier of 0.65. Using the same dataset as Miyamoto, Nguyen, and Sergeyev (2017), I find the multiplier of 1.64 a year after the public investment news shocks.

Methodologically, this paper follows Fisher and Peters (2010) who used the excess return of top three military contractors in the US as a military spending news shock. Applying the same framework, Morita (2017) used the excess return of construction industry and the sign-restriction VAR to estimate the fiscal multipliers in Japan. Recently, Fieldhouse, Mertens, and Ravn (2017) used the excess return of the Fannie Mae and Freddie Mac to estimate the impacts of their activities on mortgage market and aggregate economy. Both methodologically and conceptually, this paper is related to Shioji (2017) and Shioji (2018) who identified the news shock about public investment in Japan by combining the narrative approach and the excess return approach. He first identified dates in which significant news about future course of public investments are released on major newspapers such as the news about fiscal stimulus packages, winning the right to host major international sports events, and disasters (e.g. large earthquakes). He then measures the surprise component of the public investment news shocks by comparing the movements of stock prices between highly government-dependent construction firms and less dependent construction firms on those dates. Using this clean identification strategy, he found that public investment news shocks have a positive and significant impact on output. The current paper is different from Shioji's in that the current paper takes into account the possibility that the expectation grows gradually on non-significant news days and that changes in expectation occurs in a subtle manner. The identification scheme is also different in that the current paper uses the narrowly defined "road pavement" firms, which are not categorized as highly government-dependent firms in Shioji's due to the reportedly low share of public orders received by these road pavement firms[5]

Finally, the paper is motivated by the findings reported by Fernald (1999) who reported that when the road investment increases, productivity growth improves disproportionately in more vehicle-intensive industries in the US. Evidenced by disproportionate benefits that the vehicle-intensive industries received, he concluded that

[5]The reported share of public order for road pavement firms is on average about 30-40% between 1980-2014 according to the annual Financial Report. It is not entirely clear why the reported share of public order is relatively low for these narrowly defined firms despite that "major contractors" reported in the same Financial Report are mostly GSE-type agencies such as Japan Highway Public Corporation and Nippon Expressway Companies. One possible explanation is that the reported share only includes public orders from the formal government agencies and orders from the GSE-type agencies such as"special companies" including Japan Highway Public Corporation and Nippon Expressway Companies are classified as private.

the road investment induces productivity growth. The finding suggests that road investment is different from other types of government spendings in a sense that while government spending is usually treated as a waste in macroeconomic models, road investment increases productivity.

The rest of the paper is organized as follows. Section 2 reviews historical background of public investment policies in Japan. Section 3 describes the empirical strategy. Section 4 explains the data. Section 5 shows baseline results. Section 6 shows estimated multipliers for various macroeconomic variables. Section 7 shows result from rolling estimation. Section 8 discusses the results in light of rational agent models. Finally, Section 9 concludes.

2 Infrastructure Investment in Japan

This section provides narrative evidence of uncertainty surrounding the history of infrastructure investment policies in Japan. After the devastation of the WWII, public infrastructure investment was viewed as one of the most important government policies in Japan. The Japanese infrastructure investment policies have been affected by various factors that are often irrelevant to the current state of economy such as the long-term goals of developing stock of infrastructure, an international agreement between the US and Japan to expand the Japanese domestic demand to correct large trade imbalances, and the concerns for fiscal sustainability. With each additional variation in these factors affecting the infrastructure investment policy, a new unexpected variation is added to the series of public investment shocks.

Among the many factors listed above, the long-term plan for the provision of infrastructure is the most influential set of factors that has shaped the Japanese infrastructure investment policies. The long-term plans that had an influence over the provision of infrastructures can be classified into two: 1) high-level comprehensive plans and 2) component-specific infrastructure plans. Yada (1999) highlighted that there are four high-level comprehensive plans that reflect the overall stance of the Japanese government toward the country's economic and social development: the Economic Planning (EP), Comprehensive National Development Plans (CNDP), National Land Use Planning (NLUP), and Basic Plan for Public Investment (BPPI). Of these four plans, the latter three plans have direct implications about the provision of infrastructure, which are summarized in Table 1. The goal of the CNDP was to reduce

the imbalances among different prefectures. The NLUP supplements the CNDP in that it aims for equal development of the lands throughout Japan. Finally, the BPPI was issued after a long series of negotiations between the US and Japan, which finally settled in 1990, with both sides agreeing on correcting the large and long-running trade imbalances by expanding the Japanese domestic demand. Because their goals span for many years (often more than ten years), these plans do not directly aim at stimulating the short-run economic outcomes.

While the high-level comprehensive plans were useful for publicizing the overall government's stance on future course of public investment, they are often criticized for lack of enforcement and for a low rate of achievement. Kuroda (1996) and Koyama (2011) attribute the cause of the low achievement to the absence of agencies who took responsibility in implementing the policies. In addition to the three comprehensive plans, there were 15 long-term plans that are designed specifically for each component of public infrastructure investment, which are summarized in Table 2.[6] Notable features of these plans are that they state the amount of planned investment explicitly for the next 5 years and that the plans expire and are renewed after every 5 years. These plans are designed, proposed, and executed independently by various government agencies.[7] After initial submission of the proposals, the Ministry of Finance reviews them and negotiate with each responsible government agency to determine the final amount of the planned investment.

If the component specific plans are perfectly determined by the high-level comprehensive plans, then the announcements of new component-specific plans are perfectly anticipated, resulting in few variations in beliefs about public investment policies that only come from revisions of the comprehensive plans.[8] However, the extent to which the comprehensive plans have an influence over the component-specific plans is unclear. The component-specific plans are sometimes directly affected by the high-level comprehensive plans. The BPPI had a particularly strong influence on the component-specific plans because the BPPI was a bilateral international agreement. Yet, while the comprehensive plans suffer from low rate of achievement, the amount

[6] Table 3 shows an example of the plans for the road investment.

[7] Including Ministry of Transport, Ministry of Construction, National Land Agency, Forestry Agency, and Ministry of Agriculture, Forestry and Fisheries. Ministry of Transport, Ministry of Construction, Ministry of Land, National Land Agency, and Hokkaido Development Agency were integrated into the Ministry of Infrastructure, Transport and Tourism in 2001.

[8] Though one could argue that the information about each new comprehensive plan is released partially over time, giving some variations to the beliefs about public investment policies.

of planned investment announced in the component-specific plans was often fully realized by the target periods. The evidence is suggestive that the two types of plans are not totally in accord with each other because if the component-specific plans are solely based on the comprehensive plans, they should either both fully achieve the goals or both fail to achieve the goals. Thus, there should be some elements of uncertainty about the amount of planned investment in the component-specific plans before the announcement. In fact, in rare instances when major newspapers release prediction about the amount of planned investment for the component-specific plans, they usually mispredict.[9] Importantly, the 15 component-specific plans were renewed in different years, and thus, there are variations in the timing of the announcement for these 15 plans.

The comprehensive plans and the component-specific plans are both determined after a series of public and non-public discussions. This institutional setting makes it difficult to single out exact timing when people's belief about future course of public investment changed. Thus, taking into account the possibility that the information about the future investment policy was revealed in a gradual and subtle manner could be an important consideration.

After the collapse of the housing bubble in the early 1990s, the Japanese government launched a series of large fiscal stimulus packages, which most often include plans for public investment and infrastructure construction. With the mounting public debt, however, the public became wary of the fiscal sustainability and, consequently, the long-term plans were successively terminated in the early 2000s. Since then, most of the component-specific plans were integrated to a single "provision of social capital" plan that does not state explicit amount of planned investment. The share of public investment per GDP since 2000 declined substantially as shown in Figure 1.

