Public Investment Multipliers: Evidence from Stock Returns of the Road Pavement Industry in Japan

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Abstract

This study contributes empirical evidence of the macroeconomic impacts of public investment. I extract public investment news shocks from the excess returns of narrowly defined road pavement firms and use them as an instrument for future public investment spending. Using Japanese data for the period between 1980 and 2014, I find that when the news shock is followed by a persistent increase in public investment and a weak real interest rate response, the public investment spending has a significant stimulative effect over the medium term. The estimated cumulative multiplier is as large as 6.10, four years after the shock. However, the cumulative multiplier eventually falls below 1 after 10 years. I also report a substantial temporary improvement in aggregate labor productivity associated with a rise in public investment spending.

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

JEL Classification: E32;E62;H54.

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1 Introduction

What is the public investment multiplier, defined as the percentage increase in GDP caused by an increase in public investment spending by one percent of GDP? Understanding the macroeconomic impact of public investment is critical, given that public investment typically constitutes a large part of countercyclical fiscal packages. For example, approximately 40% of non-transfer spending in the American Recovery and Reinvestment Act (ARRA) of 2009 was allocated to public infrastructure investment. Yet, it remains an open question whether the public investment has a larger or smaller multiplier. Leduc and Wilson (2013) and Ilzetzki et al. (2013) have provided some evidence that public *investment* has larger multipliers, while Boehm (2019) has suggested that public *consumption* has larger multipliers. This study contributes empirical evidence of the dynamic macroeconomic effect of public investment by exploiting the news shocks extracted from the excess returns of road pavement firms in Japan.

Estimating public investment multipliers is challenging because of the long implementation lag associated with public investment projects. As Leeper et al. (2013) emphasize, the failure to control for public expectations about future government spending can lead to incorrect inferences. To address this concern, I use the excess returns of Japan's road pavement firms to identify surprise components of the changes in public expectations about future public investment, following Fisher and Peters (2010). If the profitability of the selected road pavement firms depends heavily on public road investments, the shocks to their excess returns can be interpreted as surprise news about future public road investment spending. I regress the excess return on a number of contemporaneous and lagged economic and financial variables. The residuals from the regression are my measure of extracted news shocks.[1] To verify that the extracted news measure is orthogonal to the current state of the economy, I conduct a series of robustness checks.

I employ the local projection-IV method using the extracted news shocks as an instru-

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

mental variable to estimate the public investment multiplier. My identification strategy relies on two crucial assumptions: the instrumental variable 1) captures news about future public investment (relevance condition) and 2) affects output only through public investment spending (exclusion restriction). The relevance condition is directly testable. I show that the extracted news shocks predict future public investment at longer horizons in a statistically significant manner. I deal with the exclusion restriction by regressing the excess return on current and lagged macroeconomic/financial variables, as described above.

I find that the cumulative public investment multiplier is approximately 1.98 a year after the shock and as large as 6.10 after four years. The cumulative multipliers then slowly decline and reach 0.60, 10 years after the shock. The estimated multipliers in the middle horizons between the second and eighth years after the shock exceed 2 and are considerably larger than conventional estimates of fiscal multipliers. However, these estimates are in line with Leduc and Wilson (2013), who estimated cumulative public investment multipliers of 1.4 on impact and 6.6 at peak using state-level US data.[2] The cumulative multipliers fall below 1, which is consistent with the conventional estimates of the fiscal multipliers, 10 years after the shock. The estimated results are robust to different specifications. In addition, I find that public investment crowds in consumption and investment and that both multipliers in the middle horizons are larger than the multipliers in previous studies, which used different government spending shocks.

Finally, I empirically explore factors that could explain the large public investment multipliers. As suggested by Ramey (2011), the size of the fiscal multiplier depends on 1) the tax rate response, 2) real interest rate response, 3) persistence of government spending, and 4) the type of government spending. Investigating whether any of these factors contribute to the large public investment multiplier, I conclude that the combination of a weak real interest rate response and high persistence of public investment spending play key roles. Put differently, when these conditions are met, public investment can be an effective tool for stimulating the aggregate economy over the medium term. Additionally, I find a substantial

[2]Leduc and Wilson (2013) do not report the cumulative multipliers, but Chodorow-Reich (2019) calculates the cumulative multipliers based on the most conservative estimates of Leduc and Wilson (2013).

temporary improvement in aggregate labor productivity over the medium term associated with a rise in public investment.

1.1 Related Literature

This study contributes to a vast literature that estimates the macroeconomic impact of government spending (e.g., Ramey and Shapiro (1998), Blanchard and Perotti (2002), and Ramey (2011)). The literature tends to focus on estimating the effects of military spending or of total government spending. However, according to Fernald (1999), public investment such as road investment differs from other types of government spending in that road investment is more productive. Thus, it is expected that the public investment multiplier is different from other types of fiscal spending multipliers. Some recent studies provided aggregate evidence on the economic impact of public investment. Ilzetzki et al. (2013) found public investment multipliers ranging between 0.4 in the short run and 1.6 in the long run in their panel of countries.[3] Using Cholesky decompositions and after controlling for forecasts, Boehm (2019) estimated the public investment multipliers for a panel of OECD countries and found that the public investment multipliers are smaller than public consumption multipliers, and attributed the smaller multipliers of public investment to high intertemporal elasticity of substitution for investment demand. Ramey (2019) summarized the recent related literature and concluded that infrastructure investment is not effective in stimulating the economy in the short run but is likely effective in the long run. This study contributes new evidence of the aggregate public investment multiplier by reporting large public investment multipliers a few years after the news shock when the increase in public investment is highly persistent.

This study is also related to Leduc and Wilson (2013), who estimated the local road investment multiplier in the US by identifying highway spending news shocks at the state level. The authors' estimates of the cumulative fiscal multiplier are considerably greater than conventional estimates: 1.4 on impact and 6.6 at its peak. Chandra and Thompson

[3] Additionally, Ellahie and Ricco (2017), who used a Bayesian VAR and US macroeconomic data, reported that public investment has larger multipliers than public consumption, well in excess of one. Examining variation in the World Bank disbursements to developing countries, Kraay (2012) found small public investment multipliers. Using US macroeconomic data from 1956 to 1997, Pereira (2000) found a highway spending multiplier of about 2. However, his estimates are probably contaminated by anticipation effects because the study does not control for changes in expectations.

(2000), Leigh and Neill (2011), and Acconcia et al. (2014) also exploited variation in public investment at the state and city levels in the US, Australia, and Italy, and found large local public investment multipliers.[4] However, as Ramey (2016) and Nakamura and Steinsson (2014) argue, establishing a direct link between local fiscal multipliers and aggregate multipliers can be difficult, because factors such as spillover effects, and national tax or interest rate responses, are absent in local multipliers.

The theoretical literature offers a wide range for the public investment multiplier. Using a neoclassical growth model, Baxter and King (1993) showed that over the long run, public investment multipliers can be between 4 and 13. Leduc and Wilson (2013) built an open economy, monetary union model to study the effects of public investment. Their model produced an on-impact multiplier of 0.3 and a peak multiplier of 2. The authors also reported that a highly persistent spending shock can produce a peak multiplier of 7. Boehm (2019) used a general macroeconomic model to show that a short-lived public investment spending shock has a small multiplier because of high intertemporal elasticity of substitution for investment demand. However, the author also noted that when the spending shocks are long-lived, the multipliers can be greater, because in such a case, the intertemporal elasticity of substitution is mitigated.[5] Overall, the peak cumulative public investment multipliers of 2 to 7 do not necessarily contradict the multipliers implied by existing macroeconomic models, particularly when investment spending is highly persistent.[6]

The remainder of this paper is organized as follows: Section 2 reviews public investment in Japan. Section 3 explains the empirical strategy, and Section 4 explains the data. Section 5 presents the baseline results, and Section 6 explores factors that might have contributed to the findings. Finally, Section 7 concludes.

[4] Garin (2019) and Buchheim and Watzinger (2017) also explored the local effects of public investment spending in the US and Germany, respectively.

[5] Additionally, Leeper et al. (2010) showed that the size of multipliers depends on the implementation lag and that a substantial delay produces a negative multiplier. Coenen et al. (2013), Albertini et al. (2014), and Bouakez et al. (2017) considered models with nominal rigidities and showed that the public investment multipliers can exceed one; however, they also noted that their results depend on the response of monetary policy, substitutability of the spending, and the implementation lag.

[6] Literature reviews of the related methodology and of the estimates of fiscal multipliers using Japanese data are available in Appendix 8.4.

2 Road Construction and Public Investment in Japan

The choice of road pavement firms as an indicator of public investment spending is motivated by the following two facts. First, road construction constitutes the largest fraction of total infrastructure investment. Between 1970 and 2013, road construction was the single-largest component of infrastructure investment in Japan, ranging from 20% to 35% of total public infrastructure investment.[7] As it accounts for the largest fraction of overall infrastructure investment, changes in road investment should reflect the overall changes in public investment.

Second, road construction is almost exclusively initiated by government-related agencies. Survey results from the 50 largest construction firms in Japan reveal that since 1985, the annual share of road investment orders issued by government-related agencies has almost always exceeded 90%.[8] The dominance of government-related agencies in the issuance of road construction orders suggests that the firms that specialize in road construction are heavily government-dependent. If that is the case, changes in public investment policies should be priced into the market valuations of road pavement firms.

