The College Of WILLIAM & MARY

Structural Breaks in Public Infrastructure Investment in the US

Alfredo M. Pereira
College of William and Mary

Martin B. Schmidt
College of William and Mary

College of William and Mary
Department of Economics
Working Paper Number 55

Previous Versions: August 2007, January 2009
Current Version: July 2009

COLLEGE OF WILLIAM AND MARY
DEPARTMENT OF ECONOMICS
WORKING PAPER # 41
Current Version: July 2009

Structural Breaks in Public Infrastructure Investment in the US

Abstract

Purpose - This paper investigates the possible existence and timing of structural breaks in public infrastructure investment in the US.
Design/methodology/approach – Results are obtained using both the conventional Chow tests as well as the multivariate Bai, Lumsdaine and Stock tests which are more appropriate for finding breaks in the context of a VAR structure. All tests consider aggregate public investment as well as nine different disaggregated categories of public investment. In addition, multivariate tests include private output, employment, and investment, the variables usually considered in the literature.
Findings - Empirical results suggest that a break in the mean of public investment occurred in the late 1970s or early 1980s. This is true at the aggregate level as well as for most types of public infrastructures.
Practical implications – The measurement of the economic effects of public investment is a critical piece of information to understand the effects of any fiscal stimulus package. The empirical evidence in the literature is somewhat inconclusive at least partially because structural breaks have been largely ignored.
Originality/value – We regard the evidence presented in this paper as the first step in the process of revisiting the analysis of the effects of such investments in a VAR framework while accounting for the presence of structural breaks.

Paper type - Research paper.

JEL Codes: C32, E62, H54

Keywords - Public investment, Infrastructures, Structural breaks, VAR models.

Alfredo M. Pereira
Department of Economics
College of William and Mary
Williamsburg, VA 23187-8795
ampere@wm.edu

Martin B. Schmidt
Department of Economics
College of William and Mary
Williamsburg, VA 23187-8795
mbschm@wm.edu

1. Introduction

In this paper we investigate empirically the issue of structural breaks in the public infrastructure investment series with the objective of identifying the existence and determining the timing of such breaks. Beginning with the seminal work of Aschauer (1989), the analysis of the effects of investment in public infrastructures in the United States has received a great deal of attention. While the earlier literature was dominated by univariate and static production or cost function approaches, more recently this literature has moved in the direction of using VAR models thereby capturing the dynamic feedbacks among the different variables [see, for example, Kamps [2005] for a discussion of the literature on the effects of public investment using a VAR approach]. This methodological shift marks the convergence of the literature on the effects of public investment in infrastructures with the more macro-oriented literature on the effects of fiscal policies. [See, for example, Perotti [2005] for a review of the literature on the macroeconomic effects of fiscal policies.]

Despite the fact that long data series - typically starting in the middle 1950s - are commonly used, the possibility of structural breaks has received scant attention. Nevertheless, even casual considerations would suggest that there are good reasons, both conceptual and methodological, why such possibility should be considered.

A shift in the patterns of public investments would be consistent with the well-cited literature which found that the 1970s marked a turning point leading to a period of substantial slowdown in public infrastructure development. Indeed, infrastructure investment stood at 0.78% of the GDP throughout the 1980s and 90s in contrast with 2.03% for the previous two decades. Furthermore, the interaction of public infrastructure investment and the economy occurred in a context of productivity growth until the 1970s, of productivity slowdown after the 1970s, and of a recovery in the 1990s. Accordingly, structural changes either in public investment or in its interaction with the rest of the economy might be expected.

These considerations become even more crucial now that the VAR approach has been widely adopted in the literature. Indeed, the importance of recognizing a structural break within VAR modeling has recently been highlighted by Ng and Vogelsang (2002) who show that OLS estimates are misspecified in the presence of a break in the included variables. This is true whether all or just one of the included series experienced a structural break in their mean. Furthermore, because the omitted mean shifts lead to inconsistent and biased estimates, forecasts and impulse response functions based on these OLS estimates would also be inconsistent and likely produce biased estimates.

Indeed, this may be the reason behind some discrepancies between the results reported in Pereira (2000) and Pereira and Andraz (2004. In these two papers, the same methodological approach and comparable data sets are used. The consideration of different time horizons, however, seems to have led to sharply different estimates of, for example, the effects of investment in freeways and roads on private output – a marginal product of about $2.0 when the period 1956-1997 is considered and about eight times higher when 1977-1999 is considered instead. One might suspect that if the individual series or the relationships among series changed in the late 1970s, the presence of structural breaks might explain the disparate estimates.