[9]For example, on Feb 11, 1997, the *Yomiuri Shimbun* predicted the planned investment for the 12th road maintenance plan to be more than 100 trillion yen. The actual amount was 78 trillion yen. On May 20th, 1982, the *Yomiuri Shimbun* reported a meeting of national road users association, in which the participants demanded that the planned investment for the 9th road maintenance plans to be 50 trillion yen. The actual amount was 38.2 trillion yen.

3 Empirical models

This section outlines the empirical strategy of the study. I first discuss the excess returns of the road pavement firms. I then discuss the local projection-IV estimation.

3.1 Excess Returns of Road Pavement Firms

I follow Fisher and Peters (2010) and treat excess return of road pavement firms as a news shock about future public investment. If the movement in the stock return reflect unexpected change in belief about future road investment, the use of excess return should alleviate the problem of anticipation effects.

The choice of road pavement firms is motivated by the following two facts: 1) the road construction constitutes the largest fraction of total infrastructure investment, and 2) the road constructions are almost exclusively initiated by government-related agencies. First, the road construction has been the single largest component of the infrastructure investment in Japan, ranging from 20-35% of total public infrastructure investment between 1970-2013 as shown in Figure 2. Since it accounts for the largest fraction of overall infrastructure investment, the changes in the road investment should be reflected in the overall changes in the public investment or even in the total government spending. Thus, in an effort to search for a group of firms whose stock return movement can be translated as a credible indicator for the future public investment or future government spending, the road pavement firms seems to be first and appropriate choice. Second, the road investment in Japan is almost exclusively initiated by government-related agencies. Figure 3 show the survey result from the 50 largest construction firms in Japan, illustrating that the share of road investment orders issued from the government related agencies has been almost always above 90 % since 1985. The dominance of the government-related agencies in the issuance of road construction orders suggests that the firms that specialize in the road construction are heavily government-dependent. If that is the case, the changes in public investment policies should be priced in to the road pavement firms' market valuation. Below, I conduct a preliminary test to assess the government-dependence of the selected road pavement firms by checking the correlation between the sales of road pavement firms and the government spending.

I define road pavement firms according to the 2007 Japan Standard Industry

Classification. The road pavement firms are the firms whose main segment of activity is classified as D-0631 (pavement construction). Pavement firms that fall into this category are Nippo, Toa Road Corporation, Maeda Road, Nippon Road, Seiki-Tokyu Kogyo, Mitsui-Sumiken Road, and Sato-Watanabe. The stock prices for the first five firms are available from 1977, while stock prices for Mitsui-Sumiken Road and Sato-Watanabe are available only from 1996 and from 2013, respectively. In order to maintain consistency, I drop the latter two firms from the dataset.

Figure 4 plot the detrended (third polynomial) log of real government spending and the detrended log of real sales for two groups of firms. On the left panel, the sales of top four construction firms (in blue dotted line) and total government spending (in red solid line) are depicted.[10] The sales of top four construction firms are studied here to compare and contrast the results with the road pavement firms. The sales of top construction firms align closely with the the total government spending until the housing bubble collapsed in beginning of the 1990s. Immediately after the bubble burst, the sales of the top construction firms plummeted. The government spending, on the other hand, steadily increased even after the burst of the bubble and eventually peaked in 1997. The dynamics of the sales of the top four construction firms and total government spending since then diverged, yielding the contemporaneous correlation between them of 0.079.

The right panel of Figure 4 shows detrended sales of the five road pavement firms in blue dotted line and total government spending in red solid line. In contrast to the top four construction firms, the sales of the road pavement firms line up well with the total government spending throughout the periods, yielding the contemporaneous correlation of 0.722. Most notably, the sales did not collapse immediately after the bubble burst but continued to rise and peaked in 1997 when the total government spending also peaked. The rise of the sales in the early 2010s also coincides with the rise of the total government spending. The initial preliminary test suggests that the sales of the selected road pavement firms depend significantly on the government spending and that the stock prices of these firms can be a credible indicator of the total government spendings. Additionally, Figure 5 show the relationships between detrended sales of the firms and the public investment. The figure conveys the same message that the correlation between the public investment and the sales of the road pavement firms is high while the correlation with the sales of top four construction

[10]Top four construction firms are: Taisei corporation, Obayashi corporation, Shimizu corporation, and Kashima.

firms is close to zero.

Motivated by these findings, I use the excess return of the selected road pavement firms as indicators for public investment news shocks. I define excess return to be the difference between the stock price of the road pavement firms and the average stock price for the market:

$$ER_t^{\text{Road}} = log(\text{Stock Price}_t^{\text{Road}}) - log(\text{Stock Price}_t^{\text{Market}}) \tag{1}$$

where $\text{Stock Price}_t^{\text{Road}}$ is the road pavement firms' average stock price and $\text{Stock Price}_t^{\text{Market}}$ is the average Nikkei stock price index. Obviously, ER_t^{Road} is endogenous because road investment was frequently used for stimulus purposes and because it likely reflects overall economic conditions. I thus regress ER_t^{Road} on current and past macroeconomic and financial variables and use the orthogonalized residuals as instruments/news shocks about public investment policies. This identification strategy is same as estimating the VAR with the excess return placed at the last in the causal order.

Following Fieldhouse, Mertens, and Ravn (2017), the excess return shocks are defined as the residual from the following regression:

$$ER_t^{\text{Road}} = \widehat{\alpha} + \widehat{\xi} W_t + \widehat{\phi}(L) V_{t-1} + er_t^{\text{Road}} \tag{2}$$

where W_t includes log difference in output, government spending, tax income, difference in unemployment rate, GDP deflator, log of fiscal stimulus package, and recession/exit indicator. V_{t-1} includes four lags of all the variables in W_t and the four lags of ER_t^{Road}, excess return of Nikkei construction industry, 1-year, 3-year and 5-year Japanese Government bond rates, and log change in real exchange rates. The baseline model does not include the current financial variables as the controls because assuming that the ER_t^{Road} does not affect the current financial variables might be too restrictive. In the robustness check, I show a version of result that includes current financial variables as the controls. The residual from the regression, er_t^{Road}, is the measure of public investment news shocks that are orthogonal to the current state of macroeconomy.

3.2 Measuring multipliers

Using the extracted measure of public investment news shocks, I estimate the effects of public investment shocks using the local projection IV method (Jordà (2005) and Ramey and Zubairy (2016)). The local projection method estimates impulse response functions directly by regressing a variable of interest h-periods ahead on shocks and lagged controls variables. The local projection IV method is same as the local projection method except that it uses the shocks as instruments for a variable and use them to estimate the causal impacts of the variable of interest on the dependent variable. One of the advantages of the local projection method is that it is a model-free estimation and does not require imposing linear restrictions on the estimated dynamic responses.

I first estimate the impulse responses to a shock in er_t^{Road}. I estimate the following regression for different horizons h:

$$y_{t+h} = \alpha_h + \gamma_h \, er_t^{\text{Road}} + \theta_h(L)X_{t-1} + \nu_{t+h} \tag{3}$$

where $y_{t+h} = \frac{Y_{t+h}-Y_{t-1}}{Y_{t-1}}$ is the sum of output from t to $t+h$ normalized by output in period $t-1$. er_t^{Road} is the measure of public investment news shocks extracted from equation 2. The regression also includes controls, X_{t-1}, which are four lags of log output, government spending, tax income, as well as level of unemployment rate, and ER^{Road}. My choice of including the unemployment rate as the control variables is based on Barro (1981) and Barro and Redlick (2011), who argued that the unemployment rate contains extra information about the business cycle movement compared to output data.

