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A Replication of "Is Public Expenditure Productive?" (*Journal of Monetary Economics*, 1989)

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Abstract

We replicate the results of the landmark paper by Aschauer (1989) on the impact of public capital on the US economy. We obtained data from his stated sources and followed his exact methods and are able to replicate his main results. We also extend his data to the period 1949 to 2015, use different data sources, DOLS and VECM estimation, and Granger causality tests. We are again able to replicate his results. Please see the longer version of our article for details.

Keywords

public capital, Aschauer, replication, DOLS, ECM, VECM

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We replicate and extend a landmark paper by Aschauer (1989) on the impact of public infrastructure. He estimated an aggregate production function using US data for 1949 to 1985 and obtained an elasticity estimate of 0.39 for public capital.[1,2] The more recent literature finds that public capital has a smaller impact than Aschauer's estimates. Contrary to this, we argue that Aschauer's results hold up to our replication efforts. Public capital may have a greater impact than the more recent literature suggests.

We also replicate Aschauer's main finding for the extended period of 1949 to 2015, using different data sources and different estimators. Our analysis has the longest span of data we have found. We find that each series contains a unit root, the collection of series is cointegrated, and there is a structural break in the public capital series. We find evidence that public capital and lagged public capital Granger cause output.

The Production Model

Aschauer (1989) posits an aggregate Cobb–Douglas production function,

$$Y_t = A_t N_t^{e_N} K_t^{e_K} G_t^{e_G} \exp(u_t), \tag{1}$$

where Y_t is private output, $A_t = \exp(a_0 + a_1 t)$ is a Hicks-neutral measure of productivity, N_t is aggregate labor, K_t is aggregate private capital, G_t is public capital, u_t is an error term, and $(a_1,\ a_2, e_N,\ e_K,\ e_G)$ are the parameters to be estimated. Aschauer estimates the following two equations:

$$y_t - k_t = a_0 + a_1 t + a_2(n_t - k_t) + a_3(g_t - k_t) + a_4 cu_t + u_t, \tag{2}$$

$$\rho_t = b_0 + b_1 t + b_2(g_t - i_t) + b_3 cu_t + e_t, \tag{3}$$

where lower case variables are in logs, cu is capacity utilization, ρ denotes total factor productivity, $i_t = s_N n_t + s_K k_t$, and s_X is the share of $X = N,\ K$ in private output. The critical parameter in these equations is e_G (represented by a_3 in equation [2] and b_2 in equation [3]), which captures the productivity of public capital.

Data

We do not have access to Aschauer's actual data. We obtain data from his stated sources and for his time period (1949 to 1985), which we refer to as Vintage data. Public capital includes federal, state, and local government's equipment and structures net of military assets but includes military family housing, civil works, industrial facilities, and military hospitals.

We update the data with the most recent publications for both his time period (1949 to 1985), which we refer to as Modern Data I and also for the extended period 1949 to 2015 (Modern Data II). We also use alternative data sources for the inputs for comparison purposes in our robustness checks. See our longer article for the details.

Main Replication Results

We present Aschauer's main results and our replication in tables 1 and 2, which match up with Aschauer's tables 1A and 1B, respectively (e.g., equation [1.2] in our table 1 is equation [1.2] in Aschauer's table 1A). All equations in tables 1 and 2 are estimated by ordinary least squares (OLS), following Aschauer, except for equation (1.4), which is estimated by the Cochrane–Orcutt method.

Our replication of Aschauer's main result finds an elasticity estimate of 0.38 in equation (1.1) in table 1 for the ratio of public capital to private capital, which is statistically the same as Aschauer's estimate of 0.39. The other estimates in 1.1 also match up well with Aschauer's results according to the p values, except for the constant terms. In equation (1.2), for example, our estimate for public capital is 0.33, which is close to Aschauer's estimate of 0.36.

We also come close to the results of Aschauer's hypothesis testing. He tests the hypothesis of constant returns in all inputs in equation (1.2) in table 2. If there are constant returns in all three inputs, the coefficients on the two capital variables will be of opposite sign and equal in magnitude. The F-statistic for our version of the test is 2.72, compared to Aschauer's F-statistic of 1.27, both of which are well below the critical value. It follows that the null hypothesis of constant returns to scale in all inputs cannot be rejected, agreeing with Aschauer.