2. Data and preliminary tests

We use annual data for 1956-1997 from Pereira [2000]. The variables are output (y), private investment (i), and public investment (pi), all in billions of 1987 dollars, and employment (e) measured in full-time equivalent employees. Data for output and employment is from the Bureau of Economic Analysis and is available on-line while the data for private and public investment come from the U.S. Department of Commerce's *Fixed Reproducible Tangible Wealth in the United States, 1925 – 1989* (1993) and their extended data until 1997.

At the disaggregated level we consider the nine types of non-military public investment provided at the source: core infrastructure investment in *freeways and roads* (pi1), *public utilities* (pi2), *sewage* (pi3), and *water systems* (pi4); investment in *educational buildings* (pi5), *hospital buildings* (pi6), *other buildings* (pi7); and investment in *conservation and development structures* (pi8) and *civilian equipment* (pi9).

To get a sense of the possibility of structural breaks, we employed a rolling version of the Chow breakpoint test. Specifically, we regressed each of the public investment series on lagged output, employment and private investment as well as its own lag. We, then, performed a series of Chow breakpoint tests, beginning in 1968 and continuing on a rolling basis through 1992. This process yields a time-series of estimates which may help to isolate any structural changes which may have occurred within the individual investment series.

The log-likelihood $\boldsymbol{X}\,\mathbf{P}^2$ p-values, on a rolling basis, are reported in Figure 1. The rolling Chow tests suggest that the majority of the public investment series have been subject to some sort of structural change. The graph for aggregate investment suggests a structural break around 1980. The disaggregated series also suggest the existence of structural breaks but their timing appears to differ across the individual series. For example, while *freeways and roads* (pi1), *water systems* (pi4) and *educational buildings* (pi5) appear to have changed behavior during late 1970s or early 1980s, *public utilities* (pi2), *sewage* (pi3), *other building* (pi7), *conservation and development structures* (pi8), and *civilian equipment* (pi9) seem to have changed during the late 1960s or early 1970s. Only *hospital building* (pi6) does not appear to have changed.

Furthermore, for some of the series the range of possible break dates is quite small while for others it is quite large. For example, *water systems* (pi4) appears to have changed behavior around 1976. In contrast the range of possible break dates for *educational buildings* (pi5), *other buildings* (pi7), and *conservation and development structures* (pi8) is anywhere between the early 1970s and the mid-1980s.

3. Evidence at the aggregate level

To examine more formally the possible existence of structural breaks, both in individual data and in the VAR estimates, we incorporated the multivariate break tests suggested by Bai, Lumsdaine and Stock (1998), BLS hereafter. Specifically BLS provides tests for whether all series or a subset of the series contains a common break. The multivariate setting has the benefit of strengthening the case for a structural break and sharpening the estimates of its timing. In addition, this approach provides confidence intervals around the estimated break by incorporating Andrews (1993) ***Sup-W*** and ***Exp*-W** test statistics to examine the null of no break. Finally, while the width of these confidence intervals is not influenced by the sample size, it is inversely related to the number of series considered, and as such the multivariate setting may provide a more precise estimate of the break date.

The actual estimation removes a number of observations from both ends of the data. The present application trims 20% of each side of the data. This represents a compromise between Andrews' (1993) recommendation of 15% and Bai and Perron's (2003) recommendation of 30% data points. However, the results obtained with 15% and 30% were qualitatively similar to those presented.

Aggregate test results are reported in Table 1. In general the tests suggest that a structural break in the VAR relationship occurred during the late 1970s or early 1980s. While no break is estimated within the individual series - the initial panel of Table 1 – or in the bi-variate context, the remaining tests begin to suggest a break in relationship between output and public investment. Specifically, when one includes both output and public investment within the tri-variate and the complete VAR setting, a structural break is found. In addition, while the timing of the break is erratic within the tri-variate setting, i.e., 1975 or 1993, the complete VAR estimates a break in 1980 with a relatively tight 90% confidence interval between 1978 and 1983.

4. Evidence at the disaggregated level

In order to determine the source of the structural change which appears to have occurred at the aggregate level we disaggregated the infrastructure investment series into its nine individual components. Test results are reported in Table 2. The univariate tests suggest that only *freeways and roads* (pi1) was subject to a significant change. The remaining series all fail to reject the null of no breaks. Specifically, the univariate test suggests that *freeways and roads* (pi1) changed in 1983. The estimated break has a 90% confidence interval between (1979, 1987). This break is consistent with the break found in the aggregate relationship in Table 1.

