

# Government Investment and Q: Theory and Evidence

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## Abstract

This paper develops and tests a Q-theoretic framework for government investment. We present a model in which a welfare-maximizing government chooses public investment while subsidizing private investment, predicting that government investment increases with government Q but decreases with private-sector Q due to local resource constraints. We construct novel regional measures of government Q from municipal bond prices and aggregate firm-level Qs to measure private-sector Q. Consistent with the model, government investment is positively related to government Q and negatively related to private-sector Q, with stronger effects in regions with larger subsidy programs. The results link corporate investment theory and public finance through market-based valuations, and offer a unified approach to studying economy-wide resource allocation.

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The confluence of the Covid-19 pandemic, rising geopolitical tensions, and growing concerns about climate change has led to some of the largest spending bills in US history, including the CARES Act of 2020, the Consolidated Appropriations Act of 2021, and the CHIPS and Science Act and the Inflation Reduction Act of 2022. Combined, these acts amount to trillions of dollars in government spending. At the same time, governments worldwide, including the United States, China, and the European Union, have increasingly embraced industrial policy, strategic subsidies, and direct intervention in capital markets, signaling a shift toward state capitalism. This renewed government presence heightens the importance of understanding century-old questions about the interaction between public investment and private-sector economic activity.

In this paper, we develop a Q-theoretical framework for studying government investment. In our model, the government invests in public capital and subsidizes private investment to maximize household welfare, while private-sector firms maximize firm value. The model yields three main predictions. First, mirroring the standard predictions of the Q-theory of investment for the private sector (e.g., [Tobin \(1969\)](#); [Hayashi \(1982\)](#)), government investment is *positively* related to government Q. This result is intuitive: the government chooses public investment to equate its marginal benefit (in terms of household utility) and marginal cost, so investment rises when government Q indicates a higher marginal benefit of public capital.

Second, in contrast to standard Q-theory predictions for private investment, government investment is *negatively* related to private-sector Q. The intuition is that private and public investment draw on locally inelastic inputs—most importantly labor (and, in practice, other scarce local factors such as land)—so higher private-sector Q induces firms to invest more and thereby tightens local resource constraints. With scarce inputs diverted toward investment production, generating consumption becomes more costly and, all else equal, equilibrium consumption falls. Because the government maximizes a concave household utility function, the marginal utility cost of further

reducing consumption is higher when consumption is already low, raising the marginal cost of additional public investment and leading the government to scale back investment when private-sector  $Q$  is high. An implication of this prediction is that the negative relationship between government investment and private-sector  $Q$  is stronger in regions where the government provides larger subsidies to local firms, as these subsidies amplify the effect of private-sector  $Q$  on local resource constraints and thus on government investment decisions.

Third, the model predicts that subsidy intensity decreases with private-sector  $Q$ . Intuitively, when private-sector  $Q$  is high, private investment is already strong and additional subsidies would further tighten local resource constraints, so the welfare-maximizing government optimally scales back subsidies.

We test these three predictions by constructing new regional measures of government  $Q$  and private-sector  $Q$ . A key challenge in estimating government  $Q$  is the absence of market-traded government equity. To overcome this challenge, we follow [Philippon \(2009\)](#) and use the market value of municipal bonds. For each municipal bond, we compute  $Q$  as the ratio of the reciprocal of maturity plus the duration-matched risk-free rate to the reciprocal of maturity plus the bond's yield. This measure is akin to the inverse of the credit spread and is conceptually similar to the market-to-book ratio of equity. We then take the mean of all bond-level  $Q$ s in a given region and year to obtain annual regional government  $Q$ s. A second challenge is to construct private-sector  $Q$  at the regional level because firms' operations are often spread across multiple regions. Rather than taking a simple average across firms in a region, we follow [Boguth, Duchin, and Simutin \(2022\)](#) and estimate regional private-sector  $Q$ s by using median regressions that invert firm-level  $Q$ s into regional private-sector  $Q$ .

Using these novel measures of  $Q$ , we estimate the sensitivity of government investment with respect to both government  $Q$  and private-sector  $Q$ . This approach connects local government in-

vestments to the economic activity of the public and private sectors via the information in municipal bond and corporate equity markets, respectively. We construct the main outcome variable, *Government investment rate*, using data from the Census’ annual survey of state and local government finances.<sup>1</sup> We scale the level of government investment by one-year-lagged government capital.

The main results can be summarized as follows. First, government investment rates are *positively* related to the marginal value of government capital, as measured by government Q, consistent with the canonical predictions of the Q-theory of investment. Quantitatively, a one-standard-deviation increase in government Q is associated with an increase of 0.573% to 0.837% in government investment rates. These estimates are statistically significant and economically meaningful relative to the average government investment rate of 13.31% in our sample. Moreover, the estimated sensitivity of government investment rates to government Q is comparable in magnitude to the estimated Q-sensitivity of corporate investment. Prior studies estimate that the Q-sensitivity of firms’ investment rates ranges between 0.3% and 0.9% (see, e.g., [Peters and Taylor \(2017\)](#); [Erickson and Whited \(2000, 2012\)](#); [Gala et al. \(2020\)](#)).

Moreover, after correcting for measurement error in government Q using the techniques proposed by [Erickson and Whited \(2000\)](#), [Erickson and Whited \(2002\)](#), [Erickson and Whited \(2012\)](#), and [Erickson et al. \(2014\)](#), investment–government Q sensitivities significantly increase. Overall, these findings suggest that state-level public spending co-moves with financial market valuations and that the Q-theory of corporate investment extends, with similar magnitudes, to government investment.

Second, and more surprisingly, government investment rates are *negatively* related to the marginal value of private-sector investment. A one-standard-deviation increase in private-sector Q is associated with a decrease of 0.147% to 0.188% in government investment rates. After correcting for measurement error in private sector Q using techniques analogous to those applied to

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<sup>1</sup>This variable encompasses a wide range of public goods and services, including air transport, education, health, highways, libraries, parks and recreation, police protection, and water, electricity, and gas supply.

government  $Q$ , the investment–private sector  $Q$  sensitivities increase by a factor of two to three, substantially heightening their economic significance.

The results obtain in specifications with state and year fixed effects and remain robust to controls for economic conditions, including gross domestic product (GDP), the debt-to-GDP ratio, and the revenue-to-GDP ratio. They also hold when we re-estimate the analyses at the county level rather than the state level, for alternative measures of government spending, in subsamples restricted to full Census years, and for alternative constructions of both private-sector  $Q$  and government  $Q$ .

Based on the model’s predictions, we conduct several additional tests to investigate the role of subsidies. First, we find that the negative relationship between government investment and private-sector  $Q$  is stronger in regions with large subsidy programs. In particular, a one–standard-deviation increase in private-sector  $Q$  is associated with a 0.221%–0.274% decline in government investment rates in states with large subsidy programs, compared with only 0.06%–0.083% in states with small subsidy programs.

Second, we use the share of federal procurement contracts earmarked for small businesses as a proxy for the intensity of local subsidies. These set-asides function as an investment stimulus by directing revenue to local firms and encouraging expansion, thereby tightening local resource constraints in a manner analogous to the subsidy programs in our framework. Consistent with our predictions, we find that the negative sensitivity of government investment to private-sector  $Q$  is stronger in states with a higher share of small-business procurement contracts.

Lastly, we test the model’s prediction that governments allocate more subsidies when private-sector investment opportunities are weak. We regress firm-by-firm subsidies on lagged private-sector  $Q$ , and find a strong and robust negative relationship. A one–standard-deviation increase in  $Q$  is associated with about a six percentage-point decline in firm-level subsidies. These results provide direct support to the core mechanism of the model, whereby subsidies are most valuable

when private-sector investment opportunities are low, and become less productive, and more costly, when private-sector  $Q$  is high.

Our paper contributes to three strands of literature. First, it extends the  $Q$ -theory of investment literature, which has focused almost exclusively on private-sector decisions, to government investment. Foundational work by [Tobin \(1969\)](#) and [Hayashi \(1982\)](#) posits that, under ideal conditions, Tobin's  $Q$  serves as a sufficient statistic for investment. Subsequent research has addressed empirical challenges, including financing frictions ([Fazzari et al., 1988](#)) and measurement error ([Gilchrist and Himmelberg, 1995](#); [Erickson and Whited, 2000, 2002, 2012](#); [Erickson et al., 2014](#); [Abel, 2018](#); [Gala et al., 2020](#)), as well as deviations from marginal-equals-average  $Q$  ([Gomes, 2001](#); [Cooper and Ejarque, 2003](#); [Alti, 2003](#); [Abel and Eberly, 2011](#)). Recent contributions highlight  $Q$ -theory's improving performance over time ([Chen and Chen, 2012](#); [Andrei et al., 2019](#)), its sensitivity to intangibles ([Peters and Taylor, 2017](#); [Wang and Zhang, 2021](#)), and noise in observed  $Q$  for identifying investment equations. Our framework innovates by incorporating a welfare-maximizing government that responds to a market-based government  $Q$  derived from municipal bond prices, alongside private-sector  $Q$ , in a general equilibrium framework. We construct novel regional measures of both, providing comprehensive empirical evidence, including a negative government-private  $Q$  relation, in a public-sector context largely absent from prior work.

Second, our analysis advances the literature on public investment, which typically examines its macroeconomic effects, such as local multipliers ([Nakamura and Steinsson, 2014](#); [Conley and Dupor, 2013](#); [Chodorow-Reich, 2019](#)). Related studies on the impact of public investment on private activity yield mixed results: positive crowding-in ([Nadiri and Mamuneas, 1991](#); [Morrison and Schwartz, 1992](#); [Erenburg and Wohar, 1995](#); [Bouakez and Rebei, 2007](#); [Acconcia et al., 2014](#); [Nakamura and Steinsson, 2014](#)) versus negative crowding-out ([Fernald, 1999](#); [Cohen et al., 2011](#); [Boehm, 2020](#)), often moderated by lags, interest rates ([Leeper et al., 2010](#); [Ramey and Zubairy, 2018](#)), or financial

constraints (Chava et al., 2024). We shift the emphasis from effects to determinants, showing that governments adjust public investment based on financial-market signals: positively to government  $Q$  and negatively to private-sector  $Q$ , especially in high-subsidy regions.

Third, we connect to work on financial markets’ informational role in real decisions (Grossman and Stiglitz, 1980; Glosten and Milgrom, 1985) and how managers use equity prices for investment (Chen et al., 2007; Foucault and Frésard, 2012; Bond et al., 2012; Wardlaw, 2020; Dessaint et al., 2018). While not providing direct causal evidence of feedback, our findings suggest governments similarly draw on municipal bond and corporate equity signals, with public investment co-moving with market-based government and private-sector  $Q$ s. This extends real-financial linkages to public settings.

## 1 Model and predictions

We develop a  $Q$ -theoretical framework of government investment and generate testable hypotheses. In the model, the government invests in public goods and subsidies to maximize household utility, while firms choose the optimal investment to maximize firm value. There are two sectors in the economy, the final-good sector and the capital-good sector.

### 1.1 Households

The representative household derives utility from consumption,  $C_t$ , and disutility from labor,  $L_t$ , and maximizes

$$E_t \sum_{t=0}^{\infty} \beta^t \ln(C_t),$$

subject to the budget constraint

$$C_t + \frac{b_t}{1 + r_{ft}} = w_t L_t + b_{t-1} + D_t + T_t, \quad (1)$$

where  $\beta \in (0, 1)$  is the discount factor,  $\psi$  is a preference parameter over labor disutility,  $1/\kappa \geq 0$  is the Frisch labor elasticity, and  $T_t$  is a government lump-sum transfer. At time  $t$ , the household purchases one-period risk-free Federal government bonds,  $b_t$ , that pay  $r_{ft} b_t$  units of goods at  $t + 1$ , where  $r_{ft}$  is the risk-free real interest rate.  $D_t$  denotes firm payout, assuming the household is the ultimate shareholder. For simplicity, we assume there is no personal income tax and that all government revenue is generated through corporate taxation.

