© Filodiritto Editore

Journal of Economic and Social Development (JESD)
Vol. 5, No. 1, March 2018

Public Infrastructure and Private Sector Productivity, Tasmania 1990-2015

MIKHAILITCHENKO Serguei[1]

[1] *Holmes Institute, Brisbane (AUSTRALIA)*
Email: smikhailitchenko@holmes.edu.au

Work code CJ02F5002

Abstract

The study utilises the recent advances in development of capital stock data at subnational level for Australian states and applies the series for analysis of the effect of the public infrastructure on the private sector productivity in Tasmania. The study employs a version of an aggregate production function to estimate the elasticity of private capital productivity with respect to the public infrastructure. The results of analysis indicate that, in the long run, contrary to the expectations, the public infrastructure contributes negatively to the private sector productivity in Tasmania. There is also some evidence that Tasmanian government is engaged in countercyclical public investment activities.

Keywords: Public capital stock, Multifactor productivity, Australia

JEL Classification: R11, C1, O56, H74

Introduction

The literature on the role of the public infrastructure on private sector productivity in Australia is very limited. Studies by Otto and Voss (1994, 1996, and 1998) and Satya (2003) are the only four studies known to the author that looked at the impact of the public capital on the Australian private capital productivity. The aggregated models used in the above-mentioned studies concluded that there is a significant positive effect of the public infrastructure on the private capital productivity, which is consistent with the estimates for the United States (Aschauer, 1989; Munnell, 1990). However, the analysis at the industry level produced mixed results showing that public infrastructure was less important for the private capital productivity and even had a negative impact for some industries (Otto and Voss, 1996). There are no studies known to the author that looked at the role of public infrastructure on the private capital productivity at the regional level for Australia.

As one might also expect, a significant amount of information might be lost not only in cross-industry aggregates but also in special aggregation of data in the Australian national accounts. As the result, there might be significant differences in the extent to which the public infrastructure affects the economies of different regions. Therefore, it is worth to look at the impact of the public capital on economic development of individual states. Although some literature in the area of regional productivity for Australia does exist (see, for example, Nguyen and Smith, 2007 and Lucas, 2003), these studies did not look at the role of the public capital and used either private capital stock only or aggregate capital stock as inputs into the models.

This study makes a step in filling the gap and, in addition, uses an updated Net Capital Stock (NCS) series available from Mikhailitchenko (2015). A matter of interest would be also to compare the estimates with the results of analysis conducted at the regional level for other countries, such as Duffy-Deno and Eberts (1989), Munnell (1990), Gu and Macdonald (2009) and Ezcurra *et al*., (2005). These studies found that the effect of the public infrastructure in regional growth was of a smaller scale than that for the nation as a whole.

The choice of Tasmania for analysis was motivated by the geographical uniqueness of this state as well as its unique rates of population growth, the amount of capital stock per capita, capital stock dynamics and capital stock composition. In addition, the author has legitimate concerns that this small state might be overlooked in future panel data analysis if it turns out to be that the differences in inter-regional interaction between economic variables are too large between the small and the large states.

Tasmania is an island economy connected to the mainland only via sea and air. Therefore, the spill-over effects from the Tasmanian public sector investment into economic performance of the neighbouring states are expected to be insignificant. The effects of the public infrastructure in Victoria and New South Wales might also have a negligible effect on economic growth and productivity in Tasmania. If this is the case, then private capital productivity of Tasmania might not be included into a panel data analysis of the productivity of Australian states.

The rest of the paper is organised as follows. Section 2 presents the model. Section 3 identifies the sources of data used in the analysis and discusses certain aspects of Tasmanian economic development. Section 4 provides a discussion of results, while Section 5 gives the concluding comments.

The Model

The study examines the effects of the public capital stock on the private capital productivity and applies the growth model as shown in equation (1) below.

$$Y_t = A_t K^{1-\beta_L} L^{\beta_L} G^{\beta_g} \qquad (1)$$

Where Y_t is the private sector contribution to the Gross State Product (GSP) of Tasmania, K_t is the private net capital stock (NCS), L_t is the number of hours worked by all employees in Tasmania and G_t is public net capital stock.