Table 2 uses total factor productivity (ρ) as the dependent variable. In equation (1.5), public capital is highly productive, and our replication is quite close to Aschauer's estimate (0.49 vs. 0.46). The other estimates also match well. Testing whether the parameters of the two capital variables are equal in magnitude but opposite in sign yields an insignificant F-stat of 3.85. We do not reject the null hypothesis of constant returns in all inputs. Lastly, equation (1.8) estimates equation (3), and our estimates coincide closely with those of Aschauer except for the constant term.

We estimate the productivity of public capital using Aschauer's functional forms, equations (2) and (3), for his period (1949 to 1985) using Modern Data I as well as for the extended period (1949 to 2015) using Modern Data II. For the shorter time period, the elasticities of public capital on private output are large and statistically significant, ranging from 0.29 to

Table 1. Replication of Aschauer's Table 1A, Vintage Data 1949 to 1985.

Equation	Constant	Time	$n-k$	$g-k$	g	k	cu	R^2	DW
DA (1.1)	−2.42	.008	.35	.39			.43	.976	1.79
	(−21.58)	(4.62)	(4.85)	(16.23)			(12.28)		
Replication	−1.29	.010	.44	.38			.41	.976	1.93
	(−3.38)	(5.74)	(5.97)	(14.42)			(11.25)		
	[.01]	[.20]	[.23]	[.67]			[.62]		
DA (1.2)	−5.60	.010	.29		.36	−.44	.45	.977	1.74
	(−10.90)	(4.46)	(3.04)		(9.79)	(−7.95)	(11.31)		
Replication	1.35	.013	.34		.33	−.47	.45	.978	1.93
	(2.18)	(5.65)	(3.51)		(8.14)	(−7.85)	(10.69)		
	[.00]	[.24]	[.64]		[.43]	[.65]	[.95]		
DA (1.3)	−0.94	.011	−.48			−.66	.74	.910	0.63
	(−2.44)	(2.48)	(−4.35)			(−6.57)	(14.24)		
Replication	5.58	.015	−.32			−.67	.71	.930	0.84
	(9.47)	(3.89)	(−3.54)			(−7.15)	(15.55)		
	[.00]	[.30]	[.09]			[.90]	[.56]		
DA (1.4)	0.19	.020	.08			−.72	.47	.963	2.05
	(0.13)	(1.42)	(0.46)			(−3.24)	(6.47)		
Replication	4.76	.027	.10			−.77	.48	.912	2.13
	(4.03)	(3.67)	(0.57)			(−3.59)	(6.46)		
	[.00]	[.35]	[.90]			[.82]	[.89]		

Note: DA refers to David Aschauer's result, and Replication is our replication of his equation. DA (1.x) refers to equation (1.x) in Aschauer's table 1A for $x = 1, 2, 3, 4$. The *t*-statistic is in parenthesis. The *p* value testing the closeness of the replication is in square brackets. DW is the Durbin–Watson statistic. Basic Equation: $y_t - k_t = a_0 + a_1 \quad t + a_2(n_t - k_t) + a_3\ (g_t - k_t) + a_4\ cu_t + u_t$.

Table 2. Replication of Aschauer's table 1B, Vintage Data 1949 to 1985.

Equation	Constant	Time	g	k	n	i	$g-i$	cu	R^2	DW
DA (1.5)	−3.87	−.002	.49					.35	.993	0.99
	(−9.56)	(−1.45)	(14.54)					(18.70)		
Replication	0.90	−.001	.46					.36	.993	0.99
	(4.82)	(−0.44)	(12.68)					(8.42)		
	[.00]	[.26]	[.36]					[.74]		
DA (1.6)	−0.72	.010	.34	−.09	−.36			.45	.998	1.73
	(−1.39)	(4.75)	(9.20)	(−0.98)	(−3.82)			(11.15)		
Replication	2.99	.013	.31	−.17	−.31			.45	.998	1.96
	(10.74)	(6.08)	(7.87)	(−1.83)	(−3.32)			(10.90)		
	[.00]	[.13]	[.48]	[.41]	[.62]			[.98]		
DA (1.7)	−1.08	.011	.37			−.45		.42	.998	1.75
	(−2.61)	(6.52)	(15.02)			(−8.19)		(17.10)		
Replication	2.93	.013	.32			−.47		.45	.998	1.95
	(10.94)	(7.27)	(12.20)			(−8.27)		(16.72)		
	[.00]	[.26]	[.08]			[.71]		[.31]		
DA (1.8)	−1.53	.009					.39	.41	.998	1.79
	(−10.01)	(35.39)					(26.33)	(18.19)		
Replication	0.77	.010					.36	.42	.997	1.88
	(6.89)	(33.78)					(22.58)	(17.07)		
	[.00]	[.05]					[.11]	[.59]		