I conduct a preliminary analysis to check whether the stock prices of the road pavement firms can be a credible indicator of future public investment spending. I plot in Figure 1 the detrended (third polynomial) log of real public investment spending and the detrended log of real sales between 1980 and 2014. In Panel (a) of Figure 1, the blue dotted line shows the average sales of the five *road pavement* firms, and the red solid line shows public investment spending.[9] The sales of the road pavement firms line up well with public investment spending during all periods, yielding the contemporaneous correlation of 0.717. For comparison, in Panel (b), I plot the average real sales of the top four *construction* firms (red line).[10] The sales of the top construction firms align closely with public investment spending until the housing bubble collapse of the early 1990s. Immediately after the bubble burst, the sales

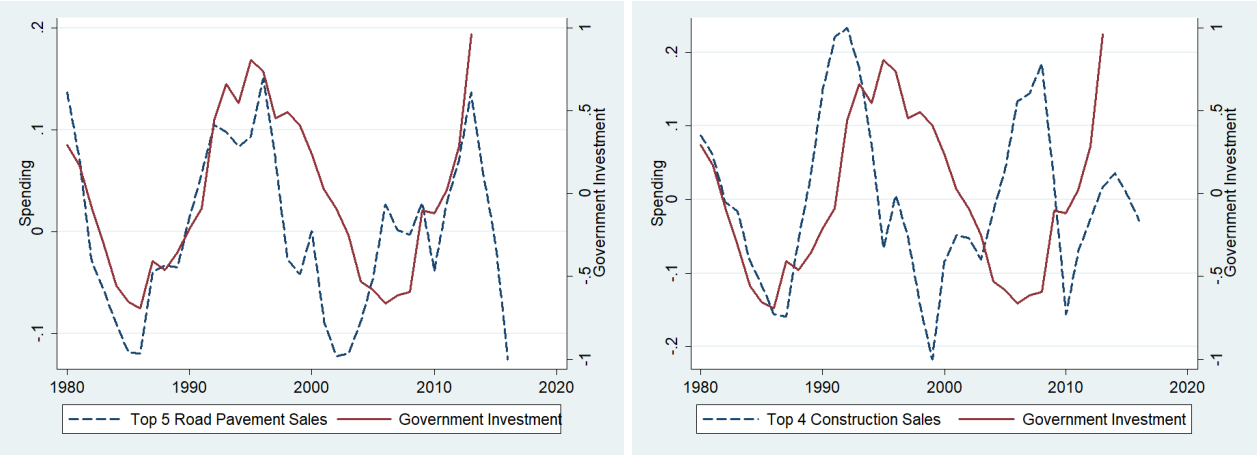
[7] Displayed in Panel (a) of Figure 8 in Appendix 8.5.

[8] Displayed in Panel (b) of Figure 8 in Appendix 8.5.

[9] The selection criterion for the road pavement firms is described in Section 4.

[10] Japan's top four construction firms, known as super general contractors, are: Taisei Corporation, Obayashi Corporation, Shimizu Corporation, and Kashima.

Figure 1: Sales and public investment



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

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

Notes. This figure shows the detrended log of real public investment spending and the detrended log of real sales of road pavement firms (Panel (a)) and the top four construction firms (Panel (b)). The road pavement firms are Nippo, Toa Road Corporation, Maeda Road, Nippon Road, and Seiki-Tokyu Kogyo. The top four construction firms are Taisei Corporation, Obayashi Corporation, Shimizu Corporation, and Kashima. Data are from the annual financial reports.

of the top construction firms plummeted, although public investment spending was still increasing. Since then, the dynamics of the sales of the top four construction firms and public investment spending have diverged, yielding the contemporaneous correlation of only 0.028.[11] The initial preliminary test suggests that the sales of the selected road pavement firms depend significantly on public investment spending.

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.

[11] Additionally, to see if the public investment spending and sales are correlated in the medium run, I conduct the same exercise using the linear and second polynomial trend for detrending. The contemporaneous correlation between the sales of *road pavement* firms and public investment spending with linear and second polynomial-detrending are 0.82 and 0.67, respectively. In contrast, the correlation between the sales of the *top four construction* firms and public investment spending with linear and second polynomial-detrending are 0.56 and 0.13, respectively. In each case, the correlation between the sales of road pavement firms and public investment spending is substantially higher.

3.1 Excess returns of road pavement firms

I define excess returns as the difference between the log average stock price of the road pavement firms and the log average stock price for the market, as follows:

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

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. I use the simple average for the baseline result because the Nikkei stock price index uses the simple average of selected stock prices.[12] Obviously, ER_t^{Road} is endogenous because road investment was frequently used for stimulus purposes and because it reflects the overall economic conditions. To avoid this issue, I regress ER_t^{Road} on the current and past macroeconomic and financial variables and use the orthogonalized residuals as instruments for public investment.

Following Fieldhouse et al. (2017), I define excess return shocks 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 the log of output, public investment, tax income, and the unemployment rate and the GDP deflator.[13] V_{t-1} includes four lags of all the variables in W_t and the four lags of financial variables, which are ER_t^{Road}, the one-year and five-year Japanese Government bond rates, and the log change in real exchange rates.[14] The residuals from the regression, er_t^{Road}, are my measure of public investment news shocks that should be orthogonal to the current and past state of the macroeconomy.

[12] I also calculate the excess returns using the geometric average of road pavement firms' stock price as a robustness check and find that the baseline results remain the same. Another candidate is the weighted average using the market capitalization as weights. However, data on the market capitalization of individual firms are available only from 1986. Thus, I do not employ the market capitalization approach.

[13] The unemployment rate is included in the control variables because Barro (1981) and Barro and Redlick (2011) argued that the unemployment rate contains extra information about the business cycle that might not be captured in the output data.

[14] The baseline model does not include the contemporaneous financial variables as controls, because it might be too restrictive to assume that ER_t^{Road} does not affect the financial variables contemporaneously. I show a version of the result that includes current financial variables as the controls in the robustness check and show that the results are unaffected.

3.2 Measuring multipliers

I estimate the public investment multiplier by employing the local projection IV method (Jordà (2005) and Ramey and Zubairy (2018)) using the extracted measure of public investment news shocks as an IV. The local projection method estimates impulse response functions directly by regressing a variable of interest h-periods ahead on shocks and lagged control variables. The local projection IV method is the same as the local projection method, except that it uses the shocks as instruments for an endogenous variable to uncover the causal impacts of the endogenous variable.

To take into account the dynamic aspect of responses in output and public investment, I calculate the cumulative output multiplier, following Ramey and Zubairy (2018):

$$\sum_{j=0}^{h} \frac{Y_{t+j} - Y_{t-1}}{Y_{t-1}} = \beta_h + M_h \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \xi_h W_t + \phi_h(L) V_{t-1} + u_{t+h}, \tag{3}$$

where $\sum_{j=0}^{h} \frac{Y_{t+j}-Y_{t-1}}{Y_{t-1}}$ is the sum of the differences in output between $t+j$ and $t-1$ normalized by the output in period $t-1$, and $\sum_{j=0}^{h} \frac{G_{t+j}-G_{t-1}}{Y_{t-1}}$ is the sum of the differences in public investment spending between $t+j$ and $t-1$ normalized by the output in period $t-1$. Because both the dependent variable and public investment spending are normalized by the output, M_h has the direct interpretation as the cumulative output multiplier. I estimate the multiplier coefficient M_h using ER_t^{Road} as the instrumental variable. Because equation 3 includes the same control variables as equation 2, instrumenting with ER_t^{Road} is the same as instrumenting with er_t^{Road}. However, instrumenting with ER_t^{Road} makes calculating the correct standard errors, and thus, avoiding the problem of the generated regressor straightforward. I calculate 90% confidence bands using heteroskedasticity and autocorrelation-consistent (HAC) standard errors. I choose automatic bandwidth selection for the estimation.

4 Data

Most of the data are identical to those provided by Miyamoto et al. (2018) and are taken from Japan's System of National Accounts (SNA). All variables are expressed in per capita,

and except for the financial variables, are deflated by the GDP deflator. Adjusted public consumption is calculated as public consumption less the transfer of goods.[15] The stock prices for road pavement firms, the average stock price of the construction industry, and the 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. I define road pavement firms according to the 2007 Japan Standard Industry Classification. Road pavement firms are firms whose main segment of activity is classified as D-0631 (pavement construction).[16] The real exchange rate between the Japanese yen and the US dollar is obtained from the BIS statistics. The producer prices of asphalt and asphalt mixture for pavement construction are taken from the Bank of Japan statistics. Tax data, obtained from the National Accounts starting in 1980Q1, are composed of the total of direct and indirect taxes minus subsidies. The dataset is quarterly and spans 1980Q2 to 2014Q1.

5 Results

This section presents the estimated results. I first describe the extracted news shocks and discuss their relevance as an instrumental variable for public investment spending. I then estimate the public investment multipliers of output.

5.1 News shock

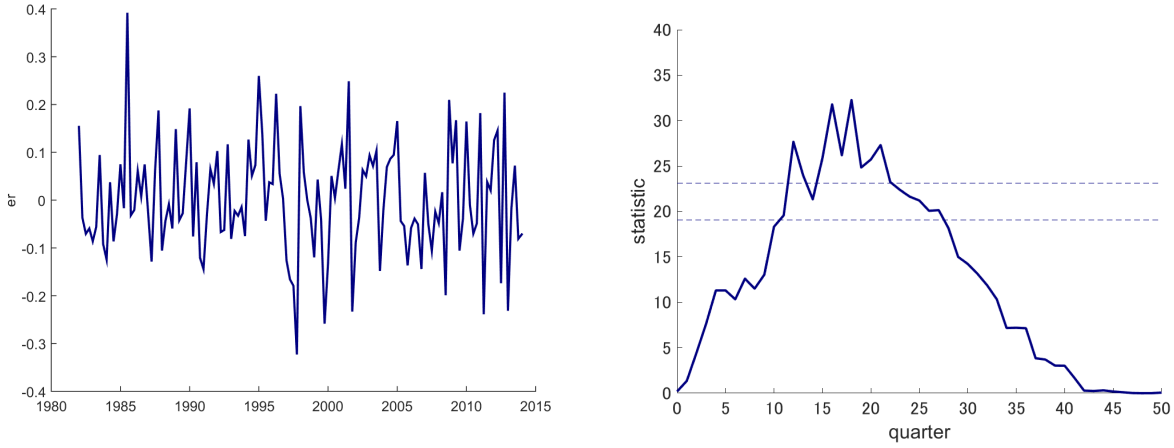
The extracted shocks, er_t^{Road}, from equation 2 are shown in Panel (a) of Figure 2. In Appendix 8.2, I highlight some significant events that are likely to be associated with the news shocks to explain what this news shock might be capturing.

To take into account the possibility that the errors are serially correlated, I follow Ramey (2016) and apply the weak instrument tests developed by Olea and Pflueger (2013) for every horizon. Panel (b) of Figure 2 shows the robust F-statistics for the first-stage relevance of

[15] For a discussion of the construction of the adjusted government spending, refer to Miyamoto et al. (2018).

[16] 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. To maintain consistency, I drop the latter two firms from the dataset.