To estimate the private capital productivity, equation (1) is further transformed into equation (2) as shown below. This approach is similar to model (3) in Otto and Voss (1996) where the public infrastructure was looked at a not purely public good in the aggregate production function.

$$Y_t / K_t = A_t \left[\frac{L_t}{K_t}\right]^{\beta_L} \times G^{\beta_g} \qquad (2)$$

As all variables are in natural logs, further transformation is possible as shown in equation (3) below.

$$Y_t - K_t = A_t + \beta_L \times (L_t - K_t) + \beta_g \times G_t \qquad (3)$$

In equation **(3)**, the term Y_t/K_t is private capital productivity; the term L_t/K_t is an inverse capital deepening measure and the term G_t is the public net capital stock. Logged values imply that the regression coefficients β_L and β_G represent the elasticity of private sector capital productivity to capital deepening and elasticity of private capital productivity to the value of the public infrastructure available. The expected sign of β_L therefore is expected to be negative, while the other two coefficients, A_t and β_G are expected to be positive due to the expected positive effect of the public infrastructure on the capital productivity in the private sector and a reasonably expected positive annual multifactor productivity growth.

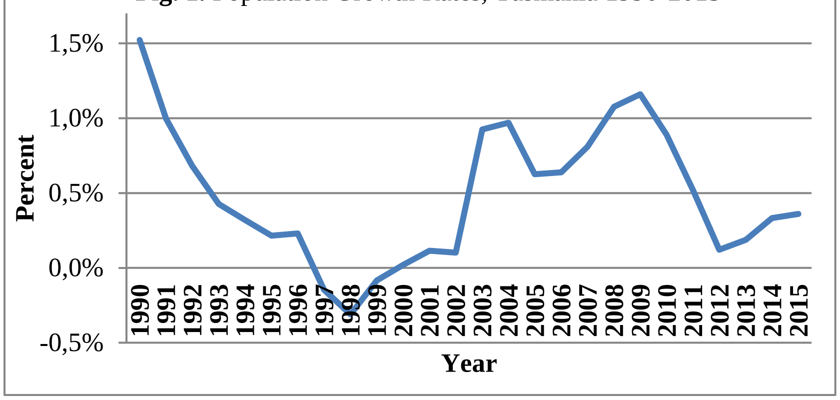
Equation **(3)** presupposes constant returns to scale in private inputs to production and allows increasing returns to scale in public infrastructure and, therefore, increasing returns to scale across all inputs. Aschauer (1989) found that, in the United States, one percent increase in the public capital stock increases the private sector productivity by 0.4 percent. Otto and Voss (1994) used aggregated Australian data and found that the corresponding figure was around 0.45 for Australia as a whole. The average figure for the Australian industries was 0.17 percent in Otto and Voss (1996).

Variables and Data Sources

In addition to its special geographic position, Tasmania, has a small population size of just over half a million residents and, in these terms, is the third smallest state in Australia, being larger in this respect than only the Northern Territory and the Australian Capital Territory. At the same time, Tasmanian population grows at the slowest pace of 0.5 percent per annum, on average.

As can be seen from the Figure 1, Tasmania experienced three consecutive years of negative population growth in 1997, 1998 and 1999, -0.1, -0.3 and -0.1 percent respectively. The only other example of negative annual regional population growth over the same period in Australia is the Northern Territory, where its population shrank by 0.3 percent in 2003. However, the average 1990-2015 annual population growth rate in the Northern Territory is 1.6 percent per annum, which is more than triple of the figure for Tasmania.

