Public Seeds, Private Blooms:

A Q-theoretical Exploration of Public and Private Investment

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Abstract

This paper studies the interaction between public- and private-sector investments in a Q-theoretical framework. We develop a model in which the government chooses optimal public-sector investment to maximize social welfare, and firms maximize their private value in anticipation of government investment. To test the predictions of the model, we hand-collect state- and county-level data on government spending, and construct novel empirical measures of regional government Qs, derived from municipal bond prices, and private-sector Qs, based on a decomposition of firm-level Qs. The main findings suggest that government spending varies with fluctuations in financial markets, and that state governments invest more, particularly through direct cash subsidies, when the valuations of local firms decline.

JEL classification: G18, G30, G10, E62
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1 Introduction

The confluence of the Covid-19 pandemic, geopolitical tensions, and worries about climate change, among other factors, has led to some of the largest spending bills ever enacted in U.S. history, including the CARES act of 2020, the Consolidated Appropriations Act of 2021, and the CHIPS and Science and Inflation Reduction Acts of 2022. Combined, these Acts amounted to trillions of dollars in government spending, and resurfaced century-old questions about public-sector spending and its relation to private-sector economic activity. In this paper, we put forth a novel approach for studying the interplay between public- and private-sector investment nested in an extended Q-theoretical framework. We provide new estimates that connect public spending across U.S. states to both the municipal bond and the corporate equity markets. As such, this work extends the existing literature that focuses on the Q-theory of investment in the private sector to consider public-sector investment, and its interaction with private-sector investment and financial markets.

In the first part of the paper, we present a general equilibrium model that jointly considers private-sector firms, households, and the government. In the model, private-sector production is financed through both private and public investments, and households consume the dividends that firms pay out. A key ingredient of the model is that the government determines investment, which consists of public investment (e.g. public goods such as infrastructure) and subsidy investment, to maximize social welfare, anticipating the impact of its investment on private-sector investment, whereas private-sector firms maximize their value using their own capital and government sponsored capital (subsidy investment) in addition to public investment. The different maximization objectives result in different investment behaviors across governments and firms.

The two main predictions of the theoretical framework can be summarized as follows. First, similar to the standard predictions of the Q-theory of investment (e.g., Tobin (1969), Hayashi (1982)) in the private sector, public investment is *positively* correlated with government Q. This result is intuitive. When incremental investments in public goods (e.g. infrastructure) increase households' welfare, the government will increase its investment since it aims to maximize households' welfare.

Second, unlike standard Q-theory predictions, public investment is *negatively* correlated with private-sector Q. The intuition behind this result is as follows. A welfare-maximizing government, which maximizes households' dividend consumption, implicitly internalizes private-sector investment productivity. When private-sector Q is low, the government has an incentive to further stimulate the private-sector's investment in order to increase firms' output and households' consumption. Conversely, when private-sector Q is high, the government has weaker incentives to stimulate private firms. As such, the relation between public investment and private-sector Q is negative. Importantly, the model differentiates between public investments (e.g. spending on infrastructure) and direct firm-level subsidies. Compared to public investments, direct subsidies are a more effective channel through which the government can induce private-sector investment because they effectively minimize firms' out-of-pocket costs. This distinction implies that the private-sector Q-sensitivity of public investment will vary with governments' subsidy policies.

To test the predictions of the model, we construct novel measures of annual, state-by-state government Qs and private-sector Qs, and hand-collect data on state-level public spending on infrastructure and subsidies. This empirical approach allows us to exploit variation across states and over time that holds constant any confounding monetary policy effects common across all states.

A key challenge in estimating government Qs is the absence of market-traded government equity. To overcome this challenge, we utilize the market value of municipal bonds to construct estimates of government Qs. This approach follows the method developed by Philippon (2009). For each municipal bond, we calculate Q as the ratio between one plus the duration-matched risk-free rate and one plus the bond's yield. This measure is akin to the inverse of the credit spread, and is similar in spirit to the market-to-book ratio of equity. We then calculate a median of all the municipal bonds' Qs in a given state in a given year to arrive at annual state-level government Qs. We choose a median as an aggregation method to stay consistent with the procedure, median regression, undertaken in constructing private-sector Q's and further explained below.

A key challenge in constructing state-level measures of private-sector Qs is that firms' operations are often spread across multiple states. To overcome this challenge, we follow the method developed by Boguth, Duchin, and Simutin (2022), and estimate state-by-state private-sector Qs by decomposing firm-level Qs. Specifically, we form portfolios of firms that operate in one or more states, and estimate a vector of implied state-level private-sector Qs. As a simple example, consider two firms that operate in the same two states: state A and B. Assume that the first firm has unit exposure of fundamentals to state A and unit exposure to state B, and the second firm has two units exposure to state A and unit exposure to state B. It is immediately clear that a portfolio long the second firm and short the first firm has unit exposure to state A and zero exposure to state B. Thus, the value of this portfolio equals the implied valuation of firms operating in state A and provides a proxy for the private-sector Qs of this state. In this example, the solution to the problem is unique and can be obtained by inverting the matrix containing the proportions of firm exposures to each state. For practical applications, the number of firms exceeds the number of states, and this matrix is not invertible. Thus, similar to Boguth, Duchin, and Simutin (2022), we implement this procedure by estimating median regressions explaining each firm's Q using its state-by-state exposure weights.

We construct our main outcome variable, public investment rate, by using data on government investment obtained from the annual survey of state and local government finances conducted by the Census. The constructed public investment encompass a wide range of infrastructure goods, such as air transport, education, health, highways, libraries, parks and recreation, police protection, water supply, electric power, and gas supply. We scale the public investment level by the calculated 1-year lagged public capital to obtain the public investment rate.

Using the above measures of government Qs, private-sector Qs, and public investment rate, we investigate the dynamics of state-level public spending in Q-theory-based specifications. The main results can be summarized as follows. First, public investment rates are positively correlated with the marginal value of public capital, as measured by government Q. This finding is consistent with the canonical predictions of the Q-theory of investment. The results suggest that a one standard deviation increase in government Q implies an increase of 0.821% to 1.027% in public investment rates. The estimates are statistically significant and economically meaningful compared to the average public investment rate of 13.34% in the sample. Moreover, the estimated sensitivity of public investment rate to government Q is comparable to the estimated Q-sensitivity of corporate investment. In particular, prior studies estimate that the Q-sensitivity of corporate investment rate ranges between 0.3% and 0.8% (see, e.g, Peters and Taylor (2017); Erickson and Whited (2000); Gala et al. (2020)). Combined, these findings suggest that state-level public spending is correlated with fluctuations in financial market valuations, and that the magnitude of the correlation is comparable to that of firm-level investments.

Second, public investment rates are negatively correlated with the marginal value of private-sector investment. Specifically, a one standard deviation increase in private-sector Q implies a decrease of 0.148% to 0.175% in public investment rates. These findings are stronger in states with large subsidy programs. Specifically, a one standard deviation increase in private-sector Q implies a decrease of 0.249% to 0.304% in public investment rates in states with large subsidy programs. We obtain similar results when we use direct measures of subsidy rates and indirect proxies of government support based on states' political affiliations. Taken together, these findings suggest that state governments invest more, particularly through direct cash subsidies, when local firms have low Qs.

The results hold in specifications that include state fixed effects and year fixed effects. They also hold after controlling for economic conditions, including gross domestic product (GDP), the debt-to-GDP ratio, and the revenue-to-GDP ratio. Furthermore, they continue to hold when we estimate the analyses at the county-level rather than the state-level, for alternative measures of government spending, in subsample specifications that focus on full census years (1997, 2002, 2007, 2012, and 2017), and for alternative measures of both private-sector Qs and government Qs.

Altogether, our paper proposes a new framework to understand the joint determination of public and private-sector investments, and provides novel empirical evidence that governments invest to support private-sector investments.

Our paper contributes to the literature that studies the impact of public investment on the private-sector. While many papers attempt to study this impact empirically, there is no consensus about its direction, let alone its magnitude. For instance, Nadiri and Mamuneas (1991), Morrison and Schwartz (1992), Erenburg and Wohar (1995), Bouakez and Rebei (2007), Acconcia et al. (2014), Nakamura and Steinsson (2014) show that public investment has a positive effect on the overall economy. In contrast, Fernald (1999), Cohen et al. (2011), and Boehm (2020) find a negative relationship. Further, Leeper et al. (2010) and Ramey and Zubairy (2018) show that the impact is nuanced and depends on public investment implementation delays or the interest rate, respectively. We add to this literature by deriving a new test that estimates this relationship based on the Q elasticity of public investment.

Our paper also contributes to a large literature on the Q-theory of investment. Early works by Tobin (1969) and Hayashi (1982) propose a model where, under arguably strict assumptions, private-sector Q is a sufficient statistic for the private-sector's investment rate. Subsequent work documents the empirical challenges that these models face, and highlights the role of financing frictions (Fazzari et al. (1988)) and measurement errors (Erickson and Whited (2000, 2002, 2012); Erickson, Jiang, and Whited (2014); Gilchrist and Himmelberg (1995); Abel (2018)). Importantly, this literature focuses exclusively on private-sector investment.[1] We add to it by applying the Q-theory of investment to public investment in specifications that consider government Q and private-sector Q jointly.

Lastly, our paper contributes to the literature on the "feedback effect" of financial markets. Grossman and Stiglitz (1980) and Glosten and Milgrom (1985) model the role of financial markets in producing and aggregating information via trading and market prices. Subsequent empirical work provides evidence that corporate managers extract information from corporate equity prices and use it to make real investment decisions (see, e.g., Chen, Goldstein, and Jiang (2007), Foucault and Frésard (2012), and Bond, Edmans, and Goldstein (2012)). We add to this literature by providing a suggestive evidence that government managers extract information from municipal bonds markets and corporate equity markets to make public investment decisions.

2 Model and hypothesis development

In this section, we extend the classic models of Baxter and King (1993), Bouakez and Rebei (2007), and Ramey et al. (2021) by introducing a new ingredient, government subsidy, and endogenizing public investment decisions. Different from the literature (e.g., Baxter and King (1993)), our work posits that the public investment is endogenously determined by the government. The government makes investment decisions that maximize household welfare.

[1] Another strand of the literature develops theoretical models in which the marginal Q is not equal to the average Q (Gomes, 2001; Cooper and Ejarque, 2003; Alti, 2003; Abel and Eberly, 2011), and analyzes investment-cash flow sensitivities within these theoretical models. Chen and Chen (2012) and Andrei, Mann, and Moyen (2019) show that the performance of the classic Q-theory has improved over time. Peters and Taylor (2017) and Wang and Zhang (2021) show that the classic Q-theory works better for firms and years with more intangible capital. Building on this literature, our paper establishes a conceptual framework that connects private-sector Q and public investment in a general equilibrium model, and provides robust empirical support for the negative relationship between them.

2.1 Setup

In this framework, both the government, representing households, and private-sector firms make investment decisions while anticipating each other's actions. Private-sector firms consider the expected actions of the government when determining their investment, while the government takes into account the private sector's investment decisions when deciding its own investment. This interdependence between the private sector and the government forms the basis for examining the relationship between their respective investment rates and the measures of Q, and allow us to develop two testable hypotheses.

2.1.1 Government

The government collects tax revenue from households and, on behalf of households, make optimal invest decisions that maximize household welfare. The accumulation of the government capital K_t^G is as follows:

$$K_{t+1}^G = (1 - \delta^G) \cdot K_t^G + I_t^G, \tag{1}$$

where δ^G is the depreciation rate of the government capital and I_t^G denotes the government investment.

The government allocates a fraction $\frac{\eta}{1+\eta}$ of government investment to firms directly as cash subsidy and the rest fraction $\frac{1}{1+\eta}$ to public capital which includes infrastructure such as high ways, bridges, or electricity and water supplies, that facilitate operation activities of private sector. By construction, η is bounded below at 0. The above capital accumulation equation highlights that while subsidy directly helps to increase private capital, the government still maintains joint-ownership of the subsidy, similar in spirit to government grants. To keep the model tractable, we set η constant and exogenous. Yet, we understand that subsidy rate η can be determined by state characteristics and thus, in our empirical study, we allow η to be a function of state characteristics such as political affiliation of state governors.