To take into account the dynamic aspect of responses in output and government spending, I calculate the cumulative output multiplier following Ramey and Zubairy (2016):

$$\sum_{j=0}^{h} y_{t+j} = \beta_h + M_h \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \phi_h(L)X_{t-1} + u_{t+h} \tag{4}$$

where G_t is the government spending in periods t and $\sum_{j=0}^{h} \frac{G_{t+j}-G_{t-1}}{Y_{t-1}}$ is the sum of the government spending from t to $t+h$ normalized by output in period $t-1$. Because both dependent variable and government spending are normalized by output, M_h has the direct interpretation as the cumulative output multiplier. M_h is estimated using the instrument, er_t^{Road}. The controls are the same as equation 3. I calculate 90%

confidence bands using the heteroskedasticity and autocorrelation consistent (HAC) standard errors. I choose automatic bandwidth selection for estimation.

4 Data

Most of the data are identical to Miyamoto, Nguyen, and Sergeyev (2017). All variables are expressed in per capita and deflated by the GDP deflator except for the financial variables. The stock prices for road pavement firms as well as Nikkei average are from the Nikkei FinancialQuest. I use the adjusted closing price on the last day of each quarter for the stock price of the firms. As Miyamoto, Nguyen, and Sergeyev (2017) notes, data for government spending are created as the sum of adjusted government consumption and public investment so that the data are consistent with other related studies. Adjusted government consumption is calculated as the government consumption less transfer of goods.[11] Tax data, obtained from the National Accounts starting in 1980Q1, are the total of direct and indirect taxes minus subsidies. The dataset spans from 1980Q2 to 2014Q1.

5 Results

This section shows the estimated results. I first describe the extracted news shock and discuss their relevance as an instrument variable for government spending. I then estimate the public investment multiplier of output.

5.1 Extracted shocks

The extracted shocks, er_t^{Road}, from equation 2 are shown in Figure 6. The extracted shocks are very volatile and there is no noticeable sign of state-dependence. I test the relevance condition of the IV by estimating the regression equation 3 with the dependent variable specified as the cumulative change in the government spending normalized by output. Figure 7 show impulse response of government spending following a shock in er_t^{Road}. The response of government spending is initially zero, but

[11] Please refer to Appendix 7 of Miyamoto et al. (2017) for the discussion of the construction of the adjusted government spending.

it gradually increases and peaks in the 5th quarters. The response is positive and statistically different from zero except for the first few quarters. Figure 8 shows the associated robust F-statistics. The F-statistic is initially low, but it increases shapely and peaks in the 5th quarter. The F-statistics exceeds the threshold value of 23.1 between the 3rd quarter and the 7th quarter. The result is somewhat strinking, given that Ramey (2016) reported that the F-statistics of Fisher and Peters (2010)'s military spending news shocks does not exceed 5 for all horizons when its relationship with the total government spending was examined. In addition, the shape of the F-statistics is different from the shapes of F-statistics using a typical BP shock, in which the peak would appear in the very short horizons. The fact that the F-statistics only peaks after 4 quarters indicates that the extracted shocks capture "news" element of the government spending. In fact, the F-statistics from the military spending news shock by Ramey and Shapiro (1998) exhibits a similar pattern, in which the peak only comes a year after the shock.

Even though the F-statistics indicates that the extracted measure of news shocks predicts the total government spending, it is not clear what component of the spending was predicted by the news shocks. To credibly estimate the public investment multipliers, the news shocks should predict the total government spending only through public investment component of the spending and not through public consumption. To this end, I estimate the regression equation 3 using (a) public investment and (b) public consumption as a dependent variable.[12] The left panel of Figure 9 show the response of public investment. The response is adjusted so that the peak response becomes 1. The pattern of response is similar to the total government spending; the initial response is close to zero, but it increases as the number of horizon increases. The response is statistically significant for almost all horizons. The right panel of Figure 9 show the response of government consumption. The response is adjusted so that the magnitude of the shock is the same as the shocks that increased the public investment by 1 at its peak. In contrast to the response of public investment, the response of public consumption is weak and is not positive. Instead, the results indicate that the responses of public consumption are sometime weakly negative at longer horizons. The evidence suggests that the extracted measure of news shocks predict the increase in total government mostly through the increase in public investment component of the government spending and not through the public consumption.

[12]Both of the variables are expressed as a cumulative sum and normalized by the output.

5.2 Output multipliers: baseline model

I now present the responses of output to an unexpected public investment news shock that increases government spending by 1 percent of output using equation 3. The impulse response of output is shown in Figure 10. The response is initially zero, but it gradually increases and peaks at 4.9 percent in the 12th quarter. The output, then, eventually returns to zero in the 24th quarter.

Next, I estimate the output multiplier that takes into consideration the dynamics of the government spending response. Figure 11 plot the output multipliers and their confidence bands. I omit the initial 2 quarters from the figure for an illustration purpose because the confidence bands are too wide due to the low F-statistics during these horizons. The result shows that the output multiplier is 1.64 four quarters after the shock. This estimate is larger than conventional estimates of output multipliers for the US and other countries including Japan. The multiplier, however, is in line with the on-impact fiscal multiplier during the zlb periods as reported in Miyamoto, Nguyen, and Sergeyev (2017) and is smaller than the road investment local fiscal multiplier reported by Leduc and Wilson (2013). The multiplier steadily increases and peaks in the 17th quarter at 4.95, which is considerably larger than the fiscal multiplier even during the zlb periods and is in line with the peak multiplier from Leduc and Wilson (2013). The multiplier then starts to slowly decline. The 90% confidence bands are initially large and include zero at short horizons, but they shrink as the number of horizon increases, making the multiplier statistically significant at the middle and long horizons.

5.3 Robustness check

I perform several robustness checks of the baseline results. To make sure that the extracted excess return shocks are orthogonal to the current state of economy, I add more control variables to equation 2. Specifically, I performed the following four robustness checks: 1) use public investment deflator instead of GDP deflator, 2) add public works order, 3) add public construction order, and 4) control contemporaneous financial variables. The public investment deflator is used instead of the GDP deflator because it might be a more suitable indicator for the cost of infrastructure construction. Public works order and public construction orders are added so that the residual variation in the excess return do not respond to the increase in the public

investment orders that are not yet reflected in the public investment data. All results are shown in Figure 12, and they remain largely the same as the baseline results. The only meaningful difference is found when contemporaneous financial variables are included in equation 2. In this case, the multiplier at the short horizons becomes more than twice larger than the baseline multiplier, which suggests that the assumption of no contemporaneous effects from the excess return of road pavement firms to other financial variables might be too restrictive. Despite this difference at the shorter horizons, the multiplier at middle and longer horizons remains close to the baseline result.

I also examine how changing the baseline specification influence the estimates of the multipliers. I first include a quadratic time trend. Second, I normalize changes in government spending and output in the equations 3 and 4 by a potential output estimated by the HP-filter. With the exception of multipliers at the longer horizons for the case of the quadratic trend, the results are similar to the baseline model. When the trend is included, the standard errors become wider at the longer horizon, which reflects low F-statistics during these horizons. However, the multipliers at shorter and middle horizons remain similar to the baseline results even when the trend is included. Normalization with the potential output does not make any meaningful difference in the estimated results.

6 Multipliers of Other Variables

I found that the public investment multipliers are considerably larger than conventional estimates of government spending multipliers. I investigate if the public investment multipliers for other macroeconomic variables are also different from the previous studies.

