The Impact of Public Infrastructure on Private Investment in the US

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1 Abstract

Economists and politicians are concerned with providing a business friendly environment conducive to investment. Public infrastructure such as roads and airports may be one determinant of private investment. It is also possible that the effects can change over lagged time. Using Congressional Budget Office statistics on public infrastructure spending at the federal, state, and local levels and the Bureau of Economic Analysis estimates of Gross Private Domestic Investment over the 51 year period from 1956 to 2007, this paper seeks to econometrically measure the relationship between the two with a distributed lag regression model. The previous literature on this topic is inconclusive. New and improved public infrastructure can encourage investment, or it can "crowd out" investment. The findings of this paper provide marginal support for the "crowding out" argument. However, there are reasons to be hesitant before applying these results to public policy.

2 Introduction

Economists and politicians spend a lot of time worrying about how best to provide a business friendly environment. Growth is highly correlated with standard of living and private firms are a key driver of growth. Private investment is an important part of an economy. A healthy economy has a lot of investment by individuals and firms.

In the United States, economists at the Commerce Department Bureau of Economic Analysis calculate Gross Private Domestic Investment (GPDI) as a way of measuring this

investment. GPDI consists of fixed investment and changes in inventory. Fixed investment includes all new structures (both residential and non-residential), equipment (both personal and for-business-purchases such as auto-mobiles), and software.[1]

Some theory suggests that governments can encourage private investment by providing new and improved public infrastructure. Firms can access more markets if there are highways, water ways, railroads, or airports with which they can receive supplies and ship finished goods. Other firms can attract more business if there is an up-to-date mass transit system. So increased infrastructure spending could lead to increased private investment. It is conceivable that it takes time to observe this increase. Firms may need time to adjust to their new demand and cost functions. Additionally, as anybody who has lived near infrastructure construction knows, these projects take time.

Other theory could predict the opposite. It is possible that government spending can "crowd out" private investment. If the government undertakes a spending project, interest rates may rise dissuading firms from purchasing new capital. Additionally, the resources being used on the projects cannot be used on private projects. In this case, the well meaning government infrastructure project can actually decrease private investment. Furthermore, lagged periods might be decreased as lengthy construction can interrupt business as usual.

We can also combine the two theories. It is possible that infrastructure spending can crowd out private investment in the short run, but after the project is completed, the improved infrastructure can create a more advantageous business environment. Private investment would fall immediately, but would increase in the following years.

[1] A Guide to the National Income and Product Accounts of the United States, http://www.bea.gov/national/pdf/nipaguid.pdf

3 Background

Over the years there has been significant research into this topic. Development economists are particularly interested in the relationship between public infrastructure and private investment. Erden and Holcombe (2005)[2] examine public infrastructure in developing countries. They find that a 10% increase in public investments in developing countries leads to about a 2% increase in private investment. However, they also determine that in advanced economies, public investment crowds out private investment.

Holtz-Eakin (1992)[3] looks at the Continental US from 1969 to 1986 at the State and regional levels. Looking at a smaller area might make sense for an infrastructure study. It is reasonable that a new highway in California may have no impact on the economy of New York. However, Holtz-Eakin finds no relationship at either aggregation level.

On the other hand, Munnell (1990)[4] finds beneficial effects from public investment. She finds that "those states that have invested more in infrastructure tend to have greater output, more private investment,and more employment growth." Munnell detects both crowding out and an increased productivity of private industry due to public investment. Private investment grew because the productivity increase outweighed the crowding out effect. In her conclusion, however, Munnell recognizes that she did not include lagged values in her study while lagged values may be important as I have explained above.