The capital accumulation for public infrastructure capital, F_t, is given by

$$F_{t+1} = (1 - \delta^F) \cdot F_t + I_t^F \tag{2}$$

$$= (1 - \delta^F) \cdot F_t + F_t \cdot i_t^F \tag{3}$$

where δ^F denotes the depreciation rate of public capital, I_t^F denotes the public investment, and i_t^F denotes its investment rate. Alternatively, the public infrastructure $I_t^F = \frac{1}{1+\eta} \cdot I_t^G$, and the public subsidy investment I_t^S is $\frac{\eta}{1+\eta} \cdot I_t^G$. Their relation can be expressed as follows:

$$I_t^S = \eta \cdot I_t^F = \eta \cdot F_t \cdot i_t^F \tag{4}$$

We assume the standard quadratic adjustment costs for the public investment as follows:

$$F_t \cdot \varphi^F(i_t^F) = F_t \cdot \frac{\kappa^F}{2} \cdot \left(i_t^F\right)^2. \tag{5}$$

2.1.2 Private-sector firm

Private-sector firms produce goods and make investment decisions that maximize their own firm value. This firm produces total output by utilizing their own capital as well as subsidy capital S_t and public capital F_t, accumulated by the government.

The production capital, H_t, includes firms' own capital and those they purchase utilizing government subsidy capital, S_t. Production capital includes machinery and plants that are used to produce goods directly. Therefore, the accumulation of production capital H_t, including subsidy from government, is given by:

$$H_{t+1} = (1-\delta^H)H_t + I_t^H \tag{6}$$

$$= (1-\delta^H)H_t + I_t^S + I_t^P \tag{7}$$

where δ^H denotes the depreciation rate for the production capital. Note that the total investment, I_t^H, consists of two components: subsidy investment, I_t^S, determined by the government, and ex-subsidy private-sector investment, I_t^P, determined by the firm. In addition, we define investment rates as

$$i_t^H = \frac{I_t^S + I_t^P}{H_t}, \quad i_t^P = \frac{I_t^P}{H_t}, \quad i_t^S = \frac{I_t^S}{H_t}$$

The firm bears all the adjustment costs of its production capital, which is assumed to be the standard quadratic adjustment costs as follows:

$$H_t \cdot \varphi^H \left(i_t^P\right) = H_t \cdot \frac{\kappa^H}{2} \cdot (i_t^P + i_t^S)^2 \tag{8}$$

This captures an intuition that even though government subsidy helps to increase private sector's capital level, the private sector still has to bear adjustment cost associated with incremental increase in the private sector's capital.

The stochastic technology shock, A_t, follows a mean-reverting process:

$$\ln A_t = (1-\rho_A) \cdot \ln A + \rho_A \cdot \ln A_{t-1} + \epsilon_t^A, \tag{9}$$

where ρ_A is the first-order auto-correlation coefficient bounded between -1 and 1, A is the steadystate value of A_t, and ϵ_t^A is a normally distributed zero-mean disturbance with standard deviation σ_A.

The firm produces with two types of capital, namely, public capital F_t in equation (3) and production capital H_t in equation (7). At date t, the firm's output is given by a standard Cobb-Douglas production function:

$$Y_t = f(F_t, H_t) = A_t \cdot (F_t)^{\theta_F} \cdot (H_t)^{\theta_H}, \tag{10}$$

where θ_F and θ_H are the curvature parameter for public and production capital, respectively.

2.1.3 Household

Household receives operating cash flows from the firm, pays the tax, T_t, and consumes the remaining amount C_t given by

$$C_t = Y_t - H_t \cdot (i_t^P + i_t^S) + I_t^S - H_t \cdot \frac{\kappa^H}{2} \cdot (i_t^P + i_t^S)^2 - T_t. \tag{11}$$

where cash inflows consists of output and subsidy whereas cash outflows consist of firms' investment, adjustment cost, and tax.

Both government subsidy investment, I_t^S, and public investment, $F_t \cdot i_t^F$ and their related adjustment costs for public capital are entirely financed by taxes. That is,

$$I_t^S + F_t \cdot i_t^F + F_t \cdot \varphi^F(i_t^F) \leq T_t. \tag{12}$$

Combining Equation (11) with Equation (12), we have the following economy-wide resource constraint

$$C_t + \underbrace{H_t \cdot (i_t^P + i_t^S) + F_t \cdot i_t^F}_{\text{total capital investments}} + \underbrace{H_t \cdot \varphi^H(i_t^P) + F_t \cdot \varphi^F(i_t^F)}_{\text{total adjustment costs}} \leq Y_t, \tag{13}$$

which represents the national accounting identity augmented with capital adjustment costs.

2.2 Optimal policies

Private-sector investment

At date t, the firm chooses the optimal ex-subsidy private investment i_t^P and the capital of the next period H_{t+1} to maximize its value V_t, which is the sum of all future discounted cash flows as follows:

$$V_t = \max_{\{i_\tau^P, H_{\tau+1}\}_{\tau=t}^{\infty}} E_t \left[\sum_{\tau=t}^{\infty} \beta^{\tau-1} \left\{ Y_\tau - H_\tau \cdot \left(i_\tau^P + i_\tau^S\right) + I_\tau^S - H_\tau \cdot \frac{\kappa^H}{2} \cdot \left(i_\tau^P + i_\tau^S\right)^2 \right\} \right], \tag{14}$$

where the stochastic discount factor applied to the stream of firm's operating cash flows is exogenously determined at β. The constrained maximization problem of choosing the total private investment rate i_t^P is as follows:

$$L_t^H = \max_{\{(i_\tau^P)^*, H_{\tau+1}\}_{\tau=t}^{\infty}} E_t \left[\sum_{\tau=t}^{\infty} \beta^{\tau-1} \left\{ Y_\tau - H_\tau \cdot \left(i_\tau^P + i_\tau^S\right) + I_\tau^S - H_\tau \cdot \frac{\kappa^H}{2} \cdot \left(i_\tau^P + i_\tau^S\right)^2 \right.\right. \tag{15}$$

$$\left.\left. - q_\tau^H \cdot \left(H_{\tau+1} - (1-\delta^H) \cdot H_\tau - H_\tau \cdot \left(i_\tau^P + i_\tau^S\right)\right) \right\} \right]$$

where q_t^H denotes the Lagrangian multiplier associated with production capital accumulation described in Equation (6).[2]

The first-order condition for firm value maximization with respect to the private investment

[2]Private-sector Q, q_t^H, measures the marginal increase in firm value V_t in response to the marginal increase in production capital, H_t, i.e., $q_t^H = \frac{\partial V_t}{\partial H_t}$.

rate, i_t^P, gives us the following result:

$$(i_t^P)^* = \frac{1}{\kappa^H} \cdot \left(q_t^H - 1\right) - i_t^S \tag{16}$$

The positive association between optimal private-sector investment rate $(i_t^P)^*$ and q_t^H resembles the standard Q theory without government subsidy: the firm increases their investment in total production capital when the marginal Q of production capital, H_t, is greater than one.

Public investment

Next, we derive the optimal public investment policy by government. The household derives utility from consumption C_t. At time t, the government on behalf of household chooses the optimal public investment rate i_t^F and the public capital of the next period F_{t+1} to maximize the lifetime utility of the household, U_t, as follows:

$$U_t = \max_{\{i_\tau^F, F_{\tau+1}\}_{\tau=t}^{\infty}} E_t \left\{ \sum_{\tau=t}^{\infty} \beta^{\tau-1} \cdot C_\tau \right\}. \tag{17}$$

where β denotes the subjective discount factor. Given that public investment level $I_t^F (= i_t^F \cdot F_t)$ is a exogenously-determined fraction $(1-\eta)$ of the government investment, I_t^G, choosing an optimal public investment, I_t^F, is equivalent to choosing an optimal government investment, I_t^G. Because an empirical measure for government spending is more closely aligned with public investment I_t^F as opposed to government investment I_t^G, as described in Section 3, we write our testable predictions in terms of public investment.

Using the Lagrangian method, we derive the optimal public investment rate, $(i_t^F)^*$, as follows:

$$L_t^F = \max_{\{(i_\tau^F)^*, F_{\tau+1}\}_{\tau=t}^{\infty}} E_t \left\{ \sum_{\tau=t}^{\infty} \beta^{\tau-1} \left[C_\tau - q_\tau^F \left(F_{\tau+1} - (1-\delta^F) \cdot F_\tau - F_\tau \cdot i_\tau^F \right) \right] \right\} \tag{18}$$

where q_t^F is the Lagrangian multiplier and captures the marginal increase in household utility U_t in response to an increase in public capital, F_t.[3]

Substituting the constraint in Equation (13) into the above equation, we have

$$\max_{\{(i_\tau^F)^*, F_{\tau+1}\}_{\tau=t}^{\infty}} E_t \left\{ \sum_{\tau=t}^{\infty} \beta^{\tau-1} \left[Y_\tau - I_\tau^H - F_\tau \cdot i_\tau^F - H_\tau \cdot \varphi^H \left(i_\tau^H \right) - F_\tau \cdot \varphi^F \left(i_\tau^F \right) \right. \right.$$
$$\left. \left. - q_\tau^F \left(F_{\tau+1} - (1-\delta^F) \cdot F_\tau - F_\tau \cdot i_\tau^F \right) \right] \right\} \tag{19}$$

The first-order condition for value maximization with respect to the public investment rate, i_t^F, is as follows:

$$F_t \cdot q_t^F = F_t \cdot (1 + \kappa^F \cdot i_t^F) + \frac{\partial I_t^H}{\partial i_t^F} + \kappa^H \cdot i_t^H \cdot \frac{\partial I_t^H}{\partial i_t^F} \tag{20}$$

Now, one may write

$$\frac{\partial I_t^H}{\partial i_t^F} = \frac{\partial I_t^H}{\partial I_t^S} \cdot \frac{\partial I_t^S}{\partial i_t^F} = \frac{\partial I_t^H}{\partial I_t^S} \cdot \eta \cdot F_t = \eta \cdot F_t \tag{21}$$

where the second to the last equality follows from Equation (4) and the last equality holds because $\frac{\partial I_t^H}{\partial I_t^S} = \frac{\partial (I_t^P + I_t^S)}{\partial I_t^S} = 1$. Thus, substituting Equation (21) into Equation (20) and dividing both sides by F_t yields:

$$q_t^F = 1 + \kappa^F \cdot (i_t^F)^* + \eta \cdot (1 + \kappa^H \cdot i_t^H) \tag{22}$$

When making decision on the optimal public invest $(i_t^F)^*$, government anticipate the optimal decision $(i_t^H)^*$ (Equation (16)) by the firms in the private sector. Therefore, assuming the i_t^H is the

[3] Similarly, government Q implies the marginal increase in household utility U_t in response to the marginal increase in public capital, F_t, i.e., $q_t^F = \frac{\partial U_t}{\partial F_t}$.

optimal decision by firms, we substitute Equation (16) into (22) and have the public investment rate $(i_t^F)^*$ as follows:

$$(i_t^F)^* = \underbrace{\frac{1}{\kappa^F} \cdot (q_t^F - 1)}_{\text{Benchmark}} - \underbrace{\frac{1}{\kappa^F} \cdot \eta \cdot q_t^H}_{\text{Subsidy effect}} \tag{23}$$

The above simple equation illustrates our main contribution. It specifies how the public investment rate is connected to the marginal benefit of public investment q_t^F and the marginal benefit of private investment q_t^H. The first item shows the benchmark case, where there is no subsidy. The second item shows that the subsidy causes public investment and private-sector Q, q^H, to be negatively correlated.

2.3 Testable Hypotheses

To empirically examine the government's investment decision, we propose a set of testable hypotheses that establish the relationship between the public investment rate and two sets of Q measures: government Q and private-sector Q. Private-sector Q captures the marginal value of private-sector capital to the private sector's overall value, while government Q captures the marginal value of public capital to households' utility value. We propose two testable hypotheses.

2.3.1 Public investment and Government Q

As shown in the first element of Equation (23), the public investment rate is positively correlated with government Q, because of the positive $1/\kappa^F$. This naturally has the following prediction:

Prediction 1. The public investment rate, i_t^F, is positively correlated with government Q, q_t^F.

When $\eta = 0$, the positive public investment-Q relation resembles the standard Q theory developed by Hayashi (1982) for private-sector investment, as follows:

$$i_t^F = \frac{1}{\kappa^F} \cdot \left(q_t^F - 1\right) \tag{24}$$

Thus, when $\eta = 0$, government Q serves as a sufficient statistic for the optimal public investment rate.

2.3.2 Public investment and private-sector Q

The second element of Equation (23) implies that the public investment to private-sector Q sensitivity is $-\frac{1}{\kappa^F} \cdot \eta$. Given that subsidy rate η is positive by construction, when $\eta \neq 0$, the second element of Equation (23) implies a negative relation between public investment and private-sector Q. Note that when $\eta = 0$, there is no relation between them, implying that non-zero subsidies is the necessary condition for the negative public investment-private-sector Q relation.

We propose the following hypothesis:

Prediction 2. The public investment rate, i_t^F, is negatively correlated with private-sector Q, q_t^H, conditional on a positive government subsidy (i.e., $\eta > 0$).

This prediction is surprisingly interesting, because it contradicts the positive investment-Q relation predicted by the standard Q-theory in the private sector. The intuition is as follows. A welfare-maximizing government, which maximizes households' dividend consumption, implicitly internalizes private-sector investment productivity. When private-sector Q is low, the government has an incentive to further stimulate the private-sector's investment in order to increase firms' output and households' consumption. Conversely, when private-sector Q is high, the government has weaker incentives to stimulate private firms. As such, the relation between public investment and private-sector Q is negative.

Importantly, the model differentiates between public investments (e.g. spending on infrastructure) and direct firm-level subsidies. Compared to public investments, direct subsidies are a more effective channel through which the government can induce private-sector investment because they effectively minimize firms' out-of-pocket costs. This distinction implies that the private-sector Q-sensitivity of public investment will vary with governments' subsidy policies.

3 Data Description

This section describes data and variable constructions.

3.1 Data

For our empirical analysis, we compile panel data on an annual basis from various sources. The main variable of interest, the public investment rate, is constructed using data on government investment obtained from the annual survey of state and local government finances conducted by the Census.[4] In addition, we gather population, outstanding debt, and revenue data from the Census. We collect state-level subsidy and GDP figures from the Bureau of Economic Analysis (BEA).

To construct the private-sector Q, we acquire establishment-level data on sales and employment from the National Establishment Time Series (NETS) database, and we collect firm-level data from Compustat/CRSP. For the government Q measure, we obtain geographical location data of municipal bonds from Refinitiv Eikon, and bond prices from the Municipal Securities Rulemaking Board (MSRB). The original Census data are available at various levels of government units, including state government, county government, municipal government, township government, special district government, and school district government. While one might initially consider analyzing the data

[4] We utilize the cleaned and accessible data provided by Pierson, Hand, and Thompson (2015) for our analysis.

at the aforementioned government units, distinct nature of government units (e.g. special district government vs. school district government) make it hard to conduct a fair comparison. Instead, we aggregate the data to one unit of observations that are widely used in the literature: state. In addition, we show that our main results are robust to different units of observations by aggregating the data to county level and conducting the county-level analysis.

The merged sample covers the period from 1994 to 2022 and encompasses data from 50 states and Washington D.C. To account for price inflation, we convert all nominal dollar amounts to constant year 2000 dollars. In order to address outliers, we winsorize all the variables at both end of 1% by years. As shown in Panel B of Table 1, the average GDP per state stands at 217.3 billion dollars, the average population per state is approximately 5.875 million people, the government book debt to GDP ratio has an average of 0.154, while the average government revenue to GDP ratio is 0.232 per state.

[Insert Table 1]

3.2 State-level government Q

In this section, we discuss how we construct government Q at the state level. We utilize data from the municipal bond market to develop a novel metric: state-level government Q. Obtaining data on state-level government Q is crucial for testing our primary hypothesis. It should be noted that governments do not sell their "ownership" to generate equity, which means we cannot create a measure comparable to value-to-sales ratios used by businesses. However, we do have access to market data for municipal bonds issued by local governments.

To construct state-level government Q, we adopt a methodology used in Philippon (2009), which utilizes corporate bond market data to construct private-sector Q. Recognizing the limitations of market data for private-sector equity, we follow Philippon's approach in spirit. Using annualized data from the municipal bond market, we define our measure, denoted as $q^F_{s,t}$, as median over bond-based q-measures, $q^B_{s,t,n}$:

$$q^F_{s,t} = \text{Median}_{n=1,2,\cdots,N}\{q^B_{s,t,n}\} = \text{Median}_{n=1,2,\cdots,N}\left\{\frac{1+r_{s,t,n}}{1+Yield_{s,t,n}}\right\} \tag{25}$$

where $Yield_{s,t,n}$ represents the yield of bond n issued by state s at time t, while $r_{s,t,n}$ denotes the risk-free rate of a hypothetical Treasury security with cash flows matched to the underlying corporate bond. N is the total number of bonds issued by the state s at time t. As pointed out by Philippon (2009), this measure bears resemblance to the inverse of the credit spread and performs better in predicting investment activities than equity markets' Q, which is echoed by Bretscher, Feldhütter, Kane, and Schmid (2020). In essence, it can be likened to the market-to-book ratio of equity. However, due to the absence of equity data for local governments, we employ its debt counterpart: the market-to-book ratio of debt. As the credit spread increases, the market-to-book ratio of debt decreases, and the aforementioned formula effectively captures this relationship.

To empirically construct the aforementioned measure, we begin by developing bond-level $q^B_{s,t,n}$ at an annual frequency. In our analysis, we utilize market data for tax-exempt municipal bonds with maturities ranging from greater than 1 year to less than 30 years. The interest rate yield curve is interpolated at six-month intervals. For each municipal bond, we retain data only from the fourth quarter of each year. This allows us to utilize the most recent data to explain the issuer's investment in the subsequent year.

Subsequently, we aggregate the bond-level $q^B_{s,t,n}$ to the state and year level. This enables us to obtain the state-level $q^F_{s,t}$ at an annual frequency. For year t, we calculate a median of bond-level $q^B_{s,t,n}$ issued by local governments within the jurisdiction of a given state s. We choose a median as an aggregation method to stay consistent with the procedure, median regression, undertaken in constructing private-sector Q's and further described in Section 3.3. In untabulated results, we show that the results remain robust to using alternative aggregate methods such as equal-weighted average.

Panel A of Table 1 provides summary statistics of the state-level government Q. Its average and standard deviation are 0.998 and 0.007, respectively. In Figure 1, we present the cross-sectional distribution of the time-series average of the estimated $q^F_{s,t}$. The figure demonstrates ample cross-sectional variation. Notably, West Virginia and Illinois exhibit the lowest average government Q, primarily driven by large municipal bond spreads. Conversely, Connecticut and Massachusetts exhibit the highest average government Q, driven by smaller municipal bond spreads.

[Insert Figure 1]

Examining the time-series variation of each state's government Q provides further insights. For illustrative purposes, we select California, Massachusetts, New York, Kentucky, Michigan, and Texas and present their respective time-series graphs in Figure 2. During the 2007-2009 period when municipal bonds experienced a significant collapse, the spread increased, resulting in a notably low government Q.

[Insert Figure 2]

3.3 State-level private-sector Q

A careful construction of state-level private-sector Q is important to our study. We use the method adopted in Boguth, Duchin, and Simutin (2022) to construct state-level private-sector Q. For a given time t, the tobin's q of all the firms[5] that operate in a state, s, can be expressed as follows:

$$q_t^{Firm} = W_t \cdot q_{s,t}^H \tag{26}$$

First, $q_{s,t}^H$ is a vector of state-level private-sector Q's, measures of our main interest to be constructed:

$$q_{s,t}^H = \begin{bmatrix} q_{s=1,t}^H & q_{s=2,t}^H & \cdots q_{s=51,t}^H \end{bmatrix},$$

Second, q_t^{Firm} is a vector of firm-level Q's, derived from private-sector equity prices. Here, we follow Boguth et al. (2022) to define firm-level Q as value-to-sales ratio where value is set to book value of debt plus market value of equity. Alternatively, one may try to construct q_t^{Firm} by utilizing corporate bond data, as proposed by Philippon (2009) and used by Bretscher et al. (2020), to construct firm-level bond-based Q measures. However, since only approximately 20% of the firm-year observations have bond data, bond-based measures do not comprehensively capture the future investment opportunities of the private sector in the state level. Consequently, we opt for equity-based measures.

Finally, W_t is a vector of weights.[6] To construct the weight W_t, we utilize establishment-level sales data. Subsequently, we employ median regression without an intercept to estimate our private-sector Q measure, $q_{s,t}^H$. Because each row of W_t sums up to 1 by definition, we exclude an intercept in the median regression to avoid collinearity issues. Furthermore, it is possible to generate different

[5]We incorporate all firms, including those in the finance and utility sectors, which are often excluded in some studies.

[6]In order to illustrate our measure construction, let us use a simplified example for time t. Let us assume that there are three firms, (1,2, and 3) and two states (S_1 and S_2). We assume that each firm has presence across two states but the relative degree of presence in each state differs across the firm.

$$\begin{bmatrix} q_{1,t}^{Firm} \\ q_{2,t}^{Firm} \\ q_{3,t}^{Firm} \end{bmatrix} = \begin{bmatrix} a_{11,t} & a_{12,t} \\ a_{21,t} & a_{22,t} \\ a_{31,t} & a_{32,t} \end{bmatrix} \cdot \begin{bmatrix} q_{1,t}^H \\ q_{2,t}^H \end{bmatrix}$$

where a_{ij} is the relative presence of firm i's in state j and $a_{i1} + a_{i2} = 1$ for all i.

versions of Q measures by using alternative measures for W_t. Section A.1 shows that our results are robust to alternative Q measures.

Figure 3 illustrates the cross-sectional distribution of the state-level time-series average of the constructed $q^H_{s,t}$ measure. As depicted, there is considerable cross-sectional variation in the data.

[Insert Figure 3]

Notably, Kentucky and South Carolina exhibit the lowest private-sector Q on average. This is primarily due to the fact that firms with establishments in these states have very low value-to-sales ratios. While the median value-to-sales ratio for firms in our sample is 1.677, it drops to 1.233 for firms in Kentucky and 1.243 for firms in South Carolina. Conversely, California has the highest private-sector Q on average, mainly driven by the fact that firms with establishments in the state have exceptionally high value-to-sales ratios. The median value-to-sales ratio for firms in California is 2.17, significantly exceeding the unconditional median of 1.677.

Interestingly, the District of Columbia exhibits one of the highest private-sector Q values, yet with a distinct driver compared to California. The median value-to-sales ratio for firms in the District of Columbia is 1.61, slightly lower than the unconditional median of 1.677. This would intuitively suggest a lower private-sector Q. However, the weight W in Equation (26) leads the District of Columbia to have a large private-sector Q. In other words, although the average firms in the District of Columbia have a lower value-to-sales ratio, those with high value-to-sales ratios have a significant presence (represented by W) in the state, resulting in the District of Columbia having the highest private-sector Q on average. To illustrate this point, let's consider the year 2005 as an example. The median value-to-sales ratio for firms whose sales in California account for at least 50% of their total sales is 2.735. Conversely, the median value-to-sales ratio for firms whose sales in the District of Columbia account for at least 50% of their total sales is 4.346.

Examining the time-series variation of each state's private-sector Q is also insightful. For illustrative purposes, we select California, Massachusetts, New York, Kentucky, Michigan, and Texas and plot their respective time-series graphs in Figure 4.

[Insert Figure 4]

Similar relative ordering of private-sector Q levels can be observed in these time series plots. For example, Kentucky consistently exhibits a lower level of private-sector Q compared to the other five states. All six states experienced a decline in private-sector Q during the financial crisis of 2007-2008. However, there is significant variation in how each state's private-sector Q reached its lowest point and subsequent recovery. Private-sector Q for California, New York, and Texas slowly recovered to pre-crisis levels. Massachusetts saw a gradual recovery to a level above the pre-crisis level, likely driven by the biotech industry. On the other hand, Michigan's private-sector Q has experienced a slower recovery, partly influenced by the struggling auto industry.

The aforementioned offsetting forces lead to variation across states and time. Panel A of Table 1 presents the summary statistics of the state-level private-sector Q constructed using sales weights. On average, it is 1.399 with a standard deviation of 0.661, which is largely consistent with the literature.

3.4 State-level public investment rate

We construct public investment rate as described below. We first discuss how we use Census data to construct the public investment. Second, we discuss how we construct capital stock measure, the denominator to the investment rate.

Census provides six distinct components for governments' total expenditure: 1) current operations, 2) capital outlay, 3) interest on debt, 4) assistance and subsidies, 5) social insurance trust expenditure, and 6) intergovernmental expenditure. To construct a measure of public investment, one might be tempted to sum up all six components.

However, there are two important considerations to bear in mind. First, we must ensure that we avoid double-counting when constructing the investment measure. Intergovernmental expenditure refers to funds transferred to other government units for specific functions or general financial support. For instance, if local government unit A transfers funds to local government unit B, which then uses those funds to purchase supplies, the same amount would be recorded as intergovernmental expenditure for unit A and as current operation expenditure for unit B. To prevent double-counting, we need to exclude government unit A's intergovernmental expenditure when aggregating data from different local government units to the state level. Intergovernmental expenditure accounts for 16% of the total expenditure. Throughout the paper, we refer to total expenditure minus intergovernmental expenditure as local public expenditure. We use public expenditure as an alternative investment measure to show that our main results are robust to different definitions of investment, despite the second caveat discussed below. As indicated in Table 1 Panel B, local public expenditure averages 39.45 billion dollars.

The second consideration pertains to excluding components that reflect prior obligations. This includes interest on debt and social insurance trust expenditure.[7] Additionally, assistance and subsidies is excluded as they encompass direct cash assistance to foreign governments and private individuals, with unclear benefits for the local private sector. These three components represent 13% of the total local public expenditure. Given the limitations of the subsidy data provided by the Census, our empirical analysis of the channel relies on state-level subsidy data from the BEA as described in Section 3.5.

Taking both of the considerations into account, we define public investment by summing current operations and capital outlay. Current operations account for 62% of the total expenditure and include expenditures for the compensation of officers and employees, as well as supplies, materials,

[7]Social insurance trust expenditure encompasses social insurance payments to beneficiaries, public employee retirement annuities and other benefits, and withdrawals of insurance or employee retirement contributions.

and contractual services. Capital outlay constitutes 9% of the total expenditure and captures purchases or constructions of capital improvements (e.g. building, land, equipment) by contractors or government employees. Both types of government expenditure encompass a wide range of infrastructure goods, such as air transport, education, health, highways, libraries, parks and recreation, police protection, water supply, electric power, and gas supply. Relevant summary statistics are presented in Table 1, with current operations averaging 29.34 billion dollars and capital outlay averaging 4.35 billion dollars. Note that our empirical measure of public investment does not include subsidies, consistent with the model's predictions that focus on subsidy-free public investment.

Next, we discuss how we construct capital stock measure. Unfortunately, the necessary data for public capital stock is not readily available and must be constructed. Our construction method relies mainly on the following capital accumulation equation:

$$K_{s,t+1}^{F} = 0.9 \cdot K_{s,t}^{F} + I_{s,t}^{F}$$

where the subscript s represents the state, and t denotes the year. According to the BEA, the annual depreciation rates for assets owned by state and local governments range from 1.5% (water and sewer systems) to 23.6% (calculating and accounting machines). Accordingly, we assume the annual depreciation rate of 10% on the public capital stock. Starting from 1967 (when the public investment data became available through the Census), we accumulate the capital stock. Specifically, we set $K_{i,1967}^{F} = 0$. This calculation is performed for both capital outlays and current operations. The capital stock of public investment, namely capital outlays and current operation, is 264.9 billion dollars per state as shown in Table 1 Panel B.

Taken together, we scale the public investment level by the calculated 1-year lagged public capital to obtain the public investment rate. Panel B shows that the average public investment rate is around 13.34%, which is close to the average corporate investment rate. The standard deviation of public investment rate is 1.711%.

3.5 Subsidy rate

Here, we closely follow Equation (4) to construct empirical measure for subsidy rate by taking a ratio between subsidy investment and public investment. We use annual state-level subsidy data, estimated and provided by the Bureau of Economic Analysis. The subsidy represents the monetary government transfers from various levels of the government agencies to the private sector that resides in the particular state. Then, we construct state-level subsidy rate measure by dividing state-level subsidy by state-level public investment. The subsidy rate is 4.7% on average.

Figure 5 (a) illustrates their cross-sectional distribution. As shown, there is wide variation in subsidy rates across states. Alaska and West Virginia have the lowest subsidy rates at 1.8% and 2.0% respectively while South Dakota and North Dakota have the latest subsidy rates at 17.5% and 18.4% respectively.

[Insert Figure 5]

3.6 Firm-level characteristics

The majority of our analysis is based on state-level panel data. In addition, we conduct a robustness analysis using firm-level panel data in Section 5.3. This allows us to test the predictions for firms' investment and establish connections with prior literature, which predominantly employs firm-level panel data. Table 1 in Panel D provides summary statistics for the firm-level panel data.

To calculate the firm-level government Q, we first construct state-level government Q measures as outlined in Section 3.2. Subsequently, we perform a weighted average of the state-level measure $q^F_{s,t}$ at the firm level, with the weights derived from each firm i's establishment-level sales data.

Lastly, we then construct the firm-level private-sector Q as the value-to-sales ratio, similar to the approach utilized in Boguth et al. (2022).

Panel D displays summary statistics for the firm-level panel data. On average, the private-sector Q at the firm level is 3.2, with a standard deviation of 4.3. It is important to note that the summary statistics for private-sector Q differ at the firm level compared to the state level due to the process of aggregation. Meanwhile, the average government Q at the firm level is 0.999. Furthermore, the sales-denominated investment rate (COMPUSTAT code: CAPX/SALE) has an average value of 6.5%, the cash flow-sales ratio (COMPUSTAT code: OIBDP/SALE) has an average value of 0.7%, and the logarithm of sales is 5.9.

4 Empirical Results

In this section, we present the results regarding the relationship between private-sector Q, government Q, and public investments. We also present evidence for the main economic channel: government subsidy.

4.1 Public investment by states

We empirically investigate how public investment, $i^F_{s,t}$, made by state s is associated with government $q^F_{s,t-1}$ and private-sector, $q^H_{s,t-1}$. Our main specification is as follows:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \epsilon_{s,t} \tag{27}$$

where α_s is state-fixed effect and δ_t is year fixed effect. To facilitate comparison between β^F and β^H, we standardize both $q^F_{s,t-1}$ and $q^H_{s,t-1}$. Notably, both Q measures are lagged by one year to ensure that government managers have access to this information when making investment decisions.

The results are summarized in columns (1), (2) and (3) of Table 2. Following the existing literature, we cluster standard errors by state and report t-statistics in parentheses.

[Insert Table 2]

We investigate our first prediction on the relation between public investment and government Q. Column (1) presents the related results. Public investment rate to government Q sensitivity (β^F) is estimated to be 0.821 and is statistically significant. One standard deviation increase in government Q implies 0.821% increase in the optimal public investment rate. Given the average public investment rate of 13.3%, the sensitivity is sizable. Adjusted within R^2 is 2.44%. This positive correlation arises because the government makes investment decisions that maximize household welfare, and government Q captures the marginal value of public capital to household welfare. The estimated positive correlation provides empirical support for Prediction 1. When the specification includes different sets of controls, the estimates in column (2) (column (3)) imply that one standard deviation increase in government Q implies 1.027% (0.828%) increase in the optimal public investment rate.

More importantly, those estimates are comparable to those estimated for the private sector. For example, the estimates by for the investment-Q relation in the private sector ranges between 0.3% about 0.8% (see, e.g, Peters and Taylor (2017); Erickson and Whited (2000); Gala et al. (2020)). This significant result implies that, contrary to the prior that the governors that do not maximize their value for themselves are not responsive to the market valuation, they make investment decision connected with municipal bond markets, the only external financing market they can resort to financing their investments.

We examine our second prediction on the interaction between public investment and private-sector Q. As shown in Column (2), the sensitivity of public investment rate to government Q (β^F) is estimated to be 1.027, which is statistically significant. This evidence provides an empirical support for Prediction 1 even in the presence of private-sector Q. More importantly, the sensitivity of public investment rate to private-sector Q (β^H) is estimated to be -0.175 and statistically significant. The negative coefficient provides supports for Prediction 2 that, when private-sector Q is low, the government is incentivized to provide subsidies to the private sector and increase public investments to stimulate private-sector investments and production.

Moreover, these estimates in column (2) imply that an one standard deviation decrease in the private-sector Q is associated with a 0.175% increase in the optimal public investment rate. Adjusted within R^2 is 6.75%. This highlights the economic significance of adding private-sector Q as including private-sector Q almost triples the linear model fitness compared to the linear model that lacks the private-sector Q. As such, significant portion of variation of public investment rate is jointly explained by variation in both government Q and private-sector Q.

Column (3) shows that our main results hold even after controlling for state-level economic conditions, including gross domestic product (GDP), the debt-to-GDP ratio, and the revenue-to-GDP ratio. This implies that financial markets – both municipal bond and corporate equity – contain information beyond regional economic statistics for government officials to use in forming public investment decisions. Estimates from column (3) imply that an one standard deviation decrease in the private-sector Q is associated with a 0.148% increase in the optimal public investment rate.

Our results are robust when we use local public expenditure to construct an alternative measure for public investment. We estimate Equation (27) using this alternative measure and summarize the results in columns (4), (5), and (6) of Table 2. Public investment rate to government Q is still positive, while public investment rate to private-sector Q is still negative. Yet, the estimates slightly differ from our benchmark results. This difference may be due to the inclusion of components in public expenditure that are not well explained by our framework. For example, the expenditure includes interest on debt and social insurance trust expenditure, which may not directly contribute to local private-sector welfare. It also includes direct cash assistance to foreign governments, and private individuals, the benefits of which to the local private sector are unclear. Despite these shortcomings, it is reassuring to see that the coefficients remain statistically significant and consistent with Predictions 1 and 2.

4.2 Subsidy channel

This section proceeds to examine the important role of subsidy. The stated predictions depend on the magnitude of subsidy as implied by our main Equation (23). First, public investment's sensitivity to government Q does not change over subsidy rate (η). Yet, while public investment rate is negatively correlated with private-sector Q for non-negligible subsidy rate ($\eta > 0$), the correlation completely disappears when the subsidy rate is small ($\eta \approx 0$). We use two empirical proxies for the subsidy rate (η) to provide supporting evidence, namely, a direct measure of subsidy rate and an indirect measure from political partisanship.

Subsidy rate

We use subsidy rate that is constructed as described in Section 3. We label the states as high (low) subsidy states if their subsidy rate is above (below) the median.

To investigate the relationship between subsidy rate and investment decisions, we estimate the following specification:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \gamma^F \cdot \mathbb{1}\{\text{Subsidy}_s\} \cdot q^F_{s,t-1} + \gamma^H \cdot \mathbb{1}\{\text{Subsidy}_s\} \cdot q^H_{s,t-1} + \epsilon_{s,t}$$

where $\mathbb{1}\{\text{Subsidy}_s\} = 1$ when the state s has subsidy rate is above the median. We present the results in Table 3.

[Insert Table 3]

A few observations are worth noting in Table 3. First, public investment rate to government Q sensitivity is not statistically sensitive to subsidy rate, as shown in the insignificant estimate of γ^F in column (1), (3), and (4). Second, in contrast, public investment rate is negatively correlated with private-sector Q only when the states have high subsidy rate. For instance, when private-sector Q and its interaction term are included, as in column (2), β^H is 0.0290 with a t-statistic of 0.538 while γ^H is –0.333 with a t-statistic of –2.709. This implies that one standard deviation increase in private-sector Q implies a decrease of 0.304% (= $\beta^H + \gamma^H$) in public investment rates in states with large subsidy programs. Similarly, estimates from column (3) (column (4)) imply that one standard deviation increase in private-sector Q implies a decrease of 0.287% (0.249%) in public investment rates in states with large subsidy programs.

Political partisanship

We use political partisanship as an indirect proxy for the subsidy rate. Our analysis of subsidy data, described in Section 3.5, shows that the average subsidy rate in states with a Republican governor is 5.15%, statistically significantly larger than 4.05% in states with a Democratic governor. This finding aligns with the perspective presented in the Wall Street Journal article titled "Republican 'Populists' for Corporate Welfare"[8]. Thus, we use political partisanship as an empirical proxy for the subsidy rate.

As an empirical proxy, we utilize the political partisanship of state governors. We collect the state-level time series data on political partisanships from state governors' websites. Within our sample, Democrat states comprise 60% of the observed time periods as shown in Table 1. Figure 5 (b) illustrates the cross-sectional distribution of political partisanship. As shown, there is variation

[8]The article can be found at https://www.wsj.com/articles/republican-populists-for-corporate-welfare-tax-deal-congress-d36818f1

in political partisanship across states. For instance, California, Oregon and Washington states have Democrat governors most of the time while Texas and Florida have Republican governors.

To investigate the relationship between political partisanship, thus subsidy rate, and investment decisions, we estimate the following specification:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \gamma^F \cdot \mathbb{1}\{\text{Rep}_s\} \cdot q^F_{s,t-1} + \gamma^H \cdot \mathbb{1}\{\text{Rep}_s\} \cdot q^H_{s,t-1} + \epsilon_{s,t}$$

where $\mathbb{1}\{\text{Rep}_s\} = 1$ when the governor of state s is a Republican the majority of the time.

[Insert Table 4]

The results in Table 4 provide further support. First, public investment rate to government Q sensitivity is not statistically sensitive to political partisanship, as shown in the insignificant estimate of γ^F in column (1), (3), and (4). Second, in contrast, public investment rate is negatively correlated with private-sector Q only when the states have Republican governors, who are associated with high subsidy rate. When private-sector Q and its interaction terms are included, as in column (2), the estimates imply that one standard deviation increase in private-sector Q implies a decrease of 0.238% ($= \beta^H + \gamma^H$) in public investment rates in states with Republican governors. Similarly, estimates from column (3) (column (4)) imply that one standard deviation increase in private-sector Q implies a decrease of 0.248% (0.201%) in public investment rates in states with Republican governors.

5 Robustness and Extensions

In this section, we conduct various robustness tests to support our main prediction. We include results from county-level analysis, examine the reallocation of capital from state to county levels and private-sector investments.

5.1 Public investment by counties

We first examine whether our main results remain consistent at the county level. We follow the similar procedure as in Section 3. One main difference is that we construct the data at the county level as opposed to the state level. We restrict the sample to non-missing observations for government Q, private-sector Q, and public investment rate. The resulting sample spans from year 1994 to 2022 and covers 326 unique counties.[9] We show the related summary statistics in Table 1 Panel C. While the summary statistics for county-level government Q and county-level public investment rates are quite similar to their state-level counterparts, the same cannot be said for private-sector Q. The county-level private-sector Q is much larger on average and more volatile than the state-level counterpart. This distinction arises because, compared to the state-level counterpart, the median regression yields much noisier measures for county-level private-sector Qs. This shows that the variable construction methodology, described in Section 3.3, is sensitive to the number of counties. Despite this shortcoming in the county-level private-sector Q measures, we show below that our main results still remain consistent at the county level.

We empirically investigate how investment, $i^F_{c,t}$, made by county c, is associated with county-level government $q^F_{c,t-1}$ and county-level private-sector $q^H_{c,t-1}$. Our specification is as follows:

$$i^F_{c,t} = \alpha_c + \delta_t + \beta^F \cdot q^F_{c,t-1} + \beta^H \cdot q^H_{c,t-1} + \epsilon_{c,t} \quad (28)$$

α_c is county-fixed effect whereas δ_t is year fixed effect. To facilitate comparison between β^F and β^H, we standardize both $q^F_{c,t-1}$ and $q^H_{c,t-1}$. Notably, Q measures are lagged by one year to ensure that government managers have access to this information when making investment decisions.

[Insert Table 5]

[9] The raw Census data covers 3,177 unique counties.

The results are summarized in Table 5 columns (1), (2) and (3). We cluster standard errors by county and report t-statistics in parentheses. Similar to the state-level analysis, the sensitivity of public investment rate to government Q is positive and statistically significant whereas the sensitivity of public investment rate to private-sector Q is negative and statistically significant. Column (3) shows that the results are robust to controlling for county-level economic conditions: population, the debt-to-population ratio, and the revenue-to-GDP ratio. Here, contrary to state-level analysis, GDP data are not readily available at the county level and thus we use population.

Moreover, as discussed in Section 3.4, we construct an alternative measure for public investment based on local public expenditure. We summarize results in Table 5 column (4), (5) and (6). Public investment rate to government Q is still positive, public investment rate to private-sector Q is still negative, and both are statistically significant. They provide supporting evidence for Prediction 1 and 2.

5.2 Capital reallocation from states to counties

Additional advantage of the county-level analysis lies in an ability to examine how the state government allocates its capital among various government units within its jurisdiction, akin in spirit to the literature on internal capital allocation.[10] For this empirical exercise, we use intergovernmental transfer from the state government to the counties. This transfer accounts for economically significant portion, 41%, of the investment that government makes at the county level.

[10]The literature in the corporate internal markets has two contrasting views – one highlighting the beneficial "winner picking" ability of headquarters, and the other emphasizing the detrimental agency conflicts and political dynamics within the firm. The bright side theories highlight the beneficial role of headquarters in allocating resources across divisions. Scholars such as Alchian (1969) and Stein (1997) argue that headquarters can create value by effectively "picking the winners" – redistributing resources from less productive divisions towards the more productive ones. This internal reallocation of capital is seen as a key advantage of the multi-divisional firm structure. In contrast, the dark side theories emphasize the agency conflicts and internal politics that can arise within internal capital markets. Building on insights of Coase (1937) about the impact of power dynamics within hierarchies, these models (e.g. Milgrom (1988)) posit that managers of weaker divisions have an incentive to lobby headquarters for more resources, in an attempt to tilt the allocation in their favor. To mitigate such inefficient lobbying behavior, headquarters may resort to "corporate socialism" by cross-subsidizing the weaker divisions at the expense of the stronger ones (Rajan et al., 2000; Scharfstein and Stein, 2000).

We empirically investigate how the state s allocates its capital to various counties c that belong to the state s. We construct the capital reallocation rate ($t^F_{c,t}$) by dividing the total intergovernmental transfer from the state government s to the county- government c by 1-year lagged county-level public capital stock. Here, the county-level capital stock is calculated as discussed in Section 3.4. We examine how the capital reallocation rate ($t^F_{c,t}$), made by state s to county c is associated with county-level government $q^F_{c,t-1}$ and county-level private-sector $q^H_{c,t-1}$. Our specification is as follows:

$$t^F_{c,t} = \alpha_c + \delta_t + \beta^F \cdot q^F_{c,t-1} + \beta^H \cdot q^H_{c,t-1} + \epsilon_{c,t} \tag{29}$$

where α_c is county-fixed effect whereas δ_t is year fixed effect. While Table 6's column (1), (2) and (3) use county-level government investment (i.e. current operation plus capital outlays), column (4), (5), and (6) use county-level public expenditure.

[Insert Table 6]

In Columns (1) and (4), we show that state government decides to allocate more funds to the county government with high level of the county-level government Q and the relation is statistically significant. Next, the statistically significant negative coefficients in Columns (2) and (5) indicate state government allocates more money to the county government with smaller county-level private-sector Q, complementing our main results that government allocate more funds to the private sector with a depressed Q. Column (3) and (6) show that the main results hold even after controlling for regional economic conditions.

5.3 Private-sector investment

In this section, we aim to empirically test the validity of the Q theory proposed by Hayashi (1982) in the context of government and private-sector investment interactions, as discussed in Section

2. Our hypotheses are derived from a general equilibrium model that considers the interplay between public investment and private-sector investment. In line with Prediction 2, one might expect a non-zero correlation between private-sector investment and government Q. However, we hypothesize that government Q does not have additional explanatory power in determining the optimal investment rate for the private sector, once private-sector Q is controlled for. In other words, private-sector Q serves as a sufficient statistic for the private-sector investment rate. This hypothesis is driven by the following observation: the costs of public investments do not explicitly affect firms' cash flows, whereas the total costs of private investments directly impact households' consumption streams, thereby influencing the government's optimal investment decisions. This inherent asymmetry between the private sector and the government leads to asymmetric predictions.

Equation (16) captures this very intuition of Q-theory. While all the empirical analyses presented thus far are based on state-level panel data, in this analysis, we utilize firm-level panel data to test this equation, following the literature on corporate investment. We use total investment, $i_t^H = i_t^P + i_t^S$ because i_t^H is observable while its individual components, subsidy-free private investment, i_t^P, and subsidy investment, i_t^S are not observable at firm level. Our specification for firm h at time t is as follows:

$$i_{h,t}^H = \alpha_h + \delta_t + \beta^H \cdot q_{h,t-1}^H + \beta^F \cdot q_{h,t-1}^F + (\text{Controls})_{h,t-1} + \epsilon_{h,t} \tag{30}$$

Control variables include the cash flow ratio (COMPUSTAT item OIBDP divided by Sales) and the logarithm of sales, which are motivated by the existing literature (e.g., (Gala et al., 2020)). We summarize the results in Table 7.

[Insert Table 7]

First, we demonstrate that the estimates for β^H are robust across different specifications in columns (1), (3), and (4). This implies that private-sector Q positively explains the private-sector investment rate. Secondly, column (2) shows that government Q alone has a positive relationship with the private-sector investment rate at the firm level. However, as demonstrated in columns (3) and (4), government Q loses its explanatory power when private-sector Q is controlled for. This provides supportive evidence that private-sector Q serves as a sufficient statistic for the private-sector investment rate.

In summary, the results of our analysis suggest that the Q theory holds for private-sector investment, with private-sector Q being a crucial determinant. However, government Q does not provide additional explanatory power once private-sector Q is taken into account. This finding aligns with our hypotheses and underscores the asymmetry between the private sector and the government in terms of investment decisions.

6 Conclusion

In this paper, we put forth a novel approach for studying the interplay between public- and private-sector investment nested in an extended Q-theoretical framework. The model builds on the existing literature that focuses on the Q-theory of investment in the private sector to consider endogenous public investment, and its interaction with private-sector investment and financial markets. Our model predicts that public investment is positively correlated with government Q (a measure of the marginal value of public capital) and negatively correlated with private-sector Q.

We then construct novel empirical measures of regional government Q's, derived from municipal bonds, and private-sector Q's, based on a decomposition of firm-level Q's. We use these measures to provide estimates that connect public spending across U.S. states to both the municipal bond and the corporate equity markets, in support of our model predictions in the Q-theoretical framework.

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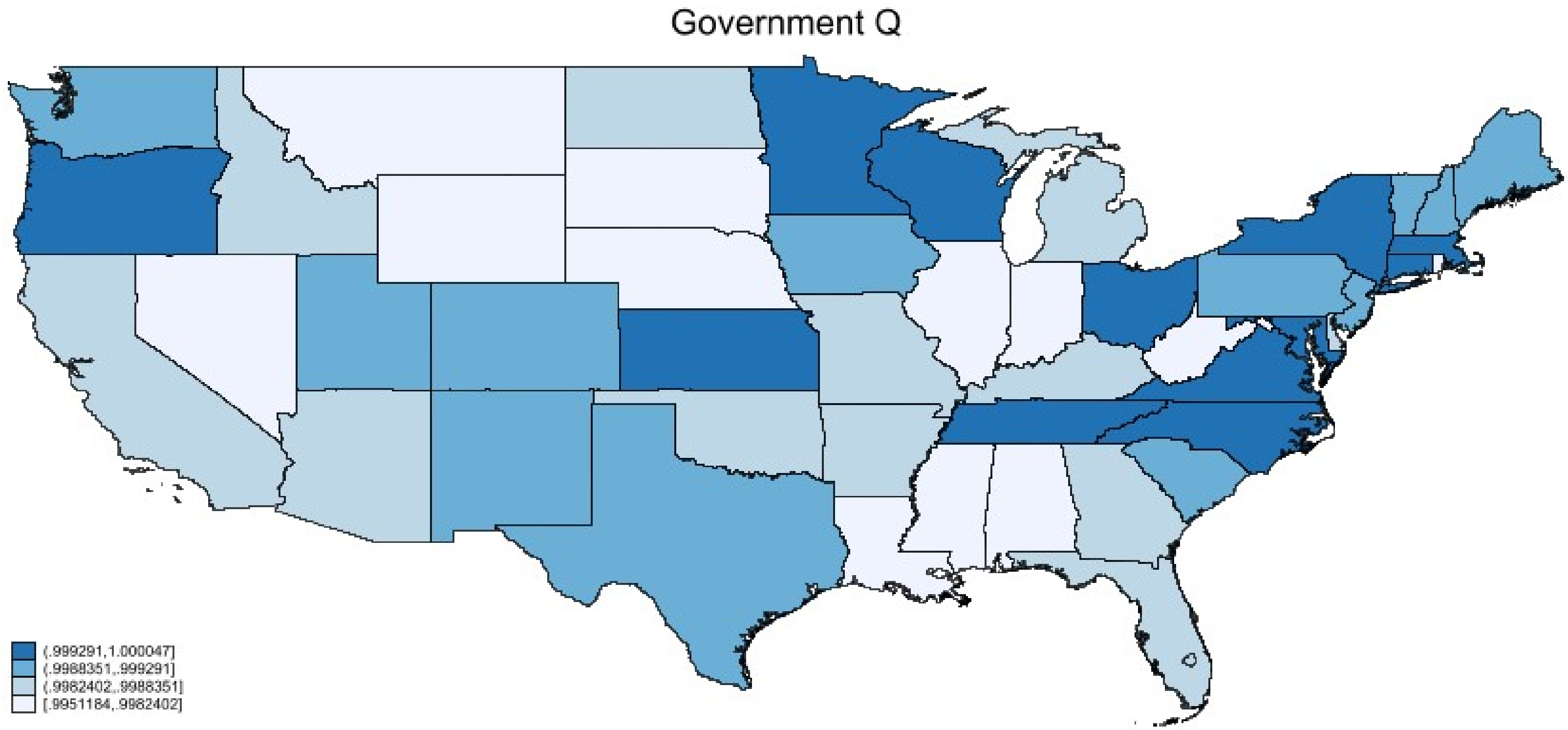

Figure 1: Cross-sectional distribution of private-sector Q an government Q

This graph shows the geographical distribution of state-level time-series average of government Q. We closely follow Philippon (2009) to construct government Q measure at state-level. Our constructed measures span from year 1994 to 2022 and cover 51 states.

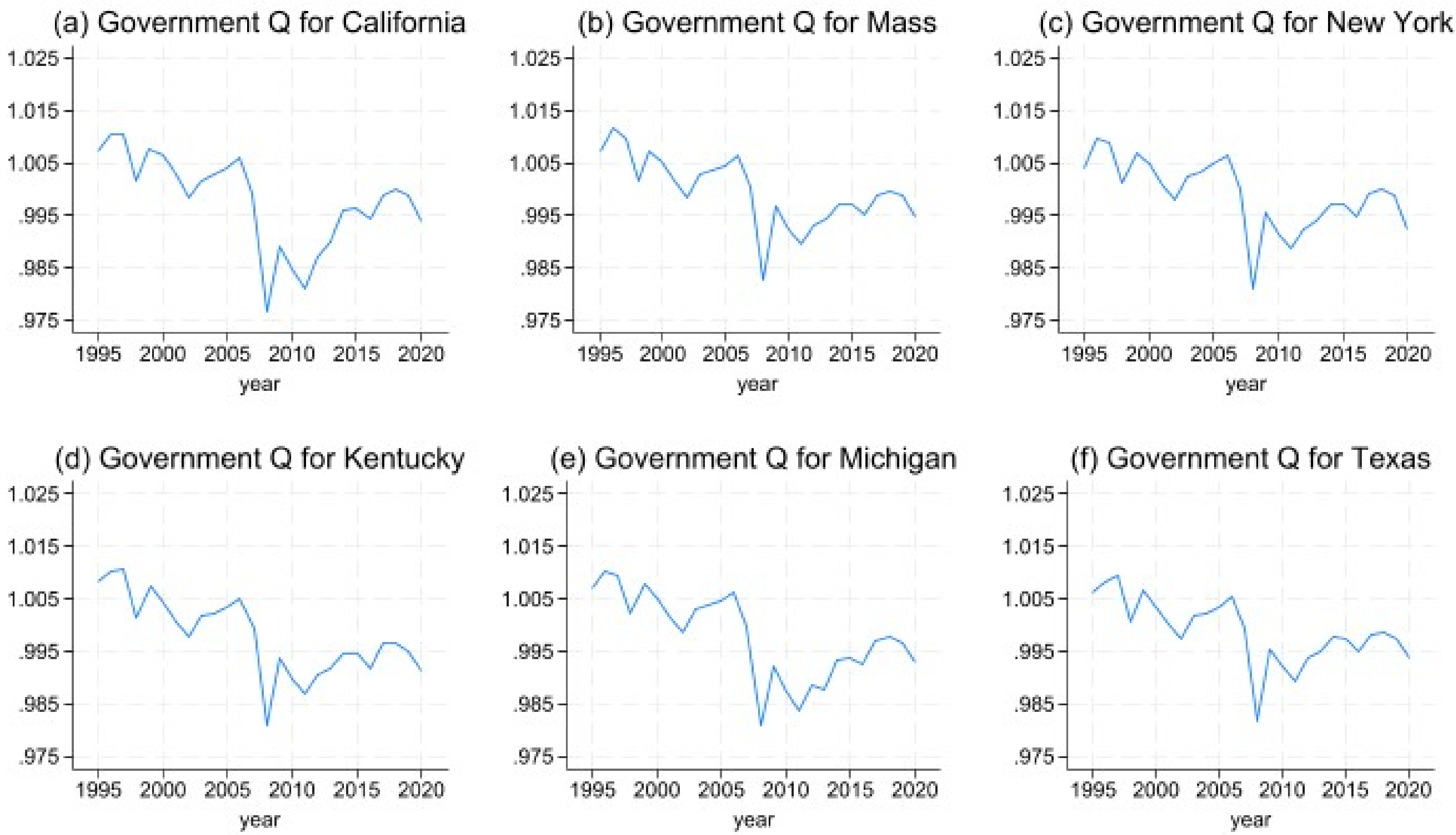

Figure 2: Time-series of government Q for different states

This graph shows the time series variation of government Q for six states: California (a), Massachusetts (b), New York (c), Kentucky (d), Michigan (e) and Texas (f).

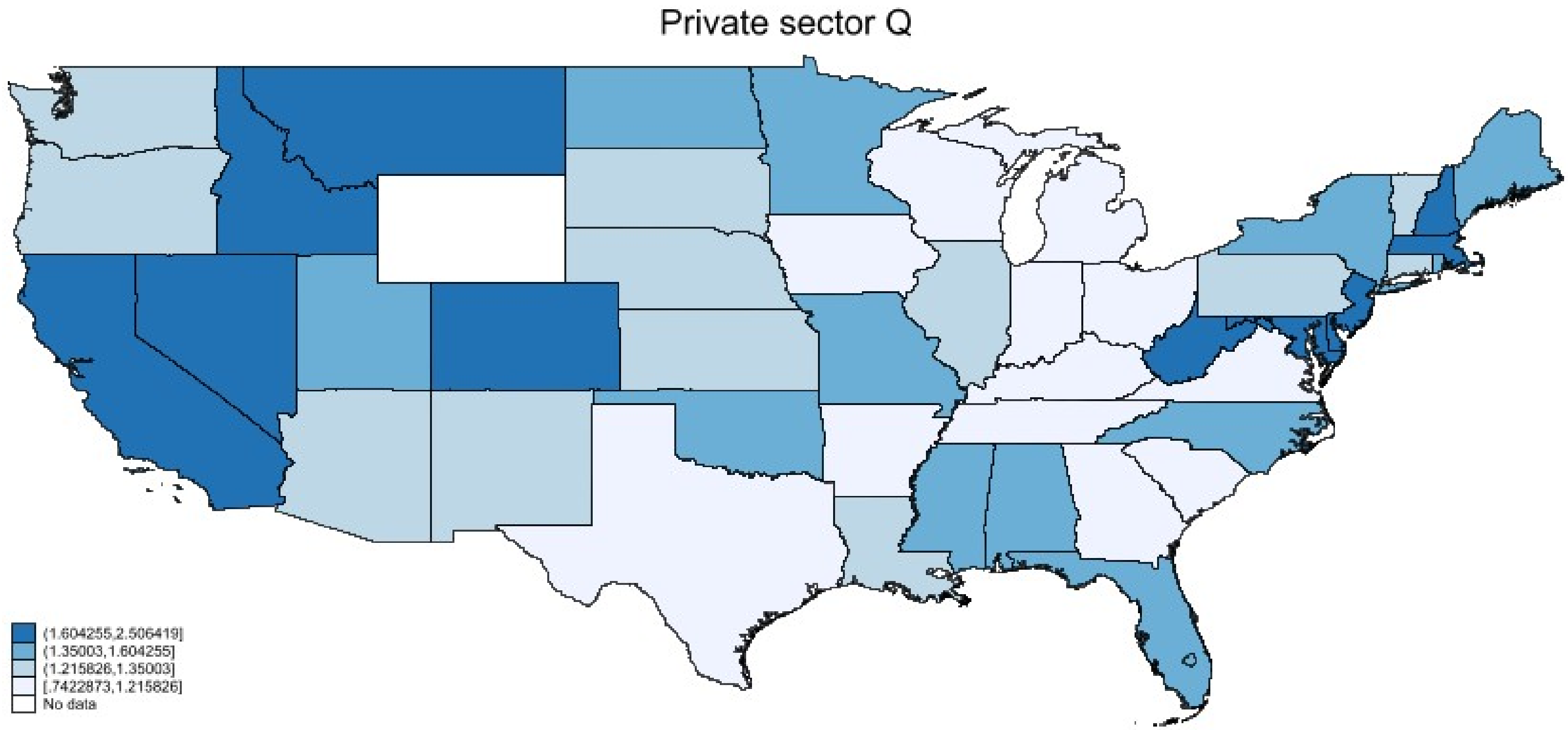

Figure 3: Cross-sectional distribution of private-sector Q an government Q

This graph shows the geographical distribution of state-level time-series average of private-sector Q. We closely follow Boguth, Duchin, and Simutin (2022) to construct private-sector Q measure at state-level. Our constructed measures span from year 1994 to 2022 and cover 51 states.

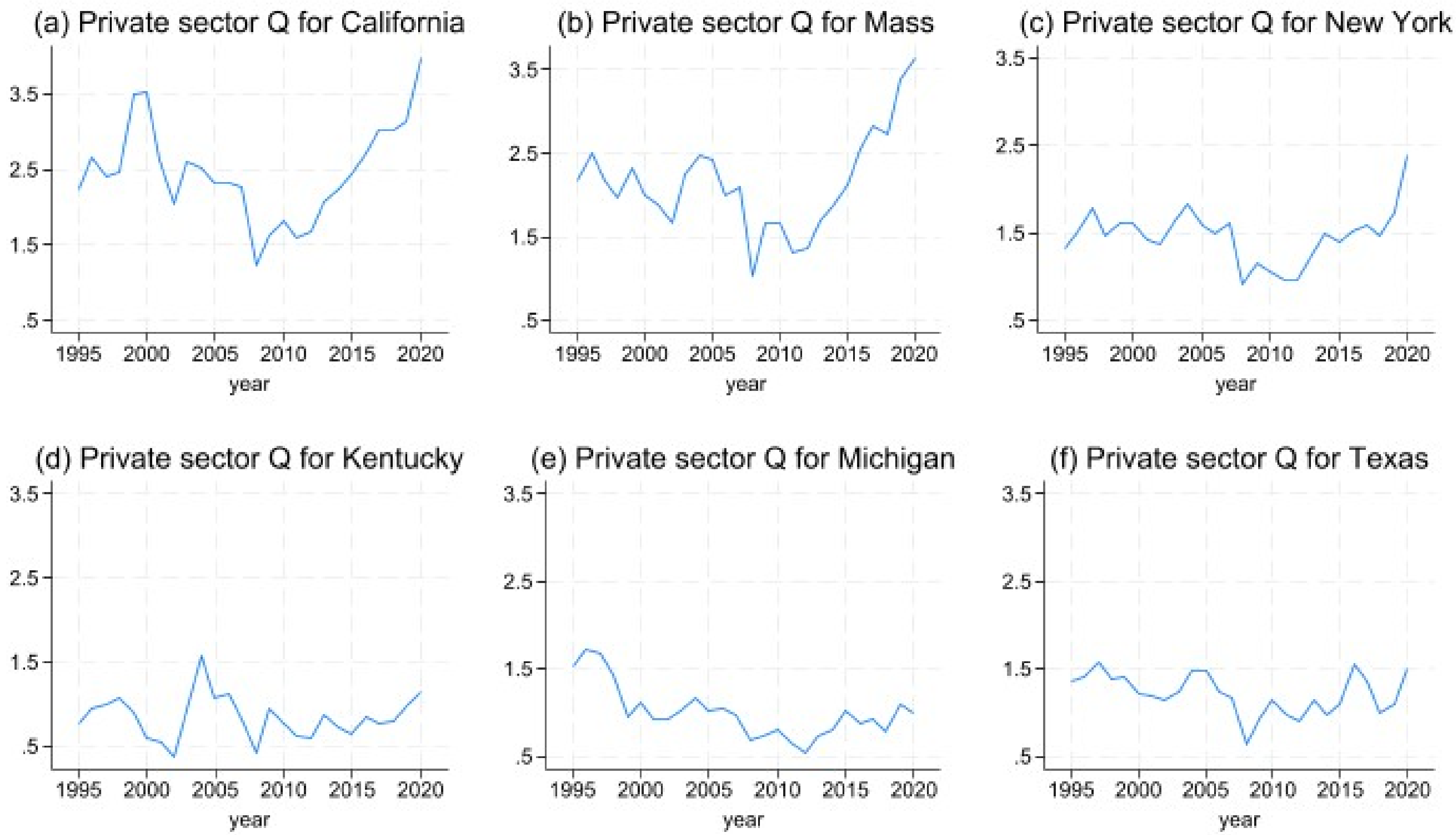

Figure 4: Time-series of private-sector Q for different states

This graph shows the time series variation of private-sector Q for six states: California (a), Massachusetts (b), New York (c), Kentucky (d), Michigan (e) and Texas (f).

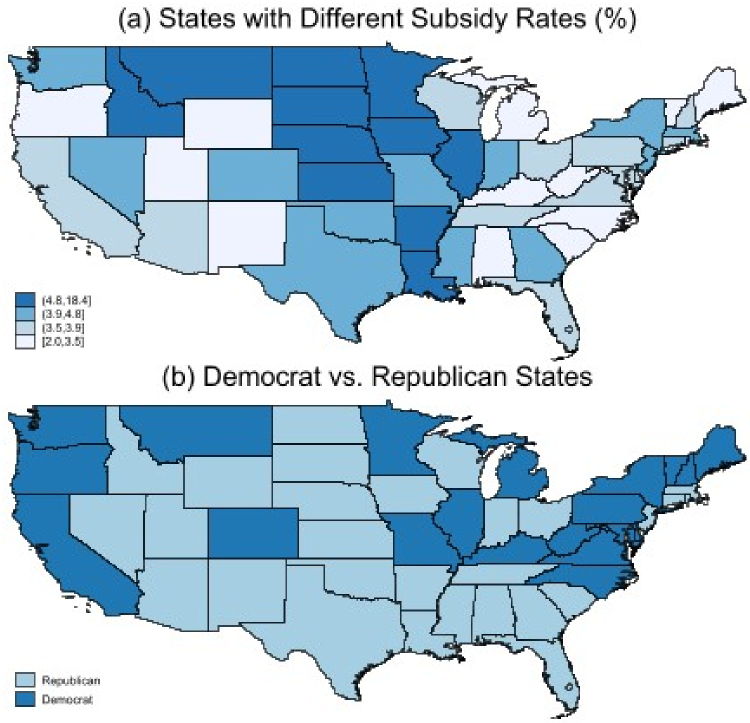

Figure 5: Heat Map for different subsample analysis

Panel A shows the geographical distribution of state-level time-series mean of subsidy rates in % as defined in Section 3.5, and Panel B shows the geographical distribution of state-level time-series mean of political partisanship of state governors.

Table 1: Summary Statistics

This table shows summary statistics of our main variables. Panel A shows summary statistics for state-level government Q and private-sector Q. Similar to Philippon (2009), state-level government Q, $q^F_{s,t}$, is constructed as a median over bond-based q-measures, $q^B_{s,t,n}$: $q^F_{s,t} = \text{Median}_{n=1,2,\cdots,N}\{q^B_{s,t,n}\} = \text{Median}_{n=1,2,\cdots,N}\left\{\frac{1+r_{s,t,n}}{1+Yield_{s,t,n}}\right\}$. Here, $Yield_{s,t,n}$ is the yield of bond n issued by state s at time t, $r_{s,t,n}$ is risk-free rate of a cash flow-matched synthetic treasury bond, and N is the total number of bonds issued by the state s at time t. Similar to Boguth, Duchin, and Simutin (2022), state-level private-sector Q ($q^H_{s,t}$) is constructed as follows: $q^{Firm}_t = W_t \cdot [q^H_{s=1,t}, q^H_{s=2,t}, \cdots, q^H_{s=51,t}]$. Here, q^{Firm}_t is value-to-sales ratio for firm $firm$. We construct two versions of W_t: sales data or employment data. Panel B shows summary statistics of state-level characteristics. Pane C shows county-level government Q, county-level private-sector Q and county-level characteristics. Panel D shows summary statistics for firm-level characteristics. $q^F_{h,t}$ is government Q for firm h at time t while $q^H_{h,t}$ is private-sector Q (measured as value-to-sales ratio) for firm h at time t. The sample spans from year 1994 to 2022 and covers 51 states (or 326 counties). All dollar amounts are in year 2000 dollars. Qs are standardized. All are in billion USD. All the variables are winsorized at 1% level.

	N	Mean	SD	p5	p10	p25	p50	p75	p90	p95
Panel A: State-level government and private-sector Q										
$q^F_{s,t}$	1,270	0.998	0.00703	0.986	0.990	0.994	0.999	1.003	1.007	1.010
$q^H_{s,t}$ (with a weight of sales)	1,250	1.399	0.661	0.618	0.762	0.967	1.269	1.633	2.257	2.663
$q^H_{s,t}$ (with a weight of employments)	1,250	1.418	0.705	0.603	0.741	0.983	1.269	1.648	2.309	2.724
Panel B: State-level characteristics										
Public expenditure (in billion USD)	1,326	39.45	51.37	4.899	6.261	10.03	24.60	44.95	80.66	131.2
Capital outlays (in billion USD)	1,326	4.350	5.477	0.519	0.616	1.274	2.783	4.823	8.443	17.32
Current operation (in billion USD)	1,326	29.34	38.09	3.602	4.692	7.600	18.22	33.33	59.14	96.93
Public capital stock - expenditure (in billion USD)	1,326	313.4	410.0	36.48	48.00	80.10	189.9	354.4	656.5	1,051
Public capital stock - investment (in billion USD)	1,326	264.9	340.6	32.08	41.72	69.94	162.4	303.9	542.5	897.0
Public expenditure rate (%)	1,326	13.23	1.690	10.90	11.25	11.91	13.02	14.30	15.61	16.32
Public investment rate (%)	1,326	13.34	1.711	10.99	11.30	12.04	13.12	14.38	15.80	16.55
Subsidy rate (%)	1,326	4.714	3.033	2.278	2.834	3.447	3.883	4.819	7.632	8.244
Republican's	1,300	0.600	0.490	0	0	0	1	1	1	1
GDP (in billion USD)	1,326	217.3	274.3	22.67	32.48	51.27	125.7	270.0	448.8	799.6
Population (in million)	1,326	5.875	6.607	0.626	0.755	1.596	4.042	6.794	12.57	19.45
Government book debt to GDP	1,326	0.154	0.0583	0.0904	0.101	0.122	0.147	0.173	0.206	0.237
Government revenue to GDP	1,326	0.232	0.0736	0.160	0.173	0.194	0.217	0.250	0.290	0.333

Panel C: County-level Q and characteristics										
$q^F_{c,t}$	6,650	0.998	0.00711	0.984	0.989	0.994	0.999	1.003	1.006	1.008
$q^H_{c,t}$	6,650	4.282	23.26	0	0	0.603	1.219	2.159	4.245	9.443
Public expenditure rate (%)	6,650	12.86	2.217	9.812	10.39	11.29	12.60	14.12	15.66	16.73
Public investment rate (%)	6,650	12.89	2.238	9.854	10.39	11.32	12.62	14.18	15.75	16.80
Intergovernmental subsidy rate (expenditure) (%)	6,650	4.938	1.610	2.516	2.905	3.720	4.890	5.963	7.006	7.790
Intergovernmental subsidy rate (investment) (%)	6,650	5.312	1.711	2.741	3.156	4.035	5.257	6.401	7.473	8.348
Population (in thousand)	6,636	577.7	805.2	106.1	136.3	206.3	357.1	677.9	1,103	1,659
Government book debt to population (in thousand)	6,636	4.270	3.078	1.175	1.553	2.365	3.483	5.096	7.949	9.995
Government revenue to population (in thousand)	6,636	4.362	1.618	2.216	2.563	3.241	4.108	5.181	6.430	7.326
Panel D: Firm-level characteristics										
$q^F_{h,t}$	61,858	0.999	0.00730	0.984	0.990	0.994	1.000	1.004	1.008	1.010
$q^H_{h,t}$	61,858	3.226	4.307	0.356	0.453	0.824	1.678	3.623	7.979	12.60
Investment / Sale (%)	61,858	6.478	8.296	0.420	0.702	1.646	3.390	7.261	17.30	26.11
Cashflow / Sale (%)	61,858	0.727	49.01	-102.0	-28.61	3.294	10.99	20.32	32.66	38.06
Log(Sale)	61,858	5.877	2.202	1.962	2.743	4.208	5.983	7.540	8.909	9.409

Table 2: Public investment by states

This table shows the relation between state-level public investment rate and state-level Qs (government Q and private-sector Q). In columns (1) and (2), we scale public investment level (capital outlays plus current operation) by lagged public capital to construct public investment rate in percentages. In columns (3) and (4), we scale public expenditure level by lagged expenditure-based public capital to construct public expenditure rate in percentages. Section 3 describes the construction of public capital. We estimate panel regressions as follows:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \epsilon_{s,t}$$

Both government Q $q^F_{s,t-1}$ and private-sector Q $q^H_{s,t-1}$ are standardized, and private-sector Q $q^H_{s,t-1}$ is constructed with a weight of sales. Standard errors are clustered by state and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)
Government Q	0.821***	1.027***	0.828***	0.769***	0.953***	0.757***
	(3.118)	(4.883)	(3.494)	(3.158)	(4.725)	(3.381)
Private-sector Q		-0.175**	-0.148**		-0.177*	-0.147**
		(-2.088)	(-2.574)		(-1.866)	(-2.207)
Log(GDP)			2.903***			3.202***
			(2.861)			(2.917)
Total Debt to GDP			-2.030			-0.996
			(-1.247)			(-0.624)
Revenue to GDP			10.21***			9.970***
			(5.171)			(4.864)
Observations	1,317	1,293	1,293	1,317	1,293	1,293
Adjusted Within R-squared	0.0244	0.0675	0.166	0.0231	0.0681	0.182
Adjusted R-squared	0.795	0.817	0.837	0.806	0.827	0.849
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Subsidy rate

This table shows how the relation between state-level public investment rate and state-level Qs (government Q and private-sector Q) varies across states with different subsidy rates. We scale public investment level (capital outlays plus current operation) by lagged public capital to construct public investment rate in percentages. Section 3 describes the construction of public capital. We estimate panel regressions as follows:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \gamma^F \cdot \mathbb{1}\{\text{Subsidy}_s\} \cdot q^F_{s,t-1} + \gamma^H \cdot \mathbb{1}\{\text{Subsidy}_s\} \cdot q^H_{s,t-1} + \epsilon_{s,t}$$

where $\mathbb{1}\{\text{Subsidy}_s\} = 1$ when the state s has subsidy rate is above the median. Both government Q $q^F_{s,t-1}$ and private-sector Q $q^H_{s,t-1}$ are standardized, and private-sector Q $q^H_{s,t-1}$ is constructed with a weight of sales. Standard errors are clustered by state and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)
Government Q	0.844***		0.975***	0.765***
	(3.127)		(5.503)	(3.724)
$\mathbb{1}\{\text{Subsidy}\} \cdot$ (Government Q)	-0.0605		-0.0357	0.0275
	(-0.533)		(-0.384)	(0.318)
Private-sector Q		0.0290	-0.00698	-0.00356
		(0.538)	(-0.155)	(-0.0872)
$\mathbb{1}\{\text{Subsidy}\} \cdot$ (Private-sector Q)		-0.333***	-0.280**	-0.245***
		(-2.709)	(-2.468)	(-2.770)
Log(GDP)				2.702***
				(3.136)
Total Debt to GDP				-2.326
				(-1.516)
Revenue to GDP				10.06***
				(5.538)
Observations	1,317	1,300	1,293	1,293
Adjusted Within R-squared	0.0251	0.0597	0.0914	0.181
Adjusted R-squared	0.795	0.815	0.822	0.840
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Political partisanship

This table shows how the relation between state-level public investment rate and state-level Qs (government Qs and private-sector Qs) varies across states with different political partisanship. We scale public investment level (capital outlays plus current operation) by lagged public capital to construct public investment rate in percentages. Section 3 describes the construction of public capital. We estimate panel regressions as follows:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \gamma^F \cdot \mathbb{1}\{\text{Rep}_s\} \cdot q^F_{s,t-1} + \gamma^H \cdot \mathbb{1}\{\text{Rep}_s\} \cdot q^H_{s,t-1} + \epsilon_{s,t}$$

where $\mathbb{1}\{\text{Rep}_s\} = 1$ when the governor of state s is Republican the majority of time. Both government Q $q^F_{s,t-1}$ and private-sector Q $q^H_{s,t-1}$ are standardized, and private-sector Q $q^H_{s,t-1}$ is constructed with a weight of sales. Standard errors are clustered by state and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)
Government Q	0.795***		0.870***	0.711***
	(3.061)		(4.477)	(3.245)
$\mathbb{1}\{\text{Rep}\} \cdot$ (Government Q)	0.00961		0.116	0.126
	(0.100)		(1.371)	(1.481)
Private-sector Q		0.0395	0.0346	0.0133
		(0.818)	(0.790)	(0.333)
$\mathbb{1}\{\text{Rep}\} \cdot$ (Private-sector Q)		-0.277**	-0.283**	-0.214***
		(-2.346)	(-2.564)	(-2.832)
Log(GDP)				2.464**
				(2.558)
Total Debt to GDP				-2.251
				(-1.388)
Revenue to GDP				9.253***
				(4.882)
Observations	1,292	1,274	1,268	1,268
Adjusted Within R-squared	0.0236	0.0354	0.0762	0.159
Adjusted R-squared	0.814	0.831	0.838	0.852
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Public investment by counties

This table shows the relation between county-level public investment rate and county-level Qs (government Qs and private-sector Qs). In column (1) and (2), we scale public investment level (capital outlays plus current operation) by lagged public capital to construct public investment rate in percentages. In column (3) and (4), we scale public expenditure level by lagged expenditure-based public capital to construct public expenditure rate in percentages. Section 3 describes how public capital is constructed. We estimate the panel regression as follows:

$$i^F_{c,t} = \alpha_c + \delta_t + \beta^F \cdot q^F_{c,t-1} + \beta^H \cdot q^H_{c,t-1} + \epsilon_{c,t}$$

Both government Q $q^F_{c,t-1}$ and private-sector Q $q^H_{c,t-1}$ are standardized, and private-sector Q $q^H_{c,t-1}$ is constructed with a weight of sales. Standard errors are clustered by county and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)
Government Q	0.390***	0.395***	0.406***	0.427***	0.429***	0.445***
	(4.165)	(4.249)	(4.719)	(3.375)	(3.407)	(3.681)
Private-sector Q		-0.0744*	-0.0738*		-0.0668	-0.0875**
		(-1.776)	(-1.865)		(-1.624)	(-2.113)
Log(Population)			-1.278*			-0.172*
			(-1.774)			(-1.804)
Total Debt to Population			-0.0567*			-0.0243
			(-1.773)			(-0.631)
Revenue to Population			0.557***			0.111
			(10.38)			(0.974)
Observations	5,307	5,307	5,301	5,307	5,307	5,301
Adjusted Within R-squared	0.00742	0.00851	0.0546	0.00695	0.00754	0.0149
Adjusted R-squared	0.631	0.631	0.649	0.422	0.422	0.427
County FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: Capital reallocation from states to counties

This table shows the relation between capital reallocation from states to counties and county-level Qs (government Qs and private-sector Qs). In column (1) and (2), we scale capital reallocation from states to counties level by lagged public capital to construct public capital reallocation rate in percentages. In column (3) and (4), we scale capital reallocation from states to counties level by lagged expenditure-based public capital to construct public capital reallocation rate in percentages. For county c and time t, we estimate:

$$t^F_{c,t} = \alpha_c + \delta_t + \beta^F \cdot q^F_{c,t-1} + \beta^H \cdot q^H_{c,t-1} + \epsilon_{c,t}$$

Both government Q $q^F_{c,t-1}$ and private-sector Q $q^H_{c,t-1}$ are standardized, and private-sector Q $q^H_{c,t-1}$ is constructed with a weight of sales. Standard errors are clustered by county and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)
Government Q	0.226***	0.229***	0.220***	0.208***	0.211***	0.202***
	(3.878)	(3.943)	(3.792)	(3.907)	(3.975)	(3.816)
Private-sector Q		-0.0397**	-0.0387**		-0.0384**	-0.0376**
		(-2.085)	(-2.017)		(-2.181)	(-2.125)
Log(Population (T))			0.362			0.352
			(0.942)			(0.977)
Total Debt to Population (T)			0.00194			-0.0121
			(0.115)			(-0.790)
Revenue to Population (T)			0.0951**			0.107***
			(2.325)			(2.829)
Observations	5,307	5,307	5,301	5,307	5,307	5,301
Adjusted Within R-squared	0.00996	0.0112	0.0169	0.00982	0.0112	0.0183
Adjusted R-squared	0.860	0.860	0.861	0.864	0.864	0.865
County FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7: Private investment by firms

This table shows the relation between firm-level private-sector investment rate and firm-level Qs (government Qs and private-sector Qs). For this analysis, unit of observation is firm-year. For firm h and time t, we estimate:

$$i^H_{h,t} = \alpha_h + \delta_t + \beta^H \cdot q^H_{h,t-1} + \beta^F \cdot q^F_{h,t-1} + \epsilon_{h,t}$$

Both private-sector Q $q^H_{h,t-1}$ and government Q $q^F_{h,t-1}$ are standardized. Standard errors are clustered by firm and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)
Private-sector Q	2.608***		2.606***	2.331***
	(24.17)		(24.10)	(22.84)
Government Q		0.649***	0.113	0.142
		(2.803)	(0.536)	(0.676)
Casfhlow / Sale				-0.0204***
				(-7.114)
Log(Sale)				-0.828***
				(-7.167)
Observations	56,674	56,674	56,674	56,674
Adjusted Within R-squared	0.0947	0.000353	0.0947	0.117
Adjusted R-squared	0.640	0.602	0.640	0.649
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix for "Public Seeds, Private Blooms"
by Zhiyao Chen, Ran Duchin, and Daniel Kim

A Data

A.1 Robustness tests

In this section, we conduct robustness tests for Prediction 1 and 2 using alternative sample and measures.

Alternative sample with full Census years
One potential source of bias in our estimates is the way Census collects data. The Census Bureau conducts a comprehensive census of state and local governments every five years, specifically in years ending in '2' and '7'. In the intervening years, a sample of state and local governments is used to collect data. During years ending in 2 or 7 (Census years), the sample covers state and local governments representing approximately 90% of the population, while the sample covers 75% of the population in the other years (Pierson et al., 2015). To address concerns that our results may be driven by non-Census years, we estimate Equation (27) using data from Census years and report the results in Table A1 column (1) and (2). The results show that the government Q is statistically significantly and positively correlated with the public investment rate, while the private-sector Q is statistically significantly and negatively correlated with the public investment rate.

Alternative measures of private-sector Q
We consider an alternative measure for private-sector Q. Following the method of Boguth, Duchin, and Simutin (2022), we construct alternative measures for private-sector Q by using establishment-level employment data, instead of sales data, to construct the weight matrix W_t. The summary statistics are presented in Table 1. Although the alternative private-sector Q measure has different summary statistics, they are not significantly different from the benchmark private-sector Q measure.

We estimate Equation (27) using this alternative version of private-sector Q. To facilitate comparison, we standardize both private-sector Q and government Q. The results are reported in Table A1 column (3) and (4). As shown, the findings remain robust to the different definition of private-sector Q, further strengthening the main conclusions documented in Section 4.1.

Table A1: Public investment: Robustness

This table shows the relation between state-level public investment rate and state-level Qs (government Q and private-sector Q). We scale public investment level (capital outlays plus current operation) by lagged public capital to construct public investment rate. Section 3 describes how government capital is constructed. For state s and time t, we estimate:

$$i^F_{s,t} = \alpha_s + \delta_t + \beta^F \cdot q^F_{s,t-1} + \beta^H \cdot q^H_{s,t-1} + \epsilon_{s,t}$$

In column (1) and (2), we use private-sector Q $q^H_{s,t-1}$ that is constructed with a weight of sales and we focus our analysis on full Census years, which are 1997, 2002, 2007, 2012, and 2017. In column (3) and (4), we use private-sector Q $q^H_{s,t-1}$ that is constructed with a weight of employments and we use the full sample. Both government Q $q^F_{s,t-1}$ and private-sector Q $q^H_{s,t-1}$ are standardized. Standard errors are clustered by state and t-statistics are reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)
Government Q	1.045*	1.266**	0.703	0.821***	1.021***	0.820***
	(1.685)	(2.133)	(1.155)	(3.118)	(4.850)	(3.470)
Private sector Q		-0.228**	-0.214**		-0.169**	-0.147**
		(-2.321)	(-2.414)		(-2.131)	(-2.496)
Log(GDP)			2.336**			2.927***
			(2.201)			(2.868)
Total Debt to GDP			-9.642***			-2.089
			(-3.035)			(-1.282)
Revenue to GDP			0.00222			10.27***
			(0.00105)			(5.099)
Observations	252	248	248	1,317	1,293	1,293
Adjusted Within R-squared	0.0293	0.0813	0.195	0.0244	0.0657	0.166
Adjusted R-squared	0.784	0.805	0.830	0.795	0.817	0.837
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.