Note: DA refers to David Aschauer's result, and Replication is our replication of his equation. DA (1.x) refers to equation (1.x) in Aschauer's table 1B for $x = 5, 6, 7, 8$. The t-statistic is in parenthesis. The p value testing the closeness of the replication is in square brackets. DW is the Durbin–Watson statistic. Basic Equation: $\rho_t = b_0 + b_1 \quad t + b_2 \, g_t + b_3 \, cu_t + e_t$.

0.48. Including the entire sample (Modern Data II) generally lowers the magnitude. Nevertheless, they remain substantial, ranging from 0.22 to 0.36.

Econometric Issues

There are several issues that Aschauer did not confront: stationarity and reverse causation from growth in output to greater investment in infrastructure. We test for unit roots and cointegration and find that each series is integrated of order one and that the collection of series is cointegrated with one vector. We use DOLS and an ECM under the single equation model used by Aschauer and others, with several refinements including a structural break in the public capital series and small sample corrections as explained in our longer article. We also estimate a VECM, which treats all the production variables as endogenous and takes the form,

$$\Delta Z_t = \alpha_0 + \alpha_1 t + \sum_{j=1}^{2} \Gamma_j \Delta Z_{t-j} - \Pi Z_{t-1} + \Phi D_t + \varepsilon_t, \tag{4}$$

where $Z = (n,\ k,\ g,\ y)'$ is endogenous and D contains exogenous variables (e.g., a structural break).

Robustness Checks

First, we estimate equation (1) in logs and consider several variations on the estimation method, OLS, DOLS, and an ECM using the Vintage data. The estimates of the public capital parameter range from 0.37 to 0.66.

We also use different sources for the data and find that public capital is productive in every variation, with the elasticity ranging from 0.32 to 0.58 for Modern Data I and from 0.18 to 0.34 for Modern Data II.

We disaggregate public capital into equipment and structures and include them separately in the estimated production function. We find the elasticity estimate for public capital structures is 0.24, while equipment does not appear to have an impact on output.

We also estimate a VECM with four equations and one cointegrating vector. The VECM estimate of the long-run public capital elasticity is 0.46 and is significant at the 1 percent level. The speed of adjustment parameter for output is significant and negative, indicating the stationarity of the cointegrating relationship.

In a block-exogeneity test, we find evidence that lagged values of public capital affect the other variables. We also perform Granger's causality tests and find that lagged values of public capital affect contemporary levels of private output.

However, we cannot reject the null hypothesis that lagged values of output do not affect public capital. The primary causality is from public capital to output.

Conclusion

We replicate the main results of Aschauer (1989) and extend them in a number of ways. It is striking how well Aschauer's results hold up.

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Supplementary Material

Supplementary material is available for this.

Notes

1. We note the sad and untimely passing of David Aschauer in 2011. His insight and the high quality of his work will be missed (see http://bangordailynews.com/2011/08/30/news/lewiston-auburn/bates-professor-stricken-during-triathlon-dies/).
2. Aschauer's (1989) paper has over 6,392 citations as of June 21, 2017. He continued this work in a series of papers in the 1980s and 1990s.

Reference

Aschauer, D. A. 1989. "Does Public Capital Crowd Out Private Capital?" *Journal of Monetary Economics* 24:171–88.

Author Biographies

Christopher Clarke is a lecturer in economics at the University of Nevada–Las Vegas. He will complete his PhD from Washington State University in 2018. He studies public capital, income inequality, and fiscal policy.

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