Figure 2: Relevance condition



(a) er_t^{Road} (b) First stage robust F-statistic

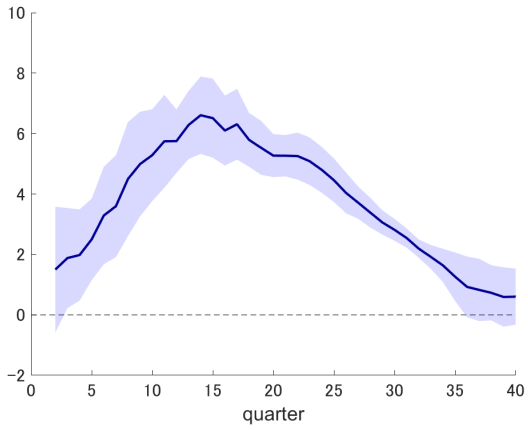
Notes. The figure shows the residual, er_t^{Road}, from the regression in equation 2 (Panel (a)) and the robust F-statistics for the first-stage relevance of ER_t in equation 3 (Panel (b)). The threshold is 23.1 for one instrument for the 5% critical value for testing the null hypothesis that the two-stage least squares bias exceeds 10% of the OLS bias, and it is 19.7 for the 10% critical value.

ER_t^{Road} in equation 3 together with the threshold values for the 5% and 10% critical values for testing the null hypothesis that the two-stage least squares bias is larger than 10% of the ordinary least squares (OLS) bias.[17] Although initially low, the F-statistic gradually increases and peaks in the 18th quarter at 32.27. The F-statistics exceed the threshold values between the 12th quarter and the 27th quarter.[18] The fact that the F-statistics only peak after eighteen quarters indicates that the extracted shocks capture the news element of public investment spending. In fact, the F-statistics from the Ramey and Shapiro (1998) military spending news shock exhibit a similar pattern, wherein the peak comes a year after the shock.

[17] Olea and Pflueger (2013)'s robust F-statistics and critical values are computed by the *weakivtest* stata command.

[18] The results contrast with the F-statistics of Fisher and Peters (2010)'s military spending shocks that are extracted from the excess returns of top military contractors. According to Ramey (2016), the F-statistics of Fisher and Peters (2010)'s shocks do not exceed 5 for all horizons. In addition, the shape of the F-statistics is different from the shapes of F-statistics using a BP method, which typically peaks during the first horizon.

Figure 3: Cumulative output multipliers



Notes. This figure shows the cumulative output multipliers at each horizon as well as 90% confidence bands estimated via the local projection-IV in equation 3.

5.2 Output responses and multipliers: baseline model

Next, I use equation 3 to estimate the cumulative output multiplier, taking into account the dynamics of the public investment spending response. Figure 3 plots the output multipliers and their confidence bands. I omit the initial two quarters and the results after the 40th quarter from the figure, because the confidence bands are too wide due to the low F-statistics during these horizons. The result shows that four quarters after the shock, the cumulative output multiplier is 1.98. The multiplier steadily increases and reaches 6.10 after four years. The multiplier reaches its peak during the 14th quarter at 6.61, and then slowly declines to 0.6 by the 40th quarter. The estimates in the middle horizons are substantially larger than the conventional estimates of cumulative output multipliers for the US and other countries, including Japan. However, the peak multipliers are in line with the local cumulative public investment multiplier reported by Leduc and Wilson (2013). The 90% confidence bands are large and include zero at short and long horizons, but they shrink in the middle, making the multiplier statistically significant during the middle horizons.

5.3 Robustness check

I perform several robustness checks of the baseline results. In particular, I first highlight two concerns that could invalidate the baseline results. The first concern is that my measure

of excess return news shock captures economic news other than the public investment that affects future output because the construction industry is known to be a highly pro-cyclical sector of the economy. The second concern is that the excess returns are possibly affected by industry-specific shocks, such as input cost shocks.[19]

To address these two concerns, I add to the control variables the contemporaneous and four lags of 1) the construction industry's average excess returns and 2) the price of asphalt mixture for pavement construction. First, by adding the excess return of the construction industry, I remove the industry-specific pro-cyclical components from the excess returns of road pavement firms. Panel (a) of Figure 4 shows the output multiplier when controlling for the excess returns of the construction industry. The multipliers almost double during the first few horizons; however, the multipliers in the middle and longer horizons, between the 12th and 20th quarters, are around 6, which align with the baseline results. The cumulative multipliers gradually reduce to 2.17 by the 40th quarter, which is higher than the baseline estimate. Nevertheless, the declining pattern is similar to the baseline results.

Panel (b) of Figure 4 shows the output multipliers when the price of asphalt mixture for pavement construction is added to the control variables. Controlling for the price of asphalt, which reflects the changes in the input costs of road pavement firms, is particularly important because many other sectors of the economy also rely on asphalt.[20] As the figure shows, controlling for the proxy of input costs does not change the baseline results substantially.[21] The output multipliers four quarters after the shock are about 2 and the multipliers sixteen quarters after the shock are between 6 and 8. The cumulative multipliers then decrease to a level below 1 by the 40th quarter in this case as well.

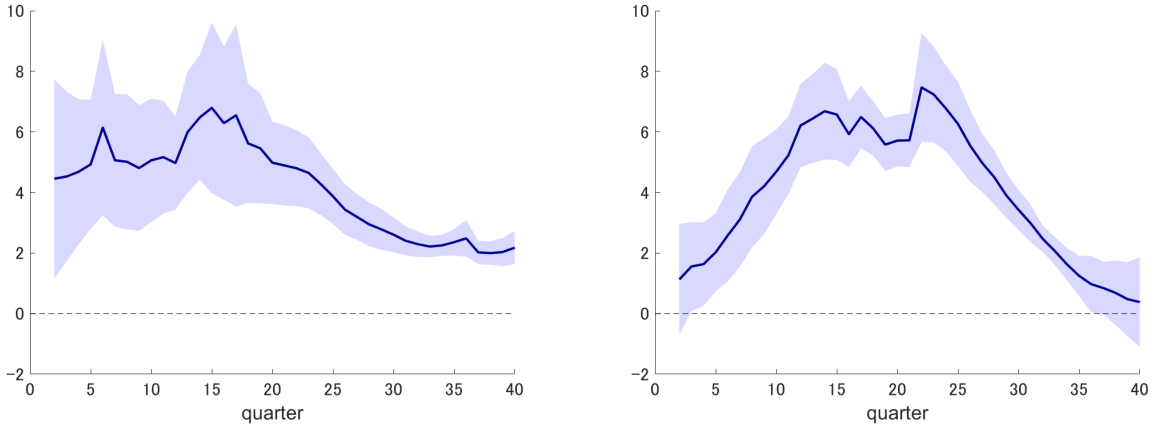
The baseline results are robust to the inclusion of other various variables as the control

[19]The industry-specific technology shock is another factor that might be captured in the excess returns. I cannot control for the changes in road pavement technology, because there is no such consistent measure. However, I suspect that the direct impact of the changes in road pavement technology on the overall economy is small because road pavement constitutes only a fraction of the overall economic activity. Thus, I suspect that excluding road pavement technology shocks from the excess returns would not substantially affect the baseline results.

[20]According to the Annual Report on Road Statistics (*Douro toukei nenpou*), more than 90% of the roads in Japan have been paved with asphalt since 1975.

[21]In Appendix 8.6, I show the results after controlling for the public investment deflator and the price of asphalt. The baseline results are also invariant to these added controls.

Figure 4: Robustness checks



(a) Construction industry excess returns

(b) Price of asphalt mixture for pavement

Notes. This figure shows the output multipliers and the 90% confidence bands estimated via the local projection-IV when the excess returns of the construction industry (Panel (a)), the price of asphalt mixture for pavement (Panel (b)) are each added to the controls.

variables.[22] I also examine how changing the baseline specification in equation 3 influences the estimates of the multipliers. In Appendix 8.6, I show that the baseline results are robust to the normalization using a potential output and to the inclusion of a quadratic trend.

Additionally, as public investment spending is often used as part of stimulus packages, I test whether the reverse causality is a serious problem by regressing er_t^{road} on eight lags of recession indicators. If the government announces a stimulus package a few quarters after the recession, er_t^{road} should be predicted by the lag indicators of recession.[23] The estimated result shows that none of the eight lags of recession indicators predicts the er_t^{road}, which suggests that the influence of reverse causality is likely limited in this study.

[22] I conduct additional robustness checks by including contemporaneous and four lags of the public construction order, the amount of the fiscal stimulus packages and recession indicators, public works orders, and two large earthquake indicators (for the *Great Hanshin-Awaji* earthquake in January 1995 and the *Great East Japan* earthquake in March 2011). Additionally, I also conduct a robustness check by including the contemporaneous financial variables, which are one-year and five-year interest rates as well as yen-dollar exchange rates. The results remain unchanged even when I control for these variables.

[23] Table 4 in Appendix 8.6 shows the estimated results.

5.4 Consumption and investment multiplier

In this section, I investigate the size of public investment multipliers for consumption and private investment. For example, I estimate the consumption multipliers using the following regression:

$$\sum_{j=0}^{h} \frac{C_{t+j} - C_{t-1}}{Y_{t-1}} = \beta_h^c + M_h^c \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \xi_h^c W_t + \phi_h^c(L) V_{t-1} + u_{t+h}^c, \tag{4}$$

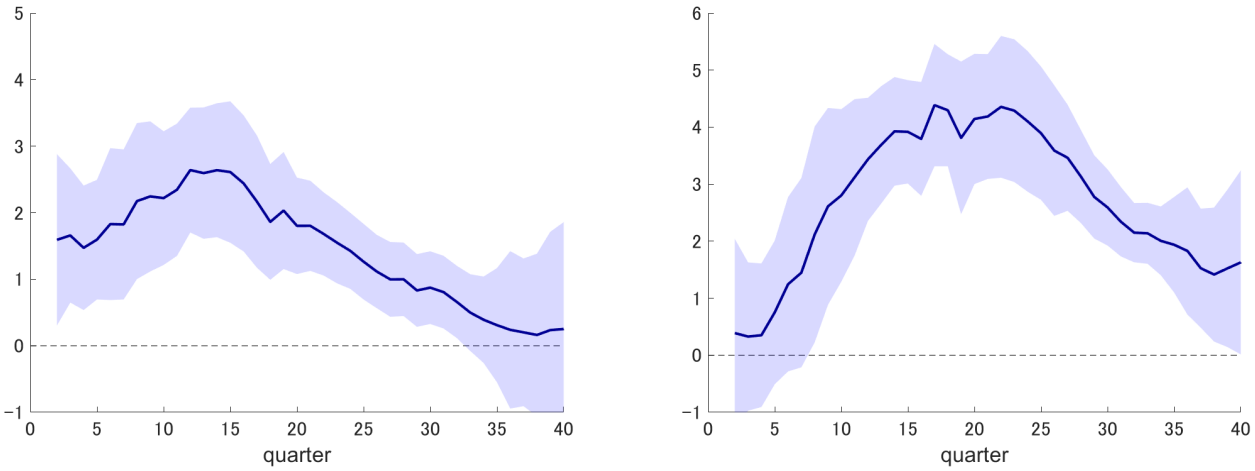
where C_{t+j} is the consumption in period $t+j$, and M_h^c is the cumulative consumption multiplier estimated using the instrument, ER_t^{Road}. The controls are the same as in equation 3.

