# Public Investment and Regional Business Fluctuations in Japan*

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**Abstract**

This paper examines the relationship between regional business fluctuations and the "discretionary" change in public investment, which is not related to the current state of the economy in the Japanese prefectures. The empirical results show that the public investment unrelated to the state of the current macroeconomic circumstances in each prefecture causes fluctuations in the regional economy. This result suggests that the increase in public investments as a part of income distribution among the regions may overheat the regional economy and that the decrease in investment after 2001 have very seriously exacerbated the regional economy's slump.

*K*eywords: Public investment in infrastructure; Discretional policy; Volatility of the regional economy

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# 1 Introduction

In the wake of the 2008 world financial crisis, many developed countries allowed public investment in infrastructure focused to boost demand for goods and services. However, public investment policy is also determined by factors other than the current macroeconomic conditions. Typically, the infrastructure investment is used for subsidies to the local government and the support of regional income and employment. Governments in some countries implemented the recent economic stimulus packages by including infrastructure investment for each region and local government.[1] However, since a portion of infrastructure investment is allocated to each region by the central government, it is also determined by the political factors and motivations of the central government to redistribute income among regions, as argued in Weingast et al. (1981), Castells and Sole-Olle (2006), Helland and Sørensen (2009), and Ihori (2011). Stoney and Krawchenko (2011) identified criticisms of politically motivated spending in the recent stimulus packages of some countries.

Public investment was a principal policy instrument for macroeconomic stabilization in Japan even in recent decades.[2] However, Japanese public investment has also been expected to function as a policy instrument to correct the disparities among regions and create support for the local governments, even if public investment is included in the economic stimulus

[1]For example, the American Recovery and Reinvestment Act of 2009 provided close to one billion dollars to finance activities associated with infrastructure improvements to provide clean, reliable drinking water to rural areas and to ensure adequate water supply to Western communities affected by drought. Moreover, the act involved competitive grants to state and local governments for transportation investments; half were allocated to low-income regions. Conversely, the third stimulus measure launched in Australia included an infrastructure provision for local community infrastructure. For details, please see OECD (2009), Stoney and Krawchenko (2011), and the website of Recivery.gov (http://www.recovery.gov/).

[2]For more on this point, please see Asako et al. (1991), Ihori (2006), Miyazaki (2009), and Miyazaki (2010a).

packages. For example, the Japanese government formulated a large number of economic stimulus packages in most years in the 1990s, with allocations focused on local areas.[3] Moreover, the stimulus packages in Japan have included infrastructure investment by local governments, as argued in Hanai et al. (2000), Pascha and Robaschik (2001), Miyazaki (2009), and Miyazaki (2010b). Recent economic stimulus packages implemented after Lehman's fall in September 2008 have involved the packages of public investment to support regional economies through subsidies for local governments. Further, the infrastructure investments by local governments and regions may become vested interests in each region including the local public sectors, as argued in Doi and Ihori (2009), Kondo (2010), and Ihori (2011).

In contrast, the Japanese government decreased its infrastructure investment from 2001 to 2007 as part of its fiscal adjustments. One of the reasons for economic slumps in most regions might be the decrease in public investment, according to a number of surveys, including the Bank of Japan's quarterly economic survey (Nichigin-Tankan). In particular, infrastructure investments decreased in most rural areas, and local public sector investment was reduced due to a decrease in intergovernmental transfers such as the local allocation tax grant. In contrast to the 1990s, infrastructure investment by local governments and in the rural parts decreased in the 2000s until Lehman's fall.

