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ABSTRACT

We examine additional travel time that arises as reconstruction of non-functioning bridges gets delayed. Our simulations show that the extent to which a budget increase reduces such additional travel time is rather modest. We show that a substantial portion of the unsolved travel time results from budgetary allocations.

1. Introduction

Infrastructure investment is vital in any economy to promote productivity and economic growth. Massive infrastructure plans have been proposed, such as President Trump's proposal in 2018 to invest $1.5 trillion nationwide. Despite a consensus that a budget increase for infrastructure will benefit the country, whether it can solve traffic congestion largely remains an open question. In this study, we quantify the extent to which a budget increase reduces additional travel time (ATT) that arises from delayed reconstruction of non-functioning bridges. Using time series data on 445 local bridges in Pennsylvania in need of reconstruction during 1992–2015, we find that such ATT amounts to 2,840,776 hours. Our simulations show that a 20% increase in the annual budget reduces the ATT by only 6.23%. We show that a substantial portion of the unsolved ATT stems from budgetary allocations.

There are studies analyzing what determines a cross-sectional distribution of a fixed budget on transportation infrastructure (Knight, 2005; Koh, 2018). We investigate how a budget increase and its allocation affect the travel time borne by public users. Other studies on the timing of infrastructure provision focus on monetary or time costs borne by contracting agency due to delay (Guccio et al., 2014; Lewis-Faupel et al., 2016). Winston and Langer (2006) show that increased highway spending may not effectively reduce traffic congestion. The type of traffic congestion that we analyze is ATT that arises from delayed investment. We develop a distinctive methodology suitable for computing such travel time accumulating over time.

2. Data

We use 7,030 observations for a panel of 445 local bridges in Pennsylvania from 1992 until 2015 or the reconstruction year, whichever is earlier. All bridges were authorized for reconstruction in 1992 by the "Bridge Bill Capital Budget (BBCB)" passed in the state legislature. Pennsylvania has one of the largest stock of deteriorated bridges in the U.S. Therefore, we observe a long delay until reconstruction in our data; 26.06% were reconstructed within 10 years, 17.74% waited 11 to 20 years, and 56.17% waited more than 21 years.

We collect information on year built, average daily traffic, sufficiency rating (SR), operation status, detour miles, reconstruction year, and bridge materials from the National Bridge Inventory (NBI). NBI is bridge-level data compiled annually by the Federal Highway Administration, which allows us to track objective usage and deterioration measures across time. Table 1 provides summary statistics in 1992. SR is an overall adequacy measure of a bridge to remain in service, where 0 (100) implies an entirely deficient (sufficient) bridge. Its formula incorporates structural adequacy, serviceability, essentiality for public use, etc. Bridges have low SR, with more than half with some usage restrictions. Reconstruction cost for every bridge in our sample is itemized in the BBCB of 1992.

3. ATT from delayed reconstruction

We quantify ATT due to delayed reconstruction, using a modified approach of Lewis and Bajari (2011). Delayed reconstruction

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Table 1
Summary statistics.

	Mean	SD
SR	46.75	25.82
Average daily traffic	821.28	2,394.38
Bridge length (meters)	23.01	47.07
Detour length (kilometers)	15.85	42.73
Reconstruction cost (2015 USD)	$785,522	$1,539,086
Share of closed bridges	2.24%	
Share of bridges with speed or load restrictions	63.00%	

of a non-functional bridge can increase travel time in two ways: there may be slowdowns from speed or load-capacity limits, or detours from a bridge closure. We calculate ATT in year t from bridge i for these two reasons respectively as:

$$Hours^L_{it} = \left[bridge\ length\ in\ miles_i \times \left(\frac{1}{\hat{mph}} - \frac{1}{mph} \right) \times average\ daily\ traffic_{it} \right] \times 365, \quad (1)$$

$$Hours^C_{it} = \left[detour\ miles_{it} \times \frac{1}{mph} \times average\ daily\ traffic_{it} \right] \times 365. \quad (2)$$

The term inside the bracket gives additional hours per day, so we multiply by 365 days to derive the yearly level. Eq. (1) only captures slowdowns that occur while crossing a bridge, as it is unlikely for local bridges in our context to have a gridlock on the roads leading to those bridges. As all bridges carry highway, we set the normal speed as $mph = 65$ and the slowdown speed as $\hat{mph} = 35$, following assumptions from Lewis and Bajari (2011). As for average daily traffic of a closed bridge in Eq. (2), we follow the NBI data and use the most recent average daily traffic before the closure.