Panel (a) of Figure 5 shows the cumulative multipliers of consumption. The multipliers are above 1 starting from the 2nd quarter, and they stay at around 2 for more than twenty quarters. The cumulative multipliers then slowly decline to zero by the 40th quarter, exhibiting the same declining pattern as the output multipliers. The consumption multipliers in the middle horizons are larger than the estimated Japanese consumption multipliers reported by Miyamoto et al. (2018).

Panel (b) of Figure 5 shows the cumulative multipliers of investment. The investment multipliers are close to zero at short horizons and gradually rise to 4 by the 20th quarter. The cumulative multipliers then decrease to 2 by the 40th quarter. Here, the declining pattern is also similar to the output and consumption multipliers; however, the multipliers stay at a higher level for investment even in the long horizons. The investment multipliers are considerably larger than the estimated investment multipliers reported by Miyamoto et al. (2018), who found that the multiplier peaks at around 1.2 even during the zlb period.[24] The

[24]If one is willing to interpret the quarter when public investment spending is dispersed, as the quarter in which the public investment project is completed, the response of public investment spending to a news shock (Panel (c) of Figure 6) suggests that the infrastructure projects are increasingly being completed between the second and fourth years after the shock, which partly explains why private investment starts to rise after two years. Additionally, according to Miyamoto et al (2018), who used government spending shocks that increase Japanese government spending immediately after the shock, private investment increases gradually between the 1st and 4th quarters during the zero lower bound (weak interest rate response) period. The gradual increase of the private investment multiplier after the shock is also observed in my estimates of private investment multipliers. However, in my study, public investment does not immediately increase, but

Figure 5: Consumption and investment multipliers



(a) Consumption multipliers

(b) Investment multipliers

Notes. This figure shows the consumption multipliers (Panel (a)) and investment multipliers (Panel (b)) as well as the 90% confidence bands estimated via the local projection-IV.

result is also in contrast with Boehm (2019), who found that public investment substantially crowds out private investment when the spending shock is short-lived. These results show that public investment multipliers for consumption and investment are notably large, especially in the middle horizons, and that the crowding-in effects are consistent with the large output multipliers found in the baseline results.[25]

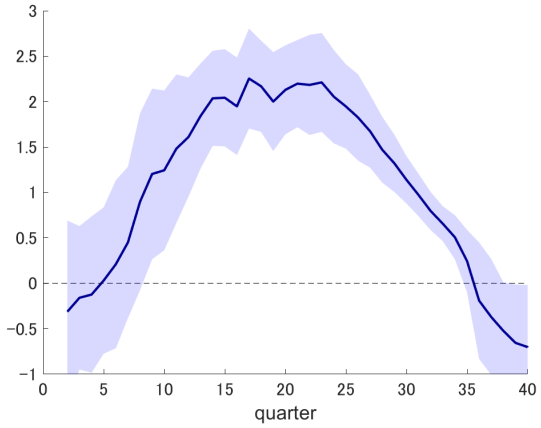
6 Discussion of the mechanism

What explains the larger public investment multipliers? Ramey (2011) explained that the government spending multipliers depend on the tax policy response, the interest rate response, the persistence of government spending, and the type of expenditure. I empirically examine the factor that might explain the large public investment multipliers.

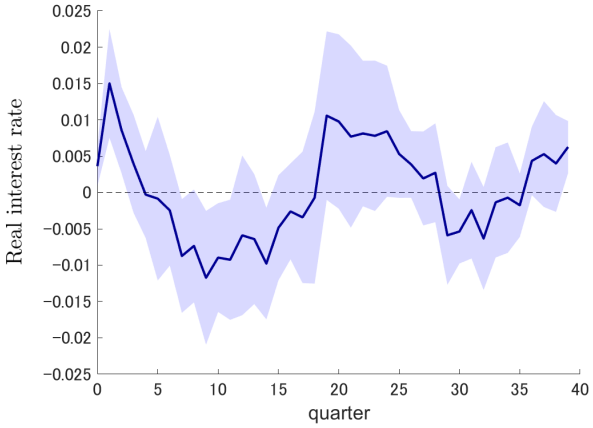
it increases only gradually after the news shock, which explains the delay in the rise of public investment multipliers in my study.

[25]In Appendix 8.8, I additionally estimate the unemployment multipliers and find that the unemployment multipliers in the middle horizons are also larger than conventional estimates.

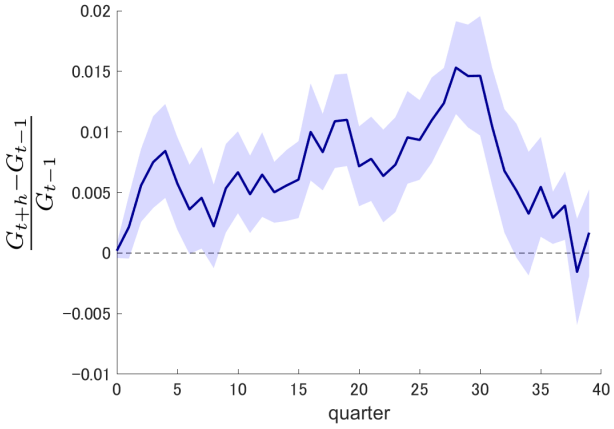
Figure 6: Tax revenue multipliers and responses of real interest rate, public investment, and aggregate labor productivity



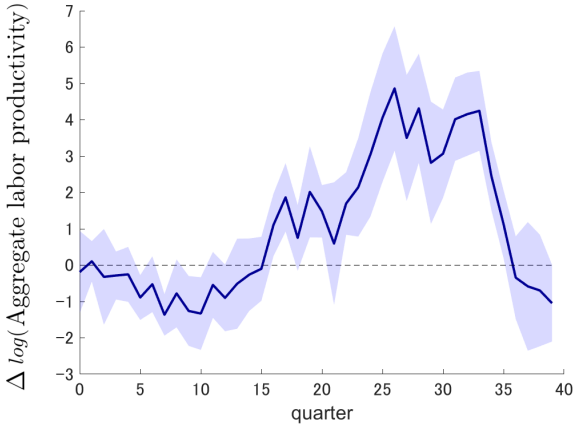
(a) Tax revenue multipliers



(b) Short-term real interest rate responses



(c) Public investment spending responses



(d) Aggregate labor productivity responses

Notes. This figure shows the tax revenue multipliers (Panel (a)), short-term interest rate impulse responses (Panel (b)), public investment spending impulse responses (Panel (c)), and aggregate labor productivity impulse responses (Panel (d)) as well as the 90% confidence bands. The multipliers are estimated via the local projection-IV using equation 4 and the impulse responses are estimated using equation 5.

6.1 Tax revenue multiplier

Ramey (2011) suggested that government spending multipliers are generally larger when the spending is deficit-financed. To explore this possibility, I first estimate the (cumulative) tax revenue multipliers using equation 4. The dependent variable is defined as a sum of the differences in tax revenues between $t+j$ and $t-1$ normalized by the output in period $t-1$.

Panel (a) of Figure 6 shows the tax multipliers. The multiplier initially is close to zero, but it increases to 2.25 by the 17th quarter. The cumulative multipliers then slowly decline to zero by the 40th quarter.

The result is somewhat mixed. The fact that the tax revenue multipliers initially increase to 2.25 means that a cumulative increase in tax revenue by the 17th quarter is 2.25 times greater than the cumulative increase in public investment. In this regard, it can be viewed that the output multipliers are large despite the aggressive tax policy. Simultaneously, in the long horizons, the cumulative tax multipliers fall to zero, meaning that the cumulative increase in the public investment spending over 10 years is not accompanied by a cumulative increase in tax revenue during the same period. In other words, in terms of the 10-year period as a whole, public investment spending is deficit-financed. If agents knew that the tax will be deficit-financed in a 10-year window, with an increase in tax in the short and middle horizons followed by a significant decline in the long horizons, then such a tax policy should contribute to the large output multipliers.

6.2 Real interest rate response

Another factor that could account for the large multiplier is the negative real interest rate response. If the real interest rate falls in response to the rise in public investment, it will have the additional effect of stimulating the economy, contributing to a larger multiplier. To examine whether such a mechanism is at work, I estimate the short-term (*realized*) real interest rate response, which is calculated as the difference between the nominal interest rate and the inflation rate (measured in CPI). The impulse responses are estimated as follows:

$$z_{t+h} = \alpha_h + \gamma_h \, ER_t^{\text{Road}} + \Lambda_h W_t + \theta_h(L) V_{t-1} + \nu_{t+h}, \tag{5}$$

where z_{t+h} is the dependent variable and equals the interest rate in period $t+h$, in this case. The control variables are identical to the ones used in equation 3. The result is shown in Panel (b) of Figure 6. The figure indicates that the real interest rate responses are weakly negative in the first 15 quarters and stay around zero afterward. The result is not surprising given that Japan experienced zero nominal interest rate and a mild but stable deflation

for about half of the sample period. The weak real interest response suggests that public investment does not crowd out private investment, which partly explains the large output and private investment multipliers.