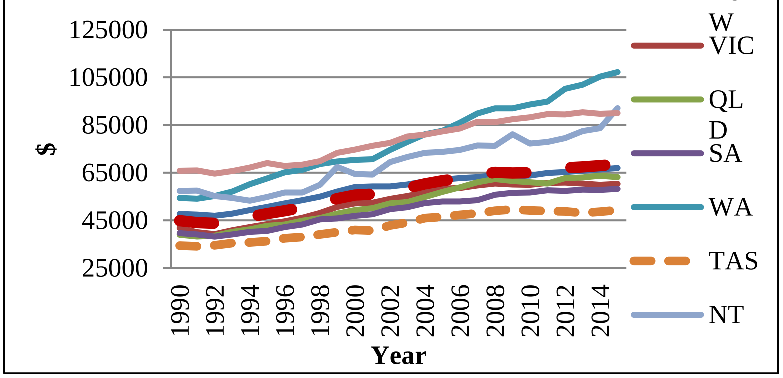
Fig. 1. Population Growth Rates, Tasmania 1990-2015



Source: ABS 3101.0, 2015

Figure 2 below shows the value of Gross State Product (GSP) per capita for Australian states and Gross Domestic Product (GDP) per capita for Australia as a whole during 1990-2015. As can be seen, Tasmania had the lowest GSP per capita among Australian states during the entire period of the last twenty-five years.

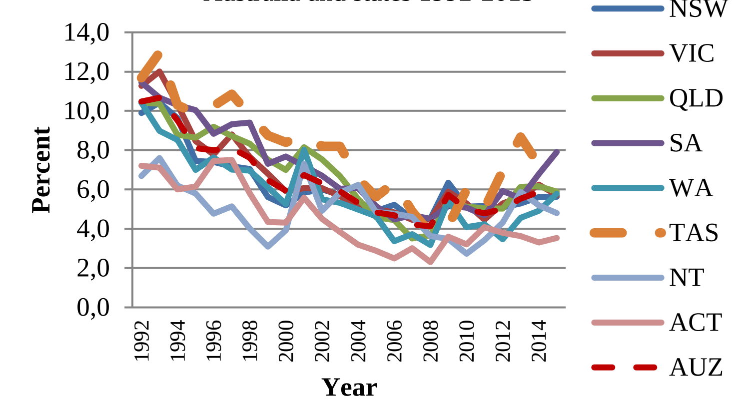
Fig. 2. Gross State Product per capita, Australia and states 1990-2015



Source: ABS 5220.0, 2015

Figure 3 below presents unemployment rates for Australian states and territories for the period from 1992 to 2015. In most years during this period the unemployment rate in Tasmania was the higher than in all other Australian regions with exception for the period 2007-2009 when Tasmanian unemployment rate fell below the national average and in 2015 when the unemployment rate in South Australia rose sharply possibly to the redundancies in the auto manufacturing industry.

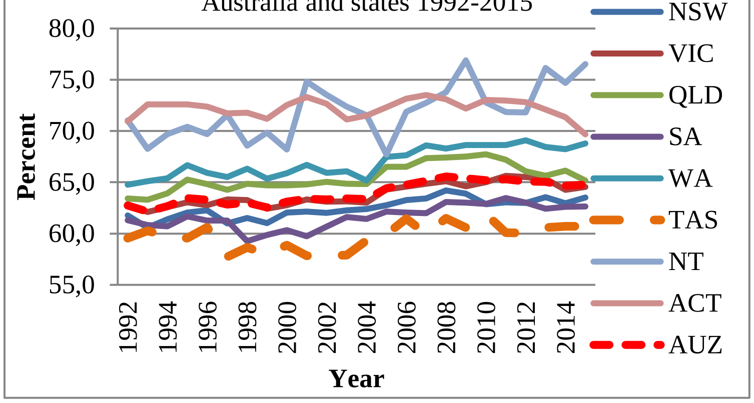
Fig. 3. Unemployment rate, Australia and states 1992-2015