6.1 Consumption and investment multiplier

As with the case for output multiplier, I compute the cumulative multipliers for consumption and investment. For example, I estimate the consumption multiplier

using the following regression:

$$\sum_{j=0}^{h} c_{t+j} = \beta_h^c + M_h^c \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \phi_h^c(L) X_{t-1} + u_{t+h} \tag{5}$$

where $c_{t+j} = \frac{C_{t+j} - C_{t-1}}{Y_{t-1}}$. M_h^c is the cumulative consumption multiplier and is estimated using the instrument, er_t^{Road}. The controls are the same as equation 4 plus the four lags of the dependent variable.

The left panel of Figure 13 show the multiplier of consumption. The multiplier is above 1 starting from the second quarter and stays at around 1 for more than 20 quarters. The investment multiplier, on the other hand, is close to zero at short horizons and gradually rises to 3 by the 17th quarters. The consumption multiplier is similar to the estimated consumption multiplier during the zlb periods in Miyamoto, Nguyen, and Sergeyev (2017). The investment multiplier is considerably larger than the estimated investment multipliers both during the normal and zlb periods in Miyamoto, Nguyen, and Sergeyev (2017), in which the multiplier even during the zlb peaks at around 1.2. The result shows that the public investment multipliers for consumption and investment are also very large.

6.2 Unemployment multiplier

To investigate if the public investment has a similarly large impact on labor market, I estimate the multiplier of the unemployment rate. As with the the output and other multipliers, I estimate the multiplier of the unemployment rate as the cumulative percentage point change in the unemployment rate in response to a change in government spending by 1 percent of output. Figure 14 show the multipliers of the unemployment rate. The multiplier is weakly positive during the first three quarters, which then gradually decreases and reaches -0.7 in the 17th quarter. The positive multiplier at short horizon is not statistically significant, while the negative unemployment rate multiplier at longer horizons is statistically significant at 90% level. The unemployment rate multiplier is similar to the multipliers during the zlb periods in Miyamoto, Nguyen, and Sergeyev (2017). Since my sample include both normal and zlb periods, the result is indicative that the public investment multiplier for the unemployment rate is also greater in magnitude than the previous estimates of the government spending multiplier.

6.3 Tax multiplier and interest rate response

What explain the larger public investmnet multipliers? Ramey (2011a) highlighted that the magnitude of multipliers crucially depends on the tax and monetary policy responses. She explained that the government spending multipliers are generally larger when the spending is deficit financed and when monetary policy response is weak. To explore the possibility that tax and interest rate responses explain the large public investment multipliers, I estimate the tax multiplier and the interest rate response. The tax rate is defined as a ratio of tax revenues to output. As with the case of other multipliers, the cumulative multipliers of the average tax rate are estimated using equation 5. The left panel of Figure 15 show the tax multiplier. The tax multiplier is initially close to zero, but it increases to 2 at its peak in the 17th quarter. Since the average tax rate seems to respond positively to the government spending, the large public investment multipliers is unlikely to be explained by the tax response.

The right panel of Figure 15 show the response of short-term nominal interest rate. The response is calculated using equation 3 with the dependent variable being replaced with the interest rate h periods ahead. The figure indicates that the short-term interest rate responds positively to the public investment news shocks. The result suggests that the large public investment multiplier is also unlikely to be explained by the weak monetary policy response. These results suggest that the estimated public investment multiplier is large not because of unresponsive tax or interest rate policies, but is likely due to other reasons including different characteristics of this type of spending.

6.4 Inflation rate multiplier

Lastly, I estimate the cumulative multiplier of inflation. The multipliers are estimated using the impulse response of the nominal price index over the cumulative change in government spending as a dependent variable in the equation 5. I use both the GDP deflator and the CPI measures of inflation, and they both produce similar results.

Figure 16 show the multipliers of inflation using the GDP deflator on the left panel and using the CPI measure on the right panel. The results from both measure of inflation indicate that the news shock is deflationary in the initial 7 quarters.

The inflation rate multipliers then rise to a positive territory after 12 quarters and become statistically significant. In summary, the public investment shocks are initially deflationary but increase the inflation rate at longer horizons.

7 Rolling estimation: declining output multiplier?

Previous sections show that the public investment multipliers on average is larger than the conventional estimates of government spending multipliers between 1980 and 2014. Another important policy relevant question is: what is the public investment multipliers given the current stock of infrastructure? If the public investment is different from other government spending for its productive capacity, one would think that the effects of public investment might depend on the marginal gain in the aggregate productivity due to the additional stock of public investment. To investigate this question, I estimate a twenty-year rolling-window regression using the equation 4.

Figure 17 show the cumulative output multipliers in the 4th quarter (on the left) and in the 6th quarter (on the right) using different twenty-year sample periods. The result is indicative of the declining output multipliers over time. The fourth quarter multiplier estimated using the 1981-2001 window is about 4 whereas the multiplier using 1990-2010 window is about 0.2. Despite that the standard error generally increases as the sample periods cover more recent periods, there is a general trend that the estimated multiplier declines over time. The declining trend is less obvious for the 6th quarter, but the trend is evident prior to 2001. The analysis does not provide rigorous statistical evidence of the declining multipliers, but it is suggestive that the public investment multipliers on the current stock of infrastructure are smaller than the multipliers 30 years ago.

8 Are the findings consistent with rational agent model?

I found that the public investment multiplier of about 1.64 a year after the shock and about 5 after four years, which is considerably larger than conventional estimates of government spending multipliers. I discuss briefly if the findings can be rationalized

using the macroeconomic models.

Despite that the fiscal multiplier is one of the most debated topics, much of the theoretical models treat the government spending as wastes. Few theoretical models studied the role of productive government spending. One of these exceptions are Baxter and King (1993), who showed that public investment multipliers can be between 4 and 13 in the long-run. Another example is Leduc and Wilson (2013) who built an open economy, monetary union model to study the effects of public investment. Their model produced on-impact multiplier of 0.3 and peak multiplier of 2. They also reported that highly persistent spending shock can produce peak-multiplier of 7. Morita (2017) built a model with price and wage stickiness, rule-of-thumb households, debt financing, and wage union, and computed the multiplier of about unity. Using a neoclassical growth model, Uhlig (2010) showed the the public investment multiplier can exceed unity in the short-run, but it could also be negative in the long-run depending on tax policy. Finally, Leeper, Walker, and Yang (2010) showed that multipliers depend on the implementation lag and that substantial delay produces negative multiplier.

Overall, the public investment multipliers of 2 to 5 do not necessarily contradict with the multipliers implied by the existing macroeconomic models. Future research agenda includes building a theoretical model to explore a mechanism behind the empirical findings of the current paper.

9 Conclusion

In this paper, I estimated the government spending multipliers using the public investment news shocks extracted from the excess return of road pavement firms in Japan. I found that the residual variation in the excess return of road pavement firms predict the future government spending and that it predict the government spending through changes in public investment.

Using the residual variation in the excess return, I found that the public investment multipliers are considerably larger than the government spending multiplier reported in previous studies. The estimated public investment multipliers are about 1.64 a year after the shock and about 5 after four years. The public investment are also found to crowd in consumption and investment. Moreover, the cumulative

multipliers of consumption and investment are both larger than the estimated multipliers in previous studies. In addition, similarly large public investment multipliers are reported for the unemployment rate.

I highlighted that the large public investment multipliers are unlikely to be explained by unresponsive interest rate and tax rate policies as both rates increase after the increase in public investment. Interestingly, the inflation rate is found to go down initially after the spending shock but it rises after 2-3 years.

Finally, I show an evidence that is consistent with the hypothesis of a declining multiplier. Using rolling estimations, I found that the public investment multipliers exhibit a general declining trend over time. The evidence is suggestive that the public investment multiplier depends on the marginal productivity of the investment and that the public investment multipliers on the current stock of infrastructure are smaller than the multipliers 30 years ago.

This paper provides one of the first direct macroeconomic estimates on the impacts of public investment. The findings suggest that, in addition to the *amount* of the spending, the *type* of government spending is also an important consideration when conducting countercyclical fiscal policies.

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Tables

Table 1: Comprehensive Public Investment Plans

(A) Comprehensive National Development Plan (CNDP)

	Approved on	*Coverage periods*	*Planned investment*
Comp. National Dev. Plan	1962.10.5	target year: 1970	N/A
2nd Comp. National Dev. Plan	1969.5.30	1966-1985	130-170 trillion yen
3rd Comp. National Dev. Plan	1977.11.4	1976-1989	370 trillion yen
4th Comp. National Dev. Plan	1987.6.30	1986-2000	1000 trillion yen
5th Comp. National Dev. Plan	1998.3.31	target year: 2010-2015	N/A

(B) National Land Use Planning (NLUP)

	Approved on	*Coverage periods*	*Planned road investment*
National Land Use Plan.	1976.5.18	1972-1985	210,000 ha
2nd National Land Use Plan.	1985.12.17	1982-1994	240,000 ha
3rd National Land Use Plan.	1996.2.23	1992-2005	200,000 ha
4th National Land Use Plan.	2008.7.4	2004-2017	70,000 ha

(C) Basic Plan for Public Investment (BPPI)

	Approved on	*Coverage periods*	*Planned investment*
Basic Plan for Pub. Invest.	1990.6.28	1991-2000	430 trillion yen
New Basic Plan for Pub. Invest.	1994.10.7	1995-2004(2007)	630 trillion yen

Notes: coverage periods in fiscal years. Planned investment for 2nd, 3rd, and 4th CNDP are expressed in yen in 1965, in 1975, and in 1980, respectively. Planned investment for NLUP include various goals including roads, farm land, forest, plain field, rivers and waterways, and housing land. The table shows the goal for road pavement only. Planned investment for BPPI are expressed in nominal values at the time of plan approval. The coverage periods for New Basic Plan for Public Investment were initially 1995-2004 but were later expanded to 1995-2007.

Table 2: List of Long-term Infrastructure Plans

		First plan began in	*duration*	*discontinued in*
(1)	*Fishing Harbors*	1951	5 years	2001
(2)	*Roads*	1954	5 years	2002
(3)	*Erosion and Flood Controls*	1960	5 years	2003
(4)	*Forest*	1992	5 years	2003
(5)	*Municipal Parks*	1972	5 years	2002
(6)	*Sewage System*	1963	5 years	2002
(7)	*Waste Disposal*	1963	5 years	2002
(8)	*Coastal Areas*	1970	5 years	2002
(9)	*Dock and Harbor*	1961	5 years	2002
(10)	*Airport*	1967	5 years	2002
(11)	*Traffic Safety Facilities*	1966	5 years	2002
(12)	*Housing*	1966	5 years	2000
(13)	*Coastal Fishing Ground*	1976	5 years	2001
(14)	*Land Improvement*	1965	10 years	continuing
(15)	*Steep Slope Failure Prevention*	1983	5 years	2002

Notes: in fiscal year.

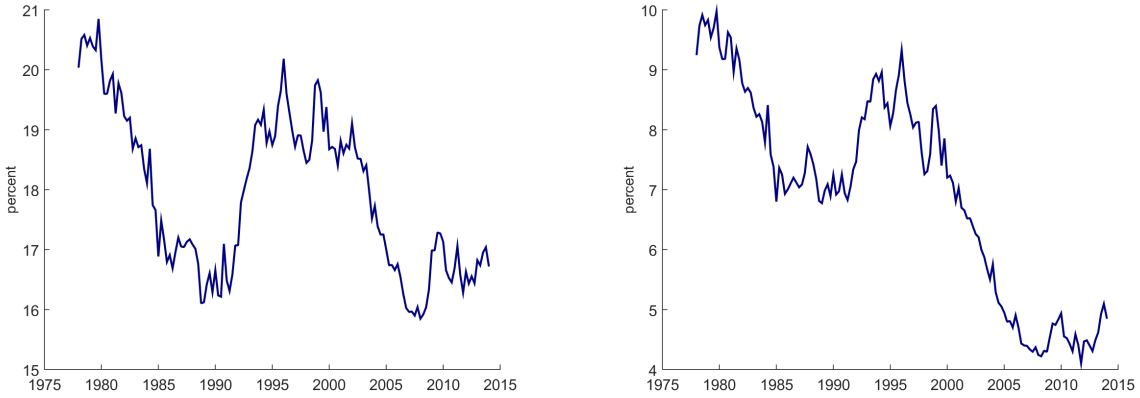
Table 3: 5-year Road Investment/Maintenance Plans

	Begins in	*Ends in*	*Planned investment*
1st plan	1954	1958	0.26 trillion yen
2nd plan	1958	1962	1 trillion yen
3rd plan	1961	1965	2.1 trillion yen
4th plan	1964	1968	4.1 trillion yen
5th plan	1967	1971	6.6 trillion yen
6th plan	1970	1974	10.35 trillion yen
7th plan	1973	1977	19.5 trillion yen
8th plan	1978	1982	28.5 trillion yen
9th plan	1983	1987	38.2 trillion yen
10th plan	1988	1992	53 trillion yen
11th plan	1993	1997	76 trillion yen
12th plan	1998	2002	78 trillion yen

Notes: in fiscal year.

Figures

Figure 1: Government spending and public investment as a share of GDP

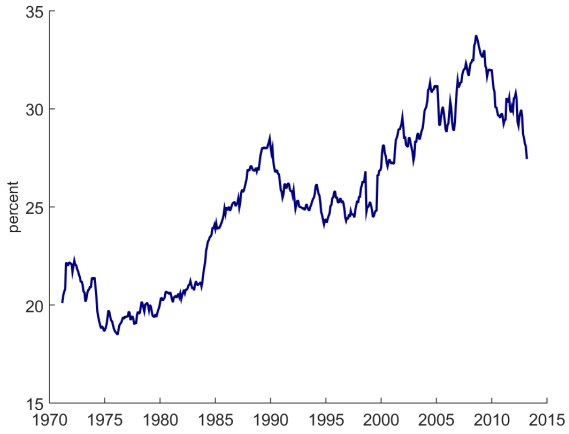


(a) Government Spending/GDP

(b) Public Investment/GDP

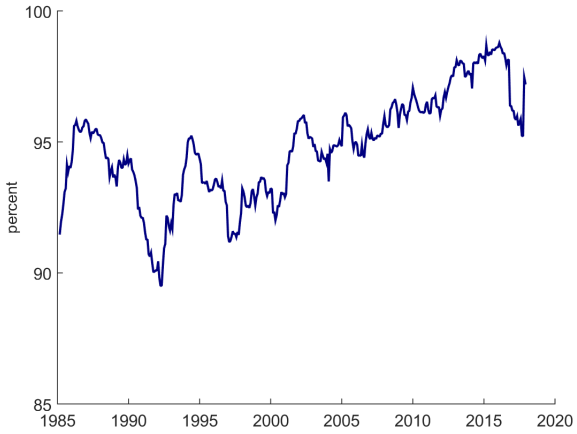
Notes: Data from SNA.