As argued in the previous paragraphs, the Japanese government has not necessarily implemented infrastructure investment by only considering the current macroeconomic conditions and might decrease portions of the investment as part of its fiscal adjustment. Changes in public expenditure for reasons other than current macroeconomic conditions may cause fluctuations in the business cycle, as argued in Fatás and Mihov (2003). If this is true of the regional economy, the volatility of regional business cycles may be

[3]Doi and Ihori (2009) showed that public investment was implemented relatively more in rural areas than in urban areas such as the Kanto and Kansai regions, in the 1990s. For more on this point, please see Figure 3.6 on page 49 in Doi and Ihori (2009).

unduly large owing to the infrastructure investment in these regions. That is, while increase of such an investment overheats the regional economy, a decrease may cool the business climate in the region and lead to a slump. As mentioned earlier, some countries used infrastructure investment to address the economic crisis after Lehman's fall, while support for local governments and low-income communities were included in the stimulus packages, just as in recent decades in Japan. However, the public financial conditions in many developed countries have deteriorated since the crisis, and the governments in these countries will be forced to reduce public spending. If a government reduces infrastructure investment in the local regions or governments, as in the 2000s in Japan, it may lead to a slump in the regional economy. Following these points, the investigation on the relationship between infrastructure investment and the fluctuation of the regional business cycles in Japan may be fertile ground for a judgment on whether the government should plan its stabilization policy by including support for the local economies or subsidies to the local governments. To our best knowledge, however, no empirical works have examined the relationship between public investment and fluctuations in the regional (or prefectural) business cycles in Japan.

The objective of this paper is to examine the relationship between public investment and fluctuations in the regional economy in Japan. We examine this by using the frameworks of Fatás and Mihov (2003). First, we estimate the volatility of the public investment policy for each region. This is assumed to be part of the public investment implemented regardless of the response to the current macroeconomic conditions. Second, we regress the economic fluctuations of each region on the volatility of the public investment and other variables. We consider the volatility of the GDP of each prefecture (hereafter, PGDP) to be the economic fluctuations of each prefecture.

Here we would like to define the "discretionary" portion of the infrastructure investment; that is, the part of a public investment implemented without relation to current macroeconomic conditions. The policy reactions by automatic stabilizers and the changes in public expenditures to respond

to the current macroeconomic circumstances are included; these portions are necessary to smooth the business fluctuations. However, the actual policy may be implemented by including a portion of the policy other than these two factors; this may cause the economy to fluctuate. Following the definition of Fatás and Mihov (2003), we define the "discretionary" change in public investment as a policy change not explained by the reaction to the current macroeconomic condition directly.

In our paper in particular, a "discretionary" factor of infrastructure investment is defined as a portion of an investment determined by political factors related to the allocation of infrastructure investment and the motivations of the central government to redistribute income among the prefectures.[4] As long as public investment policy is implemented to stabilize as well as to support of the local economy in terms of the effects on the demand side of macro economy, other factors except for the response to the current macroeconomic conditions are attributed to factors implemented by regional income redistributions and certain political aspects. If one country enters a recession, most of the regions within that country may be also in a recession. It is therefore justified for the government to plan the infrastructure investment in the form of stimulus packages to support local economies or governments. However, as long as the government plans stimulus packages by including infrastructure investment for each region, stimulus packages can also be determined by political motivation or income redistribution, regardless of the current macroeconomic conditions. Following this point, we define the "discretionary" factors of the infrastructure investment as mentioned earlier. Since these portions of infrastructure investment may be decided by the structure of industries, the strength of pressure groups, population, and public financial conditions in each region, we will consider these points when we

[4]Political factors should be identified on the basis of a number of theoretical models. However, since our framework cannot sufficiently address this point, we do not identify the specific political factors based on theoretical models but consider this following some related works in selecting the instrumental variables.

select the instrumental variables.[5]

Section 2 presents the empirical framework employed in this research. Section 3 reports our estimation results: here, we show that the "discretionary" changes in infrastructure investment in each region fluctuate the regional business cycles. The results suggest that the government should not include infrastructure investments to local regions and governments in economic stimulus packages, and must not reduce these investments at fiscal adjustments because these "discretionary" changes exacerbate the business cycle fluctuations in each region rather than smooth them. Section 4 concludes.