Source: ABS 6291.0.55.001.0, 2015

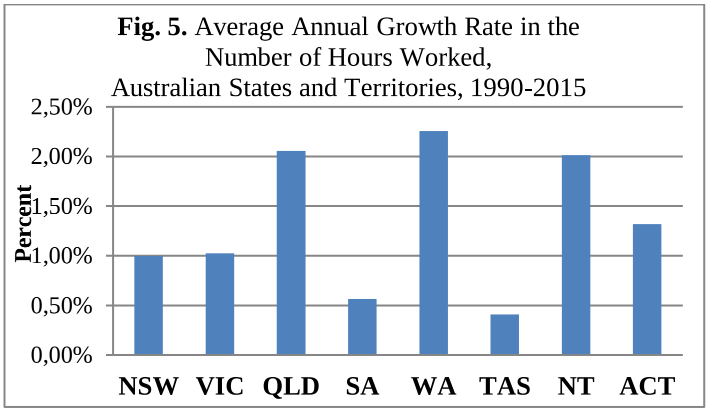
Figure 4 below presents participation rates for Australia and states during the period 1992-2015. As can be seen from the figure, Tasmanian participation rate was the lowest among Australian stated during the entire twenty-five-year period.

Fig. 4. Participation rate, Australia and states 1992-2015



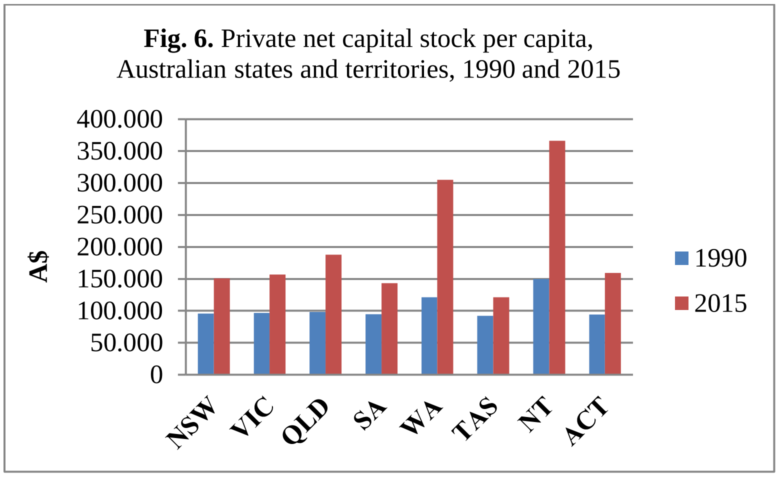
Source: ABS 6291.0.55.001.0, 2015

Figure 5 shows the average annual growth rates in the number of hours worked for the states and territories of Australia for the period 1990-2015. As can be seen, Tasmanian average growth in this category of the labour input was the lowest among Australian states.



Source: ABS 6202.0, 2015

Figure 6 presents private net capital stock (NCS) per capita for Australian states and territories for the years 1990 and 2015[1]. As can be seen, Tasmania had the lowest value of per capita NCS among Australian states in both 1990 and 2015. The growth rate of NCS per capita was the lowest in Tasmania with only 31.9 percent change during this period compared to 79.4 percent for Australia as a whole.

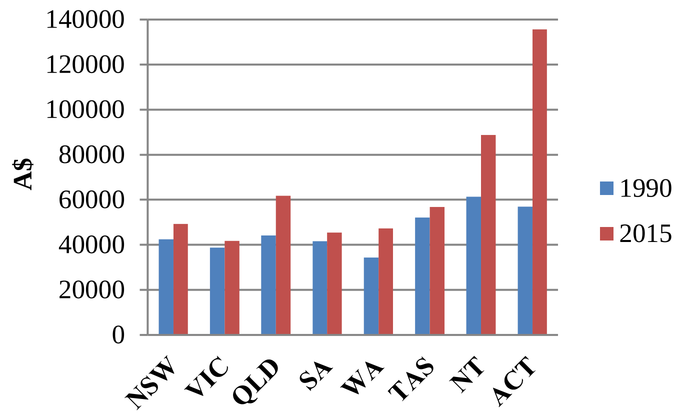


Source: Mikhailitchenko, 2015

However, Tasmania has the forth-highest value of public NCS per capita among Australian states and territories being behind ACT, NT and QLD as shown in Figure 7. At the same time, the growth rate of the public NCS per capita between 1990 and 2015 was only 9.1 percent, which was above the corresponding value only for VIC and far below 23.5 percent for Australia as a whole.