Household utility maximization leads to

$$\frac{1}{1 + r_{ft}} = \beta E_t \left[ \frac{C_t}{C_{t+1}} \right]. \quad (2)$$

Note  $r_{ft}$  is the real interest rate. With a representative household, the net saving and borrowing in the state is zero, i.e., in equilibrium  $b_t = 0$ . Labor supply is fixed at one,  $L_t = L_{c,t} + L_{k,t} = 1$ , where  $L_{c,t}$  and  $L_{k,t}$  are labor employments in the final-good and capital-good sectors, respectively

## 1.2 Final-good sector

Final good producer produces consumption goods,  $Y_t$ , using the technology

$$Y_t = A_t K_{t-1}^\gamma (L_{ct})^{1-\gamma}, \quad \text{and} \quad K_{t-1} \equiv (K_{t-1}^{\text{Pri}})^\alpha (K_{t-1}^{\text{Gov}})^{1-\alpha},$$

where  $K_{t-1}$  is a composite of private capital  $K_{t-1}^{\text{Pri}}$  and aggregate public capital  $K_{t-1}^{\text{Gov}}$ ,  $\gamma$  is the output share of labor, and  $\alpha$  is the output share of private capital relative to the total output share of private and public capital. We assume that public and private capital are Edgeworth-Pareto complements in production, in the sense that each raises the marginal product of the other.  $A_t$  is total factor productivity and follows the AR(1) process:

$$\ln A_t = \rho_a \ln A_{t-1} + \sigma_a \epsilon_t^a,$$

where  $\epsilon_t^a \sim N(0, 1)$ . Taken wage as given, the firm's optimality conditions imply that in equilibrium

$$w_t = \frac{(1-\gamma)Y_t}{L_{c,t}} \quad \text{and} \quad L_{c,t} = [(1-\gamma)A_t]^{\frac{1}{\gamma}} w_t^{-\frac{1}{\gamma}} K_{t-1}. \quad (3)$$

The after-labor-cost profit is thus  $(1-\gamma)Y_t$ . The law of motion for private capital follows

$$K_t^{\text{Pri}} = (1 - \delta^{\text{Pri}})K_{t-1}^{\text{Pri}} + I_t^{\text{Pri}},$$

with a quadratic adjustment cost measured in terms of capital-good price

$$\Phi_t^{\text{Pri}} = \frac{a}{2} \left( \frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}} \right)^2 K_t^{\text{Pri}}.$$

Firm value can be written recursively as

$$V_t \equiv V(K_{t-1}^{\text{Pri}}, A_t, S_t) = (1 - \tau_t^c)(1 - \gamma)Y_t - p_{I,t}(I_t^{\text{Pri}} + \Phi_t^{\text{Pri}}) + S_t + E_t[M_{t+1}V_{t+1}],$$

where  $M_{t+1}$  is the stochastic discount factor,  $S_t$  denotes government subsidies to firms, and  $p_{I,t}$  is the price of capital good relative to consumption good, defined later in section 1.3. We assume

that government encourages private-sector investment by providing a subsidy of  $s$  dollars for every dollar of private-sector investment related expenses, i.e.,  $S_t = s_t p_{I,t} (I_t^{\text{Pri}} + \Phi_t^{\text{Pri}})$ .<sup>2</sup>

Rewrite firm's problem as a Lagrangian

$$\begin{aligned} \mathcal{L}_t(K_t^{\text{Pri}}, A_t, S_t) = & (1 - \tau_{t+1}^c)(1 - \gamma)Y_t - p_{I,t}(I_t^{\text{Pri}} + \Phi_t^{\text{Pri}}) + s_t p_{I,t}(I_t^{\text{Pri}} + \Phi_t^{\text{Pri}}) + E[M_{t+1}\mathcal{L}_{t+1}] \\ & - q_t^{\text{Pri}} p_{I,t} [K_t^{\text{Pri}} - (1 - \delta^{\text{Pri}})K_{t-1}^{\text{Pri}} - I_t^{\text{Pri}}] . \end{aligned} \quad (4)$$

where  $q_t^{\text{Pri}}$  is the Lagrange multiplier, which measures the marginal value of one *consumption-good* unit of investment.<sup>3</sup> Firm takes the market price of labor and capital as given, and the first-order conditions with respect to  $I_t^{\text{Pri}}$  and  $K_t^{\text{Pri}}$  is given by

$$q_t^{\text{Pri}} = (1 - s_t) \left[ 1 + a \left( \frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}} \right) \right], \quad (5)$$

$$q_t^{\text{Pri}} p_{I,t} = E_t \left[ M_{t+1} \left\{ [(1 - \tau_{t+1}^c)(1 - \gamma) \frac{\partial Y_{t+1}}{\partial K_t^{\text{Pri}}} + \frac{a}{2} \left( \frac{I_{t+1}^{\text{Pri}}}{K_{t+1}^{\text{Pri}}} \right)^2 (1 - s_{t+1}) p_{I,t+1}] + q_{t+1}^{\text{Pri}} p_{I,t+1} (1 - \delta^{\text{Pri}}) \right\} \right]. \quad (6)$$

Private-sector  $q_t^{\text{Pri}}$  captures the marginal value of investment for private firms, while  $1 - s_t$  measures the effective cost of investment due to subsidies. Equation (5) implies that private-sector investment rate  $\frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}}$  increases with  $q_t^{\text{Pri}}$  and increases with  $s_t$ . Notably, the government can influence firm investment through subsidy rate  $s_t$ , which is taken as exogenous by private firms.

<sup>2</sup>Alternatively, we can simply assume that  $S_t = s p_{I,t} I_t^{\text{Pri}}$  and the results remain the same. The current assumption is made for the sake of analytical and expositional simplicity.

<sup>3</sup>This definition is to be consistent with the empirical counterpart.

### 1.3 Capital-good sector

The capital good producer uses labor to produce investment goods  $I_t$ . Its technology is given by:

$$I_t = Z_t L_{k,t}, \quad (7)$$

where  $Z_t$  is sectoral productivity and follows the AR(1) process

$$\ln Z_t = \rho_z \ln Z_{t-1} + \sigma_z \epsilon_t^z.$$

The linear production technology implies zero profits and the price of capital goods:

$$p_{I,t} = w_t/Z_t \quad \text{and} \quad L_{k,t} = I_t/Z_t. \quad (8)$$

### 1.4 Labor market clearing and equilibrium wage

Since the total labor supply is  $L_t = 1$  in equilibrium, we have  $1 = L_{c,t} + L_{k,t}$ . Together with (3)

and (8), we have

$$[(1 - \gamma)A_t]^{\frac{1}{\gamma}} w_t^{-\frac{1}{\gamma}} K_{t-1} + \frac{I_t}{Z_t} = 1$$

and thus the equilibrium wage is given by

$$w_t = (1 - \gamma)A_t K_{t-1}^{\gamma} \left(1 - \frac{I_t}{Z_t}\right)^{-\gamma}. \quad (9)$$

It's straightforward to show that equilibrium wage increases with total investment, i.e.,

$$\frac{\partial w_t}{\partial I_t} = \frac{(1 - \gamma)A_t}{Z_t} K_{t-1}^{\gamma} \left(1 - \frac{I_t}{Z_t}\right)^{-(\gamma+1)} > 0.$$

With higher wage, labor in final good production falls and output, which is given by

$$Y_t = A_t K_{t-1}^\gamma L_{c,t}^{1-\gamma} = A_t^{\frac{1}{\gamma}} K_t^\gamma (1-\gamma)^{\frac{1-\gamma}{\gamma}} w_t^{-\frac{1-\gamma}{\gamma}},$$

also falls. Importantly, this result suggests that when local labor supply is inelastic, government investment competes with private-sector investment and final-good production for labor. As a consequence, government investment can crowd out private-sector investment and output in the short run, even if public capital increases the marginal productivity of private capital as assumed in our model. In the long run, however, higher wages can attract labor inflows from outside the region, mitigating the short-run crowding-out effect and ultimately benefiting the local economy.

## 1.5 Government

Government revenues arise from corporate income taxes,  $\tau_t^c(1-\gamma)Y_t$ .<sup>4</sup> The law of motion for public capital is

$$K_t^{\text{Gov}} = (1 - \delta^{\text{Gov}})K_{t-1}^{\text{Gov}} + I_t^{\text{Gov}},$$

and government investment is subject to adjustment costs measured in terms of capital-good price,

$$\Phi_t^{\text{Gov}} = \frac{b}{2} \left( \frac{I_t^{\text{Gov}}}{K_{t-1}^{\text{Gov}}} \right)^2 K_{t-1}^{\text{Gov}}.$$

Assume that the government maximizes household utility (given the consumption level implied by equilibrium) by choosing government investment and subsidy intensity, defined as subsidies to

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<sup>4</sup>We assume no labor income tax for simplicity. It's straightforward to show that with labor income tax, government tax income can be written in equilibrium as  $[\tau_t^l(1-\alpha)/\alpha + \tau_t^c(1-\gamma)]Y_t$ .

private sectors scaled by private investment spending:

$$\mathcal{G}(K_t^{\text{Gov}}, K_t^{\text{Pri}}, A_t) = \max_{\{s_t, I_t^{\text{Gov}}\}} \{\ln C_t + E_t [M_{t+1} \mathcal{G}_{t+1}]\} \quad (10)$$

subject to the budget constraint

$$\tau_c(1 - \gamma)Y_t = s_t p_{I,t}(I_t^{\text{Pri}} + \Phi_t^{\text{Pri}}) + p_{I,t}(I_t^{\text{Gov}} + \Phi_t^{\text{Gov}}) + T_t, \quad (11)$$

where  $\mu \equiv \tau_c^c(1 - \gamma) > 0$ ,  $S_t$  is government subsidies to firms,  $I_t^{\text{Gov}}$  is government investment, and  $T_t$  is the lump-sum transfer to households. Combining the household budget constraint, firm payout, and the government budget constraint yields the aggregate resource constraint:

$$C_t = Y_t - p_{I,t}(I_t^{\text{Pri}} + \Phi_t^{\text{Pri}} + I_t^{\text{Gov}} + \Phi_t^{\text{Gov}}). \quad (12)$$

### 1.5.1 Government Lagrangian

Taking market prices of capital and labor as given, government maximizes household welfare by choosing the optimal public investment and subsidy rate. The government's optimization problem can be written as the Lagrangian

$$\begin{aligned} \mathcal{L}_t^{\text{Gov}} = & \max_{\{s_t, I_t^{\text{Gov}}\}} \{\ln C_t + E_t [M_{t+1} \mathcal{L}_{t+1}^{\text{Gov}}]\} \\ & - q_t^{\text{Gov}} p_{I,t} [K_t^{\text{Gov}} - (1 - \delta^{\text{Gov}})K_{t-1}^{\text{Gov}} - I_t^{\text{Gov}}] \\ & - \lambda_t^{\text{Gov}} [s_t p_{I,t}(I_t^{\text{Pri}} + \Phi_t^{\text{Pri}}) + p_{I,t}(I_t^{\text{Gov}} + \Phi_t^{\text{Gov}}) + T_t - \mu Y_t], \end{aligned} \quad (13)$$

where the multiplier  $\lambda_t^{\text{Gov}} \geq 0$ . The first-order conditions with respect to  $I_t^{\text{Gov}}$ ,  $K_t^{\text{Gov}}$ , and  $s_t$  yield

$$q_t^{\text{Gov}} = \left( \lambda_t^{\text{Gov}} + \frac{1}{C_t} \right) \left[ 1 + b \left( \frac{I_t^{\text{Gov}}}{K_{t-1}^{\text{Gov}}} \right) \right], \quad (14)$$

$$q_t^{\text{Gov}} p_{I,t} = E_t \left[ M_{t+1} \left\{ \frac{1}{C_{t+1}} \left[ \frac{\partial Y_{t+1}}{\partial K_t^{\text{Gov}}} + \frac{b}{2} \left( \frac{I_{t+1}^{\text{Gov}}}{K_t^{\text{Gov}}} \right)^2 p_{I,t+1} \right] \right. \right. \\ \left. \left. + \lambda_{t+1}^{\text{Gov}} \left[ \mu \frac{\partial Y_{t+1}}{\partial K_t^{\text{Gov}}} + \frac{b}{2} \left( \frac{p_{I,t+1} I_{t+1}^{\text{Gov}}}{K_t^{\text{Gov}}} \right)^2 p_{I,t+1} \right] + q_{t+1}^{\text{Gov}} p_{I,t+1} (1 - \delta^{\text{Gov}}) \right\} \right], \quad (15)$$

$$-\frac{1}{C_t} \frac{\partial C_t}{\partial S_t} + \lambda_t^{\text{Gov}} p_{I,t} \left[ I_t^{\text{Pri}} + \Phi_t^{\text{Pri}} + s_t \left( 1 + a \frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}} \right) \frac{\partial I_t^{\text{Pri}}}{\partial s_t} \right] \quad (16)$$

$$= E_t \left[ M_{t+1} \left( \frac{1}{C_{t+1}} \frac{\partial C_{t+1}}{\partial s_t} + \lambda_{t+1}^{\text{Gov}} \mu \frac{\partial Y_{t+1}}{\partial s_t} - \lambda_{t+1}^{\text{Gov}} p_{I,t+1} s_{t+1} \frac{\partial \Phi_{t+1}^{\text{Pri}}}{\partial s_t} \right) \right], \quad (17)$$

where equation (5) is used to substitute for firm investment  $I_t^{\text{Pri}}$ .