# 2 Empirical Framework

To clarify the discretionary change in public investment defined in the former section, we estimate the following equation:

$$GI_{it} = \alpha_i + \beta_t + \gamma_i Y_{it} + \delta_i GI_{it-1} + \epsilon_{it}, \tag{1}$$

where $i$ and $t$ are prefecture and year indices, respectively. $\alpha_i$ is a set of the dummies for each prefecture; $\beta_t$ is a set of year dummies. $GI_{it}$ is the logarithm of real public investment (or public capital formation) relative to PGDP, and $Y_{it}$, the logarithm of real PGDP per capita. These specifications follow Fatás and Mihov (2003). $\epsilon_{it}$ is an error term, and we interpret the prefecture-specific volatility of $\hat{\epsilon_{it}}$ as a quantitative estimate of discretionary policy. We calculate volatility as the standard deviation of $\hat{\epsilon_{it}}$ and will denote it as ${\sigma_i}^{\epsilon}$, the discretionary change in public investment not explained by a response to the economic situation.[6] This idea was employed in many earlier

[5]Fatás and Mihov (2003) define the factor deciding "discretion" as the political regime or institutional environment such as the electoral systems and the types of governance (presidential or not) of each country. However, since the factors assumed in Fatás and Mihov (2003) are not different among each region in one country, these factors are not considered in our paper.

[6]The reasons we focus on the effect of public investment are as follows: first, the budget deficit and tax revenues are substantially affected by the business cycles and it is very

studies including Perotti (1998), Alesina et al. (2002), and Fatás and Mihov (2003).

Equation (1) contains a one-period lagged value of $GI_{it}$. Therefore, we estimate equation (1) by using the dynamic panel estimation developed by Arellano and Bond (1991) and Blundell and Bond (1998). We use the system GMM method developed by Blundell and Bond (1998). This method enables us to avoid the downward bias of the coefficient of the lagged dependent variable even in finite N and T cases such as this one (N = 47 and sample periods = 18), compared with the method developed by Arellano and Bond (1991); it is also advantageous in avoiding the problem of weak instruments.[7] Here, the instrument of the level equations is the lagged dependent variable and the difference of the independent variable is $Y_{it}$.

We estimate the effect of ${\sigma_i}^{\epsilon}$ on the volatility of PGDP. The volatility of PGDP is the standard deviation of the growth rate of PGDP of each prefecture, ${\sigma_i}^{y}$. The basic specification is as follows:

$$\log {\sigma_i}^{y} = const. + \tilde{\alpha}{\sigma_i}^{\epsilon} + \tilde{\beta}X_i + v_i, \tag{2}$$

where $X_i$ is the independent variable that affects the volatility of PGDP other than ${\sigma_i}^{\epsilon}$, and $v_i$ is disturbance.[8] The estimation of equation (2) is done using the residuals of equation (1) and the standard deviation of the growth rate of the PGDP. Therefore, when we estimate equation (2), independent variables are the "average" over the full sample and we conduct the cross-section estimation following by Fatás and Mihov (2001) and Fatás and Mihov

difficult to determine the "discretionary" policy response that we define; second, public investment policy in Japan has been used as a policy instrument to stabilize the macroeconomy as well as to revitalize the regional economy, as discussed earlier. Above all, the second reason tells us that among all public expenditures, public investment may include three components of public expenditures: policy reactions by the automatic stabilizers, the proper response to the current economic conditions, and "discretionary" changes in the fiscal policy unrelated to the current macroeconomic environment.

[7]For more details, please see Blundell and Bond (1998) and Baltagi (2005).

[8]We use a semi-log specification because some of the independent variables become negative and cannot take logarithms.

(2003).

For $X_i$, we first use the ratio of government expenditures (government capital formation + government consumption) per PGDP as the size of the government of each region. This is done because the larger the size of government activities within a region, the larger the volatility of PGDP may be, according to Fatás and Mihov (2001) and Fatás and Mihov (2003). For the size of the government, we also consider the government revenues per PGDP for alternatives following Fatás and Mihov (2001). Second, the per capita PGDP is added because economic fluctuation may become larger in low-income regions. Finally, the openness of each prefecture (net export/PGDP) is used because the openness may cause the economy to fluctuate in the region as in the cross-country case.