[1] See appendix for details of the PIM methodology to derive NCS

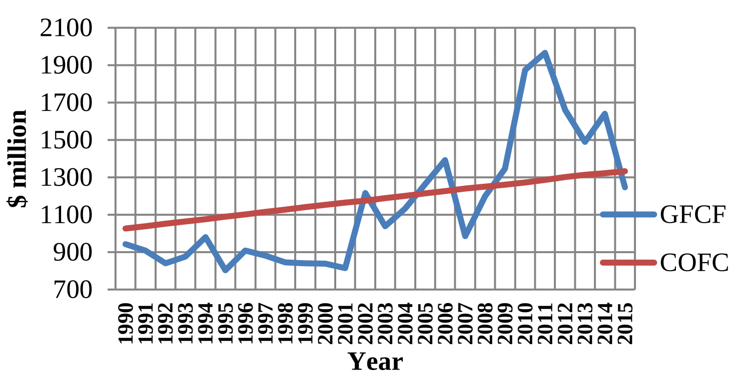
Fig. 7. Public net capital stock per capita, Australian states and territories, 1990 and 2015



Source: Mikhailitchenko, 2015

Figure 8 below shows the reasons for the slow growth of the public NCS per capita in Tasmania. As can be seen, in most years since 1990 public capital depreciation measured as Consumption of Fixed Capital (COFC) in Tasmania exceeded the public investment measured as Gross Fixed Capital Formation (GFCF), resulting in disinvestment in the public capital stock of this state in most periods 1990 to 2009 and some growth in public capital stock in 2010-2014. This is unique for Tasmania and was not observed in any other Australian state or territory.

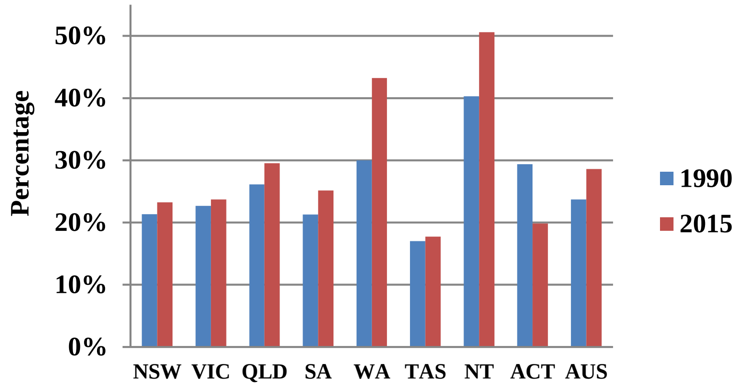
Fig. 8. Public Gross Fixed Capital Formation and Consumption of Fixed Capital: Tasmania, 1990-2015



Source: Mikhailitchenko, 2015 and ABS 5220.07, 2015

There are also significant differences in the composition of the capital stocks between the states. As can be seen from Figure 9 below, the proportion of private non-dwelling construction comprising of non-residential buildings and private infrastructure was the lowest for Tasmania in both 1990 and 2015.

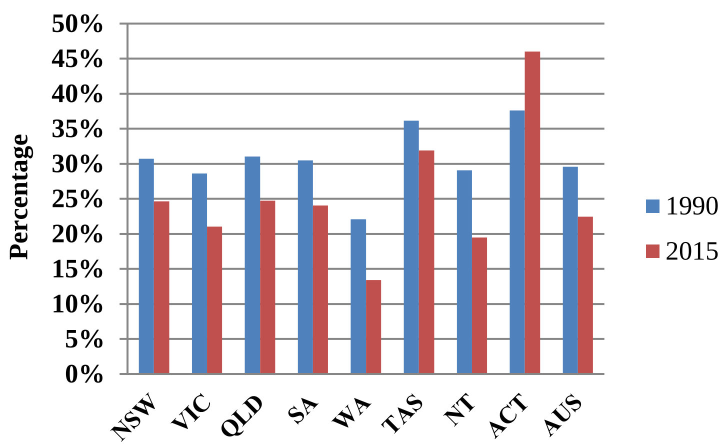
Fig. 9. Proportion of Private Non-Dwelling Construction in the total Net Capital Stock, Australia and states, 1990 and 2015