Notice that because the government maximizes household welfare, the marginal cost of government investment depends negatively on the level of consumption, reflecting the concavity of household utility. Intuitively, when consumption is low, the government understands that diverting an additional unit of consumption toward government investment imposes a disproportionately larger disutility on households. This consideration is absent from the private-sector investment– $q$  relation. As shown below, this distinction plays a central role in generating the negative relation between government investment and private-sector  $q$  when at least one production factor—labor in our case—is inelastically supplied. Drawing on the preceding analysis, we formally state our main prediction:

**Prediction 1.** *Government investment,  $I_t^{\text{Gov}}/K_{t-1}^{\text{Gov}}$ , positively depends on government  $q_t^{\text{Gov}}$  but negatively depends on private-sector  $q_t^{\text{Pri}}$ . The proof is provided in Appendix A.1.*

There are two key mechanisms underlying Prediction 1. First, the government maximizes household welfare, and household preferences exhibit diminishing marginal utility of consumption.<sup>5</sup>

<sup>5</sup>This property holds for any concave utility function, including the widely used CRRA and Epstein–Zin prefer-

Second, because labor supply is inelastic—at least in the short run—the capital-good sector must compete with the final-good sector for labor. Higher investment raises the demand for capital good, which increases labor demand in the capital-good sector. This, in turn, drives up the equilibrium capital-goods price  $p_{I,t}$  and wage  $w_t$ , and reduces final-goods production. Consequently, holding everything else constant, higher private or government investment lowers the level of consumption, thereby making government investment more costly at the margin for a welfare-maximizing government. In this sense, government investment can crowd out private-sector investment and final-goods production in the short run – even when public and private capital are complements in production – and government investment benefits the private sector in the long run.

This crowding-out effect directly generates the negative relation between government investment and private-sector  $q_t^{\text{Pri}}$ . A higher private  $q^{\text{Pri}}$  strengthens private-sector investment incentives, leading to higher private-sector investment. All else equal, this effect makes government investment more costly at the margin to the government, generating a negative relation between government investment and private-sector  $q_t^{\text{Pri}}$ .

The positive relation between government investment and government  $q$  follows from the structure of the government’s marginal cost of government investment. Specifically, the marginal cost has two components: (i) the marginal adjustment cost of government investment,  $1 + b(I^{\text{Gov}}/K_{t-1}^{\text{Gov}})$ , which increases in the government investment rate, and (ii) the marginal utility cost of reducing consumption,  $1/C_t$ , which also rises as investment increases and consumption falls. Both channels imply that the marginal cost of government investment is increasing in the investment rate. Since  $q^{\text{Gov}}$  equals the marginal benefit of government investment, it has to equal the marginal cost of government investment in equilibrium, yielding a positive  $q$ –investment relation for the government.

Furthermore, the model yields the following implication:

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ences. Such preferences imply that households value additional consumption less when they already have more, and value it more when consumption is scarce.

**Prediction 2.** *The response of government investment to private-sector  $q_t^{\text{Pri}}$  becomes less negative with larger subsidy intensity. The proof is provided in Appendix A.1.*

Appendix A.1 shows that with higher subsidy rate  $s_t$ ,  $a_2$  is more negative. Because the subsidy lowers the effective cost of private-sector investment, firms respond more strongly to changes in their marginal benefit  $q^{\text{Pri}}$ , as implied by equation (5). This heightened responsiveness amplifies the impact of private-sector  $q_t^{\text{Pri}}$  on factor demand, thereby strengthening the sensitivity of the government's marginal cost of government investment to private-sector  $q_t^{\text{Pri}}$  through the crowding-out mechanism described earlier.

In addition, the government's FOC on the optimal subsidy intensity leads to the following prediction:

**Prediction 3.** *The government subsidy intensity, defined as subsidy scaled by private investment spending, negatively depends on private-sector  $q_t^{\text{Pri}}$ . The proof is provided in Appendix A.2.*

The intuition is straightforward. A subsidy encourages private investment by lowering its effective cost. The government therefore weighs the immediate cost of the subsidy—reduced current consumption—against its long-run benefit of expanding private capital and raising future output and consumption. Because output exhibits decreasing returns to private capital, the marginal benefit of subsidizing additional investment is smaller when private investment is already high, which is captured by a higher private-sector  $q_t^{\text{Pri}}$ . At the same time, the marginal cost of the subsidy is greater when private-sector  $q_t^{\text{Pri}}$  is high, since stronger private investment further suppresses current consumption, holding everything else constant, as discussed above.

## 2 Data and Variables

We describe the datasets used in our empirical analysis and then present our measures of government  $Q$ , regional private-sector  $Q$ , government investment rates as well as subsidy rates.

### 2.1 Data

We collect data from multiple sources for our empirical tests.

We use municipal bond data to construct government  $Q$  for each region and year, closely following the literature (e.g., [Schwert \(2017\)](#); [Chava et al. \(2024\)](#)). We obtain geographical identifiers for municipal bonds from Refinitiv Eikon and bond prices from the Municipal Securities Rulemaking Board (MSRB). Our analysis focuses on tax-exempt municipal bonds with maturities between 1 and 30 years. To ensure that  $Q$  reflects the most recent information when explaining investment in the subsequent year, we retain bond data only from the fourth quarter of each year. Following standard practice (e.g., [Peters and Taylor \(2017\)](#)), we use annual Compustat and CRSP data to construct firm-level  $Q$ .

To construct the outcome variable, the government investment rate, we use the Census' annual survey of state and local government finances.<sup>6</sup> The Census reports data at various levels of government, including states, counties, townships, special districts, and school districts. We aggregate the data to the state or county level, which is standard in the literature.<sup>7</sup> The sample covers the period from 1994 to 2022 and includes 50 states and Washington, D.C. To account for inflation, we convert all nominal dollar amounts to year-2000 dollars. To mitigate the influence of outliers, we winsorize all variables each year at the 1st and 99th percentiles.

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<sup>6</sup>We use the cleaned and accessible dataset provided by [Pierson, Hand, and Thompson \(2015\)](#).

<sup>7</sup>Analyzing data at more granular levels is not feasible because the structure of local governments varies across US regions and is therefore difficult to compare.

## 2.2 Regional government Q

The Q-theoretical approach requires measures of regional government Q and private-sector Q. This subsection introduces our approach to constructing regional government Q, while the next subsection explains how we estimate regional private-sector Q.

A key challenge in estimating government Q is the absence of market-traded government equity. To address this challenge, we follow [Philippon \(2009\)](#) and use the market value of municipal bonds.

Using annualized municipal bond data, we construct bond-based Q as follows. For each municipal bond  $n$  issued by a government unit in region  $j$  (state or county) in year  $t$ , we define

$$q_{j,t,n}^B = \frac{1/\text{Mat}_{j,t,n} + r_{j,t,n}}{1/\text{Mat}_{j,t,n} + \text{Yield}_{j,t,n}},$$

where  $\text{Yield}_{j,t,n}$  is the yield of bond  $n$ ,  $\text{Mat}_{j,t,n}$  is the remaining maturity of bond  $n$ , and  $r_{j,t,n}$  is the yield on a hypothetical Treasury security with cash flows matched to those of the bond. This measure, used by [Philippon \(2009\)](#) and [Bretschler, Feldhütter, Kane, and Schmid \(2020\)](#), is conceptually similar to the inverse of the credit spread and analogous to the market-to-book ratio of equity: as the credit spread widens, the market-to-book ratio of debt declines.

We aggregate the bond-level Qs,  $q_{j,t,n}^B$ , to construct annual regional government Q,  $q_{j,t}^{\text{Gov}}$ . For each region  $j$  and year  $t$ , this is defined as the cross-sectional mean of the bond-level Qs. We exclude municipal bonds issued by state governments during this aggregation. As shown in [Philippon \(2009\)](#), bond prices are informative about  $q$  only when default risk is positive. Because U.S. state governments are not legally permitted to default, their bonds do not convey meaningful information about  $q$ . We therefore retain only bonds issued by sub-state governmental units—such as municipalities and special districts—which are legally allowed to default.<sup>8</sup>

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<sup>8</sup>[Gao et al. \(2010\)](#) studies how differences in state policies toward financially distressed municipalities affect municipal borrowing costs.

Our empirical analyses consider two regional levels: states and counties. Panel A of Table 1 reports summary statistics for state-level government  $Q$ , which has an average of 0.982 and a standard deviation of 0.0468. Panel B reports summary statistics for county-level government  $Q$ , which exhibits similar characteristics.

Figure 1 illustrates the cross-sectional distribution of state-level government  $Q$ . Wyoming and Vermont have the lowest average government  $Q$ , largely due to high municipal bond spreads, whereas Connecticut and Massachusetts have the highest average government  $Q$ .

[Insert Figure 1]

We also examine the time-series behavior of state-level government  $Q$ . Figure 2 illustrates this by plotting the series for New Mexico, Tennessee, and California. The three states exhibit a similar overall pattern. For instance, during the 2007–2009 period, when municipal bond markets were under severe stress, bond spreads widened sharply and government  $Q$  declined markedly in all three states. At the same time, substantial cross-sectional heterogeneity remains. In the full sample, 81% of the variation in government  $Q$  reflects a common time-series component, while the remaining 19% is driven by cross-sectional differences across states.

[Insert Figure 2]

### 2.3 Regional private-sector $Q$

We now describe how we construct regional measures of private-sector  $Q$  using firm-level data. The main challenge is that many firms operate in multiple regions. To address this, we follow [Boguth, Duchin, and Simutin \(2022\)](#) and estimate regional private-sector  $Q$  by decomposing firm-level  $Q$  across regions.

We proceed in two steps. First, we construct firm-level  $Q$ . We measure firm-level  $Q$  as the ratio of firm value to sales, where value is the sum of the book value of debt and the market value of

equity. For each year  $t$ , we form an  $I \times 1$  vector of firm-level Qs,  $q_t^{Firm}$ , where  $I$  is the number of public firms. Given that our ultimate objective is to derive private-sector Q at the regional level, it is prudent to include as many firms as possible that are domiciled in the particular region. To this extent, we construct firm-level Q for all firms, including utility and finance firms which are typically omitted from the literature studying the relation between firm-level Q and firm-level investment. While bond-based measures of Q (as in [Philippon \(2009\)](#) and [Bretscher et al. \(2020\)](#)) are also available, only about 20% of firm-year observations in our sample have bond data. To maximize sample coverage and obtain precise estimates, we therefore rely on equity-based Q.

Second, we convert firm-level Q across regions (states or counties) to regional private-sector Qs. Following [Boguth et al. \(2022\)](#), we form portfolios of firms operating in one or more regions and estimate a vector of implied regional Qs. For each year  $t$ , we write

$$q_t^{Firm} = W_t \cdot q_t^{Pri}, \quad (18)$$

where  $W_t$  is an  $I \times J$  matrix of firm-region weights. The  $(i, j)$ -th element of  $W_t$  captures the relative presence of firm  $i$  in region  $j$ , and each row of  $W_t$  sums to one. We construct  $W_t$  using establishment-level sales or employment from the National Establishment Time Series (NETS) database. The vector  $q_t^{Pri}$  is a  $J \times 1$  vector of implied regional private-sector Qs in year  $t$ :

$$q_t^{Pri} = \left[ q_{j=1,t}^{Pri}, q_{j=2,t}^{Pri}, \dots, q_{j=J,t}^{Pri} \right]',$$

where  $J$  is the number of regions. Because  $q_t^{Pri}$  is unobserved whereas  $q_t^{Firm}$  and  $W_t$  are observed, we estimate  $q_t^{Pri}$  using a matrix inversion technique as in [Boguth et al. \(2022\)](#). Specifically, we run median regressions without an intercept to obtain our estimates of regional private-sector Q,  $q_{j,t}^{Pri}$ .<sup>9</sup>

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<sup>9</sup>Because each row of  $W_t$  sums to 1 by construction, including an intercept would generate collinearity; we therefore omit the intercept.

Panel A of Table 1 reports summary statistics for state-level private-sector Q. Based on establishment-level *sales*, state-level private-sector Q has an average of 1.399 and a standard deviation of 0.661. Based on establishment-level *employment*, the corresponding figures are 1.419 and 0.705. Panel B reports summary statistics for county-level private-sector Q. Based on sales multiples, the average county-level private-sector Q is 4.282 with a standard deviation of 23.26, indicating that county-level Qs are, on average, larger and more volatile than their state-level counterparts. Our main results, however, are robust at both the state and county levels.

Figure 3 shows the cross-sectional distribution of private-sector Q across states, revealing substantial heterogeneity.

[Insert Figure 3]

Average private-sector Q is lowest in Kentucky and South Carolina (1.233 and 1.243, respectively) and highest in California (2.17), well above the unconditional median of 1.677.

We also examine the time-series behavior of state-level private-sector Q. For illustration, Figure 4 plots Q over time for New Mexico, Tennessee, and California.

[Insert Figure 4]

Similar to government Q, the three states share a common broad pattern, yet substantial cross-sectional heterogeneity remains. For example, private-sector Q falls in all three states during the 2007–2008 financial crisis, but the magnitude of the decline and the speed of the subsequent recovery differ markedly. In addition, the three states exhibit very different time-series averages of private-sector Q.

## 2.4 Government Investment Rate

We construct annual regional government investment rates, defined as the ratio of government investment to government capital. We first describe how we measure government investment and

then explain how we construct government capital.

We define *government investment* as the sum of current operations, capital outlay, and assistance and subsidies.<sup>10</sup> Current operations account for 63% of total expenditure and include compensation of officers and employees, as well as spending on supplies, materials, and contractual services. Capital outlay constitutes 9% of total expenditure and captures purchases or construction of capital improvements (e.g., buildings, land, equipment) by contractors or government employees. Both current operations and capital outlays cover a broad range of public goods, including air transport, education, health, highways, libraries, parks and recreation, police protection, water supply, and electric power and gas supply. Assistance and subsidies account for about 1% of total expenditure and include transfers to foreign governments, private individuals, and nongovernmental organizations.