Industrial structure may also affect business fluctuations in each region. For example, the larger the proportion of manufacturing industries, the larger the economic fluctuation will be. To capture this effect, we add the ratio of the manufacturing industries per PGDP. Moreover, the fluctuations may change according to the characteristics of the industries in each region. To address this, we use the specialization index following Fatás and Mihov (2001).

$\tilde{\alpha}$ is expected to be both positive and negative. If $\tilde{\alpha}$ is estimated to be positive, ${\sigma_i}^{\epsilon}$ makes business fluctuations larger. This means that the discretionary change in public investment causes the regional economy to fluctuate substantially. Conversely, if $\tilde{\alpha}$ is estimated to be negative, the discretionary policy may smooth the business fluctuations of each region. The size of the government, openness, and proportion of manufacturing industries are expected to be positive, while the per capita PGDP is expected to be negative. The coefficient of specialization index is estimated to be both positive and negative.

Incidentally, the "discretionary" change in infrastructure investment, ${\sigma_i}^{\epsilon}$, may be an endogenous variable because such a portion of the investment may be determined by political factors, industrial structure, income level,

and other social or economic factors in a region. Moreover, the size of government may be larger in a recession and smaller in a better time. The possible endogeneity of these two variables are dealt with by using instrumental variables.

# 3 Empirical Results

Our annual panel covers the period 1990 - 2007 for 47 prefectures in Japan. We begin the sample periods after the 1990s because the Cabinet Office of Japan does not provide the data before the 1980s based on System of Integrated Environment and Economic Accounting (SEEA) proposed by the United Nations in 1993. Moreover, though we obtain the data from 1990 to 2003 expressed in real terms by the deflator of 1995, we cannot acquire the real term data by the deflator of 1995 for the period 2004 - 2007. Therefore, we must construct the data for 2004 - 2007 expressed in real terms by the deflator of 2000.[9]

First, we present the results of equation (1) in Table 1. Before presenting the results, we determine that there is no second-order serial correlation for the disturbances in the first difference equation. This test is important because the consistency of the GMM estimator relies on no autocorrelation between the disturbance of period t and period t-1. According to the results shown in the table, we can confirm that there is no serial correlation between $\Delta v_{it}$ and $\Delta v_{i,t-2}$. The lagged value of the dependent variable is set as one period. In order to avoid the too many instruments problem pointed out by Okui (2009) and Roodman (2009), we assume the possible lagged values of instrumental variables as at most two periods. Moreover, to confirm the validity of the instrumental variables, we perform the over-identification restriction test. As shown in Table 1, since we cannot reject the null, we confirm that our choice of instrumental variables is valid. The result shows

[9]For more details on this point and the source of the data, please see Appendix A.

that $\gamma_i$ is negative but insignificant.

Second, we discuss the estimation results of equation (2). As discussed in Section 2, both ${\sigma_i}^{\epsilon}$ and government size are affected by political factors, population, the industrial structures in the region, and the fiscal conditions of the government both in the prefecture and in the municipalities within the prefectures. Therefore, we also estimate equation (2) using two-stage least squares method (hereafter 2SLS). To perform it, we select the appropriate instrumental variables. First, as Fukui and Fukai (1996), Fukao and Saito (2006), Kondo (2009), and Saito (2010) point out, infrastructure investment in each region in Japan features pork barrel spending, as examined in theoretical works by Weingast et al. (1981) and Ihori (2011). Based on this, we would like to add the variables which identify the strength of the interest groups. We use the average ratio of workers in the construction industries to all workers and the ratios of workers in primary industries to all workers. There are two reasons for this: first, the greater the portion of construction workers, the stronger the pressure for the infrastructure investment in the region may be; second, since these two industries are main support organizations of the Liberal Democratic Party (hereafter LDP) in Japan, which has been a ruling party for the vast majority of our sample period, these variables become good proxies for the strength of the LDP support organizations in each region.[10] To address industrial structure and population, we use the average ratio of the production of the primary industry per PGDP and the average values of the population. Finally, for budget conditions, we employ the average ratio of the local government debt outstanding in each region (the issue of local government bonds in the prefecture and in the municipal-

