

## Key Points

- President Trump proposes to increase infrastructure investment by \$1.5 trillion over 10 years by attaching incentives to \$200 billion of new federal spending. However, this plan lacks details about implementation. We, therefore, consider three possible options.
- By 2027, we estimate that GDP is between 0.0 and 0.5 percent larger than under current law, depending on which one of the three policy options is used. By 2037, GDP is between 0.0 and 0.4 percent higher.
- By 2027, debt held by the public is between 0.4 and 0.9 percent larger than under current law. By 2037, debt is between 0.4 percent lower and 0.6 percent larger.

## Summary

This brief reports Penn Wharton Budget Model's (PWBM) estimates of the effects of three options for \$200 billion of federal government investment in infrastructure. We include options where federal dollars are used as incentives for non-federal spending of \$1.3 trillion.

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# Options for Infrastructure Investment: Dynamic Modeling

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## Introduction

From roads, which help people and goods move from place to place, to electricity that fuels computers, public infrastructure enables households and businesses to engage in economic activity. Recently, [concerns](#) have been raised that America's infrastructure is lagging behind. Data available at [USAFacts](#) points out that in 2015, [14 percent](#) of America's bridges were functionally obsolete and another [10 percent](#) were structurally deficient. Meanwhile, in 2014, commuters spent an [extra 42 hours](#) stuck in traffic.

To this end, President Trump has proposed that the federal government invest [\\$200 billion](#) over 10 years to provide incentives for a total investment of [\\$1.5 trillion](#) in infrastructure by federal, state and local governments and the private sector.

[However, other proposals in the White House's Fiscal Year 2018 Budget](#) reduce federal infrastructure spending. In [our companion policy brief](#) that we are releasing simultaneously with this brief, we show that the total increase in federal spending will likely be well less than \$200 billion, indeed, potentially resulting in a reduction in federal spending by as much as \$55 billion over 10 years. However, for the purposes of the calculations contained in this brief, we take the additional \$200 billion of infrastructure investment by the federal government as given, ignoring these other potential offsets. This assumption, therefore, provides an upper bound on the likely effectiveness of the President's infrastructure plan.

Still, the White House's budget lacks detail for how this new \$200 billion will be invested in public capital ("infrastructure") and so we consider three options:

- Option 1: A \$200 billion increase in government spending on public capital.
- Option 2: A \$200 billion increase in government spending on public capital paired with an additional investment of \$1.3 trillion in public capital from the private sector which is funded by efficient user-fees

(e.g., toll road fees).

- Option 3: The same as Option 2 but where user-fees are now tax deductible.

## Infrastructure as a Complement to Private Capital

Previous empirical studies find that public capital serves as a complement, rather than a substitute, to private capital. Aschauer (1989)<sup>1</sup> uses national time-series data to find large positive effects on the return to private capital from public investment in equipment and structures. On the other hand, Holtz-Eakin (1994)<sup>2</sup> uses state-level data to find negligible effects. Following those empirical findings, most researchers generally treat public capital as a complement to private capital, including Baxter and King (1993)<sup>3</sup> and Leeper et al. (2010).<sup>4</sup>

A [recent 2016 study](#) by leading experts at the Congressional Budget Office (CBO) estimates the impact that public infrastructure investment has on the economy, where public infrastructure is modeled as an investment that complements private capital and labor. The CBO study evaluates hypothetical increases in infrastructure rather than possible options associated with the 2018 Fiscal Year Budget. There are a few key differences in modeling strategies between CBO and us. First, our analysis uses the [PWBM's dynamic OLG model](#), which includes a large range of forward-looking households that make labor and savings decisions in the context of other policy variables, including taxes and spending programs. Aggregate savings and labor in CBO's model responds contemporaneously to economic changes based on reduced-form rules derived from CBO estimates and related literature. As a result, CBO's model, for example, generates the same economic response to a given deficit, regardless of the underlying policy creating that deficit. In contrast, by explicitly modeling the decisions made by households and firms in the economy, PWBM's model response is policy specific and nonlinear. Second, we present analysis of public-private partnership investments, which is at the center of President Trump's plan. Third, our results test for sensitivity to assumptions about the rates of spending and rates of building infrastructure projects.