We next construct government capital. Because direct data on the government capital stock are not available, we infer capital using a perpetual-inventory method:

$$K_{j,t+1}^{\text{Gov}} = 0.9 \cdot K_{j,t}^{\text{Gov}} + I_{j,t}^{\text{Gov}},$$

where  $j$  indexes regions (states or counties) and  $t$  indexes years. According to the BEA, annual depreciation rates for regional government assets range from 1.5% (water and sewer systems) to 23.6% (calculating and accounting machines), so we adopt an average depreciation rate of 10% for government capital. We initialize the capital stock in 1967, the first year with available Census

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<sup>10</sup>The Census survey reports six components of total government expenditure: (1) current operations, (2) capital outlay, (3) interest on debt, (4) assistance and subsidies, (5) social insurance trust expenditures, and (6) intergovernmental expenditures. We exclude intergovernmental expenditures to avoid double-counting transfers between government units. For example, if unit A transfers funds to unit B, which then purchases supplies, the same dollar amount would appear as intergovernmental expenditure for A and as current operations for B. To prevent double-counting, we drop A's intergovernmental expenditures when aggregating to the state or county level; intergovernmental expenditures account for about 16% of total expenditures. We also exclude interest on debt and social insurance trust expenditures, which reflect past obligations rather than current investment decisions. Social insurance trust expenditures include social insurance payments to beneficiaries, public employee retirement benefits, and withdrawals of contributions; together, interest and social insurance trust expenditures represent about 11% of total spending.

investment data, by setting  $K_{j,1967}^{\text{Gov}} = 0$ , and then iterate the accumulation equation separately for capital outlays and current operations. Table 1 shows that the resulting capital stock associated with government investment (current operations plus capital outlays) averages \$271.4 billion per state.

[Insert Table 1]

We define the government investment rate as government investment divided by the one-year-lagged government capital stock. The average government investment rate is 13.31%, which is close to the average corporate investment rate of about 12.9% (see, e.g., [Erickson and Whited \(2012\)](#)). The standard deviation of the government investment rate is 1.686 percentage points.

## 2.5 Subsidies

We construct a direct proxy for subsidies, subsidy-sales ratio, and one indirect proxies, namely, procurement.

### 2.5.1 State-level subsidy-sales ratio

We use the state-level subsidy-to-sales ratio as an empirical proxy for subsidy intensity. As discussed in Section 1, the model defines subsidy intensity as government subsidies scaled by private-sector investment. Because comprehensive investment data are not available for the private sector—particularly for non-listed firms—we instead scale state-level subsidies by state-wide private-sector sales.

State-level subsidy data are obtained from the BEA. We obtain annual state-level subsidy data from the BEA. These subsidies represent monetary transfers from government agencies to the private-sector firms located in each state. Importantly, they differ from the Census-based category “assistance and subsidies,” which includes transfers to foreign governments, private individuals,

and nongovernmental organizations. Total private-sector sales at the state are constructed by aggregating sales across all establishments located within each state. As reported in Table 1, the average subsidy intensity (i.e., the subsidy-to-sales ratio) is 0.388%. Figure 5 shows that there is wide variation in subsidy rates across states.

[Insert Figure 5]

### 2.5.2 State-level procurement contracts

We use the share of federal procurement contracts earmarked for small businesses as an empirical proxy for local subsidy intensity. To the extent that procurement set-asides function like an investment stimulus—by directing contract revenue toward local firms and encouraging expansion—they can tighten local resource constraints (e.g., through higher demand for labor and other inelastic local inputs) in the same way as the subsidy programs in the model. Therefore, states with a larger share of procurement contracts set aside for small businesses can be viewed as having higher effective subsidy intensity.

Following the literature (e.g., Brogaard et al. (2024)), we calculate the share of dollar amounts of procurement contracts set aside for small businesses as a measure of subsidy intensity. We construct this measure using the state of performance of federal procurement contracts, which allows us to map these set-asides to the states where the subsidized economic activity takes place. As discussed in Brogaard et al. (2026), these data are available only for the period 2007–2024, resulting in a more limited sample relative to our full sample, which spans 1994–2022.

As reported in Table 1, the average subsidy intensity (measured as the share of procurement contracts set aside for small businesses) is 19.62%.

### 2.5.3 Firm-level subsidy intensity

We construct firm-level subsidy intensity measure, using firm-level subsidy data from GoodJob<sup>11</sup>. Consistent with the definition of subsidy rate in the model, subsidy is normalized by firm-level capital investment, CAPX.

Table 1's Panel C summarizes summary statistics for not only subsidy intensity but also other firm characteristics such as firm-level Q, cashflow and size. Firm-level Q, scaled by sales, is 3.594 on average while subsidy intensity is 7.998% on average.

## 2.6 Regional characteristics

We collect data on population, outstanding debt, and revenue from the Census, and state-level GDP from the BEA. Panel A of Table 1 reports summary statistics for state-level economic indicators. Between 1994 and 2022, the average state GDP is \$217.3 billion, the average population is about 5.875 million, the average book-debt-to-GDP ratio is 0.154, and the average revenue-to-GDP ratio is 0.232.

Panel B of Table 1 summarizes county-level economic indicators. To construct the county sample, we start from the 1,423 counties in the Census dataset with establishment-level data; these counties account for 82.3% of the total US population. To ensure the stability of the conversion method in Section 2.3, we restrict the sample to counties with at least 100 establishments in every year between 1994 and 2022, reducing the sample to 343 counties. We then further restrict to counties that have issued municipal bonds, which are required to compute local government Q (Section 2.2), yielding a final sample of 326 counties. Although this is a subset of all counties, it still captures a large share of economic activity: relative to the 1,423 counties with establishment-level data, the final sample includes 86.1% of establishments, 92.5% of sales, 90.3% of employment, and

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<sup>11</sup><https://subsidytracker.goodjobsfirst.org/>

77.2% of the population. As shown in Panel B, the average county population is about 578,000. The average book-debt-to-population ratio is 4.27 (in thousands), and the average revenue-to-population ratio is 4.362 (in thousands).<sup>12</sup>

### 3 Government investment and Qs

We empirically examine how regional government investment relates to government Q and private-sector Q, testing Prediction 1.

Several units of observation could in principle be used for this test, but data limitations mean that no single choice is unambiguously superior. We therefore present evidence at two regional levels: states and counties.

State-level analysis has the advantage that private-sector Q is estimated more precisely, since each state contains far more establishment-level data than a typical county (see Section 2.3). However, it is more susceptible to aggregation bias on the government side. As discussed in Section 2.2, state-level government Q must be inferred by aggregating bonds issued by many sub-state entities—such as municipalities and special districts—that are legally permitted to default and make independent investment decisions. This necessarily combines heterogeneous government units. County-level analysis, by contrast, is based on more homogeneous sub-state entities and therefore suffers less from this source of aggregation bias.

For these reasons, we report both state-level and county-level results to provide complementary and more robust tests of the model’s predictions.

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<sup>12</sup>We use population as the denominator because GDP is not available at the county level.

### 3.1 State-level evidence

We estimate the following regression specification:

$$i_{j,t}^{\text{Gov}} = \alpha_j + \delta_t + \beta^{\text{Gov}} \cdot q_{j,t-1}^{\text{Gov}} + \beta^{\text{Pri}} \cdot q_{j,t-1}^{\text{Pri}} + \epsilon_{j,t}, \quad (19)$$

where  $\alpha_j$  denotes region fixed effects and  $\delta_t$  denotes year fixed effects. To facilitate comparison between  $\beta^{\text{Gov}}$  and  $\beta^{\text{Pri}}$ , we standardize both  $q_{j,t-1}^{\text{Gov}}$  and  $q_{j,t-1}^{\text{Pri}}$ . Both Q measures are lagged by one year to ensure that government officials can observe them when making investment decisions.

Table 2 reports the sensitivity of state-level government investment to government and private-sector Qs. The table presents estimates from panel regressions, with standard errors clustered by state;  $t$ -statistics are reported in parentheses.

[Insert Table 2]

Column (1) examines the sensitivity of government investment rates to government Q. The estimated coefficient  $\beta^{\text{Gov}}$  equals 0.714 and is statistically significant at the 1% level. Because Q is standardized, this estimate implies that a one-standard-deviation increase in government Q is associated with a 0.714 percentage point increase in the government investment rate. Relative to the average government investment rate of 13.3%, this sensitivity is economically meaningful. Alternative specifications with varying sets of controls yield similar results. In particular, columns (3), (4), and (6) indicate that a one-standard-deviation increase in government Q is associated with increases in government investment rates of 0.837, 0.573, and 0.712 percentage points, respectively.

These estimates are comparable to investment-Q sensitivities in the private sector, which typically range between 0.3 and 0.9 percentage points (see, e.g., [Peters and Taylor \(2017\)](#); [Erickson and Whited \(2000, 2012\)](#); [Gala et al. \(2020\)](#)). Overall, the evidence suggests that state government investment co-moves with financial market valuations and that the Q-theory of corporate investment

extends, with similar magnitudes, to government investment. In particular, government officials appear to condition investment decisions on information in the municipal bond market, which provides a market-based proxy for the marginal value of government capital. In the model, a higher government  $Q$  corresponds to a higher marginal benefit of public investment; consistent with this mechanism, governments invest more when municipal bond prices imply a higher government  $Q$ .

Column (2) examines the sensitivity of government investment to private-sector  $Q$ . The estimated coefficient  $\beta^{\text{Pri}}$  equals  $-0.174$  and is statistically significant at conventional levels. Column (3) includes both government and private-sector  $Q$  simultaneously and shows that both coefficients are highly statistically significant, economically meaningful, and of opposite sign. A one-standard-deviation increase in government  $Q$  and a one-standard-deviation *decrease* in private-sector  $Q$  are associated with increases in government investment rates of 0.837 and 0.188 percentage points, respectively. This divergence in sensitivities motivates the theoretical framework developed earlier, in which an augmented  $Q$  model of government investment captures the interaction between the marginal product of capital in the public and private sectors.

The  $R^2$  significantly increases when both government and private-sector  $Q$  are included in the specification, indicating that a substantial share of the variation in government investment rates is jointly explained by the two  $Q$  measures. Columns (4), (5), and (6) show that the main results are robust to controlling for state-level economic conditions, including GDP, the debt-to-GDP ratio, and the revenue-to-GDP ratio. This pattern indicates that financial markets—both municipal bond markets and corporate equity markets—contain information beyond what is captured by coarse macroeconomic indicators and that this information is reflected in government investment decisions.

### 3.2 State-level evidence with measurement error correction

Because government  $q$  and private-sector  $Q$  are proxies for unobservable marginal values of public investment and private investment opportunities, they inevitably contain measurement error. Such error is well known to induce attenuation bias in linear regressions. To address this concern, we employ established measurement-error correction techniques to adjust for potential error in both government  $q$  and private-sector  $Q$ . In particular, we use fourth higher order estimator introduced and used in [Erickson and Whited \(2000, 2002, 2012\)](#); [Erickson et al. \(2014\)](#). Table 3 reports the corresponding results.

[Insert Table 3]

The table reports several sets of results. It first presents the measurement-error-corrected coefficient estimates. It also reports, for each proxy, an index of measurement quality,  $\tau^2$ . As documented in [Erickson and Whited \(2012\)](#), this correction method performs poorly in small samples, especially when the data are within-transformed. Column (3) appears to suffer from this issue: the implied  $\tau^2$  for private-sector  $Q$  exceeds one, even though  $\tau^2$  must lie between zero and one ([Erickson and Whited, 2012](#)). We therefore focus our discussion on the results reported in columns (1), (2), (4), (5), and (6).

After correcting for measurement error, the investment–government  $Q$  sensitivities increase substantially, ranging from 1.154 to 2.690. The investment–private-sector  $Q$  sensitivities also grow in magnitude, ranging from  $-0.342$  to  $-0.511$ , about two to three times as large as the uncorrected estimates. The Sargan–Hansen  $J$ -test  $p$ -values are comfortably large across all six specifications, indicating that the overidentifying restrictions imposed by the measurement-error framework are not rejected by the data. While informative, these estimates should be interpreted with caution, as their validity depends on the underlying identification assumptions in [Erickson and Whited \(2000,](#)

2002, 2012); Erickson et al. (2014).

### 3.3 County-level evidence

We now estimate investment–Q sensitivities at the county level. The results are reported in Table 4. As before, and following the existing literature, standard errors are clustered by county and  $t$ -statistics are reported in parentheses.

[Insert Table 4]

The county-level results are broadly consistent with the state-level evidence. The sensitivity of government investment rates to government Q is positive and statistically significant, whereas the sensitivity to private-sector Q is negative and statistically significant. Column (1) shows that the sensitivity of government investment rates to government Q,  $\beta^{\text{Gov}}$ , equals 0.257 and is statistically significant at conventional levels. A one-standard-deviation increase in government Q is associated with a 0.257 percentage point increase in the government investment rate. Relative to the average government investment rate of 12.9%, this effect is economically meaningful. Alternative specifications in columns (3), (4), and (6) yield similar estimates of 0.260, 0.254, and 0.256 percentage points, respectively. While these sensitivities are somewhat smaller than their state-level counterparts, they are comparable to private-sector investment–Q sensitivities, which typically range between 0.3 and 0.9 percentage points (see, e.g., Peters and Taylor (2017); Erickson and Whited (2000, 2012); Gala et al. (2020)).