[10]Kondo (2009) assumes the construction industry as a pressure group, and uses the proportion of construction workers as one of the instrumental variables. Moreover, Nakazato (1999a) and Nakazato (1999b) use the proportion of workers in the primary industries as one of the instruments to identify the strength of support for LDP. Following these works, we use these two variables as proxies for the strength of the interest groups for infrastructure investment.

ities within a prefecture).[11]

Before we present the results of the estimated coefficients, we determine the validity of the instrumental variables as well as the correlation between ${\sigma_i}^\epsilon$ and the instrumental variables used in the 2SLS estimation. The results are presented in Table 2. "Case 1" is the results using the indicator of government size as the government expenditures per PGDP, and "Case 2," using government revenues per PGDP. According to the results of the Sargan test shown in Table 2, the null cannot be rejected for all the cases. Moreover, as also shown in Table 2, the values of partial $R^2$ are relatively large and the p-values of the partial F statistics are less than 0.05.[12] Based on these results, our choice of instrumental variables is valid and the correlations between ${\sigma_i}^\epsilon$ and the instrumental variables are strong enough.

The estimation results are shown in Tables 3 (OLS) and 4 (2SLS).[13] First, the coefficient of ${\sigma_i}^\epsilon$ is positive and significant. This means that public investments that are implemented for reasons other than response to the current macroeconomic conditions that cause fluctuations in the regional economy. In other words, our results suggest that public investment influenced by some of the political factors and the motivations of the central government to redistribute income among the prefectures make regional business fluctuation large. Tables 4 and 5 also show the results of multiplying the coefficient of urban and rural dummy variables by ${\sigma_i}^\epsilon$.[14] In both urban and rural areas,

[11]The production of the construction industries per PGDP, dependency ratio, and the square measure of the prefecture may be also considered as instrumental variables. However, when we conduct the 2SLS estimation by adding these variables as instruments, the correlation between the instruments and ${\sigma_i}^\epsilon$ is weak.

[12]Following the scenarios on the judgment of weak instruments shown in Cameron and Trivedi (2005), we employ the methods based on partial $R^2$ and partial F statistics. For details, please see Cameron and Trivedi (2005).

[13]For all cases, we confirm that the disturbances are not heteroscedastic by Breusch and Pagan's (1979) heteroscedasticity test.

[14]Urban areas are Miyagi, Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Shizuoka, Aichi, Kyoto, Osaka, Hyogo, Nara, Okayama, Hiroshima, and Fukuoka. Rural area are the other 30 prefectures.

the coefficients of ${\sigma_i}^\epsilon$ are positive and significant. The results suggest that even in urban areas, infrastructure investment for the support of the regional economy and the local government causes the regional business cycles to fluctuate.

For other variables, the proportion of manufacturing industries is estimated to be the expected sign and significant in all cases. These results show that the larger the proportion of the manufacturing industries, the more volatile the regional economy is. On the other hand, the coefficient of government size is not always estimated to be positive and significant; this suggests that the intervention of the public sector in the regional economy is not necessarily harmful to the region from the perspective of business fluctuations.

To determine the robustness of the results, we reestimate equation (1) by adding other variables and changing the specifications, and then recalculate ${\sigma_i}^\epsilon$.[15] By doing this, we confirm whether the results shown in Tables 3 and 4 are strongly confirmed. First, we reestimate equation (1) by adding the tax revenues and both the lending outstanding and tax revenues. We perform these exercises to clarify ${\sigma_i}^\epsilon$ by considering other policy variables such as monetary policy and tax policy. Second, we reestimate equation (1) by taking the logarithm of the level variable of public investment and PGDP. Finally, we reestimate equation (1) using the private PGDP (PGDP excluding government consumption and investment) instead of PGDP. In all cases, the coefficients of ${\sigma_i}^\epsilon$ are positive and significant in estimating equation (2), just as the results shown in Tables 3 and 4. Therefore, we strongly confirm that the infrastructure investment policy in Japan fluctuate the regional business cycles.[16]

[15]The estimation results of equation (1), the Sargan test, and the correlations between endogenous variables and instrumental variables are not shown for the sake of brevity. These results can be obtained from the author upon request.