6.3 Persistence of public investment

The third factor that could contribute to the large fiscal multiplier is the persistence of government spending. To investigate this, I calculate the impulse response of public investment spending using equation 5, where in this case, $z_{t+h} = \frac{G_{t+h}-G_{t-1}}{Y_{t-1}}$, which is the growth of the public investment from period t to $t+h$ normalized by the output in period $t-1$. As Panel (c) of Figure 6 shows, the public investment response is positive and highly persistent, returning to zero only about nine years after the shock.[26] When the spending shock is persistent, the intertemporal substitution for investment demand is mitigated. This finding is consistent with the strong crowd-in effects of private investment discussed in Section 5.4.

Simultaneously, note that the public investment keeps increasing until it reaches its peak in the 28th quarter, in contrast to the output multiplier, which peaks as early as the 14th quarter, as Figure 3 shows. The difference in the timing of the peaks hints at the possibility that the output responds strongly, long before the public investment outlays. This is likely because economic agents foresee the highly persistent rise in public investment spending and increase their demand even when only a part of the overall public investment expenditure is dispensed. In such a case, a cumulative increase in output relative to a cumulative increase in public investment spending can be substantially large in the short and middle horizons. Combined with the mitigated intertemporal substitution effects for investment demand, the highly persistent public investment spending can produce a strong stimulative effect in the middle horizons.

[26] In Appendix 8.1, I describe the history of infrastructure investment in Japan, in which long-term (5-10 years) planning was common. The response of public investment corresponds to the span of these plans.

6.4 Aggregate labor productivity response

Finally, I examine if the increase in public investment spending raises aggregate productivity. I define aggregate labor productivity simply as the GDP over hours worked.[27] The response is calculated using equation 5, wherein $z_{t+h} = log(A_{t+h}) - log(A_{t-1})$ and A_{t+h} is the aggregate labor productivity in period $t+h$. The figure shows that the labor productivity response is weakly negative in the first 15 quarters. Labor productivity then starts to rise and stays at a high level between the 16th quarter and 34th quarter. It then declines to zero after the 33rd quarter. Thus, I conclude that public investment spending improves aggregate labor productivity temporarily, but there seems to be no long-run effect.

7 Conclusion

In this study, I use public investment news shocks extracted from the excess returns of road pavement firms in Japan to estimate public investment spending multipliers. The estimated multiplier is 6.10, four years after the news shock, and public investment is found to crowd in private consumption and investment. However, in the long horizons, the cumulative public investment multipliers are estimated to fall below 1. Investigating the mechanism, I conclude that an announcement of a public investment project that is followed by a persistent rise in public investment and a weak real interest rate response can be highly stimulative between two and five years after the announcement. Additionally, I report a temporary improvement in aggregate labor productivity after a rise in public investment spending.

[27] Quarterly utilization-adjusted total factor productivity data equivalent to Fernald (2014) are not available for Japan.

8 Appendix

8.1 Japanese infrastructure investment policies

The Japanese infrastructure investment policies have been affected by various factors, including the long-term goals of developing the infrastructure stock, international agreements between the US and Japan to expand Japanese domestic demand to correct large trade imbalances, and concerns regarding fiscal sustainability. The announcement of the long-term goals and agreements described above usually includes the total yen amount of planned investment for the next five to ten years, and the coverage periods of these long-term plans frequently overlap, which provides an ample source of unexpected variation in expectations for future public investment.

Of the factors listed above, the long-term plan for the construction of infrastructure has most influenced Japanese infrastructure investment policies. Two long-term plans have had an influence over infrastructure provisioning: 1) high-level comprehensive plans and 2) component-specific infrastructure plans. As highlighted by Yada (1999), four high-level comprehensive plans reflect the overall stance of the Japanese government toward the country's economic and social development: Economic Planning (EP); Comprehensive National Development Plans (CNDP); National Land Use Planning (NLUP); and the Basic Plan for Public Investment (BPPI). Of these four, the latter three have direct implications for infrastructure construction, which Table 1 summarizes. The goal of the CNDP was to reduce imbalances among different prefectures. The NLUP supplements the CNDP in that its goal is the equal development of lands throughout Japan. Finally, the BPPI was issued after a long series of negotiations between the US and Japan; these were finally settled in 1990 when both sides agreed to correct large and long-running trade imbalances by expanding Japanese domestic demand. As their goals span many years (often more than ten), these plans do not directly aim to stimulate short-run economic outcomes.

Although the high-level comprehensive plans were useful for publicizing the government's overall stance on the future course of public investment, they were often criticized because they lacked enforcement and had a low rate of achievement. Kuroda (1996) and Koyama

(2011) attributed the low achievement rate to the absence of agencies responsible for implementing the policies. In addition to the three comprehensive plans, 15 long-term plans are specifically designed for each component of public infrastructure investment (see Table 2).[28] Notably, the plans explicitly state 1) the amount of planned investment for the next five years and 2) that the plans expire and are then renewed every five years. Various government agencies design, propose, and independently execute the plans.[29] After an initial submission of the proposals, the Ministry of Finance reviews them and negotiates 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. This results in some variations in beliefs about public investment policies, which come only from revisions of the comprehensive plans.[30] The BPPI had a particularly strong influence on the component-specific plans because the BPPI was a bilateral international agreement. However, the extent to which the comprehensive plans influence component-specific plans is unclear. In fact, major newspapers usually mispredict the amount of planned investment for component-specific plans.[31] Importantly, the 15 component-specific plans were renewed in different years, and consequently, 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 identify exactly when people's beliefs about the future course of public investment change.

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

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

[30] Nonetheless, one could argue that information about each new comprehensive plan is gradually released over time, resulting in some variation in beliefs about public investment policies.

[31] For example, on February 11, 1997, the *Yomiuri Shimbun* predicted that the planned investment for the 12th road maintenance plan would be more than 100 trillion yen. The actual amount was 78 trillion yen. On May 20, 1982, the *Yomiuri Shimbun* reported a meeting of the National Road Users Association, in which the participants demanded that the planned investment for the 9th road maintenance plans should be 50 trillion yen. The actual amount was 38.2 trillion yen.

Thus, it could be important to consider the possibility that the release of information about future investment policy was gradual and subtle.

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 included plans for public investment and infrastructure construction. However, with public debt mounting, the public became wary of fiscal sustainability, and consequently, the long-term plans were successively terminated in the early 2000s. Since then, most of the component-specific plans have been integrated into a single "provision of the social capital" plan that does not explicitly state the amount of planned investment. Starting around 1996, the share of public investment per GDP declined substantially, as shown in Figure 7.

8.2 Extracted news shocks and significant events

In this section, I highlight some notable events that might be associated with the movement in news shocks, as illustrated in Figure 2. First, the largest positive news shock in Figure 2 occurred during the 3rd quarter of 1985. On August 19, 1985, the Ministry of Construction proposed a long-term plan for 21st century infrastructure construction that widely expanded the infrastructure plans for the next 15 years. The proposal became the basis for the fourth Comprehensive National Development Plan as well as five component-specific long-term plans that were to be renewed the following year. Major newspapers, including Nikkei shimbun, Yomiuri shimbun, and Asahi shimbun, reported on August 20, 1985, that by 2000, the Ministry of Construction proposed spending 341 trillion yen for infrastructure and 388 trillion yen for housing. At that time, the proposal by the conservative administration, led by Prime Minister Nakasone, was viewed as aggressive. The Nakasone administration strongly promoted a conservative fiscal budget, and under Nakasone, all component-specific long-term plans, which started before he became prime minister, failed to reach their goals. Another significant event during the 3rd quarter of 1985 was the Plaza Accord. Signed on September 22, 1985, the Plaza Accord between Japan, the US, and three other nations, aimed to depreciate the US dollar against the Japanese yen and German Deutsche Mark. Following the announcement of the accord, the Japanese yen significantly appreciated. The

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 investments for second, third, and fourth CNDP are expressed in yen in 1965, 1975, and 1980, respectively. Planned investment for NLUP includes various goals, including roads, farmland, forest, plain field, rivers and waterways, and housing land. The table shows the goal for road pavement only. Planned investments for BPPI are expressed in nominal values at the time of plan approval. The coverage periods for the New Basic Plan for Public Investment initially were 1995-2004 but later were expanded to 1995-2007.

Plaza Accord no doubt had a considerable impact on the future course of the Japanese economy, and it might explain to some extent the magnitude of the shock that occurred during the 3rd quarter of 1985. However, the magnitude of the shock remains largely the same even after I control for the exchange rate during this period. Thus, the large positive shock that occurred during the 3rd quarter of 1985 cannot be explained by the Plaza Accord alone.

The magnitude of positive news shocks, on average, becomes smaller over time. Two of the larger shocks in recent years occurred during the second and the last quarters of 2012. In June 2012, the opposition party of the Liberal Democratic Party (LDP) announced and

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: Five-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.

proposed a bill called the "Basic Act for National Resilience" (or Kokudo Kyoujinka Kihon Houan), which aimed to vastly expand infrastructure investment. The bill, a response to

the Great East Japan Earthquake of 2011, mandated that infrastructure investment spend a total of 200 trillion yen over the next ten years. Since the LDP was still an opposition party when the bill was proposed, the bill did not pass the Congress, but it hinted that once the LDP became the ruling party, which was expected to happen the following year, a large fiscal expansion would occur.[32] In November 2012, Prime Minister Noda and the LDP leader Abe agreed to dissolve the Diet and call for a surprise snap election. The general election took place the following month. The LDP became the ruling party and the new administration was formed under the newly-elected Prime Minister Abe in December 2012. That the new shocks reacted positively in the 2nd and 4th quarters of 2012 suggests that the shocks picked up the surprise components of the news about the future course of infrastructure spending during these periods.

I now turn to a discussion of some negative new shocks. Starting in the 1st quarter of 1997 and lasting until the last quarter of 1997, a series of negative shocks occurred. During these periods, concern about fiscal sustainability became a prime issue for the Hashimoto administration, and concrete measures to suppress government spending included reducing the scale of the BPPI and other long-term infrastructure plans. A series of negative news shocks during this period appeared to coincide with the government's announcement that it would scale back its infrastructure plans.