Figure 2: Percent of Road Investment



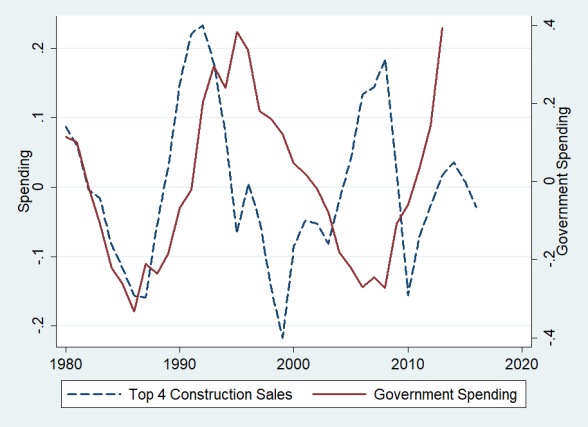
Notes: Data from Comprehensive Statistics on Construction (Kensetsu-Sougou Toukei) conducted by Ministry of Land, Infrastructure, The series in the figure is calculated by dividing the road construction orders by total infrastructure construction orders, both in 12-month moving-average.

Figure 3: Share of Road Construction Orders from Government-related Agencies

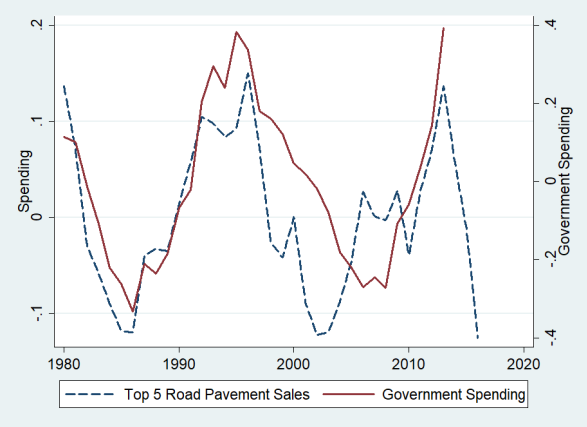


Notes: Data from Current Survey on Orders Received for Construction, big 50 constructors (A-group survey) conducted by Ministry of Land, Infrastructure, Transport and Tourism. The series in the figure is calculated by dividing the road construction orders by total infrastructure construction orders, both in 12-month moving-average.

Figure 4: Sales and total government spending



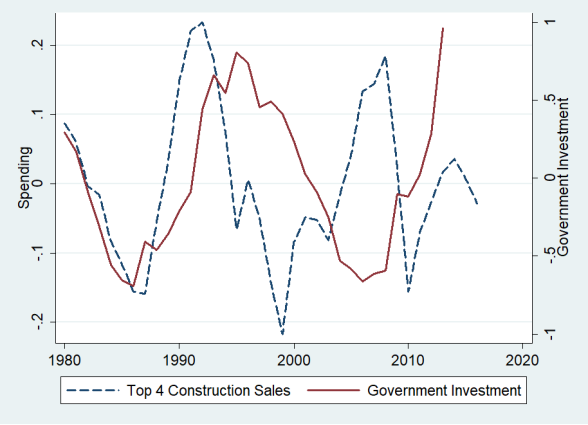
(a) Sales of top 4 construction firms



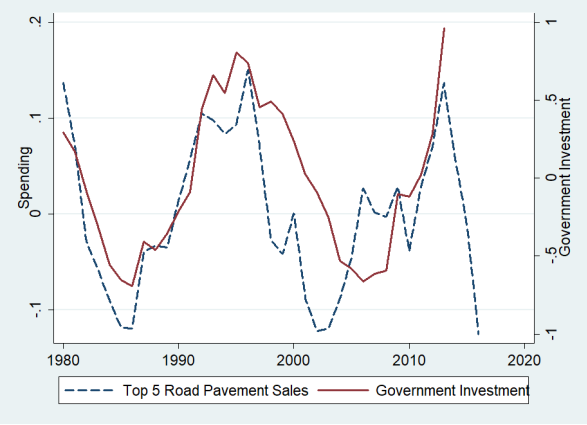
(b) Sales of 5 road pavement firms

Notes: Top 4 construction firms are Taisei corporation, Obayashi corporation, Shimizu corporation, and Kashima. Road pavement firms are Nippo, Toa Road Corporation, Maeda Road, Nippon Road, Seiki-Tokyu Kogyo
Source: Annual financial report

Figure 5: Sales and public investment



(a) Sales of top 4 construction firms
$\text{Corr}(\text{Sales}_t, \text{Pub.Inv}_t) = 0.028$



(b) Sales of 5 road pavement firms
$\text{Corr}(\text{Sales}_t, \text{Pub.Inv}_t) = 0.717$

Figure 6: er_t^{Road}

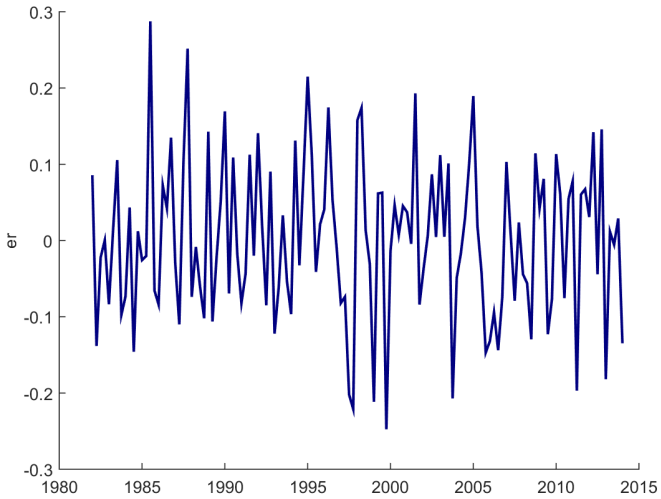
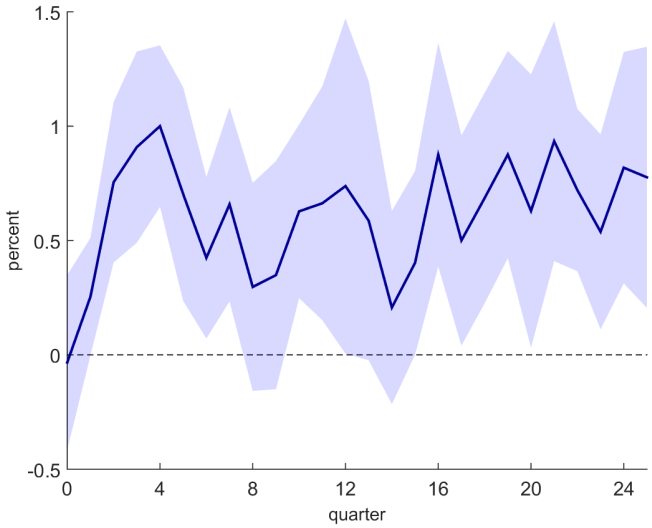
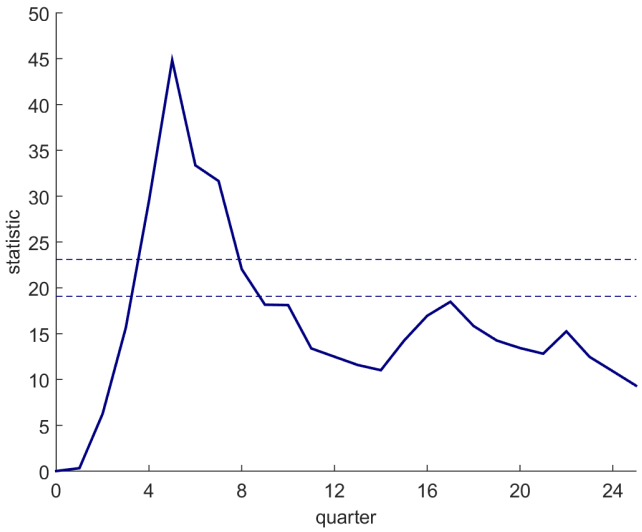


Figure 7: Government spending impulse response



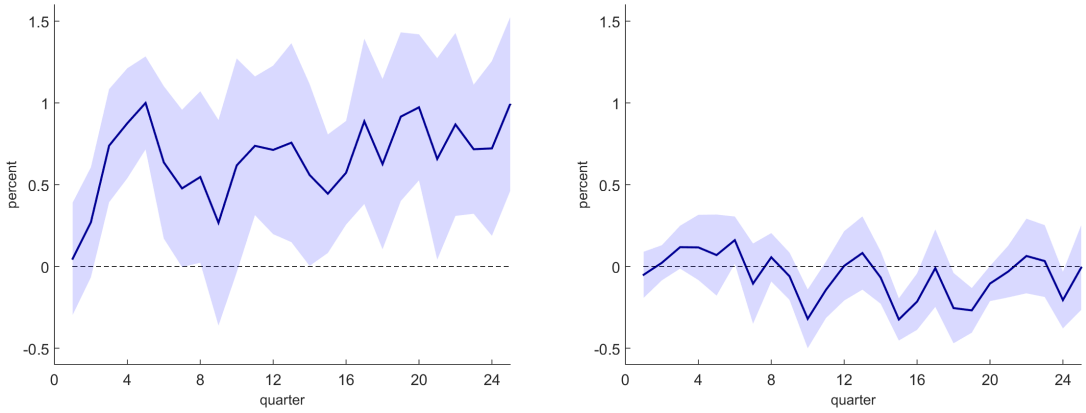
Notes: Shaded are represents 90% confidence bands. The responses are adjusted so that the peak effect is 1.

Figure 8: First stage robust F-statistic



Notes: The threshold is 23.1 for one instrument for the 5% critical value for testing the null hypothesis that the two-stage least squares bias exceeds 10% of the OLS bias, and 19.7 for 10% critical value.

Figure 9: Response of public investment and public consumption

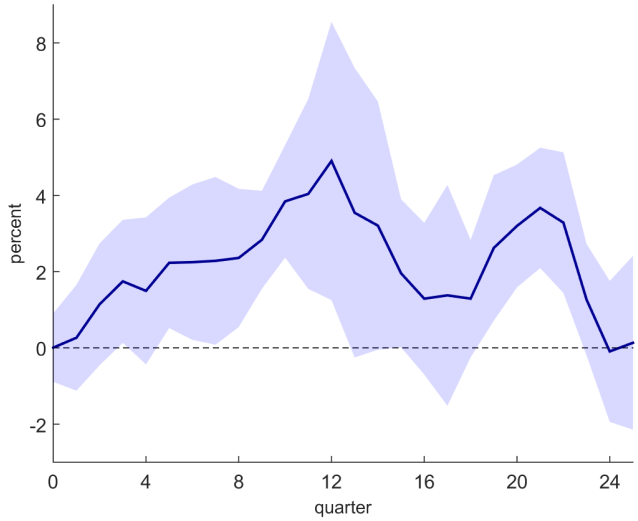


(a) Public investment

(b) Public consumption

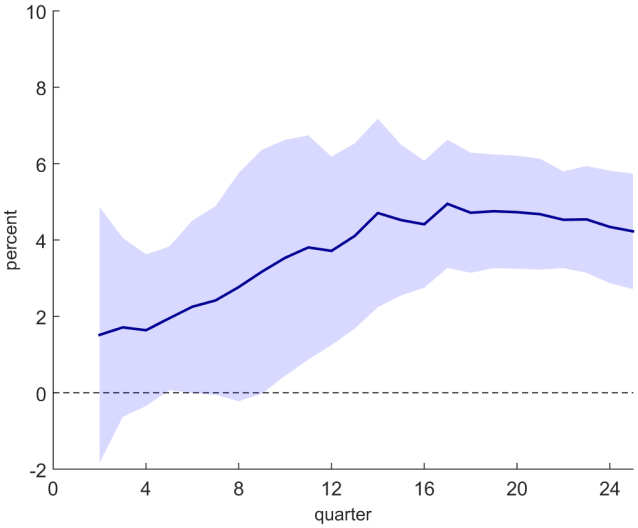
Notes: Shaded are represents 90% confidence bands. The responses are adjusted so that the peak response of public investment is 1.

Figure 10: Response of output



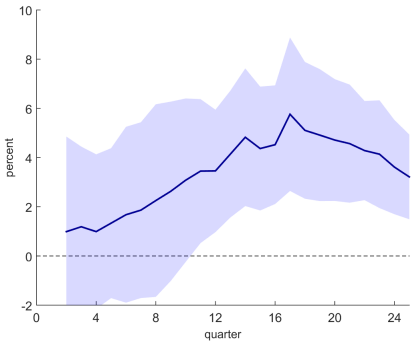
Notes: Shaded area represents 90% confidence bands

Figure 11: Cumulative output multipliers

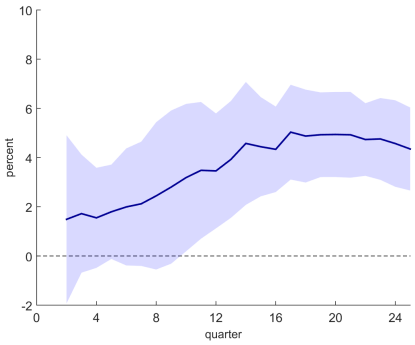


Notes: Shaded area represents 90% confidence bands

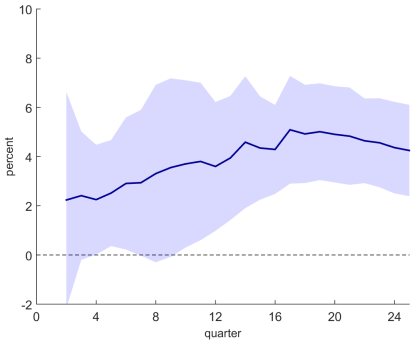
Figure 12: Robustness checks



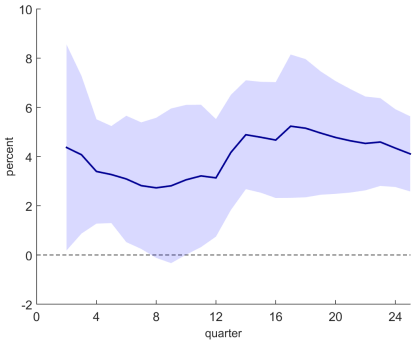
(1) Public investment deflator



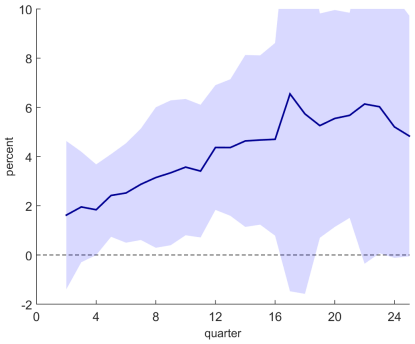
(2) Public works order



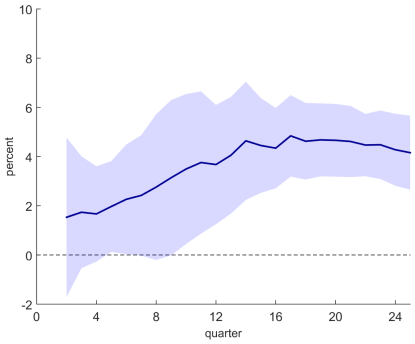
(3) Public construction order



(4) Contemporaneous financial var.

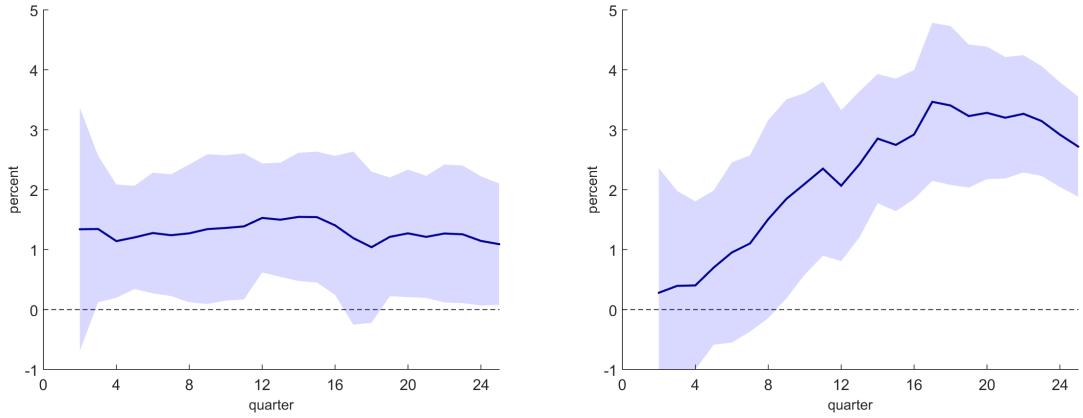


(5) With trend



(6) Potential output

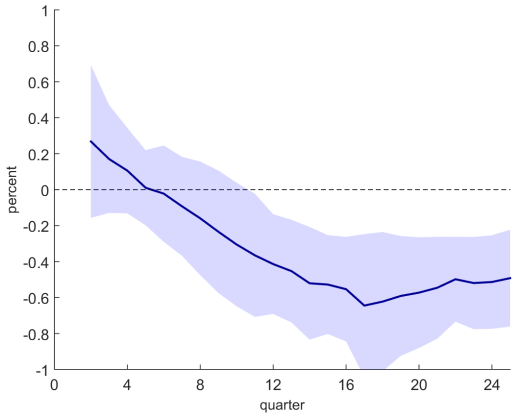
Figure 13: Consumption and investment multipliers



Consumption Investment

Notes: Shaded areas represent 90% confidence bands

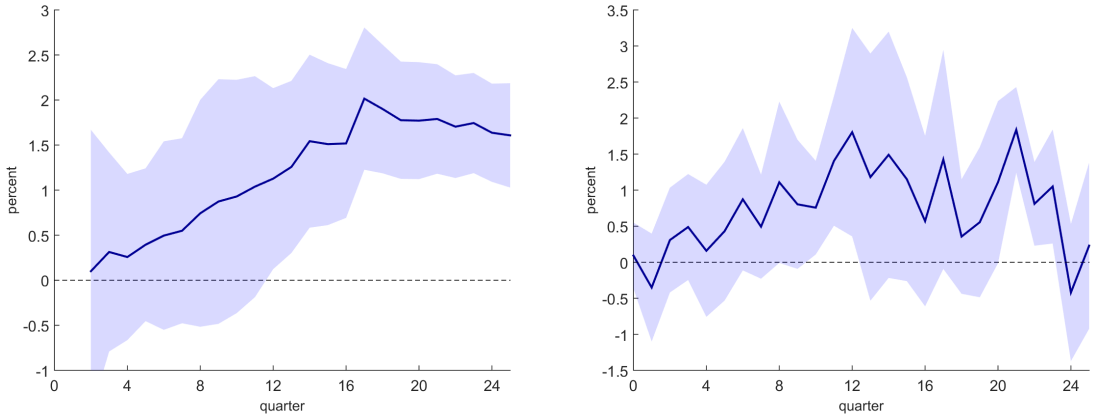
Figure 14: Unemployment rate multipliers



Unemployment rate

Notes: Shaded areas represent 90% confidence bands

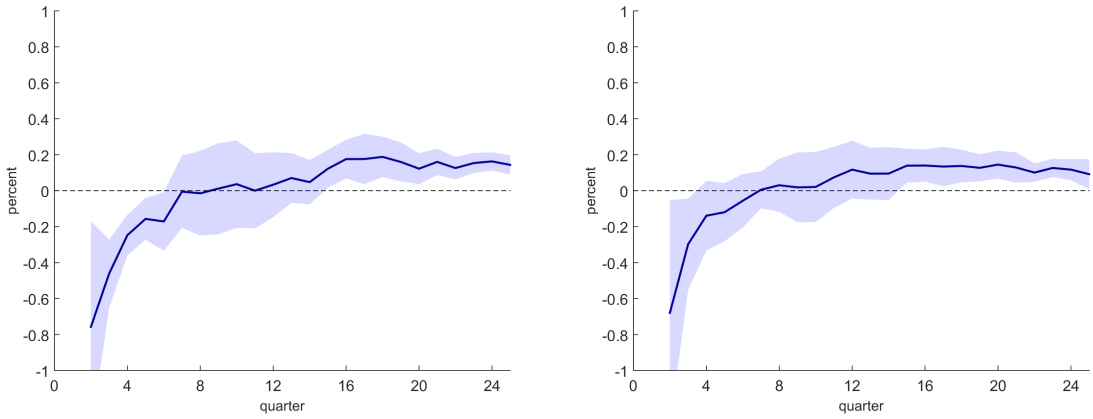
Figure 15: Tax multiplier and interest rate response



Tax | Short-term nominal rate

Notes: Shaded areas represent 90% confidence bands

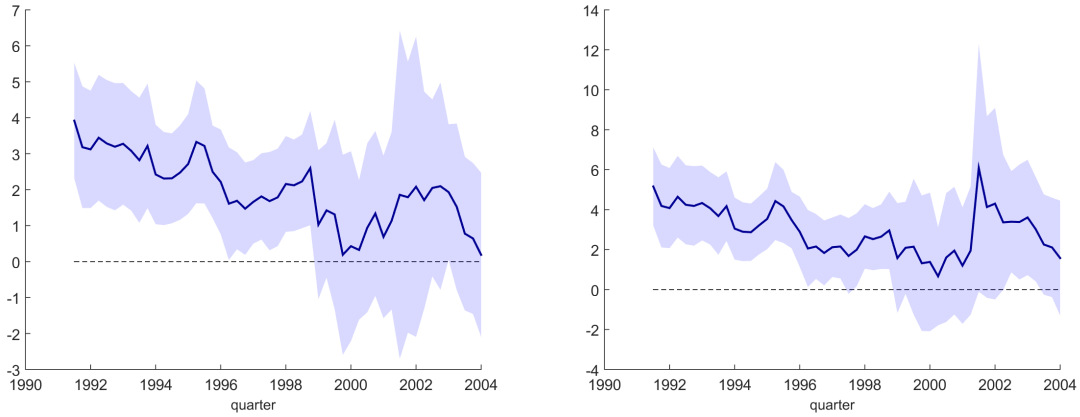
Figure 16: Inflation multipliers



Inflation (GDP deflator) | Inflation (core CPI)

Notes: Shaded areas represent 90% confidence bands

Figure 17: Rolling estimation



(a) 4 quarters after the news

(b) 6 quarters after the news

Notes: The year of a reported multiplier corresponds to the middle year of the 80-quarter window. For example, a multiplier reported for 2000Q1 is estimated over the period 1990Q1-2010Q1.
Notes: Shaded areas show confidence bands with 1 standard error