[16]Detailed results for these reestimations can be obtained from the author upon request.

# 4 Conclusions

This paper examines the effect of public investment on business fluctuations in the Japanese prefectures. The empirical results show that infrastructure investment for the support of the local economies and local public sectors, which we term "discretionary" changes in public investment, may increase the business fluctuations in each prefecture. The results also suggest that while the economic stimulus packages in the 1990s, which include infrastructure investment for the support of local governments and each region may overheat the regional economies. The decrease in such types of infrastructure investment from 2001 to 2007 may have caused it to deteriorate. Moreover, such types of infrastructure investment fluctuate regional business cycles both in urban and rural areas. One policy implication from our results is that the government should not plan economic stimulus packages to support local governments and regions given the business fluctuations in each region. The other implication is that the government should not decrease such investment during fiscal adjustment's periods.

Furthermore, Asako et al. (1994) show that the public investment policy in postwar Japan that focused on equity rather than efficiency led to losses of the productivity. The public capital formulated by the local public sector, along with political pressure, caused inefficiency in the regional economy, according to Miyazaki (2004). Earlier works suggest that the infrastructure investment implemented because of political factors and the central government's motivations to redistribute income among the regions leads to the formation of less productive public capital. Our results imply that such types of infrastructure investment are not justified on the demand side of the regional economy.

Incidentally, relations with economic growth may be also considered, as done in Ramey and Ramey (1995), Fatás and Mihov (2001), and Fatás and Mihov (2003). Moreover, we do not compare the effects of investment by central and local governments, as in the case of Miyazaki (2009). We attempt to confirm the different results by this comparison. Further, we do not examine

equation (2) based on certain theoretical model; we only consider political and distributional factors in selecting instrumental variables. By building the theoretical model for the determination equation instead of only selecting the instruments, we are able to consider the political and distributional factors more precisely. These points should be considered in future research.

# A Data Set

Data for the prefectural GDP, output of the manufacturing industries, output of the primary industries, government capital formation, government consumption, net export, and the population in each prefecture come from the Annual Report on Prefectural Accounts by the Cabinet Office in Japan. The data from 1990 to 2003 are expressed in real terms by the deflator of 1995. However, we were unable to acquire the real term data by the deflator of 1995 over the period 2004 - 2007. Therefore, we construct the 2004 data expressed in real terms by the deflator of 2000 as follows:

$$Y_{i,2004}{}^{*} = Y_{i,2003} * g_{i,2003-2004}{}^{*}, \tag{3}$$

where $Y_{i,2004}{}^{*}$ is the 2004 data expressed in real terms by the deflator of 2000, $Y_{i,2003}$ is the 2003 data expressed in real terms by the deflator of 2000, and $g_{i,2003-2004}{}^{*}$ is the real growth rate over 2003-2004 of the variable Y. We acquire the 2005-2007 data expressed in real terms by the deflator of 2000, following the procedure given above.

The ratios of workers in the primary and construction industries were determined by dividing the number of workers in these industries by the total number of workers. These data come from the Labor Force Survey of the Ministry of Internal Affairs and Communications (hereafter MIAC).[17]

[17]The data of the Labor Force Survey can be obtained at three - year intervals. Therefore, we construct the average ratio of these two variables based on data from 1990, 1992, 1995, 1997, 2000, 2002, 2005, and 2007.

Data on the lending outstanding in each prefecture are from the Financial and Economic Statistics of Prefectures by the Bank of Japan.

The index of specialization is based on Fatás and Mihov (2001), following Krugman (1991). Let $s_{ji}$ be the share of industry j in prefecture i, we measure specialization as

$$SPEC_i = \sum_{j=1}^{I} |s_{ji} - s_{j,A}|, \tag{4}$$

where $s_{j,A}$ represents the share of industry j in Japan as a whole. There are eleven comparable sectors.[18] All of the data are from Annual Report on Prefectural Accounts by the Cabinet Office in Japan.