We calculate ATT aggregated across 445 bridges during 1992–2015 as:

$$\sum_{i=1}^{445} \sum_{t=1992}^{2015} I(t \leq reconstruction\ year_{it}) \times \left[I(limit)_{it} \times Hours^L_{it} + I(close)_{it} \times Hours^C_{it} \right]. \quad (3)$$

Note that there is no ATT once a bridge is reconstructed or operates normally. Calculating Eq. (3) gives ATT of 2,840,776 hours in total. There is a huge variation across bridges, with the average (median) value of a bridge being 6,376 (51) hours. One caveat is that the calculation does not take account of the effects of drivers' behavioral responses to slowdowns or detours on traffic.

4. Policy analyses

We first lay out empirical groundwork necessary for policy simulations. We recover the annual budget during our sample period, by summing up reconstruction cost of the bridges actually chosen in each year. Next, a bridge reconstructed in t may not be chosen for reconstruction by t in some simulations. As the data after t reflect the status of a bridge that has been reconstructed, we need to simulate what the bridge status would have been if reconstruction delay had continued. We estimate the updating process of SR and operation status, and use the estimated parameters to simulate counterfactual outcomes for the reconstructed bridges.[1] We check the goodness of fit for the counterfactual outcomes in Table 2, using 364,621 observations of other local bridges in Pennsylvania outside of our sample. Lastly, we assume that if delay had continued, the average daily traffic would have been the average of its previous values given stable average daily traffic across time.

[1] The estimation results are in the Appendix.

Table 2
Goodness of fit for counterfactual outcomes using out-of-sample data.

Criteria	Variable	Data	Prediction
length < mean	Average SR	70.16	69.65
	Share of usage-limited bridges	15.48%	13.64%
	Share of closed bridges	1.16%	1.13%
length ≥ mean	Average SR	70.91	70.51
	Share of usage-limited bridges	6.23%	6.47%
	Share of closed bridges	1.08%	0.95%

Notes: The mean length is 36.3 meters in the out-of-sample data.

Table 3
Goodness of fit for SR-based allocation.

	Data	Simulation
Number of selected bridges	199	201
Aggregate budget spent (2015 USD)	$127,799,335	$127,386,955
Average SR in 1992 for selected bridges	36.8	21.01
ATT (hours)	2,840,776	2,859,581
ATT per bridge on average (hours)	6,376	6,424

Table 4
A budget increase policy.

Budget increase	Additional amount (2015 USD)	Change in ATT	95% CI
10%	$12,779,933	−3.35%	[−3.95%, −2.74%]
20%	$25,559,867	−6.23%	[−6.83%, −5.62%]

We now simulate a policy where we increase the annual budget by a fixed percentage and allocate it in accordance with the allocation patterns observed in the data. The Department of Transportation in many states claim that SR is the key prioritization guideline. In each year, we sort bridges by SR and allocate the annual budget until the leftover budget is insufficient to fund any remaining bridge. Table 3 shows that although bridges with low SR are slightly overselected, the SR-based allocation fits the data quite well given the original budget. Therefore, we run 5,000 simulations given the SR-based allocation rule and a budget increase to derive ATT outcomes. Table 4 shows that a 20% increase in the annual budget (i.e. additional \$25.55 million in 2015 USD) decreases ATT by only 6.23% (178,151 hours). A substantial portion of the unsolved ATT comes from budgetary allocations. The formula for SR reflects various factors other than travel time: structural adequacy, strategic highway network designations, waterway adequacy, etc. Therefore, a bridge with large ATT but mediocre SR may not necessarily be prioritized.

To elaborate on this point, we simulate an alternative policy in which for a 2-year period, the government's funding temporarily targets bridges that would induce large ATT if not reconstructed. We select the 20% annual budget increase and implement the SR-based allocation except the targeted years. We formulate this 2-year-period targeting with the contest success function from the literature (Tullock, 1980). The probability of targeting bridge i in an affordable set F_t equals:

$$P_{it} = \frac{C^{\alpha}_{it}}{\sum_{j \in F_t} C^{\alpha}_{jt}}, \quad (4)$$

where

$$C_{it} = I(limit)_{it} \times Hours^L_{it} + I(close)_{it} \times Hours^C_{it}.$$

Non-negative parameter α captures the extent to which targeting reflects the ATT that would result over that year if reconstruction were delayed.

Table 5
A targeting policy.

Targeted years	α	Change in ATT	95% CI
1993–1994	1	−26.11%	[−26.80%, −25.42%]
	2	−32.88%	[−33.53%, −32.23%]
1998–1999	1	−28.44%	[−29.04%, −27.84%]
	2	−32.05%	[−32.63%, −31.47%]
2003–2004	1	−29.24%	[−29.65%, −28.83%]
	2	−32.26%	[−32.63%, −31.88%]

In Table 5, we apply targeting to different periods. When $\alpha = 1$, the probability of targeting bridge i is proportional to its relative magnitude of ATT. The reduction effect becomes greater when $\alpha = 2$, since the relative probability of targeting bridge i over j becomes more sensitive to the ratio of the respective ATT with a larger α,

$$\frac{P_{it}}{P_{jt}} = \left(\frac{C_{it}}{C_{jt}}\right)^{\alpha} \text{ for } i, j \in F_t.$$

A 20% increase in the annual budget now decreases ATT by approximately 32%, compared to 6.23% in Table 4. Deteriorated bridges can become non-functional any time, and our simulation results reflect dynamically evolving operation status of bridges. Under the SR-based allocation, ATT occurs persistently over the years. We find that targeting in any periods thus reduces ATT significantly in the next several years. Overall, the government's budgetary allocations critically determine travel time outcomes. Our finding does not suggest that the SR-based allocation is inefficient. The government clearly faces multiple objectives: low traffic, safety, environmental protection, regional development, etc. Our finding rather shows that it is overly optimistic to anticipate that ATT will be reduced significantly by a budget increase.

5. Conclusion

We quantify ATT induced from delayed investment and examine a budget increase policy. Policy simulations show that a budget increase may not significantly reduce such travel time and we offer an explanation based on budgetary allocations. In future research, it would be interesting to conduct a comprehensive cost–benefit analysis that investigates consequences of changing budgetary allocations.

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Appendix. See Tables A.1 and A.2

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2019.108901.

References

Guccio, C., Pignataro, G., Rizzo, I., 2014. Do local governments do it better? Analysis of time performance in the execution of public works. Eur. J. Political Econ. 34, 237–252.
Knight, B., 2005. Estimating the value of proposal power. Am. Econ. Rev. 95 (5), 1639–1652.
Koh, Y., 2018. Universalism and the value of political power. Internat. Econom. Rev. 59 (3), 1375–1402.
Lewis, G., Bajari, P., 2011. Procurement contracting with time incentives: Theory and evidence. Q. J. Econ. 126 (3), 1173–1211.
Lewis-Faupel, S., Neggers, Y., Olken, B.A., Pande, R., 2016. Can electronic procurement improve infrastructure provision? Evidence from public works in India and Indonesia. Am. Econ. J.: Econ. Policy 8 (3), 258–283.
Tullock, G., 1980. "Efficient rent seeking" Toward a Theory of the Rent-Seeking Society. College Station:Texas A&M. University Press,
Winston, C., Langer, A., 2006. The effect of government highway spending on road users' congestion costs. J. Urban Econ. 60 (3), 463–483.