## Our Modeling

The [dynamic version of PWBM](#) is based on a [general equilibrium overlapping-generations \(OLG\) model](#) where households maximize their welfare in a forward-looking manner. Households respond to policy changes by altering how much to work and save, given wages and interest rates. The OLG framework is the workhorse model used in modern public economics.

Our model, therefore, allows us to capture an important trade-off for modeling infrastructure: while more public capital can increase the productivity of labor and capital, larger deficits, which are used to finance the additional investment, can work to reduce private capital formation.

Consistent with our previous dynamic analysis and the [empirical evidence](#), our projections assume that the U.S. economy is 40% open and 60% closed. Specifically, 40% of new government debt is purchased by foreigners. As [discussed in previous analysis](#), we typically perform estimates under two different assumptions about the initial rate of return on capital: (a) a "high" return, where the return to capital is assumed to be the marginal product of capital net of depreciation, and (b) a "low" return, where the return to capital is assumed to be close to the risk-free (Treasury bill) rate. For new infrastructure spending, the distinction between the two assumptions are not that important, and so we provide provide estimates for the "high" return case.

To more precisely capture the role of public capital, we modify the production function in our standard Dynamic OLG model to include public capital as a separate component that is a complement to private capital, as based on previous research.<sup>5</sup> The production function used in PWBM's standard Dynamic OLG model is given by:

$$Y_t = AK_t^\alpha L_t^{1-\alpha}$$

where “K” represents aggregate capital, “L” represents aggregate labor, and the greek letter “alpha” represents the production function capital share. By now including public capital more explicitly, the production function becomes:

$$Y_t = AK_t^{-g\alpha_g}(K_t)^\alpha L_t^{1-\alpha}$$

Public capital, therefore, behaves similar to “total factor productivity” that complements private capital and labor, increasing their relative productivities. (If public capital were instead modeled as a substitute to private capital then more public capital would increase labor productivity but reduce the productivity of private capital.) Public capital, therefore, leads to a larger economy, a higher return on private investment and larger wages for workers.

The explicit inclusion of public capital into our production function, therefore, requires two additional modeling assumptions, which we use for policy Options 1 - 3:

- Public capital’s own “alpha” value (elasticity of output to public capital): We apply findings from the literature<sup>6</sup> and use a value in the middle of the estimated range (0.05), for all three options. Sensitivity analysis presented below considers other values.
- The rate at which money dedicated to public infrastructure is invested as well as the speed at which infrastructure investments are then ready for use: We assume investment is focused on “shovel-ready projects” and so, we double the rate at which CBO (2016) assumes money is invested as well as those investments are ready for use. Sensitivity analysis presented below consider slower and faster values.

**Option 1: Deficit-Financed Spending of \$200 billion**

In this option, the federal government directly spends \$200 billion, which is deficit financed, to increase public capital over 10 years. There is no net increase in private contributions to public capital. This option, therefore, explores the scenario in which the federal government spends more money but private spending is actually “infra-marginal” in nature, that is, representing spending that would have otherwise occurred even without the additional \$200 billion.

Table 1 shows that, in 2027, this policy change is projected to increase public capital by 1.1 percent. However, its effect on the size of the economy is negligible. Because this policy is deficit financed, by 2027, debt rises by 0.9 percent. The increase in debt depresses private capital services by 0.1 percent, despite the fact that public capital serves as a complement.

**Table 1: Option 1 Effects on Key Variables Relative to Current Policy in Year Shown**

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Year	Revenue (% change)	Debt (% change)	GDP (% change)	Hours Worked (% change)	Average Hourly Wages (% change)	Public Capital Services (% change)	Private Capital Services (% change)
2027	0.1%	0.9%	0.0%	0.0%	0.0%	1.1%	-0.1%
2037	0.0%	0.6%	0.0%	0.0%	0.0%	0.7%	-0.1%

Note: Consistent with our previous dynamic analysis and the [empirical evidence](#), the projections above assume that the U.S. economy is 40 percent open and 60 percent closed. Specifically, 40 percent of new government debt is purchased by foreigners. The government is assumed to focus spending on "shovel ready" projects and so, the above projections assume double the spending rates and building rates applied by CBO (2016). Consistent with empirical evidence, the projections above assume that the elasticity of output to a change in public capital is 0.05. The projections above assume a high rate of return to private capital. Projections that assume a low rate of return to private capital are not materially different. Revenue estimates change with the distribution of taxable income that reflect a dynamic economy.