For government revenues, we sum the national tax revenues and local government revenues (including the transfers from the central government). The national tax revenues are the national taxes withheld in each prefecture from the annual statistical report of the national tax agency, and the local government revenues are from the annual statistical report on local public finance published by MIAC. Data on outstanding local government bonds are from the annual statistical reports on local government bonds by MIAC. We calculate this by adding the debt outstanding in each prefecture to the debt of all municipalities within a prefecture.

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Table 1: The estimation results of equation 1 (System GMM estimation; sample size = 799)

| | |
|---|---|
| $Y_{it}$ | $0.926^{***}$ |
| | (0.131) |
| $GI_{it-1}$ | -0.179 |
| | (0.044) |
| constant | 0.657 |
| | (0.112) |
| Test statistics for serial correlation (1st stage) | -3.931 |
| p-value | 0.000 |
| Test statistics for serial correlation (2nd stage) | 0.934 |
| p-value | 0.350 |
| $\chi^2$ statistics for OID test | 27.935 |
| p-value | 0.998 |

Note: The dummy variables for prefectures and years are not shown for the sake of brevity. "OID test" is the over - identification restriction test. Standard errors are in parentheses. Levels of significance are indicated by asterisks: $* = 1\%$.

Table 2: The results of the Sargan test and the test on the correlation between endogenous variable and instrumental variables

| | Case 1 (expenditures) | | Case 2 (revenues) | |
|---|---|---|---|---|
| Partial $R^2$ for ${\sigma_i}^{\epsilon}$ | 0.269 | | 0.262 | |
| Partial $R^2$ for urban dummy $*$ ${\sigma_i}^{\epsilon}$ | | 0.289 | | 0.208 |
| Partial $R^2$ for rural dummy $*$ ${\sigma_i}^{\epsilon}$ | | 0.188 | | 0.273 |
| Partial $R^2$ for the government size | 0.728 | | 0.248 | |
| Partial $R^2$ for the government size | | 0.434 | | 0.254 |
| Partial F statistics for ${\sigma_i}^{\epsilon}$ | 2.77 | | 2.77 | |
| (p-value) | 0.003 | | 0.032 | |
| Partial F statistics for urban dummy $*$ ${\sigma_i}^{\epsilon}$ | | 7.48 | | 7.48 |
| (p-value) | | 0.000 | | 0.000 |
| Partial F statistics for rural dummy $*$ ${\sigma_i}^{\epsilon}$ | | 8.49 | | 8.49 |
| (p-value) | | 0.000 | | 0.000 |
| Partial F statistics for government size | 20.72 | | 6.08 | |
| (p-value) | 0.000 | | 0.000 | |
| Partial F statistics for government size | | 20.72 | | 6.08 |
| (p-value) | | 0.000 | | 0.000 |
| Sargan statistics | 1.478 (3) | 1.628 (3) | 0.994 (2) | 1.294 (2) |
| (p-value) | 0.687 | 0.653 | 0.608 | 0.524 |

Endogenous variable are ${\sigma_i}^{\epsilon}$ and the government size. Instruments include the proportion of workers in the primary industries to all workers, the proportion of workers in the construction industry to all workers, the average values of the population, the average values of production by the primary industries per PGDP, and the average ratio of the level of outstanding local government debt in each region. Partial $R^2$ is Shea's (1997) partial $R^2$. The Sargan statistics are chi-square statistics for the over identification restriction test and follow the degree of freedom shown in parentheses.