Source: Mikhailitchenko, 2015

However, as can be seen from Figure 10 below, the proportion of public assets in the total NCS in Tasmania was the second highest among Australian states and below only for ACT. This proportion declined between 1990 and 2015 for all states except ACT, which probably reflects the expansion of the Federal government public service capabilities. The large proportion of public capital stock in Tasmania indicates that public infrastructure might play a significant role in the state economic development and that this role might be more important than the role of public investment in other Australian states.

Fig. 10. Proportion of public assets in the total Net Capital Stock, Australia and states, 1990 and 2015



Source: Mikhailitchenko, 2015

According to the discussion above, Tasmanian economy is unique indeed. A rigorous economic analysis of this state might provide some important insights into regional economic development and the role of provision of public infrastructure, in particular.

Estimation Results and Discussion

The author starts from a traditional growth decomposition approach and proceeds with a time series analysis of the data in order to test the coefficients for statistical significance. Table 1 below reports the units root tests of the variables (p-values given in parenthesis). As can be seen from Table 1, $\boldsymbol{Y_t/K_t}$ and $\boldsymbol{L_t/K_t}$ exhibit unit roots at level but are stationary in the first difference, which implies that these series are ***I(1)*** processes. Further Kwiatkowski-Phillips-Schmidt-Shin unit root test revealed that the hypothesis that G_t has a unit root at the first difference couldn't be rejected at 10 percent significance level. Therefore, G_t, despite the risk of having a unit root in the first difference, this variable is also considered an *I(1)* process.

Table 1. Unit root tests

Level	**ADF**	**PP**	**1st difference**	**ADF**	**PP**
Y_t/K_t	-1.8497 (0.6499)	-1.4978 (0.8031)	$d(Y_t/K_t)$	-4.9270*** (0.0031)	-7.3694*** (0.0000)
L_t/K_t	-1.4442 (0.8216)	-1.5095 (0.7988)	$d(L_t/K_t)$	-4.2854** (0.0132)	-3.4827* (0.0642)
G_t	-1.2606 (0.8782)	-0.3134 (0.9859)	$d(G_t)$	-2.6903 (0.2486)	-2.603 (0.2486)

, ** and * indicate that the t-statistic is significant at 10, 5 and 1 percent level of significance respectively*

Table 2 below shows Johansen system co-integration test results with p-values given in parenthesis. As can be seen, there is at least one co-integrating equation, which makes it possible to proceed with modelling the relationship between the specified variables using an error-correction methodology.

Table 2. Co-integration test results

Level	**None**
Trace Statistic	22.2996** (0.0501)
Maximum Eugen value	35.1928*** (0.0086)

, ** and * indicate that the t-statistic is significant at 10, 5 and 1 percent level of significance respectively*

However, as Otto and Voss (1994, 1996) noted, it is not always clear if the public expenditure is purely exogenous variable or it is greatly influenced by political considerations, in which output growth and unemployment usually play a major role. Therefore, this study assumes that the private output variable and all input variables can be endogenous and applies a vector error-correction model (VEC) to estimate the aggregate production function as per equation (3). This approach allows to distinguish between the short-run and the long-run dynamics as well as to estimate the rate of adjustment towards the long-run equilibrium after a shock.

Specifying the long run relationship between the variables in a VEC and correctly identifying the dependent and independent variables is extremely important as misspecification might lead to a bias in the estimates and also severely affects the significance of the estimated coefficients. Therefore, it is advisable to conduct a Grange causality test before estimating a VEC. Table 3 presents the basic Granger causality test results. As can be seen, contrary to the expectations, it is the public capital and not the output is the dependent variable, implying that the government of Tasmania is actively engaged in using fiscal instruments for macroeconomic management.