The benefit to the BLS tests, however, is the ability to assess breaks in the relationship between variables. Therefore, Table 2 presents test results for the disaggregated series with the earlier VAR variables, i.e., output, private investment, and employment. The tests generally find a significant break in the VAR structure during the late 1970s and early 1980s. This is the case for *freeways and roads* (pi1), *public utilities* (pi2), *sewage* (pi3) and *water systems* (pi4) and *other buildings* (pi7). For *educational buildings* (pi5) the break seems to have been earlier while for *conservation and development* (pi8) it seems to have been later. Only in the cases of *hospital building* (pi6) and *civilian equipment* (pi9) do we fail to find a significant change during the sample data.

5. Conclusions

Our empirical tests suggest that a break in the mean of aggregate infrastructure investment occurred in the late 1970s or early 1980s. The same is true for investment in freeways and roads, public utilities, sewage, water systems, and other buildings. For educational buildings the break seems to have been earlier while for conservation and development it seems to have been later. Only in the cases of hospital buildings and conservation and civilian equipment we find no evidence of structural breaks.

We regard this evidence as the first step in the process of revisiting the analysis of the effects of infrastructure investment. The methodological implication of our results is clear – either use data after the late 1970s or if using data from before, the existence of structural breaks cannot be ignored.

References

Andrews, D. 1993. " Tests for Parameter Instability and Structural Change with Unknown Change Point." *Econometrica* 61(4): 821-56.

Bai, Jushan, and Pierre Perron. 2003. "Computation and Analysis of Multiple Structural Change Models." *Journal of Applied Econometrics* 18: 1-22.

Bai, Jushan, Robin L. Lumsdaine, and James H. Stock. 1998. "Testing for and Dating Common Breaks in Multivariate Time Series." *Review of Economic Studies* 65: 395-432.

Kamps, C. (2005). The Dynamic Effects of Public Capital: VAR Evidence for 22 OECD Countries. *International Tax and Public Finance* 12: 533-58.

Ng, Serena and Timothy J. Vogelsang. 2002. "Analysis of Vector Autoregressions in the Presence of Shifts in Mean." *Econometric Reviews* 21(3):353-81.

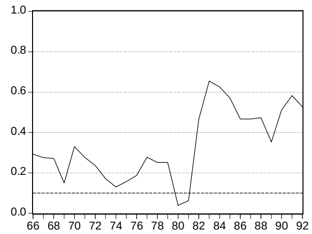
Pereira, Alfredo M. 2000. "Is all Public Investments Create Equal?" *Review of Economics and Statistics*. 82(3): 513-518.

Pereira, Alfredo M. and Jorge M. Andraz. 2004. "Public Highway Spending and State Spillovers in the US," Applied Economics Letters. 11: 785-88.

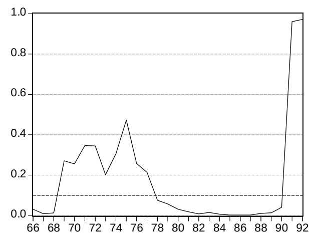
Perotti, R. (2005). Estimating the Effects of Fiscal Policy in OECD Countries, CEPR D.P. 4842.