### Option 2: Deficit-Financed Spending with Incentives and User Fees

Secondly, we examine a deficit-financed \$200 billion federal government investment in public capital that is now effective at inducing an additional \$1.3 trillion investment in public capital by the private sector (e.g., toll roads, repairs to electricity and water distribution, and other public-private partnerships). The additional \$1.3 trillion of induced spending on public capital is funded by user-fees, which are modeled as an efficient lump-sum tax on households over the next 10 years.

The results are summarized in Table 2. Under this plan, by 2027, public capital increases by 8.1 percent and GDP by 0.5 percent. However, by 2027, debt is 0.4% larger than under current law, due to larger deficits. By 2037, though, debt actually falls by 0.4 percent, due to increased revenue associated with faster economic growth.

Table 2: Option 2 Effects on Key Variables Relative to Current Policy in Year Shown

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Year	Revenue (% change)	Debt (% change)	GDP (% change)	Hours Worked (% change)	Average Hourly Wages (% change)	Public Capital Services (% change)	Private Capital Services (% change)
2027	1.1%	0.4%	0.5%	0.3%	0.4%	8.1%	0.1%
2037	0.8%	-0.4%	0.4%	0.0%	0.3%	5.4%	0.2%

Note: Consistent with our previous dynamic analysis and the [empirical evidence](#), the projections above assume that the U.S. economy is 40 percent open and 60 percent closed. Specifically, 40 percent of new government debt is purchased by foreigners. The government is assumed to focus spending on "shovel ready" projects and so, the above projections assume double the spending rates and building rates applied by CBO (2016). Consistent with empirical evidence, the projections above assume that the elasticity of output to a change in public capital is 0.05. The projections above assume a high rate of return to private capital. Projections that assume a low rate of return to private capital are not materially different. Revenue estimates change with the distribution of taxable income that reflect a dynamic economy.

Comparing these results to Policy 1, therefore, indicates that most of the gains in economic growth come from increased private participation in creating new public infrastructure. Since private participation is fully financed using efficient user fees rather than deficit financed, it effectively stimulates economic growth.<sup>7</sup>

### Option 3: Deficit-Financed Spending with Incentives and Tax Deductible User Fees

Option 3 retains all the elements of Option 2 but allows a fraction<sup>8</sup> of the user-fees to be deductible as a business expense, which leads to less corporate tax revenue.

Table 3 shows that the effects of Option 3 on the the budget and the economy are very similar to Option 2, despite a small loss in revenues due to the deductibility of user fees for businesses.

**Table 3: Option 3 Effects on Key Variables Relative to Current Policy in Year Shown**

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<b>Year</b>	<b>Revenue (% change)</b>	<b>Debt (% change)</b>	<b>GDP (% change)</b>	<b>Hours Worked (% change)</b>	<b>Average Hourly Wages (% change)</b>	<b>Public Capital Services (% change)</b>	<b>Private Capital Services (% change)</b>
2027	1.1%	0.4%	0.5%	0.3%	0.4%	8.1%	0.1%
2037	0.7%	-0.3%	0.4%	0.0%	0.3%	5.4%	0.2%

Note: Consistent with our previous dynamic analysis and the [empirical evidence](#), the projections above assume that the U.S. economy is 40 percent open and 60 percent closed. Specifically, 40 percent of new government debt is purchased by foreigners. The government is assumed to focus spending on "shovel ready" projects and so, the above projections assume double the spending rates and building rates applied by CBO (2016). Consistent with empirical evidence, the projections above assume that the elasticity of output to a change in public capital is 0.05. The projections above assume a high rate of return to private capital. Projections that assume a low rate of return to private capital are not materially different. Revenue estimates change with the distribution of taxable income that reflect a dynamic economy.