Table 3. Granger causality test results

Null hypothesis	**F-statistic**	**p-value**
G_t doesn't Granger cause Y_t/K_t	2.0777	0.1527
Y_t/K_t doesn't Granger cause G_t	5.0354	0.0176**
L_t/K_t doesn't Granger cause Y_t/K_t	0.7885	0.4820

Y_t/K_t doesn't Granger cause L_t/K_t	1.8357	0.1867
L_t/K_t doesn't Granger cause G_t	0.5158	0.6052
G_t doesn't Granger cause L_t/K_t	4.4453	0.0261**

, ** and * indicate that the t-statistic is significant at 10, 5 and 1 percent level of significance respectively*

Equation (4) presents the estimation results of the long-run relationship of equation (2) with p-values of the estimated coefficients given in parenthesis.

$$\frac{Y_t}{K_t} = -0.41 \times \frac{L_t}{K_t} - 0.04 \times G_t$$

(0.0108)** (0.0629)*

R^2_{adj}=0.626

, ** and * indicate that the t-statistic is significant at 10, 5 and 1 percent level of significance respectively (2-tail tests)*

The estimated results[2] indicate that there is a long-run positive relationship between the private capital productivity and the public net capital stock. A one percent increase in the later results in around 0.04 percent decrease in the former. A one percent increase in the capital to labour ration results is a 0.4 percent increase in private capital productivity. An immediate problem in the estimates is that the adjustment coefficient towards the long-run equilibrium indicates that the error term becomes larger over time as, although of a small absolute value (0.0023) it has a positive sign. Although this might indicate a problem with the model specification, the public investment cannot be considered as purely endogenous due to the political factors influencing the government expenditure. The short-run VEC coefficient for the differenced Y_t/K_t term is negative 0.1640, which provide some further evidence that Tasmanian government is conducting a countercyclical fiscal policy.

Conclusion and Future Work

The estimated results suggest a weak negative effect of the public infrastructure on the private sector productivity in Tasmania. The long-run elasticity of the private capital productivity with respect to the public capital is -0.04. The long-run elasticity of the private capital productivity in Tasmania with respect to the public infrastructure is significantly lower than the estimates of Otto and Voss (1994) for Australia as a whole and Aschauer (1989) for the United States.

The negative elasticity of private capital for Tasmania is not in accord with the estimates at sub national level in other countries in studies such as Ezcurra (2005) for Spain and Hamalainen and Malinen (2011) for Finland, where the public capital was found playing a significant positive role in the private sector productivity growth.

There is an evidence of countercyclical fiscal policy conducted by the government in Tasmania. However, as can be seen, the government's effort doesn't result in a long-term growth and can only be considered as a short-term stimulus for the state's economy.

The results must be treated with caution due to the sensitivity of VEC estimates to the model specification and the quality of inputs into the model. In future, the author will try several other model specifications including the multistage least squares in order to determine the true effect of the public capital on economic growth and private capital productivity. In addition, the author will attempt developing the capital services series and use these data as the capital input instead of the NCS.

Further, the author will conduct similar analysis for the rest of the states of Australia to determine if there are any substantial differences in productivity between the regions with respect to the public infrastructure.

[2] The error term of the model has been tested for normality using a Jackie-Berra test. No abnormality of the error term has been detected

Finally, the author plans building a panel data model that allows for special spill-over effects between Australian states and territories, which will make it possible to find out if and in which direction the development of public infrastructure in one state causes economic growth and productivity growth in neighbouring states.

Some consideration will be given to the possible effect of the small population size of some states, which might reduce the extent to which small state are able to exploit economies of scale in public infrastructure compared to more densely populated regions, or at least, in some parts of those.