Another series of negative news shocks started during the 2nd quarter of 2005 and continued until the 4th quarter of 2006. On August 8, 2005, the Diet dissolved and Prime Minister Koizumi called for a snap general election. The election resulted from Prime Minister Koizumi's long political struggle to privatize Japan's postal service, which he accomplished after winning the snap election. Postal privatization had important implications for future infrastructure spending because Japan's postal service was taking deposits and using them to fund road investment and other government expenses. The postal privatization meant that the government could no longer freely use those deposits for government expenses. Starting in the 2nd quarter of 2005, the news shocks became negative for six consecutive quarters,

[32]The approval rating of the administration in July 2012 was 28%, according to Nikkei shimbun, and 23%, according to Mainichi shimbun, and many expected that the LDP would win the next election

which might reflect the negative fiscal shocks associated with postal privatization and its ramification during these periods.

8.3 Comparison of Japanese and US public investment

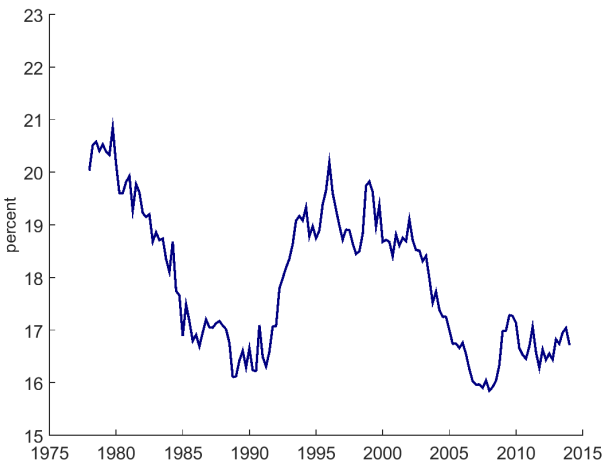
Although understanding the scale of the public investment multiplier is crucial for assessing the effectiveness of fiscal policies, its empirical investigation using macroeconomic data is challenging because of the long implementation lag associated with public investment projects. Highlighting the difficulty of controlling for the anticipation effects of public investment in the US, Ramey (2016) noted that although the highway system was a significant component of government spending between the late 1950s and the early 1970s, "most of the spending on the US highway system was anticipated once the highway bill was passed in 1956." In addition, after the highway system was completed, variation in public investment in the US became substantially smaller, making it difficult to estimate the public investment multipliers using US aggregate data, even after the 1980s.

Infrastructure investment in Japan, on the other hand, has been driven by various factors that are often irrelevant to the current state of the economy, such as the renewals of the long-term plan for developing an infrastructure stock, international agreements between the US and Japan to expand Japanese domestic demand to correct large trade imbalances, and concerns about long-term fiscal sustainability.[33] Changes in these factors provide unexpected variations in public investment that can be used to estimate the aggregate public investment multipliers.[34] Figure 7 shows Japanese government spending (Panel (a)) and public investment (Panel (b)) as a share of GDP as well as the government spending share and public investment share for the US (Panel (c) and Panel (d)). Two important differences between the US and Japan emerge from the figure. First, between 1978 and 2014, public investment as a share of GDP in Japan was, on average, about twice as large as that of the US. Second, during the same periods, the share of public investment in Japan was approximately three

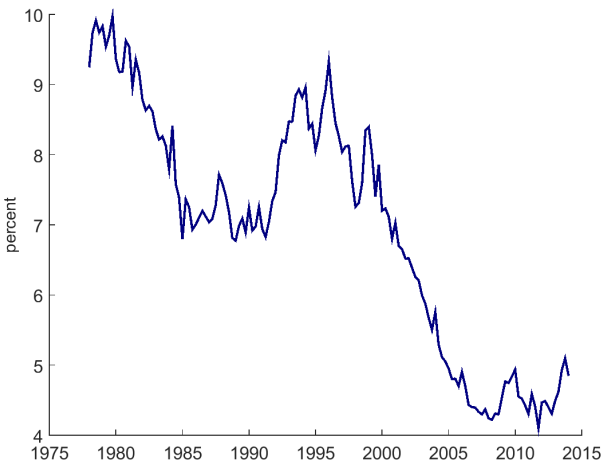
[33]Public investment = infrastructure investment + public inventory investment. As infrastructure investment accounts for the majority of public investment, I use the terms "public investment" and "infrastructure investment" interchangeably.

[34]The details of these factors and a brief description of the history of Japanese public investment are found in Appendix 8.1.

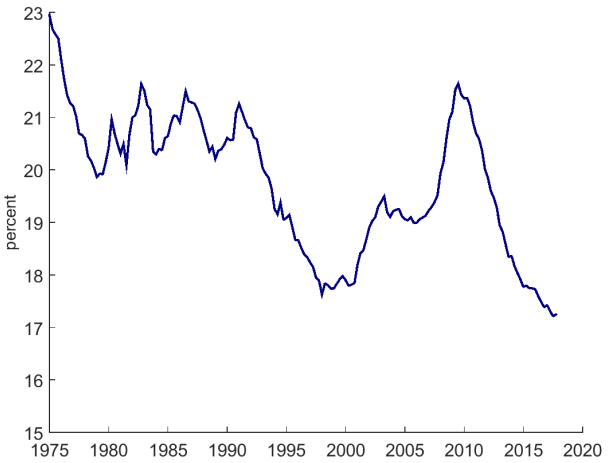
Figure 7: Government spending and public investment as a share of GDP



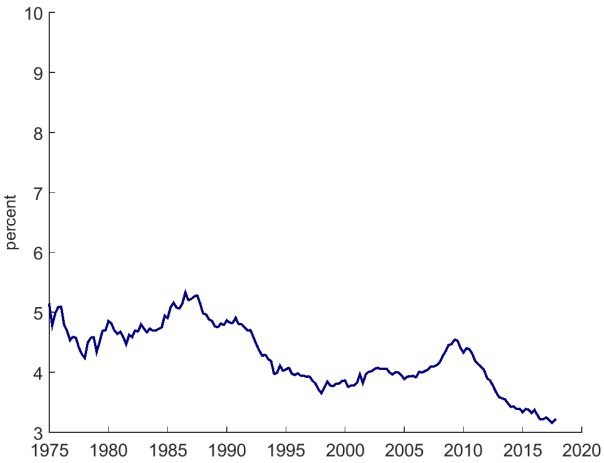
(a) Japan: Government Spending/GDP



(b) Japan: Public Investment/GDP



(c) United States: Government Spending/GDP



(d) United States: Public Investment/GDP

Notes. This figure shows Japanese government spending per GDP (Panel (a)), Japanese public investment per GDP (Panel (b)), US government spending per GDP (Panel (c)), and US public investment per GDP (Panel (d)). Data are from SNA for Japan and NIPA for the US.

times more volatile than in the US. The standard deviation of public investment per GDP in Japan between 1978 and 2014 was 0.0133 while the standard deviation in the US during the same period was only 0.0046. The variability of Japanese public investment helps to

precisely estimate the multipliers. These features make the Japanese experience valuable for learning the macroeconomic impacts of public investment.

8.4 Additional literature review

Several researchers have estimated the fiscal multiplier in Japan. Using the BP methods and controlling for government spending forecasts, Miyamoto et al. (2018) estimated fiscal multipliers in Japan under normal periods as well as under zero lower bound (zlb) periods. The authors found cumulative fiscal multipliers of 0.6 under normal periods and 1.5 under zlb periods. Kuttner and Posen (2002) used the BP method to find government expenditure multipliers well in excess of one in Japan. Bayoumi (2001), who also employed the BP method, reported a multiplier of 0.65. Miyazaki et al. (2018) investigated the effect of public investment on the stock market under the zero lower bound environment.[35] Using the same dataset as Miyamoto et al. (2018), I find the cumulative multiplier of 6.10 four years after public investment news shocks.

Methodologically, this study follows Fisher and Peters (2010), who used the excess returns of three top military contractors in the US as a military spending news shock. Applying the same framework, Morita (2017) used the excess returns of the construction industry and the sign-restriction VAR to estimate fiscal multipliers in Japan. Recently, Fieldhouse et al. (2017) used the excess returns of Fannie Mae and Freddie Mac to estimate the impacts of their activities on the mortgage market and the aggregate economy. This study is also related to Shioji (2017) and Shioji (2018), who combined the narrative approach and the excess return approach to identify news shocks about public investment in Japan. Shioji first identified dates when significant news concerning future public investments was released in major newspapers.[36] The author then measured the surprise component of the news shocks by comparing the movements of stock prices on those dates in highly government-dependent construction firms and in less dependent construction firms. He found that public investment news shocks have a positive and statistically significant impact on output. The

[35] Additionally, Fujii et al. (2013) and Miyazaki (2018) estimated the local and aggregate effects of public investment in Japan on private investment.

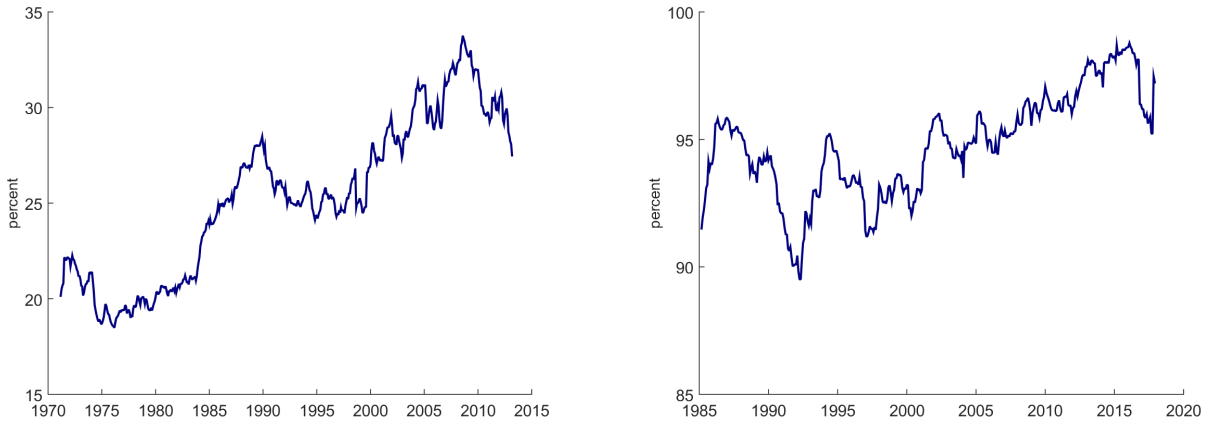
[36] For example, news about fiscal stimulus packages and disasters (such as large earthquakes).

current study differs from Shioji's in that I take into account the possibility that expectation grows gradually on days not identified as significant news days, thereby avoiding the problem inherent in the narrative approach, which is the subjectivity of date selection.

8.5 Japanese road investment statistics

Figure 8 shows Japanese road investment as a share of total government spending in Panel (a) and the share of road construction orders from government-related agencies based on surveys of the 50 largest Japanese construction firms in Panel (b). The figure indicates that the road pavement spending closely reflects public investment spending.

Figure 8: Road investment spending



(a) Road investment as a share of total government spending

(b) Share of road construction orders from government-related agencies

Notes. This figure shows the road investment as a share of total government spending (Panel (a)) and the share of road construction orders from government-related agencies (Panel (b)). Data for Panel (a) are from the Comprehensive Statistics on Construction (Kensetsu-Sougou Toukei) conducted by the Ministry of Land, Infrastructure, Transport, and Tourism. The series in Panel (a) is calculated by dividing the road construction orders by total infrastructure construction orders, both in a 12-month moving average. Data for Panel (b) are from the Current Survey on Orders Received for Construction, the 50 largest construction firms in Japan (A-group survey), conducted by the Ministry of Land, Infrastructure, Transport, and Tourism. The series in Panel (b) is calculated by dividing the road construction orders by total infrastructure construction orders, both in a 12-month moving average.

8.6 Additional robustness checks

In this section, I perform additional robustness checks. Panels (a) and (b) of Figure 9 show the output multipliers when the public investment deflator and the price of asphalt are added to the control variables. These variables are alternative measures for the changes in the input costs of road pavement firms. As the figure shows, the baseline results are robust to the inclusion of these proxies of input costs. Additionally, Panel (c) shows the output multipliers when the public construction orders are added to the control. The public construction orders are controlled so that the residual variation in the excess return does not respond to the increase in public investment orders not yet reflected in the public investment data. Panel (d) shows the multipliers after controlling for contemporaneous financial variables, which are one-year and five-year interest rates as well as yen-dollar exchange rates. The output multipliers are invariant to these added controls.

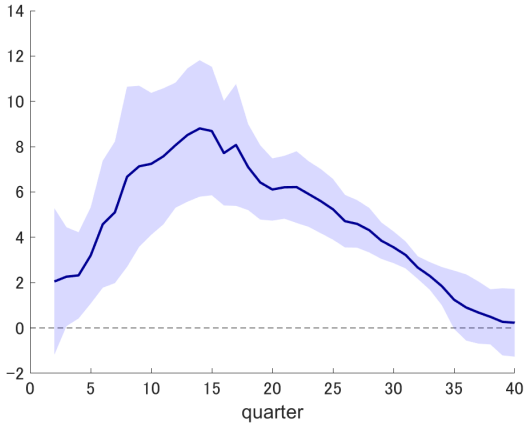
In addition, I briefly introduce how baseline results change when using different model specifications in equation 3. First, I include a quadratic time trend (Panel (e) of Figure 9). Second, I normalize changes in public investment spending and output in equation 3 using a potential output estimated by the HP-filter (Panel (f)). With the exception of multipliers over the middle horizons in the case of the trend, the results are similar to the baseline model. When the trend is included, the cumulative multiplier exceeds 12 in the middle horizon. However, the multipliers at the shorter and longer horizons remain similar to the baseline results, even when the quadratic trend is included. Normalization with the potential output does not make any meaningful difference to the estimated results.

Additionally, I conduct a test for reverse causality, as described in Section 5.1. Specifically, I estimate the following regression:

$$\begin{aligned} er_t^{\text{road}} =& \alpha + \beta_0 \text{recession}_t + \beta_1 \text{recession}_{t-1} + \beta_2 \text{recession}_{t-2} + \beta_3 \text{recession}_{t-3} + \beta_4 \text{recession}_{t-4} \\ &+ \beta_5 \text{recession}_{t-5} + \beta_6 \text{recession}_{t-6} + \beta_7 \text{recession}_{t-7} + \beta_8 \text{recession}_{t-8} + \eta_t, \end{aligned}$$

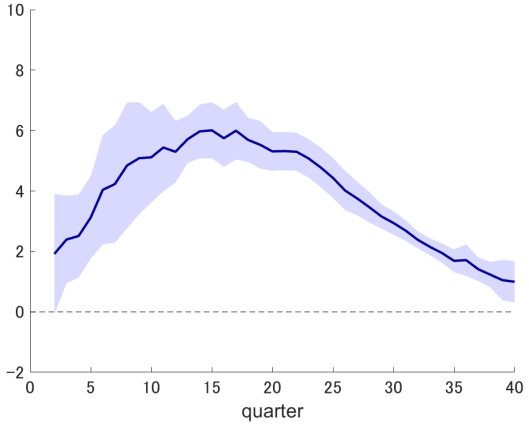
where recession_t is the recession indicator in period t. Table 4 shows the result. None of

Figure 9: More robustness checks

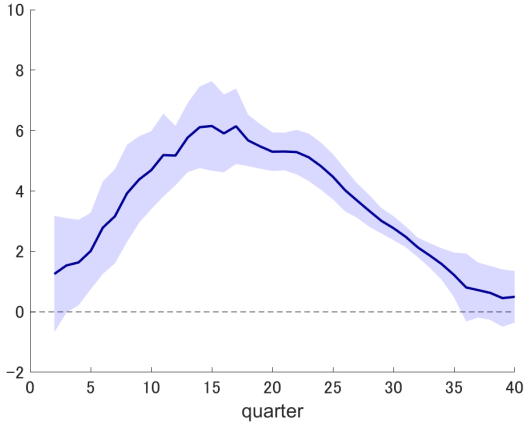


(a) Public investment deflator

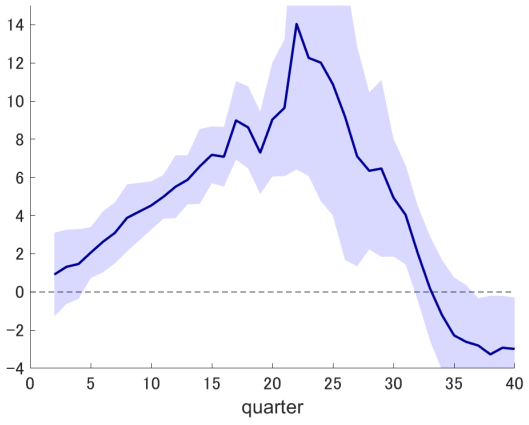
(b) Price of asphalt



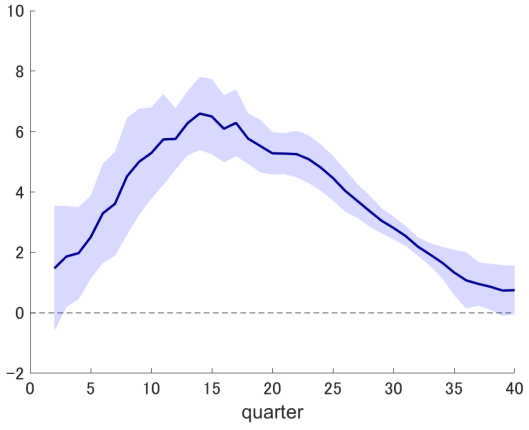
(c) Public construction order



(d) Contemporaneous financial var.



(e) With trend



(f) Using potential output

Notes. This figure shows the output multipliers and the 90% confidence bands estimated via the local projection-IV when the public investment deflator (Panel (a)), price of asphalt (Panel (b)), public construction order (Panel (c)), contemporaneous financial variables (Panel (d)) and the trend (Panel (e)) are added to the controls. Additionally, this figure shows the output multipliers when the potential output extracted by the HP-filter is used for the normalization of output in equation 3 (Panel (f)).

the eight lags of recession indicators predicts the er_t^{road}, which suggests that the influence of reverse causality is likely limited in this study.

Table 4: Test for reverse causality

	coefficient	t-statistics
Recession Indicator$_t$	-0.23	-0.58
Recession Indicator$_{t-1}$	0.03	0.05
Recession Indicator$_{t-2}$	-0.25	-0.62
Recession Indicator$_{t-3}$	0.00	0.01
Recession Indicator$_{t-4}$	-0.42	-1.09
Recession Indicator$_{t-5}$	-0.14	-0.35
Recession Indicator$_{t-6}$	-0.09	-0.24
Recession Indicator$_{t-7}$	-0.12	-0.31
Recession Indicator$_{t-8}$	0.07	0.18
Observations	123	
R^2	0.0189	
p-value for F-test for joint significance	0.987	

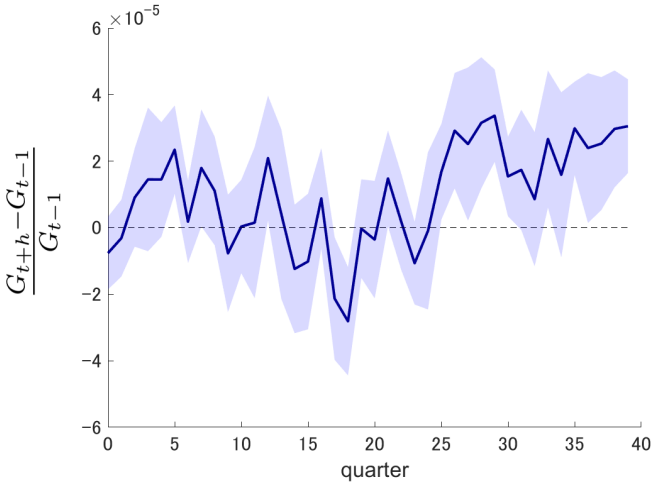
The table shows the results of the regression where the dependent variable is er_t^{Road} and the independent variables are eight lags of recession indicators. Specifically, the regression is as follows: $er_t^{\text{road}} = \alpha + \beta_0 \text{recession}_t + \beta_1 \text{recession}_{t-1} + \beta_2 \text{recession}_{t-2} + \beta_3 \text{recession}_{t-3} + \beta_4 \text{recession}_{t-4} + \beta_5 \text{recession}_{t-5} + \beta_6 \text{recession}_{t-6} + \beta_7 \text{recession}_{t-7} + \beta_8 \text{recession}_{t-8} + \eta_t$. The null hypothesis for F-test is $\beta_0 = \beta_1 = \beta_2 = \cdots = \beta_8 = 0$.