The negative sensitivity of government investment to private-sector Q also persists at the county level. Column (3) indicates that  $\beta^{\text{Pri}} = -0.0711$ , statistically significant at the 10% level, implying that a one-standard-deviation decrease in private-sector Q is associated with a 0.0711 percentage point increase in the government investment rate. Columns (4), (5), and (6) show that this pattern

is robust to controlling for county-level economic indicators—population, the debt-to-population ratio, and the revenue-to-population ratio.

Taken together, we confirm our model predictions that government investment rates are positively related to government  $Q$  and negatively related to private-sector  $Q$  at the state- and county-level. In Section C of the Appendix, we show that our findings remain robust, using an alternative sample with full Census years and an alternative measure of private-sector  $Q$  with a weight of establishment-level employment.

## 4 Empirical evidence on government subsidies

Governments allocate their resources across capital expenditures (government investment) and transfers to private-sector firms in the form of cash subsidies. We proceed to examine two predictions generated by our model in Section 1 related to subsidies: (i) subsidies amplify the (absolute) sensitivity of government investment to private-sector  $Q$ , and (ii) government subsidies decrease with private-sector  $Q$ .

### 4.1 Government investment and private-sector $Q$

We examine how the sensitivity of government investment to private-sector  $Q$  varies with subsidy intensity, as stated in **Prediction 2**, which extends **Prediction 1**. Because the available subsidy measures are only observed at the state level, we do not conduct a county-level analysis in this subsection. Consistent with our state-level investment analysis, we employ several state-level proxies for subsidy intensity, including the subsidy-to-sales ratio, the share of federal procurement contracts awarded to small businesses, and political affiliation.

### 4.1.1 Subsidy-sales ratio

In this subsection, as discussed in Section 2.5.1, we use the state-level subsidy-to-sales ratio as an empirical proxy for subsidy intensity. We split states each year into high- and low-subsidy groups based on the median subsidy-to-sales ratio and estimate the following state-level specification:

$$i_{j,t}^{\text{Gov}} = \alpha_j + \delta_t + \beta^{\text{Gov}} \cdot q_{j,t-1}^{\text{Gov}} + \beta^{\text{Pri}} \cdot q_{j,t-1}^{\text{Pri}} \\ + \gamma^{\text{Pri}} \cdot \mathbb{1}\{\text{Subsidy}_{j,t-1}\} \cdot q_{j,t-1}^{\text{Pri}} + \gamma^{\text{Sub}} \cdot \mathbb{1}\{\text{Subsidy}_{j,t-1}\} + \epsilon_{j,t},$$

where  $\mathbb{1}\{\text{Subsidy}_{j,t-1}\} = 1$  if the subsidy rate in state  $j$  at time  $t - 1$  is above the year- $t - 1$  median and 0 otherwise. The results are reported in Table 5.

[Insert Table 5]

The results in Table 5 yield several conclusions. First, the sensitivity of government investment rates to government Q remains positive and statistically significant, with magnitudes similar to those in the baseline regressions in Section 3.1.

Second, consistent with **Prediction 2**, the sensitivity of government investment rates to private-sector Q is more negative in high-subsidy states than in low-subsidy states. In column (3), which includes government Q, private-sector Q and its interaction with the high-subsidy indicator, the coefficient on private-sector Q,  $\beta^{\text{Pri}}$ , equals  $-0.0805$  (with a  $t$ -statistic of  $-2.017$ ), whereas the coefficient on the interaction term,  $\gamma^{\text{Pri}}$ , equals  $-0.193$  (with a  $t$ -statistic of  $-2.016$ ). Together, these coefficients imply that a one-standard-deviation increase in private-sector Q is associated with a 0.274 percentage point decrease ( $= \beta^{\text{Pri}} + \gamma^{\text{Pri}}$ ) in government investment rates in high-subsidy states. Columns (2) and (4) yield similar effects, with decreases of 0.250 and 0.221 percentage points, respectively, for states with large subsidy programs.

Taken together, these results support the model’s emphasis on the role of direct government subsidies in shaping the sensitivity of government investment to private-sector Q. Local governments that actively support private investment through subsidy programs adjust their own investment more strongly in response to fluctuations in private-sector Q.

#### 4.1.2 Federal procurement contracts earmarked for small businesses

In this subsection, as discussed in Section 2.5.2, we use the share of federal procurement contracts earmarked for small businesses as an empirical proxy for local subsidy intensity. We split states each year into high- and low-small-business groups based on the median share of procurement contracts set aside for small businesses and estimate the following state-level specification:

$$i_{j,t}^{\text{Gov}} = \alpha_j + \delta_t + \beta^{\text{Gov}} \cdot q_{j,t-1}^{\text{Gov}} + \beta^{\text{Pri}} \cdot q_{j,t-1}^{\text{Pri}} + \gamma^{\text{Pri}} \cdot \mathbb{1}\{\text{HighSmallBusiness}_{j,t-1}\} \cdot q_{j,t-1}^{\text{Pri}} + \gamma^{\text{Small}} \cdot \mathbb{1}\{\text{HighSmallBusiness}_{j,t-1}\} + \epsilon_{j,t},$$

where  $\mathbb{1}\{\text{HighSmallBusiness}_{j,t-1}\} = 1$  if the share of procurement contracts set aside for small businesses in state  $j$  at time  $t - 1$  is above the year- $t - 1$  median and 0 otherwise. The results are reported in Table 6.

[Insert Table 6]

The results in Table 6 yield several conclusions. First, the sensitivity of government investment rates to government Q remains positive and statistically significant, with magnitudes similar to those in the baseline regressions in Section 3.1.

Second, the sensitivity of government investment rates to private-sector Q is more negative in high-small-business states than in low-small-business states. In column (3), which includes government Q, private-sector Q and its interaction with the high-small-business indicator, the

coefficient on private-sector  $Q$ ,  $\beta^{\text{Pri}}$ , equals  $-0.121$  (with a  $t$ -statistic of  $-1.441$ ), whereas the coefficient on the interaction term,  $\gamma^{\text{Pri}}$ , equals  $-0.106$  (with a  $t$ -statistic of  $-2.239$ ). Together, these coefficients imply that a one-standard-deviation increase in private-sector  $Q$  is associated with a 0.227 percentage point decrease ( $= \beta^{\text{Pri}} + \gamma^{\text{Pri}}$ ) in government investment rates in high-small-business states. Columns (2) and (4) yield similar effects, with decreases of 0.226 and 0.170 percentage points, respectively, for states with large subsidy programs.

In short, using various proxies for subsidies, our extensive tests confirm our **Prediction 2** that the negative relation between government investment and private-sector  $Q$  is strengthened by government subsidies.

## 4.2 Subsidy and Private-sector $Q$

Lastly, we examine **Prediction 3** on how governments allocate subsidy in response to private-sector  $Q$ . To remain consistent with the state-level empirical analysis in Section 4.1.1, one might consider state-level subsidy-to-sales ratio to proxy subsidy intensity. However, this measure is potentially misleading in testing the relation between private-sector  $Q$  and subsidy intensity. If the level of subsidies is fixed and the government does not actively adjust its policy, an increase in private-sector  $Q$  mechanically raises firm sales, which in turn lowers the subsidy-to-sales ratio. This mechanical relationship would generate a negative correlation between subsidy intensity and private-sector  $Q$  even in the absence of the economic mechanism described in Section 1.

To test **Prediction 3** in a conceptually clean way, more natural way is to use the subsidy-to-investment ratio. Unfortunately, reliable private-sector investment data are available only at the firm level for publicly listed firms. As a result, a firm-level analysis provides the best feasible approach for empirically evaluating **Prediction 3**. More specifically, using data described in Section

2.5.3, we regress firm-level subsidy intensity on firm-level Q as follows:

$$i_{i,t}^{\text{Firm}} = \alpha_i + \delta_t + \beta^{\text{Firm}} \cdot q_{i,t-1}^{\text{Firm}} + \epsilon_{j,t},$$

We report the results in Table 7. Consistent with **Prediction 3**, subsidy intensity is negatively related to firm-level private-sector Q. As shown in column (1), a one-standard-deviation increase in firm-level Q is associated with a 6.088 percentage-point decline in subsidy intensity. This negative and statistically significant relationship remains robust when we control for firm size and cash flow—measured by log(sales) and cash flow, respectively, following [Gala et al. \(2020\)](#)—as reported in columns (2)–(4).

[Insert Table 7]

Taken together, these results support **Prediction 3**: governments provide more subsidies when private-sector investment opportunities are weak. When private-sector  $q_t^{\text{Pri}}$  is low, the marginal return to subsidizing investment is high, whereas when  $q_t^{\text{Pri}}$  is high, additional subsidies are less productive and more costly in terms of foregone current consumption.

## 5 Conclusion

This paper integrates government investment into a Q-theoretical framework and provides new empirical evidence on how public investment responds to market-based valuations. Building on a model in which a welfare-maximizing government allocates resources across public investment and private-sector subsidies, we show that government investment rises with government Q but falls with private-sector Q due to local resource constraints. Private-sector subsidies also decline as private-sector Q rises and increase the (absolute) sensitivity of government investment to private-sector Q, amplifying the countercyclical role of public investment.

Using our novel regional measures of government  $Q$  from municipal bond prices and private-sector  $Q$  derived from firm-level valuations, our empirical findings strongly support these predictions: government investment increases with the marginal value of public capital and decreases with the marginal value of private-sector capital. We further show that this negative relationship with private-sector  $Q$  is amplified in regions with large subsidy programs, and that government subsidies fall as private-sector  $Q$  rises.

Together, these results highlight that public investment respond systematically to valuations embedded in financial markets. By linking government investment decisions to market-based measures of  $Q$ , the paper bridges corporate investment theory and public finance, offering a unified framework for analyzing resource allocation between the public and private sectors.

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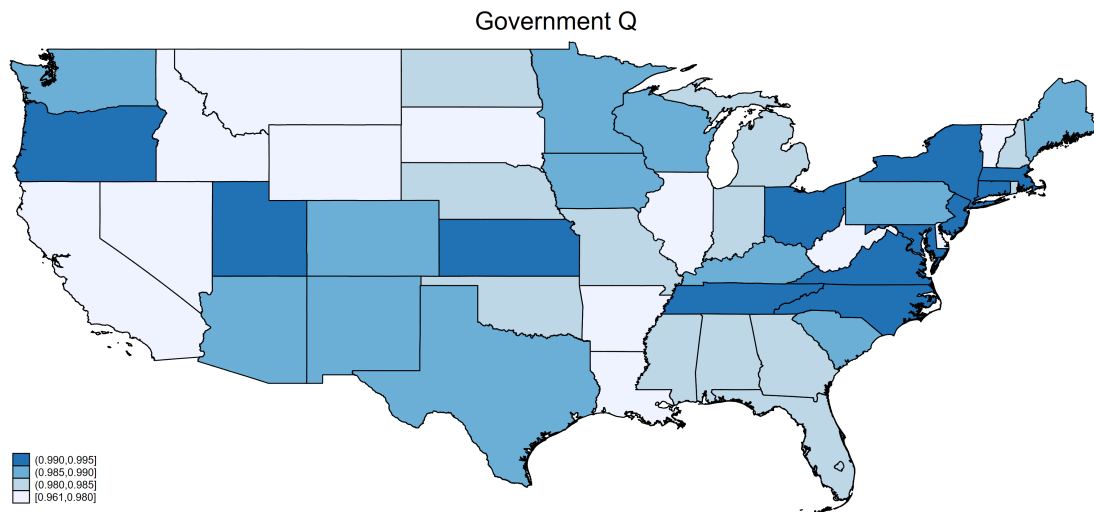


Figure 1: Cross-sectional distribution of state-level government Q

This figure plots the average government Q by state over the 1994–2022 sample period. Higher values indicate higher market-implied valuations of government capital. Government Q is constructed from municipal bond yields as described in Section 2.2.