Figure 1 - Rolling Chow Tests

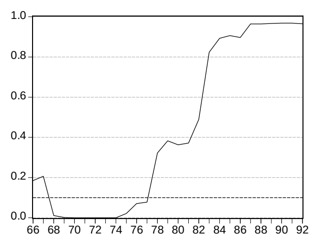
Aggregate Public Investment - pi



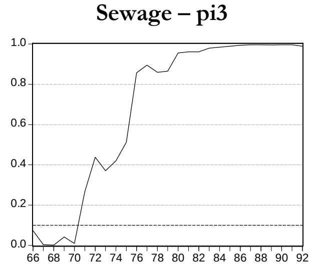
Freeways and Roads - pi1



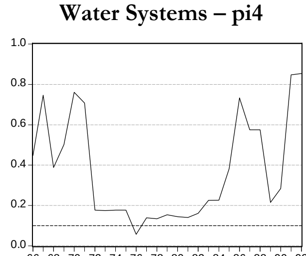
Public Utilities – pi2



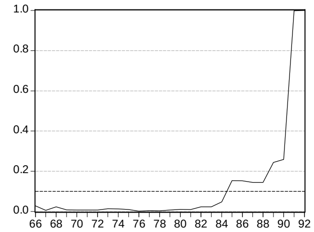
Sewage – pi3



Water Systems – pi4

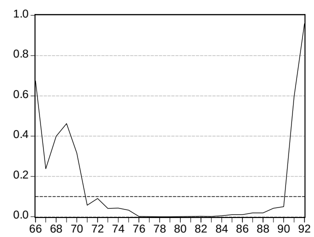


Educational Buildings – pi5

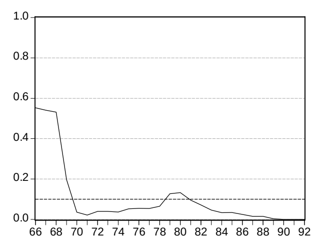


Hospital Buildings – pi6

Other Buildings – pi7



Conservation and Development – pi8



Civilian Equipment - pi9

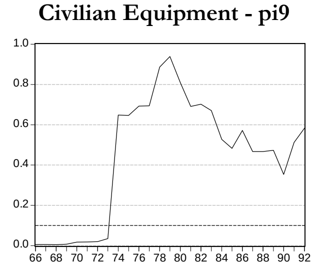


Table I - BLS Structural Break Tests: aggregate results

Variable (lag)	Sup-W	Exp-W	Break	90% CI
		Univariate		
y (2)	4.46	0.82	1970	(1960, 1980)
i (1)	1.38	0.13	1987	(--, --)
e (2)	0.69	0.11	1990	(-- , --)
pi (1)	3.46	0.88	1984	(1967, --)
		Bivariate and Trivariate VARs		
y,i (3)	8.84	2.85	1993	(1989, 1995)
y,e (2)	4.59	0.82	1974	(1964, 1984)
y,pi (2)	8.25	2.74	1975	(1968, 1982)
i,e (3)	8.38	2.45	1993	(1980, 1996)
i,pi (1)	3.27	0.84	1987	(1965, --)
e,pi (2)	3.48	0.90	1983	(1967, --)
y,i,e (3)	9.79	3.49	1993	(1989, 1995)
y,i,pi (3)	**12.51**	**4.32**	**1993**	**(1989, 1995)**
y,e,pi (2)	**17.52**	**6.38**	**1975**	**(1972, 1978)**
i,e,pi (3)	8.40	2.38	1993	(1988, 1996)
		The Complete VAR		
y,i,e,pi (3)	**25.85**	**10.4**	**1980**	**(1978, 1983)**

Notes: Boldface represents rejection of the H_0: No Breaks at the 10% level.

Table II – BLS Structural Break Tests: disaggregated results

variable (lag)	Sup-W	Exp-W	Break	90% CI
Univariate				
pi1 (1)	**13.10**	**4.88**	**1983**	**(1979, 1987)**
pi2 (1)	1.57	0.19	1977	(--, --)
pi3 (1)	1.43	0.24	1975	(--, --)
pi4 (1)	1.50	0.15	1990	(1959, --)
pi5 (1)	2.08	0.35	1968	(--, 1996)
pi6 (1)	3.10	0.64	1990	(1978, --)
pi7 (1)	2.59	0.63	1984	(1960, --)
pi8 (1)	6.11	1.55	1990	(1983, --)
pi9 (1)	2.46	0.48	1978	(--, --)
The Complete VAR				
y, i, e, pi2 (3)	**38.70**	**16.81**	**1977**	**(1976, 1978)**
y, i, e, pi3 (3)	**11.88**	**4.49**	**1983**	**(1978, 1987)**
y, i, e, pi4 (3)	**14.05**	**5.05**	**1983**	**(1978, 1987)**
y, i, e, pi5 (2)	**11.53**	**3.86**	**1968**	**(1967, 1971)**
y, i, e, pi6 (3)	11.25	4.17	1983	(1978, 1987)
y, i, e, pi7 (3)	**19.07**	**7.08**	**1981**	**(1978, 1983)**
y, i, e, pi8 (3)	**47.50**	**21.18**	**1993**	**(1992, 1994)**
y, i, e, pi9 (2)	6.29	2.17	1989	(1984, 1996)

Notes: Boldface represents rejection of the H_0: No Breaks at the 10% level.