8.7 Response in public consumption

To credibly estimate the public investment multipliers, my public investment news measure should predict only the public investment spending component of government expenditure and not public consumption. Therefore, I estimate regression equation 5 using public consumption as the dependent variable.[37] Figure 10 shows the response in public consumption to a shock in my public investment news measure. The response in public consumption is slightly negative in the middle horizons and is positive after the 25th quarter. However, the magnitude of the response is about one-fiftieth of the response in the public investment that Panel (c) of Figure 6 shows. This implies that the extracted measure of news shocks mainly captures the effect of an increase in public investment and not of a change in public

[37]The public consumption is expressed as the change in public consumption spending normalized by output.

Figure 10: Public consumption impulse response



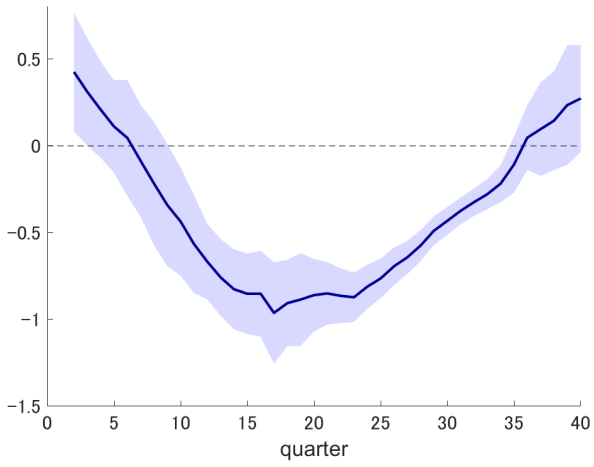
Notes. The figure shows the impulse responses of public consumption and the 90% confidence bands.

consumption.

8.8 Unemployment multiplier

To investigate whether the public investment has a similarly large impact on the labor market, I estimate the multiplier of the unemployment rate. As with the output and other multipliers, I estimate the multiplier of the unemployment rate as the cumulative percentage point change in the unemployment rate that occurs in response to a change in public investment spending of 1% of output. Figure 11 shows the multipliers of the unemployment rate. The multiplier is weakly positive during the first few quarters and then gradually decreases, reaching -0.96 in the 17th quarter. The unemployment multipliers then start to increase and reach zero by the 40th quarter. The unemployment rate multipliers over the medium term are statistically significant. According to Miyamoto et al. (2018), the unemployment rate multipliers are similar to the government spending multipliers during the zlb periods. Given that the sample in this study includes both normal and zlb periods, the result indicates that the public investment multipliers for the unemployment rate in the middle horizons are also greater in magnitude than previous estimates of the government spending multiplier.

Figure 11: Unemployment rate multipliers



Unemployment rate

Notes. The figure shows the unemployment rate multipliers and the 90% confidence bands via the local projection-IV.

References

Acconcia, A., Corsetti, G. and Simonelli, S. (2014), 'Mafia and public spending: Evidence on the fiscal multiplier from a quasi-experiment', *American Economic Review* **104**(7), 2185–2209.

Albertini, J., Poirier, A. and Roulleau-Pasdeloup, J. (2014), 'The composition of government spending and the multiplier at the zero lower bound', *Economics Letters* **122**(1), 31–35.

Barro, R. J. (1981), 'Output effects of government purchases', *Journal of Political Economy* **89**(6), 1086–1121.

Barro, R. J. and Redlick, C. J. (2011), 'Macroeconomic effects from government purchases and taxes', *Quarterly Journal of Economics* **126**(1), 51–102.

Baxter, M. and King, R. G. (1993), 'Fiscal policy in general equilibrium', *American Economic Review* pp. 315–334.

Bayoumi, T. (2001), 'The morning after: explaining the slowdown in japanese growth in the 1990s', *Journal of International Economics* **53**(2), 241–259.

Blanchard, O. and Perotti, R. (2002), 'An empirical characterization of the dynamic effects of changes in government spending and taxes on output', *Quarterly Journal of Economics* **117**(4), 1329–1368.

Boehm, C. E. (2019), 'Government consumption and investment: Does the composition of purchases affect the multiplier?', *Journal of Monetary Economics* .

Bouakez, H., Guillard, M. and Roulleau-Pasdeloup, J. (2017), 'Public investment, time to build, and the zero lower bound', *Review of Economic Dynamics* **23**, 60–79.

Buchheim, L. and Watzinger, M. (2017), 'The employment effects of countercyclical infrastructure investments'.

Chandra, A. and Thompson, E. (2000), 'Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system', *Regional Science and Urban Economics* **30**(4), 457–490.

Chodorow-Reich, G. (2019), 'Geographic cross-sectional fiscal spending multipliers: What have we learned?', *American Economic Journal: Economic Policy* .

Coenen, G., Straub, R. and Trabandt, M. (2013), 'Gauging the effects of fiscal stimulus packages in the euro area', *Journal of Economic Dynamics and Control* **37**(2), 367–386.

Ellahie, A. and Ricco, G. (2017), 'Government purchases reloaded: Informational insufficiency and heterogeneity in fiscal vars', *Journal of Monetary Economics* **90**, 13–27.

Fernald, J. G. (1999), 'Roads to prosperity? assessing the link between public capital and productivity', *American Economic Review* **89**(3), 619–638.

Fernald, J. G. (2014), A quarterly, utilization-adjusted series on total factor productivity, Federal Reserve Bank of San Francisco.

Fieldhouse, A., Mertens, K. and Ravn, M. O. (2017), 'The macroeconomic effects of government asset purchases: evidence from postwar us housing credit policy', *Quarterly Journal of Economics* .

Fisher, J. D. and Peters, R. (2010), 'Using stock returns to identify government spending shocks', *Economic Journal* **120**(544), 414–436.

Fujii, T., Hiraga, K. and Kozuka, M. (2013), 'Effects of public investment on sectoral private investment: A factor augmented var approach', *Journal of the Japanese and International Economies* **27**, 35–47.

Garin, A. (2019), 'Putting america to work, where? evidence on the effectiveness of infrastructure construction as a locally targeted employment policy', *Journal of Urban Economics* **111**, 108–131.

Ilzetzki, E., Mendoza, E. G. and Végh, C. A. (2013), 'How big (small?) are fiscal multipliers?', *Journal of monetary economics* **60**(2), 239–254.

Jordà, Ò. (2005), 'Estimation and inference of impulse responses by local projections', *American Economic Review* **95**(1), 161–182.

Koyama, Y. (2011), 'Exploring the national comprehensive development plans "zenkoku-sougou-kaihatsu-keikaku toha nani de attanoka"', *Tochi Sougou Kenkyuu* .

Kraay, A. (2012), 'How large is the government spending multiplier? evidence from world bank lending', *The Quarterly Journal of Economics* **127**(2), 829–887.

Kuroda, S. (1996), *On the regional and city analysis and economic location theory "Chiiki toshi bunseki to keizai ricchi ron"*, Taimeidou.

Kuttner, K. N. and Posen, A. S. (2002), 'Fiscal policy effectiveness in japan', *Journal of the Japanese and International Economies* **16**(4), 536–558.

Leduc, S. and Wilson, D. (2013), 'Roads to prosperity or bridges to nowhere? theory and evidence on the impact of public infrastructure investment', *NBER Macroeconomics Annual* **27**(1), 89–142.

Leeper, E. M., Walker, T. B. and Yang, S.-C. S. (2010), 'Government investment and fiscal stimulus', *Journal of Monetary Economics* **57**(8), 1000–1012.

Leeper, E. M., Walker, T. B. and Yang, S.-C. S. (2013), 'Fiscal foresight and information flows', *Econometrica* **81**(3), 1115–1145.

Leigh, A. and Neill, C. (2011), 'Can national infrastructure spending reduce local unemployment? evidence from an australian roads program', *Economics Letters* **113**(2), 150–153.

Miyamoto, W., Nguyen, T. L. and Sergeyev, D. (2018), 'Government spending multipliers under the zero lower bound: Evidence from japan', *American Economic Journal: Macroeconomics* **10**(3), 247–77.

Miyazaki, T. (2018), 'Interactions between regional public and private investment: evidence from japanese prefectures', *The Annals of Regional Science* **60**(1), 195–211.

Miyazaki, T., Hiraga, K. and Kozuka, M. (2018), Stock market response to public investment under the zero lower bound: Cross-industry evidence from japan, *in* 'Working Papers, University of California-Irvine, Department of Economics', number 171806.

Morita, H. (2017), 'Effects of anticipated fiscal policy shock on macroeconomic dynamics in japan', *Japanese Economic Review* **68**(3), 364–393.

Nakamura, E. and Steinsson, J. (2014), 'Fiscal stimulus in a monetary union: Evidence from us regions', *American Economic Review* **104**(3), 753–92.

Olea, J. L. M. and Pflueger, C. (2013), 'A robust test for weak instruments', *Journal of Business & Economic Statistics* **31**(3), 358–369.

Pereira, A. M. (2000), 'Is all public capital created equal?', *Review of Economics and Statistics* **82**(3), 513–518.

Ramey, V. A. (2011), 'Can government purchases stimulate the economy?', *Journal of Economic Literature* **49**(3), 673–85.

Ramey, V. A. (2016), Macroeconomic shocks and their propagation, *in* 'Handbook of Macroeconomics', Vol. 2, Elsevier, pp. 71–162.

Ramey, V. A. (2019), Macroeconomic consequences of infrastructure investment, *in* 'Economics of Infrastructure Investment', University of Chicago Press.

Ramey, V. A. and Shapiro, M. D. (1998), Costly capital reallocation and the effects of government spending, *in* 'Carnegie-Rochester Conference Series on Public Policy', Vol. 48, Elsevier, pp. 145–194.

Ramey, V. A. and Zubairy, S. (2018), 'Government spending multipliers in good times and in bad: evidence from us historical data', *Journal of Political Economy* **126**(2), 850–901.

Shioji, E. (2017), 'Extracting fiscal policy expectations from a cross section of daily stock returns', *UTokyo Price Project Working Paper Series* (095).

Shioji, E. (2018), 'Infrastructure investment news and business cycles: Evidence from the var with external instruments'.

Yada, T. (1999), *On the structure and policy of national land in the 21st century "21 seiki no kokudo-kouzou to kokudo-seisaku"*, Taimeidou.