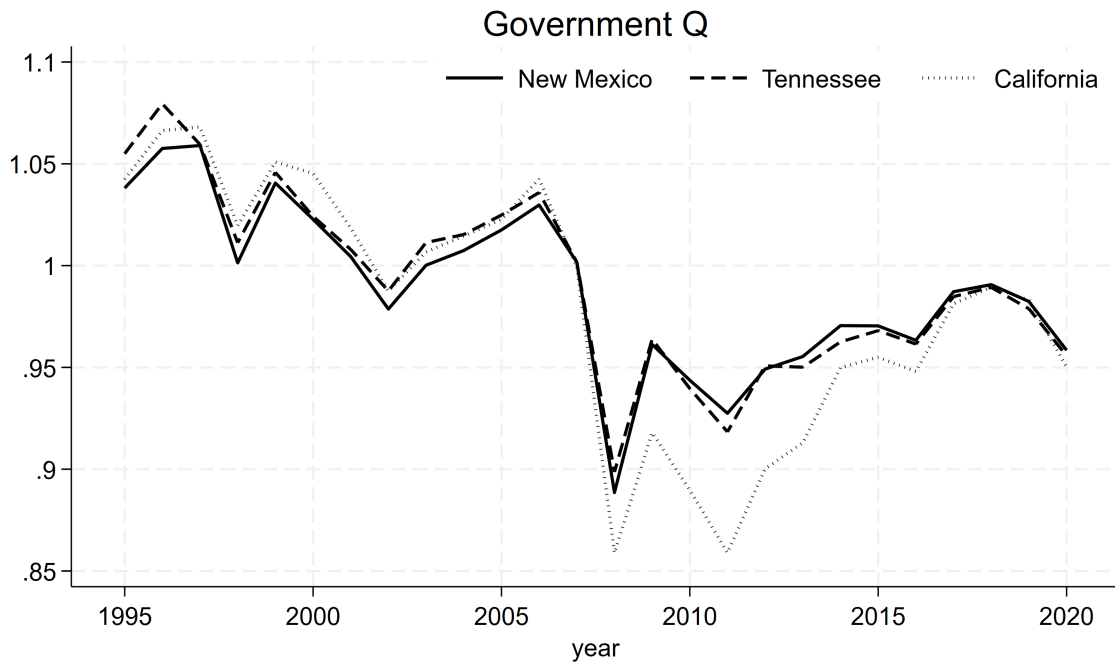


Figure 2: Time-series of government Q for selected states

This figure plots the time series of government Q for California, Massachusetts, New York, Kentucky, Michigan, and Texas. The shaded area corresponds to the 2007–2009 financial crisis, during which municipal bond spreads widened and government Q declined.

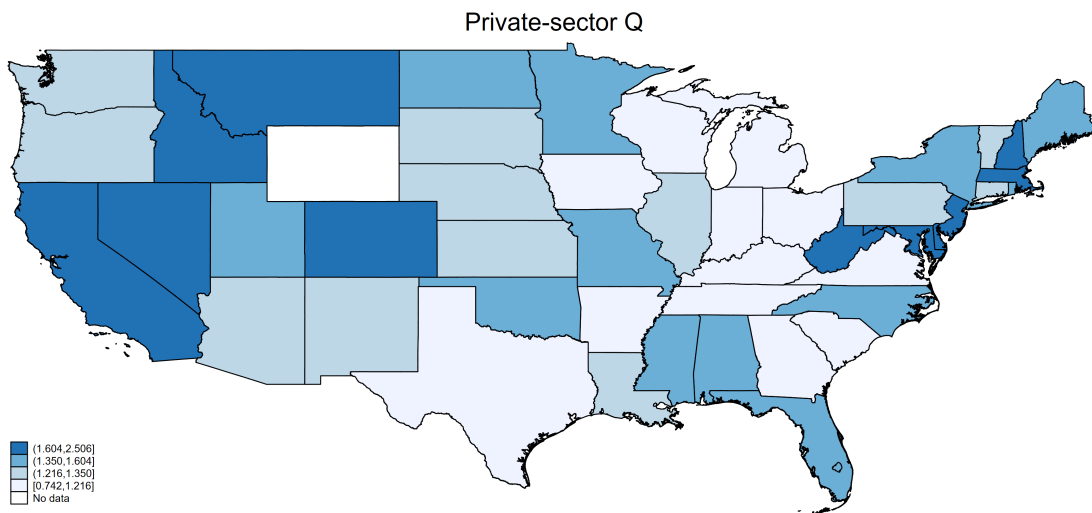


Figure 3: Cross-sectional distribution of state-level private-sector Q  
 This figure shows the distribution of average private-sector Q across states over 1994–2022, where private-sector Q is constructed from firm-level Qs and establishment-level activity as described in Section 2.3.

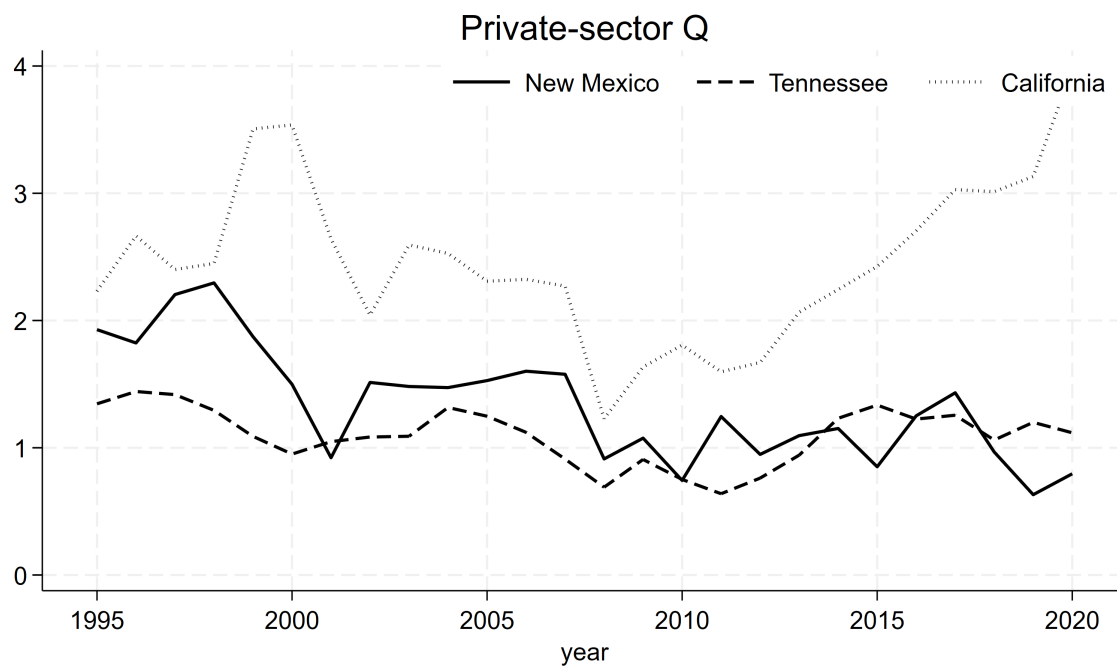


Figure 4: Time-series of private-sector Q for selected states

This figure plots private-sector Q over time for California, Massachusetts, New York, Kentucky, Michigan, and Texas. All six states experience a decline in private-sector Q during the 2007–2008 financial crisis, followed by heterogeneous recovery paths.



Table 1: Summary statistics

|   | N     | Mean   | Std. dev. | Median |
|---|-------|--------|-----------|--------|
| Panel A: State-level variables                                |       |        |           |        |
| Government Q  | 1,267 | 0.982  | 0.0468    | 0.983  |
| Private-sector Q (with a weight of sales)                     | 1,250 | 1.399  | 0.661     | 1.269  |
| Private-sector Q (with a weight of employment)                | 1,250 | 1.419  | 0.705     | 1.269  |
| Government capital stock - investment (in billion USD)        | 1,326 | 271.4  | 350.3     | 166.6  |
| Government investment rate (%)                                | 1,326 | 13.31  | 1.686     | 13.10  |
| Subsidy-sales ratio (%)                                       | 1,326 | 0.388  | 0.498     | 0.201  |
| Share of federal procurement contracts for small business (%) | 801   | 19.62  | 14.59     | 16.95  |
| GDP (in billion USD)  | 1,326 | 217.3  | 274.3     | 125.7  |
| Population (in million)                                       | 1,326 | 5.875  | 6.607     | 4.042  |
| Government book debt to GDP                                   | 1,326 | 0.154  | 0.0583    | 0.147  |
| Government revenue to GDP                                     | 1,326 | 0.232  | 0.0736    | 0.217  |
| Panel B: County-level variables                               |       |        |           |        |
| Government Q  | 6,650 | 0.984  | 0.0449    | 0.985  |
| Private-sector Q (with a weight of sales)                     | 6,650 | 4.282  | 23.26     | 1.219  |
| Private-sector Q (with a weight of employment)                | 6,189 | 5.617  | 42.92     | 1.480  |
| Government investment rate (%)                                | 6,650 | 12.86  | 2.228     | 12.60  |
| Intergovernmental rate (%)                                    | 6,650 | 5.312  | 1.711     | 5.257  |
| Population (in thousand)                                      | 6,636 | 577.7  | 805.2     | 357.1  |
| Government book debt to population (in thousand)              | 6,636 | 4.270  | 3.078     | 3.483  |
| Government revenue to population (in thousand)                | 6,636 | 4.362  | 1.618     | 4.108  |
| Panel C: Firm-level variables                                 |       |        |           |        |
| Firm-level Q (scaled by sales)                                | 8,028 | 3.594  | 43.64     | 1.732  |
| Subsidy intensity (scaled by sales)                           | 7,942 | 7.998  | 312.0     | 0.172  |
| Cashflow (scaled by sales)                                    | 8,028 | 0.0782 | 3.337     | 0.159  |
| Log(Sale)   | 8,028 | 8.338  | 1.636     | 8.328  |

This table reports summary statistics for the main variables used in the analysis at the state (Panel A), county (Panel B) levels and firm (Panel C) over the 1994–2022 sample period. All monetary values are expressed in year-2000 dollars. Government and private-sector Q are standardized within level and year. Government investment rate is defined as government investment divided by lagged government capital. See Section 2 for variable definitions and data sources.

Table 2: Government investment and Q: Baseline OLS

|                   | (1)                 | (2)                 | (3)                  | (4)                 | (5)                  | (6)                   |
|-------------------|---------------------|---------------------|----------------------|---------------------|----------------------|-----------------------|
| Government Q      | 0.714***<br>(3.025) |                     | 0.837***<br>(3.360)  | 0.573**<br>(2.272)  |                      | 0.712**<br>(2.648)    |
| Private-sector Q  |                     | -0.174*<br>(-1.972) | -0.188**<br>(-2.300) |                     | -0.147**<br>(-2.481) | -0.160***<br>(-2.784) |
| Log(GDP)          |                     |                     |                      | 3.349***<br>(3.039) | 3.092***<br>(3.124)  | 2.837***<br>(2.963)   |
| Total Debt to GDP |                     |                     |                      | -2.009<br>(-1.186)  | -2.381<br>(-1.425)   | -1.975<br>(-1.233)    |
| Revenue to GDP    |                     |                     |                      | 10.96***<br>(5.523) | 10.86***<br>(5.532)  | 10.34***<br>(5.233)   |
| Observations      | 1,313               | 1,300               | 1,289                | 1,313               | 1,300                | 1,289                 |
| R-squared         | 0.804               | 0.818               | 0.826                | 0.830               | 0.841                | 0.845                 |
| Controls          | No                  | No                  | No                   | Yes                 | Yes                  | Yes                   |
| State FE          | Yes                 | Yes                 | Yes                  | Yes                 | Yes                  | Yes                   |
| Year FE           | Yes                 | Yes                 | Yes                  | Yes                 | Yes                  | Yes                   |

This table reports panel regressions of state-level government investment rates on lagged government Q and lagged private-sector Q over 1994–2022. The dependent variable is the government investment rate in state  $j$  and year  $t$ , defined as government investment divided by lagged government capital. Government Q and private-sector Q are standardized within year. All specifications include state and year fixed effects; standard errors are clustered at the state level, and  $t$ -statistics are reported in parentheses.

Table 3: Government investment and Q: Measurement error correction

|                               | (1)                | (2)                   | (3)                   | (4)                 | (5)                   | (6)                   |
|-------------------------------|--------------------|-----------------------|-----------------------|---------------------|-----------------------|-----------------------|
| Government Q                  | 2.690**<br>(2.355) |                       | 1.212***<br>(3.391)   | 4.129***<br>(2.585) |                       | 1.154**<br>(2.267)    |
| Private-sector Q              |                    | -0.342***<br>(-3.340) | -0.0805**<br>(-2.089) |                     | -0.511***<br>(-5.645) | -0.484***<br>(-6.876) |
| Log(GDP)                      |                    |                       |                       | 2.829**<br>(2.296)  | 2.647***<br>(3.124)   | 2.335***<br>(3.025)   |
| Total Debt to GDP             |                    |                       |                       | 0.485<br>(0.284)    | -2.892<br>(-1.640)    | -2.120<br>(-1.262)    |
| Revenue to GDP                |                    |                       |                       | 9.548***<br>(4.273) | 10.39***<br>(6.199)   | 9.858***<br>(5.630)   |
| Observations                  | 1,313              | 1,300                 | 1,289                 | 1,313               | 1,300                 | 1,289                 |
| State FE                      | YES                | YES                   | YES                   | YES                 | YES                   | YES                   |
| Year FE                       | YES                | YES                   | YES                   | YES                 | YES                   | YES                   |
| $\tau^2$ for government Q     | 0.265<br>0.125     |                       | 0.660<br>0.246        | 0.161<br>0.0881     |                       | 0.742<br>0.354        |
| $\tau^2$ for private-sector Q |                    | 0.509<br>0.325        | 2.409<br>1.548        |                     | 0.297<br>0.103        | 0.356<br>0.101        |
| Sargan-Hansen J-stat p-val    | 0.338              | 0.311                 | 0.819                 | 0.841               | 0.219                 | 0.108                 |

This table reports panel regressions of state-level government investment rates on lagged government Q and lagged private-sector Q over 1994–2022. More specifically, it reports measurement-error-corrected estimates following [Erickson and Whited \(2000, 2002, 2012\)](#); [Erickson et al. \(2014\)](#). The dependent variable is the government investment rate in state  $j$  and year  $t$ , defined as government investment divided by lagged government capital. Government Q and private-sector Q are standardized within year. All specifications include state and year fixed effects; standard errors are clustered at the state level, and  $t$ -statistics are reported in parentheses. Reliability ratios ( $\tau$ ) are reported in brackets.