Table 3: The estimation results of equation (2) by OLS (Dependent variable = the volatility of the prefectural GDP; sample size = 47)

| | Case 1 (expenditures) | | Case 2 (revenues) | |
|---|---|---|---|---|
| ${\sigma_i}^{\epsilon}$ | 1.283*** | 1.215*** | | |
| | (0.382) | (0.391) | | |
| Urban dummy | | 1.063** | | 0.909** |
| $* \ {\sigma_i}^{\epsilon}$ | | (0.444) | | (0.417) |
| Rural dummy | | 1.247*** | | 1.223*** |
| $* \ {}^*{\sigma_i}^{\epsilon}$ | | (0.347) | | (0.349) |
| Per capita PGDP | 0.063 | 0.033 | 0.016 | 0.010 |
| (average) | (0.075) | (0.075) | (0.072) | (0.073) |
| Net export/PGDP | -0.650 | -0.572 | -0.773* | -0.687* |
| (average) | (0.523) | (0.525) | (0.536) | (0.527) |
| Government | | | | |
| expenditures/PGDP | 1.411** | 0.919 | | |
| (average) | (0.760) | (0.999) | | |
| Government revenues/PGDP | | | 0.609 | 0.187 |
| (average) | | | (0.585) | (0.658) |
| Share of the | | | | |
| manufacturing industries | 2.564*** | 2.251*** | 2.306*** | 2.045*** |
| (average) | (0.472) | (0.498) | (0.453) | (0.448) |
| Specialization index | -0.323 | -0.115 | -0.134 | -0.0002 |
| (average) | (0.435) | (0.434) | (0.431) | (0.422) |
| constant | -5.435*** | -5.127*** | -5.052*** | -4.815*** |
| | (0.456) | (0.514) | (0.531) | (0.391) |
| $\bar{R}^2$ | 0.459 | 0.471 | 0.428 | 0.461 |

Standard errors are reported in parentheses. Levels of significance are indicated by asterisks: $* = 10\%$, $** = 5\%$, and $*** = 1\%$.

Table 4: The estimation results of equation (2) by 2SLS (Dependent variable = the volatility of the prefectural GDP; sample size = 47)

| | Case 1 (expenditures) | | Case 2 (revenues) | |
|---|---|---|---|---|
| ${\sigma_i}^{\epsilon}$ | 2.536*** | 2.497*** | | |
| | (0.766) | (0.806) | | |
| Urban dummy | | 1.807** | | 1.800*** |
| $* \ {\sigma_i}^{\epsilon}$ | | (0.703) | | (0.648) |
| Rural dummy | | 2.103*** | | 2.074*** |
| $* \ {}^{*}{\sigma_i}^{\epsilon}$ | | (0.633) | | (0.604) |
| Per capita PGDP | 0.035 | -0.012 | -0.018 | -0.033 |
| (average) | (0.083) | (0.090) | (0.079) | (0.077) |
| Net export/PGDP | -0.659 | -0.546 | -0.570 | -0.459 |
| (average) | (0.556) | (0.576) | (0.611) | (0.589) |
| Government | | | | |
| expenditures/PGDP | 1.560** | 0.605 | | |
| (average) | (0.925) | (2.169) | | |
| Government revenues/PGDP | | | 1.430* | 0.759 |
| (average) | | | (0.937) | (1.520) |
| Share of the | | | | |
| manufacturing industries | 2.576*** | 2.020* | 2.306*** | 2.035** |
| (average) | (0.513) | (0.756) | (0.512) | (0.550) |
| Specialization index | -0.324 | 0.052 | -0.302 | 0.015 |
| (average) | (0.469) | (0.512) | (0.490) | (0.473) |
| constant | -5.703*** | -5.068*** | -5.572*** | -5.093*** |
| | (0.508) | (0.906) | (0.486) | (0.573) |
| $\bar{R}^2$ | 0.314 | 0.385 | 0.251 | 0.369 |

Endogenous variable are ${\sigma_i}^{\epsilon}$ and the government size. Instruments include the proportion of workers in the primary industries to all workers, the proportion of workers in the construction industry to all workers, the average values of the population, the average values of production by the primary industries per PGDP, and the average ratio of the level of outstanding local government debt in each region. Standard errors are reported in parentheses. Levels of significance are indicated by asterisks: $*$ = 10%, $**$ = 5%, and $***$ = 1%.