**Sensitivity to the Speed of Adjustment**

The projections presented above assume that the government focuses on shovel ready public infrastructure projects by doubling the spending and building rates used in [CBO \(2016\)](#). To show the sensitivity of our results to this assumption, Table 4 considers "fast" and "slow" speeds as well. Under the "fast" speed, all spending and building is completed within just three years, consistent with shovel ready projects sped up by a reduced regulatory burden. Under the "slow" speed, we use the spending and building rates applied by [CBO \(2016\)](#), consistent with a broad array of long-term infrastructure projects that are not shovel ready. In general, a faster rate of spending and building leads to more economic growth than a slower rate.

**Table 4: Option 2, Sensitivity of Dynamic Results to the Speed of Adjustment in Year Shown**

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Year	Speed of Adjustment	Revenue (% change)	Debt (% change)	GDP (% change)	Hours Worked (% change)	Average Hourly Wages (% change)	Public Capital Services (% change)	Private Capital Services (% change)
2027	Slow	0.7%	0.6%	0.3%	0.3%	0.2%	5.2%	0.0%
	Medium	1.1%	0.4%	0.5%	0.3%	0.4%	8.1%	0.1%
	Fast	1.4%	0.1%	0.6%	0.3%	0.5%	9.5%	0.3%
2037	Slow	0.6%	0.0%	0.3%	0.0%	0.2%	5.0%	0.0%
	Medium	0.8%	-0.4%	0.4%	0.0%	0.3%	5.4%	0.2%
	Fast	0.8%	-0.6%	0.4%	0.0%	0.4%	5.2%	0.4%

Note: Consistent with our previous dynamic analysis and the [empirical evidence](#), the projections above assume that the U.S. economy is 40 percent open and 60 percent closed. Specifically, 40 percent of new government debt is purchased by foreigners. A slow speed of adjustment applies the same rates of spending and building as in CBO (2016), a medium speed of adjustment doubles those rates, a fast speed of adjustment assumes all spending and building occur in three years. Consistent with empirical evidence, the projections above assume that the elasticity of output to a change in public capital is 0.05. The projections above assume a high rate of return to private capital. Projections that assume a low rate of return to private capital are not materially different. Revenue estimates change with the distribution of taxable income that reflect a dynamic economy.

### Sensitivity to the Response of GDP to Public Capital

Consistent with the literature,<sup>9</sup> the projections above assume that the elasticity of output to a change in public capital is 0.05. Under this assumption, a one percent increase in public capital leads to a 0.05 percent change in GDP in a static model. To show the sensitivity of our results to this assumption, Table 5 considers a low and high elasticity case. In general, the larger the elasticity, the more economic growth.

Table 5: Option 2, Sensitivity of Dynamic Results to the Response of GDP to Public Capital in Year Shown

[DOWNLOAD DATA](#)

Year	Return to public capital	Revenue (% change)	Debt (% change)	GDP (% change)	Hours Worked (% change)	Average Hourly Wages (% change)	Public Capital Services (% change)	Private Capital Services (% change)
2027	Low	0.6%	0.6%	0.3%	0.3%	0.1%	8.1%	0.0%
	Medium	1.1%	0.4%	0.5%	0.3%	0.4%	8.1%	0.1%
	High	2.2%	0.0%	1.1%	0.3%	0.9%	8.1%	0.5%
2037	Low	0.3%	0.1%	0.1%	0.0%	0.1%	5.4%	-0.1%
	Medium	0.8%	-0.4%	0.4%	0.0%	0.3%	5.4%	0.2%
	High	1.7%	-1.4%	0.9%	0.1%	0.9%	5.4%	1.0%

Note: Consistent with our previous dynamic analysis and the [empirical evidence](#), the projections above assume that the U.S. economy is 40 percent open and 60 percent closed. Specifically, 40 percent of new government debt is purchased by foreigners. The government is assumed to focus spending on "shovel ready" projects and so, the above projections assume double the spending rates and building rates applied by CBO (2016). The low elasticity of GDP to public capital is 0.025, the medium elasticity is 0.05, the high elasticity is 0.10. The projections above assume a high rate of return to private capital. Projections that assume a low rate of return to private capital are not materially different. Revenue estimates change with the distribution of taxable income that reflect a dynamic economy.

## Conclusion

President Trump has presented a broad outline for infrastructure policy, with a federal commitment of \$200 billion to stimulate a total of \$1.5 trillion in new investment. Many of the details, however, have not yet been specified. This brief presented the economic and budgetary impact of three possible options.

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