Table 4: County-level government investment

|                   | (1)                 | (2)                 | (3)                  | (4)                  | (5)                  | (6)                  |
|-------------------|---------------------|---------------------|----------------------|----------------------|----------------------|----------------------|
| Government Q      | 0.257***<br>(3.478) |                     | 0.260***<br>(3.509)  | 0.254***<br>(3.769)  |                      | 0.256***<br>(3.799)  |
| Private-sector Q  |                     | -0.0685<br>(-1.644) | -0.0711*<br>(-1.702) |                      | -0.0676*<br>(-1.715) | -0.0703*<br>(-1.777) |
| Log(GDP)          |                     |                     |                      | -1.260*<br>(-1.724)  | -1.189<br>(-1.633)   | -1.267*<br>(-1.735)  |
| Total Debt to GDP |                     |                     |                      | -0.0550*<br>(-1.715) | -0.0582*<br>(-1.793) | -0.0551*<br>(-1.716) |
| Revenue to GDP    |                     |                     |                      | 0.566***<br>(10.75)  | 0.571***<br>(10.88)  | 0.566***<br>(10.74)  |
| Observations      | 5,307               | 5,307               | 5,307                | 5,301                | 5,301                | 5,301                |
| R-squared         | 0.654               | 0.653               | 0.655                | 0.672                | 0.671                | 0.672                |
| County FE         | YES                 | YES                 | YES                  | YES                  | YES                  | YES                  |
| Year FE           | YES                 | YES                 | YES                  | YES                  | YES                  | YES                  |

This table reports regression estimates of the relation between county-level government investment rates and county-level Q (government Q and private-sector Q). Government investment is scaled by lagged government capital to obtain a percentage investment rate. Both government Q  $q_{j,t-1}^{\text{Gov}}$  and private-sector Q  $q_{j,t-1}^{\text{Pri}}$  are standardized.  $t$ -statistics in parentheses are based on heteroskedasticity-consistent standard errors clustered by county. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table 5: Government investment, private-sector Q, and subsidy-sales ratio

|  | (1)                 | (2)                 | (3)                   | (4)                  |
|--|---------------------|---------------------|-----------------------|----------------------|
| Government Q   | 0.819***<br>(3.178) |                     | 0.970***<br>(3.576)   | 0.737**<br>(2.577)   |
| Private-sector Q   |                     | -0.0649<br>(-1.651) | -0.0805**<br>(-2.017) | -0.0825*<br>(-1.867) |
| $\mathbb{1}\{\text{Subsidy}\} \cdot (\text{Private-sector Q})$ |                     | -0.185*<br>(-1.801) | -0.193**<br>(-2.016)  | -0.138*<br>(-1.801)  |
| $\mathbb{1}\{\text{Subsidy}\}$                                 |                     | 0.183**<br>(2.052)  | 0.192**<br>(2.226)    | 0.125*<br>(1.797)    |
| Log(GDP)   |                     |                     |                       | 2.881***<br>(2.936)  |
| Total Debt to GDP  |                     |                     |                       | -4.023**<br>(-2.127) |
| Revenue to GDP   |                     |                     |                       | 9.719***<br>(5.241)  |
| Observations   | 1,267               | 1,250               | 1,243                 | 1,243                |
| R-squared  | 0.810               | 0.829               | 0.836                 | 0.854                |
| Controls   | No                  | No                  | Yes                   | Yes                  |
| State FE   | Yes                 | Yes                 | Yes                   | Yes                  |
| Year FE  | Yes                 | Yes                 | Yes                   | Yes                  |

This table reports state-level regressions of government investment rates on government Q, private-sector Q, and their interactions with an indicator for above-median subsidy rates. The high-subsidy indicator equals one if the state's subsidy rate in year  $t - 1$  is above the year-specific median, and zero otherwise. Government Q and private-sector Q are standardized. All specifications include state and year fixed effects; standard errors are clustered by state.

Table 6: Government investment, private-sector Q, and federal procurement contracts

|  | (1)                 | (2)                  | (3)                   | (4)                   |
|--|---------------------|----------------------|-----------------------|-----------------------|
| Government Q   | 0.900***<br>(3.063) |                      | 0.933***<br>(3.119)   | 0.504*<br>(1.803)     |
| Private-sector Q   |                     | -0.0918<br>(-1.007)  | -0.121<br>(-1.441)    | -0.110<br>(-1.673)    |
| $\mathbb{1}\{\text{HighSmallBusiness}\} \cdot (\text{Private-sector Q})$ |                     | -0.134**<br>(-2.392) | -0.106**<br>(-2.239)  | -0.0599<br>(-1.411)   |
| $\mathbb{1}\{\text{HighSmallBusiness}\}$                                 |                     | -0.153**<br>(-2.493) | -0.154***<br>(-2.710) | -0.0861*<br>(-1.872)  |
| Log(GDP)   |                     |                      |                       | 4.254***<br>(3.720)   |
| Total Debt to GDP  |                     |                      |                       | -8.473***<br>(-2.996) |
| Revenue to GDP   |                     |                      |                       | 8.406***<br>(2.961)   |
| Observations   | 798                 | 789                  | 789                   | 789                   |
| R-squared  | 0.815               | 0.811                | 0.820                 | 0.850                 |
| Controls   | No                  | No                   | Yes                   | Yes                   |
| State FE   | Yes                 | Yes                  | Yes                   | Yes                   |
| Year FE  | Yes                 | Yes                  | Yes                   | Yes                   |

This table reports state-level regressions of government investment rates on government Q, private-sector Q, and their interactions with an indicator for above-median small business share. The high small business indicator equals 1 if the state's share of federal government procurement contracts set aside for small businesses in year  $t-1$  is above the year-specific median, and zero otherwise. Government Q and private-sector Q are standardized. All specifications include state and year fixed effects; standard errors are clustered by state.

Table 7: Firm-level subsidy and private-sector Q

|              | (1)                   | (2)                   | (3)                   | (4)                   |
|--------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Firm-level Q | -6.088***<br>(-3.190) | -6.620***<br>(-2.965) | -6.127***<br>(-3.297) | -6.612***<br>(-2.953) |
| Log(Sale)    |                       | -59.89<br>(-1.026)    |                       | -55.86<br>(-0.922)    |
| Cashflow     |                       |                       | -6.873***<br>(-7.206) | -4.820*<br>(-1.869)   |
| Observations | 5,944                 | 5,944                 | 5,944                 | 5,944                 |
| R-squared    | 0.091                 | 0.094                 | 0.092                 | 0.095                 |
| Firm FE      | Yes                   | Yes                   | Yes                   | Yes                   |
| Year FE      | Yes                   | Yes                   | Yes                   | Yes                   |

This table reports state-level regressions of government investment rates on government Q, private-sector Q, and their interactions with an indicator for above-median subsidy rates. The high-subsidy indicator equals one if the state's subsidy rate in year  $t - 1$  is above the year-specific median, and zero otherwise. Government Q and private-sector Q are standardized. All specifications include state and year fixed effects; standard errors are clustered by state.

Appendix for  
“Government Investment and Q: Theory and Evidence”

by Zhiyao Chen, Ran Duchin, Daniel Kim and Erica X.N. Li

A. Mathematical Proofs

B. Variable definitions

C. Robustness tests

C.1 Alternative sample with full Census years

C.2 Alternative measure of private-sector Q

C.3 Internal capital allocation

# A Mathematical Proofs

## A.1 Investment- $q$ Relation

### Proof of Prediction 1 and Prediction 2:

From equation (5), we can write

$$\frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}} = \frac{1}{a} \left[ \frac{q_t^{\text{Pri}}}{1-s_t} - 1 \right]$$

so that

$$C_t = Y_t - p_{I,t}(I_t^{\text{Gov}} + \Phi_t^{\text{Gov}} + I_t^{\text{Pri}} + \Phi_t^{\text{Pri}}).$$

Equation (14) can be written as an implicit function of

$$F \left( \frac{I_t^{\text{Gov}}}{K_{t-1}^{\text{Gov}}}, q_t^{\text{Gov}}, q_t^{\text{Pri}} \right) \equiv \left( \lambda_t^{\text{Gov}} + \frac{1}{C_t} \right) \left[ 1 + b \frac{I_t^{\text{Gov}}}{K_{t-1}^{\text{Gov}}} \right] - q_t^{\text{Gov}} = 0. \quad (20)$$

We derive the Taylor approximation of public investment rate  $i_t^{\text{Gov}} \equiv \frac{I_t^{\text{Gov}}}{K_{t-1}^{\text{Gov}}}$  as a function of public and private Tobin's  $q$ ,  $q_t^{\text{Gov}}$  and  $q_t^{\text{Pri}}$  at their sample means  $\bar{q}^{\text{Gov}}$  and  $\bar{q}^{\text{Pri}}$ :

$$i_t^{\text{Gov}} = \bar{i} + a_1(q_t^{\text{Gov}} - \bar{q}^{\text{Gov}}) + a_2(q_t^{\text{Pri}} - \bar{q}^{\text{Pri}}) + \mathcal{O}(q_t^{\text{Gov}}, q_t^{\text{Pri}}),$$

where

$$a_1 = \left. \frac{\partial i_t^{\text{Gov}}}{\partial q_t^{\text{Gov}}} \right|_{q_t^{\text{Gov}}=\bar{q}^{\text{Gov}}, q_t^{\text{Pri}}=\bar{q}^{\text{Pri}}} \quad \text{and} \quad a_2 = \left. \frac{\partial i_t^{\text{Gov}}}{\partial q_t^{\text{Pri}}} \right|_{q_t^{\text{Gov}}=\bar{q}^{\text{Gov}}, q_t^{\text{Pri}}=\bar{q}^{\text{Pri}}}.$$

Differentiate the both sides of equation (20), and get:

$$\frac{\partial i_t^{\text{Gov}}}{\partial q_t^{\text{Gov}}} = \frac{1}{b(\lambda_t^{\text{Gov}} + \frac{1}{c_t}) - \frac{1}{c^2} \frac{\partial c_t}{\partial i_t^{\text{Gov}}}} \quad (21)$$

$$\frac{\partial i_t^{\text{Gov}}}{\partial q_t^{\text{Pri}}} = \frac{\frac{1}{a(1-s_t)} \frac{\partial c_t}{\partial i_t^{\text{Pri}}}}{\frac{b(c_t \lambda_t^{\text{Gov}} + 1)^2}{q_t^{\text{Gov}}} - \frac{\partial c_t}{\partial i_t^{\text{Gov}}}}. \quad (22)$$

With  $\partial p_{I,t}/\partial I_t > 0$  and  $\partial Y_t/\partial I_t < 0$  from Section 1.4, we can show that given  $K_{t-1}^{\text{Gov}}$  and  $K_{t-1}^{\text{Pri}}$

$$\begin{aligned}\frac{\partial c_t}{\partial i_t^{\text{Gov}}} &= K_{t-1}^{\text{Gov}} \left[ \frac{\partial Y_t}{\partial I_t} - p_{I,t} (1 + b i_t^{\text{Gov}}) - \frac{\partial p_{I,t}}{\partial I_t} (I_t + \Phi_t) \right] < 0 \\ \frac{\partial c_t}{\partial i_t^{\text{Pri}}} &= K_{t-1}^{\text{Pri}} \left[ \frac{\partial Y_t}{\partial I_t} - p_{I,t} (1 + a i_t^{\text{Pri}}) - \frac{\partial p_{I,t}}{\partial I_t} (I_t + \Phi_t) \right] < 0,\end{aligned}$$

where  $i_t^{\text{Pri}} \equiv \frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}}$  is the private investment rate,  $I_t = I_t^{\text{Gov}} + I_t^{\text{Pri}}$  is the sum of public and private investments, and  $\Phi_t = \Phi_t^{\text{Gov}} + \Phi_t^{\text{Pri}}$  is the sum of public and private investment adjustment costs. Thus, it's straightforward to show that  $a_1 > 0$  and  $a_2 < 0$ . Therefore, the first-order Taylor approximation implies **Prediction 1**.

Moreover, equation (22) immediately indicates that all else equal, higher  $s_t$  leads to more negative  $a_2$ . This implies **Prediction 2** QED.