[2]Erden, Lutfi and Randall Holcombe, 2005. The Effects of Public Investment in Developing Economies. Public Finance Review Vol 33 No 5 575-602

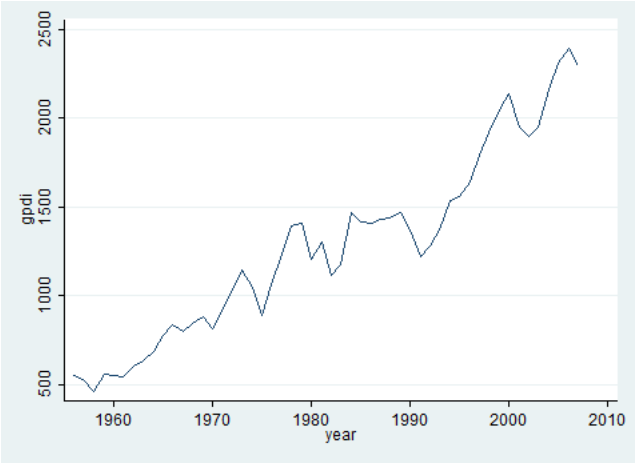
[3]Holtz-Eakin, Douglas, 1992. Public-sector Capital and the Productivity Puzzle. NBER Working Paper No 4122

[4]Alicia H. Munnell, 1990. "How does public infrastructure affect regional economic performance?," Conference Series ; [Proceedings], Federal Reserve Bank of Boston, pages 69-112.

4 Descriptive Statistics

From the Congressional Budget Office, I was able to collect total annual infrastructure spending data, aggregated from the federal, state, and local levels, between 1956 and 2007. The data was in millions of nominal dollars but by using CPI data from the Bureau of Labor Statistics and dividing by one thousand, I used the data in billions of 2007 Dollars. Similarly, from the FRED database of the St. Louis Federal Reserve I collected annual GPDI data from the same time period and converted it into billions of 2007 Dollars.

Over the 52 years, real GPDI ranged from $463 billion to $2.4 trillion with a mean of $1.27 trillion and a standard deviation of $527 billion. However, as you can see in Figure 1, there is a clear trend.



Because there is a clear positive trend, we want to use the first difference. A Dickey-Fuller test confirmed that we cannot reject the existence of a unit root. A Dickey-Fuller test also also allows us to confirm the first difference is stationary. Over the 52 years (and 51 observations) the change in real GPDI ranged from $-202 billion to $293 billion with a mean of $34 billion and a standard deviation of $108 billion.

A similar analysis shows that we need to use the first difference for total public

infrastructure spending. Total public infrastructure spending, which includes spending at the federal, state, and local levels, ranged between $-9 billion and $14.8 billion with a mean of $4.9 billion and a standard deviation of $5.25 billion.

The total public infrastructure data breaks down into spending on highways, mass transit, railroads, aviation, water transport, water resources, and water supply and waste treatment. Each of these subsections break down further into new capital spending and operation and maintenance costs. This can allow us to look more closely at the impact of new infrastructure spending and different types of infrastructure.

5 Regression Analysis

The first regression worth running is a simple OLS. I regressed GPDI on total public infrastructure spending. The results can be seen in Table 1. All regression tables are appended at the end of this paper.

This first model shows no relationship between infrastructure spending and private investment. This is somewhat expected. There must be some omitted variable bias. We have already discussed the need for lags in the total infrastructure spending data and other determinants of investment. The table below has the information criterion required to let us make an informed decision on the correct number of lags to include in this model.

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-276.128				13676.2	12.3612	12.3912	12.4415*
1	-275.807	.64245	1	0.423	14097.1	12.3914	12.4363	12.5118
2	-274.1	3.4127	1	0.065	13665.1	12.36	12.4199	12.5206
3	-272.834	2.5324	1	0.112	13510.5	12.3482	12.423	12.5489
4	-269.931	5.8068*	1	0.016	12423*	12.2636*	12.3534*	12.5045
5	-269.263	1.3349	1	0.248	12619.9	12.2784	12.3831	12.5594
6	-268.751	1.0241	1	0.312	12913	12.3	12.4198	12.6212

The regression should include four lags according to most of the information criterion. Table 2 has the results of our second model updated accordingly.

Adding multiple lags does not substantially help the model. It is worth noting, and is counter intuitive, that the signs on these coefficients are the opposite of what I would have expected. My guess would have been that crowding out and construction interfering with ordinary business would reduce private investment in the first year or two but the improved infrastructure would increase private investment afterwards. The data reveals the opposite. That said, it could very easily just be random noise. These results are far from significant; the F-statistic of .32 means that we cannot reject the null hypothesis that all of the coefficients are zero. This model shows no relationship between public infrastructure spending and private investment.

Maybe we are using the wrong measure of infrastructure spending. Perhaps looking at spending for new capital and spending for maintenance separately can reveal something we don't currently see. It is reasonable to hypothesize that maintenance and operation will crowd out investment in the next period because spending necessarily comes with taxes. Furthermore, as infrastructure ages, maintenance costs may rise while reliability and effectiveness fall. Alternatively, it is possible that at the aggregate level, it could provide stimulus. Workers employed in infrastructure operation and maintenance have an income and spend money that they may have otherwise been unable to spend. It is also possible that new infrastructure spending will crowd out investment in the current period, but boost investment in subsequent periods. Our third model's results[5] can be seen in Table 3.

This model does not add much to our analysis. It is still not significant. The only significant term is the third lag of the first difference of new infrastructure capital. The

[5]Note: Both total new capital spending and operation and maintenance spending have a unit root so we again must use the first difference

data show a significant decrease in private investment three years after a project was started. Due to the weakness of the model, I don't put much stock in this result.

If we want to learn anything about the impact of infrastructure spending on private investment we need to improve our model. To do this, we need to account for some of the omitted variable bias by adding some structure. Economic theory tells us that interest rates have an impact on investment. Higher interest rates mean that an investment project needs to have a higher expected return to be worth completing. Thus, higher interest rates should reduce private investment. We should add the Federal Funds Rate[6] to our regression.

In order to make this model as strong as possible, we need to carefully select the proper number of lags. The table below provides a number of information criterion with which was can choose the proper number of lags for the model.

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-267.326				13301.6	12.333	12.3932*	12.4952*
1	-266.823	1.0071	1	.316	13611.8	12.3556	12.4308	12.5583
2	-266.152	1.3414	1	.247	13827	12.3705	12.4608	12.6138
3	-265.754	.79632	1	.372	14225	12.3979	12.5032	12.6818
4	-262.9	5.7082*	1	.017	13093.1*	12.3136*	12.4339	12.638
5	-262.579	.64134	1	.423	13527.5	12.3445	12.4798	12.7095
6	-262.259	.60134	1	.438	13995.6	12.3763	12.5267	12.7818
7	-262.259	.0382	1	.845	14674	12.4209	12.5863	12.8669

It appears that four lags will give us the best model. Results of the regression with four lags for each of the independent variables are in Table 4.

This is by far our best regression. It is highly significant and very informative. The most significant variables are the first lag of the Federal Funds Rate and the first lagged difference in new infrastructure capital. As expected, an increase in the interest rate

[6]Data downloaded from the FRED database, aggregated as an annual rate. Note: the Federal Funds Rate is already stationary

leads to a decrease in private investment. The more interesting result is that this model provides evidence that private investment will be crowded out by public infrastructure projects. A $1 billion increase in the difference in infrastructure capital corresponds with a $12 billion decrease in the change in private investment. This is likely due to a combination of crowding out and construction interfering with ordinary business.

More surprising however is the persistence of the negative impact of new infrastructure capital on private investment. The third and fourth lag are relatively significantly negative. The cumulative dynamic multiplier over the four lags of new capital infrastructure investment is -27.13. This means that a $1 billion increase in the difference of new infrastructure capital spending corresponds with a $27 billion decrease in the private investment rate over four years.

Another interesting result is the continuously positive coefficients on the operation and maintenance terms. This indicates that there is a stimulative effect in maintaining the present stock of infrastructure. The cumulative dynamic multiplier for this is 26. This means that a $1 billion increase in the change in maintenance spending corresponds with an increase in private investment rate of $26 billion over four years.

The CBO data collected break infrastructure spending down into subsections. These subsections are highways, mass transit, railroads, aviation, water transport, water resources, and water supply and waste treatment. It is possible that different types of infrastructure have different impacts on investment. While this interesting to think about, the regression is much more difficult. Having this many variables leads to issues of multicollinearity.

6 Conclusions

This paper has sought to shed some more light on the impact of infrastructure investment on private investment in the United States. The data show that the crowding out effect, possibly combined with the reality of construction, lead to a negative impact. An increase in public infrastructure projects corresponds with a decrease in private investment.

However, this should not be viewed as the end of the discussion. It is still possible that there are regional effects not captured in this analysis. Additionally, it is imperative that I point out that this paper used infrastructure spending. This metric does not necessarily capture the quality of the projects. For example, the most expensive infrastructure project of all time, Boston's Big Dig, and similar poorly executed, inefficient, needlessly expensive projects should not be expected to increase private investment. Projects such as this and Alaska's infamous "bridge to nowhere" throw an interesting wrinkle into the analysis. I hope that future research can find a way to control for the quality of public projects. This, I suspect, impacts studies at the state, regional, and aggregate levels.

Yet another issue to consider is the possible endogeneity of infrastructure spending. New government infrastructure projects may be counter-cyclical. An economy in recession may have little private sector investment. But government fiscal policy, in an attempt to spur recovery, may increase public sector infrastructure. This could be another possible explanation for the negative relationship between the two. On the other hand, at the state and local levels, infrastructure spending may be pro-cyclical. When the economy struggles and tax revenues fall, public projects may be shelved or cancelled. In this case, we would expect to see a positive relationship between infrastructure and investment.

A final interesting thought experiment is about some minimum level of public in-

frastructure. Taken to the extreme, I find it impossible to imagine any private investment occurring in the absence of basic roads and electricity. At the other extreme, if all an economy's resources are used by the public sector, there is no room for any private investment. It is quite reasonable that there could be decreasing returns to infrastructure. The big question for policy makers should be "at what point do the marginal costs exceed the marginal benefits?"

7 Regression Tables

Table 1: Model 1

	m1	
	Coef.	p-value
Change in Total Public Infrastructure	–.383	.897
Constant	36.111	.092
Adj. R^2	–.020	
No. of cases	51	

Table 2: Model 2

	m2	
	Coef.	p-value
Change in Lag Tot Pub Inf	1.559	.644
Two Lags	–1.203	.722
Three Lags	–1.891	.578
Four Lags	–1.667	.621
Constant	52.318	.112
Adj. R^2	–.063	
No. of cases	47	
F-Stat	.32	
Prob > F	.86	

Table 3: Model 3

	m3	
	Coef.	p-value
First Lagged Difference of Capital	–5.409	.287
Second Lag	5.487	.311
Third Lag	–12.256	.031*
Fourth Lag	5.489	.271
First Lagged Difference of Operation	8.091	.292
Second Lag	–.788	.914
Third Lag	9.457	.202
Fourth Lag	–9.027	.241
Constant	26.243	.589
Adj. R^2	–.013	
No. of cases	47	
F-Statistic	.93	
Prob > F	.5	

Table 4: Model 4

	m4	
	Coef.	p-value
First Lag of Fed Funds Rate	–48.245	.000*
Second Lag	19.629	.106
Third Lag	19.902	.088
Fourth Lag	–11.583	.135
First Lagged Difference in Capital	–12.596	.001*
Second Lag	1.243	.743
Third Lag	–8.713	.033*
Fourth Lag	–7.074	.070
First Lagged Difference in Operation	.880	.865
Second Lag	1.803	.721
Third Lag	15.227	.004*
Fourth Lag	8.102	.154
Constant	136.135	.006*
Adj. R^2	.577	
No. of cases	47	
F-statistic	6.23	
Prob > F	.0000	

8 Works Cited

A Guide to the National Income and Product Accounts of the United States, http://www.bea.gov/national/pdf/nipaguid.pdf

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