REFERENCES

1. Aschauer, D.A. (1989), ‘Is public expenditure productive?’, *Journal of Monetary Economics*, **23**, 177-200.
2. Australian Bureau of Statistics (various years), *Australian National Accounts: State Accounts*. Cat. No. 5220.0. ABS: Canberra.
3. Australian Bureau of Statistics (2015), *Labour Force, Australia, Detailed - Electronic Delivery*. Cat. No.6291.0.55.001. ABS: Canberra.
4. Duffy-Deno, K. and Eberts, R. 1989. Public Infrastructure and Regional Economic Development: A Simultaneous Equations Approach. Working paper No. 890. Federal Reserve Bank of Cleveland.
5. Ezcurra, R., Gil, C., Pascual, P. and Rapun, M. (2005), ‘Public capital, regional productivity and spatial spill-overs’, *The Annals of Regional Science*, **39**, 471-494.
6. Gu, W. and Macdonald, R. (2009), *The Impact of Public Infrastructure on Canadian Multifactor Productivity*, Statistics Canada, Cat. No.15-206-X.
7. Hamalainen, P. and Malinen, T. (2011), ‘The relationship between regional value-added and public capital in Finland: What do the new panel econometric techniques tell us?’ *Empirical Economics*, **40**(1), 237-252.
8. Mikhailitchenko, S. (2015), ‘Estimates of Net Capital Stock and Consumption of Fixed Capital for the Australian States and Territories, 1990-2013’, Paper presented at 2015 Australian Conference of Economists, July 9, Brisbane, Australia.
9. Mikhailitchenko, S. 2016 (Pending). Estimates of Productive Capital Stock for the States and Territories of Australia, 1990-2014. *Journal of Economic and Social Measurement*.
10. Mikhailitchenko, S., Nguyen, D.T. and Smith, C. (2005), ‘Estimates of Capital Stocks for the States and Territories of Australia, 1985-2004’, *Economic Analysis and Policy*, **35**(1&2), 1-22.
11. Morrison, C.J. and A.E. Schwartz (1996), ‘State Infrastructure and Productive Performance’, *American Economic Review*, **86**, 1095-1111.
12. Munnell A. (1990), ‘Why has productivity growth declined? Productivity and public investment’, *New England Economic Review*, Jan/Feb, 3-22.
13. Otto, G. and Voss, G. (1994), ‘Public Capital and Private Sector Productivity’, *Economic Record*, **70**(209), 121-132.
14. Otto, G. and Voss, G. (1996), ‘Public Capital and Private Production in Australia’, *Southern Economic Journal*, **62**(3), 723-38.
15. Otto, G. and Voss, G. (1998), ‘Is Public Capital Provision Efficient?’ *Journal of Monetary Economics*, **42**(1), 47-66.
16. Satya, P. (2003), ‘Effects of Public Infrastructure on Cost Structure and Productivity in the Private Sector’, *Economic Record*, Otto, G. and Voss, G. (1996), (247), 446-461.

Appendix

Net capital stock (NCS) by type of asset has been derived as a sum of gross fixed capital formation (GFCF) discounted by the age-specific depreciation rates, δ_t in each year of service as per ABS (5216.0, 2012) and by the age-specific retirement rates as per Winfrey’s (1938) survival function.

$$K_t^{ij} = \sum_{\tau=0}^{T} I_{t-\tau}^{ij}(1-\delta_\tau^{ij})(1-\theta_\tau^{ij})$$

where K_t^{ij} is NCS $I_{t-\tau}^{ij}$ is the real value of investment of type i in a region j with the remaining service life of t-τ; $\delta_\tau^{ij}$is the accumulated loss of efficiency of an asset when it reaches the age τ; $\theta_\tau^{ij}$is the accumulated value of loss of assets due to their retirement from the stock.

The investment data for dwellings, ownership transfer costs, non-dwelling construction, machinery and equipment, cultivated biological products, intellectual property products, and public assets are available for the period 1986-2015 are published by the ABS (Cat. No. 5206.0 and 5220.0). Where the GFCF series are not long enough, which is the case for most of the variables, the population size was used as a proxy for investment data.