## A.2 Mathematical Proofs: Subsidy- $q^{\text{Pri}}$ Relation

### Proof of Prediction 3:

Define  $i_t^{\text{Pri}} \equiv \frac{I_t^{\text{Pri}}}{K_{t-1}^{\text{Pri}}}$  and we can easily show that

$$K_{t-1}^{\text{Pri}} \frac{\partial i_t^{\text{Pri}}}{\partial s_t} = \frac{K_{t-1}^{\text{Pri}}}{a} \frac{q_t^{\text{Pri}}}{(1 - s_t)^2}.$$

Divide both sides of the FOC wrt  $s_t$  by  $K_{t-1}^{\text{Pri}} \frac{\partial i_t^{\text{Pri}}}{\partial s_t}$  and write its scaled R.H.S. as

$$\text{R.H.S.} \equiv \Theta_t = E_t M_{t+1} \left[ \left( \frac{1}{C_{t+1}} + \lambda_{t+1}^{\text{Gov}} \right) p_{I,t+1} \frac{a}{2} \left( \frac{I_{t+1}^{\text{Pri}}}{K_t^{\text{Pri}}} \right)^2 + \left( \frac{1}{C_{t+1}} + \mu \right) \alpha \frac{Y_{t+1}}{K_t^{\text{Pri}}} \right]. \quad (23)$$

Since  $\frac{\partial K_t^{\text{Pri}}}{\partial s_t} > 0$ ,  $\frac{\partial K_t^{\text{Pri}}}{\partial q_t^{\text{Pri}}} > 0$  and  $\frac{\partial \Theta_t}{\partial K_t^{\text{Pri}}} < 0$ , it can be shown that by using the Chain Rule:

$$\frac{\partial \Theta_t}{\partial s_t} < 0, \quad \text{and} \quad \frac{\partial \Theta_t}{\partial q_t^{\text{Pri}}} < 0$$

Similarly, the L.H.S. of the FOC wrt  $s_t$  after the same scaling can be written as

$$\text{L.H.S.} \equiv \mathcal{H}_t = \left( \frac{p_{I,t}}{C_t} + \lambda_t^{\text{Gov}} p_{I,t} s_t \right) \frac{q_t^{\text{Pri}}}{1-s_t} + \lambda_t^{\text{Gov}} p_{I,t} \frac{\left( \frac{q_t^{\text{Pri}}}{1-s_t} - 1 \right) + \frac{1}{2} \left( \frac{q_t^{\text{Pri}}}{1-s_t} - 1 \right)^2}{\frac{q_t^{\text{Pri}}}{(1-s_t)^2}},$$

which can be simplified as

$$\mathcal{H}_t = \left( \frac{p_{I,t}}{C_t} + \lambda_t^{\text{Gov}} p_{I,t} s_t \right) \frac{q_t^{\text{Pri}}}{1-s_t} + \frac{\lambda_t^{\text{Gov}} p_{I,t}}{2} \left[ q_t^{\text{Pri}} - \frac{(1-s_t)^2}{q_t^{\text{Pri}}} \right]. \quad (24)$$

Since both  $s_t$  and  $q_t^{\text{Pri}}$  raises private investment, resulting in higher capital price  $p_{I,t}$  and lower consumption  $C_t$ , all else equal, it can be shown that

$$\frac{\partial \mathcal{H}_t}{\partial s_t} > 0, \quad \text{and} \quad \frac{\partial \mathcal{H}_t}{\partial q_t^{\text{Pri}}} > 0.$$

We differentiate the both sides of the FOC w.r.t.  $s_t$ , i.e.,  $\mathcal{H}_t = \Theta_t$ , by  $q_t^{\text{Pri}}$  and get

$$\frac{\partial s_t}{\partial q_t^{\text{Pri}}} = \frac{\frac{\partial \mathcal{H}_t}{\partial q_t^{\text{Pri}}} - \frac{\partial \Theta_t}{\partial q_t^{\text{Pri}}}}{\frac{\partial \Theta_t}{\partial s_t} - \frac{\partial \mathcal{H}_t}{\partial s_t}} < 0.$$

QED.

## B Variable definitions

### State-level Q and characteristics

- *Government Q*: The median of all bond-level Q values corresponding to local governments within the state's jurisdiction. Each bond-level Q is calculated as the ratio of one plus the duration-matched risk-free rate to one plus the municipal bond's yield, following Philippon (2009).
- *Private sector Q (with a weight of sales)*: State-level private sector Q values are derived by decomposing firm-level Qs, using firms' state-level sales as weights, following the method of Boguth et al. (2022).
- *Private sector Q (with a weight of employment)*: State-level private sector Q values are derived by decomposing firm-level Qs, using firms' state-level employment as weights, following the method of Boguth et al. (2022).
- *Government capital stock*: Government capital stock is calculated using an annual capital accumulation equation, assuming a depreciation rate of 10% and an initial capital stock level of zero in 1967.
- *Government investment rate*: Government investment rate is defined as government investment, scaled by the one-year lagged government capital stock, where investment is defined as the sum of current operations, capital outlays, and assistance and subsidies, as reported by the Census.
- *Subsidy rate*: Subsidy rate is defined as subsidy investment, scaled by government investment. Annual state-level subsidy data is estimated and provided by the BEA. Annual state-level investment data is provided by Census.
- *GDP*: The GDP, provided by BEA.
- *Population*: The total population as reported by the Census.
- *Government book debt to GDP*: Total local government debt scaled by GDP, as reported by the Census.

- *Government revenue to GDP*: Total local government revenue scaled by GDP, as reported by the Census.

### County-level Q and characteristics

- *Government Q*: The median of all bond-level Q values corresponding to local governments within the county's jurisdiction. Each bond-level Q is calculated as the ratio of one plus the duration-matched risk-free rate to one plus the municipal bond's yield, following [Philippon \(2009\)](#).
- *Private sector Q (with a weight of sales)*: County-level private sector Q values are derived by decomposing firm-level Qs, using firms' county-level sales as weights, following the method of [Boguth et al. \(2022\)](#).
- *Government investment rate* : Government investment is scaled by the one-year lagged government capital stock, where investment is defined as the sum of current operations, capital outlays, and assistance and subsidies.
- *Intergovernmental subsidy rate (investment)*: Total intergovernmental transfers from the state government to county governments, scaled by the one-year lagged county-level government capital stock.
- *Population*: The total population as reported by the Census.
- *Government book debt to population*: Total local government debt scaled by population, as reported by the Census.
- *Government revenue to population*: Total local government revenue scaled by population, as reported by the Census.

## C Robustness tests

This section presents a series of robustness tests based on alternative samples and alternative measures of private-sector  $Q$  and government investment. The results confirm that the main findings hold using alternative sample choices or variable constructions.

### C.1 Alternative sample with full Census years

A potential concern is that our estimates may be influenced by the way the Census Bureau collects data. The Census of Governments is conducted every five years, in years ending in 2 and 7, and provides comprehensive coverage of state and local governments. In intervening years, the Census uses samples of governments. In Census years, the sample covers roughly 90% of the population, whereas in non-Census years the coverage is about 75% (Pierson et al., 2015). To address the possibility that our results are driven by non-Census years, we re-estimate equation (19) using only Census years and report the state-level estimates in columns (1)–(3) of Table A1.

The results confirm that government  $Q$  remains statistically significantly and positively related to the government investment rate, while private-sector  $Q$  remains statistically significantly and negatively related to the government investment rate. Thus, restricting the sample to full Census years does not alter the main conclusions.

### C.2 Alternative measure of private-sector $Q$

We next consider an alternative construction of private-sector  $Q$ . Following Boguth, Duchin, and Simutin (2022), we recompute regional private-sector  $Q$  using establishment-level employment, rather than sales, to construct the weight matrix  $W_t$ . Summary statistics for this alternative measure are reported in Table 1. Although the distribution of the employment-weighted private-sector  $Q$  differs somewhat from that of the benchmark sales-weighted measure, the differences are not substantial.

We then re-estimate equation (19) using this employment-based  $Q$ . For comparability, both government  $Q$  and private-sector  $Q$  are standardized. The corresponding state-level results are reported in columns (4)–(6) of Table A1. The positive sensitivity of government investment to government  $Q$  and the negative sensitivity to private-sector  $Q$  remain statistically and economically

significant, indicating that the main findings are robust to the choice of private-sector Q measure.

### C.3 Internal capital allocation

We study state-to-county budget allocation, analogous to firm internal capital markets. The literature contrasts “bright side” efficiency (e.g., [Alchian \(1969\)](#); [Stein \(1997\)](#)) with “dark side” inefficiencies like cross-subsidization ([Coase \(1937\)](#); [Milgrom \(1988\)](#); [Rajan et al. \(2000\)](#); [Scharfstein and Stein \(2000\)](#)).

Extending this to public Q-theory, we focus on intergovernmental transfers (41% of county investment). We construct reallocation rates  $t_{c,t}^{\text{Gov}}$  as transfers from state  $s$  to county  $c$  divided by lagged county capital (per [Section 2.4](#)). We estimate

$$t_{c,t}^{\text{Gov}} = \alpha_c + \delta_t + \beta^{\text{Gov}} \cdot q_{c,t-1}^{\text{Gov}} + \beta^{\text{Pri}} \cdot q_{c,t-1}^{\text{Pri}} + \epsilon_{c,t}, \quad (25)$$

with results in [Table A2](#).

States allocate more to high-government-Q counties: column (1) shows +0.182 percentage points per standard deviation (1% significant). They also favor low-private-Q counties: column (2) shows +0.0362 percentage points per standard-deviation *decrease*; column (3) gives +0.184 for government Q and +0.0380 for private-sector Q decrease. Controls in columns (4)–(6) yield similar results.

These mirror main findings: states reallocate per Q-theory, boosting high-government-Q, low-private-Q counties.

Table A1: Government investment with alternative Q measures

|                   | (1)                 | (2)                   | (3)                   | (4)                 | (5)                  | (6)                  |
|-------------------|---------------------|-----------------------|-----------------------|---------------------|----------------------|----------------------|
| Government Q      | 1.185***<br>(2.763) | 1.488***<br>(3.565)   | 1.074***<br>(2.702)   | 0.714***<br>(3.025) | 0.826***<br>(3.341)  | 0.701**<br>(2.639)   |
| Private-sector Q  |                     | -0.259***<br>(-2.891) | -0.241***<br>(-2.755) |                     | -0.180**<br>(-2.318) | -0.157**<br>(-2.666) |
| Log(GDP)          |                     |                       | 1.961*<br>(1.934)     |                     |                      | 2.867***<br>(2.972)  |
| Total debt to GDP |                     |                       | -8.773***<br>(-2.716) |                     |                      | -2.039<br>(-1.271)   |
| Revenue to GDP    |                     |                       | -0.412<br>(-0.212)    |                     |                      | 10.39***<br>(5.154)  |
| Observations      | 251                 | 247                   | 247                   | 1,313               | 1,289                | 1,289                |
| R-squared         | 0.835               | 0.856                 | 0.873                 | 0.804               | 0.825                | 0.845                |
| State FE          | YES                 | YES                   | YES                   | YES                 | YES                  | YES                  |
| Year FE           | YES                 | YES                   | YES                   | YES                 | YES                  | YES                  |

This table reports regressions of state-level government investment rates on government Q and alternative constructions of private-sector Q. In columns (1)–(3), private-sector Q is constructed using sales weights and the sample is restricted to full Census years (1997, 2002, 2007, 2012, 2017). In columns (4)–(6), private-sector Q is constructed using employment weights and the full sample is used. Government investment is scaled by lagged public capital. Both government Q and private-sector Q are standardized.  $t$ -statistics in parentheses are based on heteroskedasticity-consistent standard errors clustered by state. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table A2: Internal capital allocation of state budgets

|                   | (1)                 | (2)                  | (3)                   | (4)                 | (5)                  | (6)                  |
|-------------------|---------------------|----------------------|-----------------------|---------------------|----------------------|----------------------|
| Government Q      | 0.182***<br>(4.095) |                      | 0.184***<br>(4.129)   | 0.178***<br>(4.042) |                      | 0.180***<br>(4.076)  |
| Private-sector Q  |                     | -0.0362*<br>(-1.853) | -0.0380**<br>(-2.019) |                     | -0.0353*<br>(-1.790) | -0.0371*<br>(-1.952) |
| Log(GDP)          |                     |                      |                       | 0.401<br>(1.039)    | 0.452<br>(1.164)     | 0.398<br>(1.032)     |
| Total debt to GDP |                     |                      |                       | 0.00321<br>(0.192)  | 0.001000<br>(0.0590) | 0.00314<br>(0.187)   |
| Revenue to GDP    |                     |                      |                       | 0.0949**<br>(2.330) | 0.0980**<br>(2.416)  | 0.0946**<br>(2.327)  |
| Observations      | 5,307               | 5,307                | 5,307                 | 5,301               | 5,301                | 5,301                |
| R-squared         | 0.869               | 0.868                | 0.869                 | 0.870               | 0.869                | 0.870                |
| County FE         | YES                 | YES                  | YES                   | YES                 | YES                  | YES                  |
| Year FE           | YES                 | YES                  | YES                   | YES                 | YES                  | YES                  |

This table studies the relation between state-to-county capital reallocations and county-level Q. Capital reallocation is scaled by lagged county-level government capital to obtain a percentage reallocation rate. Both government Q and private-sector Q are standardized.  $t$ -statistics in parentheses are based on heteroskedasticity-consistent standard errors clustered by county. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .