# Tobin's q Does Not Measure Firm Performance: Theory, Empirics, and Alternatives*

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**Abstract**

Tobin's q is often used to proxy for firm performance when studying the relation between corporate governance and firm performance. However, our theoretical and empirical analysis demonstrate that Tobin's q does not measure firm performance since underinvestment increases rather than decreases Tobin's q. As an alternative to Tobin's q, our theoretical framework provides two new operating efficiency measures: the first assesses scale efficiency and the second assesses cost discipline. These proxies, which are justified by the ideal of maximizing firm value net of invested capital, decompose Tobin's q and can be computed for a wide cross-section of firms using the same data. In a canonical governance-performance regression specification, these operating efficiency measures lead to a different conclusion than Tobin's q.

Keywords: Firm Performance, Operating Efficiency, Tobin's q

# 1 Introduction

Empirical finance often requires proxies for variables of interest. Proxies must be chosen carefully because inappropriate proxies can cause a hypothesis to be spuriously rejected or accepted. Indeed, the need for proxies results in joint tests of the stated hypotheses and the validity of the chosen proxies. Ideally, proxies would originate from a theoretical framework that justifies their use under reasonable assumptions that have empirical support. Following this ideal, we provide a theoretical framework to derive operating efficiency measures that serve as proxies for firm performance. Our theoretical and empirical analysis also demonstrate that a high Tobin's q (or high ROA) does not indicate good firm performance, in contrast to existing studies that assume this relation. Specifically, Tobin's q is endogenous with respect to managerial decisions regarding a firm's scale, with underinvestment inflating Tobin's q.

Our theoretical framework is derived from managerial decisions regarding scale and cost discipline. For the single-product firm in our framework, scale is defined as the quantity of output produced. The operating efficiency measures we propose as proxies for firm performance assess scale decisions and cost discipline based on gross margins and operating expenses, respectively. These theoretically-motivated measures originate from a benchmark maximization of firm value net of invested capital, hence the maximization of a firm's net present value. Absent uncertainty, Tobin's q is proportional to the difference between these measures of operating efficiency.

An ideal manager in our framework would maximize their firm's market value net of invested capital. Operating at an inefficient scale and with lax cost discipline result in deviations from this objective. To illustrate the importance of scale and the deficiency of Tobin's q as a proxy for firm performance, consider a firm with a Tobin's q of 1.5 whose \$15 market value is based on a \$10 investment. If expanding the firm's scale through a \$20 investment increases its market value by \$24, Tobin's q decreases to 1.3 despite the \$4 increase in the firm's net present value.[1] This simple example demonstrates that maximizing Tobin's q does not maximize firm value. More formally, although underinvestment increases Tobin's q, from the perspective of maximizing shareholder wealth, it is optimal to increase investment until a firm's marginal profit is zero.[2]

Our framework highlights the conflicting implications of better firm performance on Tobin's q. Better operating efficiency in terms of scale decreases Tobin's q by mitigating underinvestment, while better operating efficiency in terms of cost discipline increases To-

[1]Tobin's q equals $\frac{\$15+\$24}{\$10+\$20} = 1.3$ after the capital investment.

[2]Tobin's marginal q, if it could be estimated, would also be subject to our framework's critique.

bin's q. This dependence on the relative importance of scale decisions versus cost discipline implies the net impact of better operating efficiency on Tobin's q is ambiguous.[3] However, when interpreting a high Tobin's q as evidence of good firm performance, the existing literature does not account for scale decisions but assumes that variation in Tobin's q is driven entirely by variation in cost discipline.

The ambiguous relation between firm performance and Tobin's q in our framework leads us to propose two types of operating efficiency measures that proxy for firm performance. These measures capture the implications of scale decisions and cost discipline separately. Scale decisions are evaluated by normalizing a firm's gross margin, defined as sales minus cost of goods sold, by a proxy for its natural scale. A high value for this operating efficiency measure indicates that firm operations are at a safe but inefficiently small scale. Cost discipline is evaluated by a similar normalization of operating expenses. A relatively high cost measure signifies poor operating efficiency due to lax cost discipline.

Three proxies for the natural scale of a firm are used in the denominator of our operating efficiency measures. As with Tobin's q, the first denominator is the book value of total assets, while the second denominator is property, plant, and equipment (PPE). The third denominator is sales, which is not complicated by the valuation of intangible assets, nor deviations between the book value and market value of a firm's assets. However, the use of sales complicates the cost measure, which becomes dependent on scale decisions. Therefore, the book value of total assets is the preferred denominator for our operating efficiency measures unless the mismeasurement of total assets is expected to be severe in a particular application.

Our empirical results indicate that underinvestment often inflates Tobin's q. Several robustness tests confirm this conclusion. Indeed, underinvestment inflates Tobin's q across firms with different levels of intangible assets. Therefore, accounting conservatism towards intangible assets is not responsible for the positive relation between our scale-based operating efficiency measure and Tobin's q. Furthermore, our conclusion that underinvestment is inflating Tobin's q cannot be attributed to financing constraints. Instead, consistent with John and Litov (2010)'s conclusion that high credit ratings are associated with managerial conservatism towards investment, the impact of underinvestment on Tobin's q is strongest in firms with access to debt financing.

A separate cross-sectional analysis accounts for cash flow dynamics and investment frictions such as adjustment costs. This analysis uses firm-level time series averages for Tobin's q and our operating efficiency measures to confirm the long-term positive relation between Tobin's q and underinvestment as well as the inverse relation between Tobin's q and lax cost

[3] Similarly, a high return on assets can either be attributed to underinvestment or stringent cost discipline.

discipline. The persistence of poor operating efficiency at the firm level is also difficult to reconcile with temporary investment frictions being responsible for these relations.

When examining the relation between corporate governance and firm performance, our theoretically-motivated proxies for firm performance have novel economic implications. Gompers, Ishii, and Metrick (2003) interpret the inverse relation between their managerial entrenchment index (G index) and Tobin's q, which is also present in our sample, as evidence that better corporate governance improves firm performance. However, replacing Tobin's q with our operating efficiency measures indicates that a low G index, which signifies less managerial entrenchment, does not improve firm performance. Instead, using Tobin's q as a proxy for firm performance induces the spurious conclusion that a lower G index corresponds with better firm performance, when higher values of Tobin's q actually coincide with greater underinvestment.

Our framework is consistent with empirical research that documents underinvestment and lax cost discipline in firms with weak governance. One motivation for underinvestment appears in the literature on the "quiet life" hypothesis, which includes Bertrand and Mullainathan (2003), Low (2009), as well as Giroud and Mueller (2010). Higher profit margins, a lower likelihood of being replaced due to negative demand shocks (career concerns), and the need for less monitoring all make underinvestment attractive to managers. The relevance of governance to cost discipline is documented by Core, Holthausen, and Larcker (1999) as well as Cronqvist, Heyman, Nilsson, Svaleryd, and Vlachos (2009). However, our framework does not rely on any specific mechanism in the existing governance literature. Instead, as with Tobin's q, our operating efficiency measures are intended to be used as general proxies for firm performance. We only invoke prior empirical research to justify our framework's focus on scale and cost discipline, with underinvestment being a more relevant deviation from a firm's optimal scale than overinvestment. If overinvestment is expected to be problematic in a particular sample, our framework remains valid but the interpretation of our operating efficiency measures is different.

Our framework's main contribution is two operating efficiency measures that serve as alternative proxies for firm performance. While a single measure of total operating efficiency may be desirable, for simplicity, deviations from optimal cost discipline and scale are not estimated since better firm performance along each dimension unambiguously lowers their respective operating efficiency measure. These unknown deviations impose linear and quadratic losses, respectively, on firm value. Moreover, having two operating efficiency measures enables researchers to identify the channel through which operating inefficiency reduces firm performance.

Overall, the relation between corporate governance and firm performance is an important research question that can only be addressed with appropriate proxies for firm performance. Our contribution is to provide theoretically-motivated measures of operating efficiency that are appropriate proxies for firm performance.

## 2 Theoretical Framework

Our intent is not to provide a detailed structural model. Instead, we provide a theoretical framework to motivate proxies for firm performance that can be used in empirical tests of hypotheses involving firm performance, such as the relation between corporate governance and firm performance. In our framework, managers are entrusted with two crucial tasks; they determine their firm's scale and control operating expenses. Although our framework abstracts from leverage and taxes, an extension that incorporates riskless debt is provided.

Our framework assumes that cash flows are either constant or can interpreted as expected values, which are constant, plus noise. Our later empirical analysis examines the robustness of these assumptions.

Scale decisions determine the number of units of output the firm produces. This quantity is denoted $y$. Our empirical implementation assumes that firms within the same industry are similar but may have a distinct intrinsic scale. Thus, scale decisions in our framework are determined within a particular product market. Empire-building by aggregating across different products is not a scale decision but is addressed later in this section.

Through the firm's price and cost of goods sold, we assume that the firm's output level is relevant to its gross margin. Downward sloping demand curves imply that marginal revenue is decreasing, with the slope reflecting the scale of the firm's potential market and its monopoly power in the product market. Furthermore, decreasing returns to scale imply that the marginal cost of output is increasing. No assumptions regarding the relative sensitivity of marginal revenue versus marginal costs to output are imposed on our framework since these sensitivities are expected to vary across industries. Instead, we focus on gross margins that are reduced by additional output due to a combination of decreasing marginal revenue and increasing marginal costs. Specifically, the price of the firm's output is given by

$$P(y) = P_0 - a_p \, y \,, \tag{1}$$

where $a_p \geq 0$ represents the sensitivity of prices to output and $P_0 > 0$. Furthermore, the firm's cost of goods sold is given by

$$C(y) = C_0 + a_c \, y \,, \tag{2}$$

where $a_c \geq 0$ represents the sensitivity of production costs to output (constant or decreasing returns to scale) and $C_0 > 0$. The gross margin per unit of output $G(y)$ equals the difference between $P(y)$ and $C(y)$

$$\begin{aligned} G(y) &= P_0 - a_p\, y - (C_0 + a_c\, y) \\ &= G_0 - \frac{y}{2a}\,, \end{aligned} \tag{3}$$

where we define $G_0 = P_0 - C_0$ and $a = \frac{1}{2\,(a_p + a_c)}$. The following two inequalities $P_0 > C_0$ and $a_p + a_c > 0$ are assumed.[4] As output levels are not observed in financial databases, and defining $y$ in a consistent manner across firms would be difficult, $G(y)$ is multiplied by $y$ to obtain a dollar-denominated amount for the firm's gross margin. We measure this dollar-denominated gross margin $y\,G(y)$ as sales minus cost of goods sold in our later empirical implementation.

Management decisions also determine the firm's operating expenses, $cy$. The per unit operating expense $c$ varies according to managerial cost discipline with a lower bound of $c_0$.[5] The firm's dollar-denominated net profit after operating expenses equals

$$\begin{aligned} yG(y) - cy &= y\left(G_0 - \frac{y}{2a}\right) - cy \\ &= y\,(G_0 - c) - \frac{y^2}{2a}\,. \end{aligned} \tag{4}$$

Although the $a$ parameter links profitability with output, $a$ is not exclusively a measure of product market competition since greater competition would also lower $G_0$.

For simplicity, managerial decisions regarding capital and output are treated as a single decision regarding the quantity of output to produce in our framework. In particular, the amount of capital required to produce one unit of output equals $k > 0$. The assumption of a linear production function implies the total amount of required capital to produce $y$ units of output is $ky$. Hall and Jorgenson (1967) also assume capital and output result from a single decision, with output being a function of capital in their model.

## 2.1 Theoretical Ambiguity of Tobin's q

For the simple firm in our framework, the net profit in equation (4) equals its cash flow in a single period. The constant $r$ is the appropriate interest rate for discounting future cash

[4] With the exception of the alternative operating efficiency measures introduced later that have sales in their denominator, the assumptions $a_p \geq 0$ and $a_c \geq 0$ are not required. For example, the framework can allow for increasing returns to scale with $a_c < 0$ provided the downward slope in the demand curve is sufficient, $a_p + a_c > 0$, to ensure that the gross margin is decreasing in scale.

[5] While $y$ and $c$ are not stochastic, viewing them as expected values does not change our framework's economic implications in the absence of bankruptcy costs and asymmetric information.

flows and the rental rate on capital. Thus, the per-period cash flow in equation (4) yields a market value of

$$M(y,c) \;=\; \sum_{t=1}^{\infty} \frac{y\left(G_0 - \frac{y}{2a}\right) - cy}{(1+r)^t} = \frac{y\left(G_0 - c\right) - \frac{y^2}{2a}}{r}\,. \tag{5}$$

Normalizing this market value by capital, $ky$, yields Tobin's q in our framework

$$q(y,c) \;=\; \frac{G_0 - c - \frac{y}{2a}}{rk}\,. \tag{6}$$

Observe that Tobin's q is a decreasing function of output since $\frac{\partial q(y,c)}{\partial y} = -\frac{1}{2a}$ is negative. Therefore, in our framework, better operating efficiency has an ambiguous influence on Tobin's q since better operating efficiency decreases $c$ while increasing $y$, causing Tobin's q to increase and decrease, respectively. In contrast, the existing literature's assumption that a high Tobin's q corresponds to better firm performance ignores the relevance of scale decisions. However, unless marginal profits are independent of output ($a = \infty$), and therefore equal to $G_0$ in equation (3), scale decisions are relevant to Tobin's q.

In our framework, using Tobin's q as a proxy for firm performance is tantamount to assuming that cross-sectional variation in Tobin's q is driven entirely by differences in their cost discipline. Specifically, an inverse relation between Tobin's q and $R_c$ justifies using Tobin's q as a proxy for firm performance provided $q(y,c)$ in equation (6) is independent of output and equal to $\frac{G_0 - c}{rk}$ as a consequence.

## 2.2 Operating Efficiency Measures

The ideal manager in our framework maximizes their firm's market value minus its invested capital

$$\max_{c,y}\; M(y,c) - ky \;=\; \max_{c,y}\; \frac{y\left(G_0 - c - rk\right) - \frac{y^2}{2a}}{r}\,. \tag{7}$$

This objective maximizes the firm's net present value.[6] Equation (7) is a concave function that achieves its maximum at

$$y^* \;=\; a\left(G_0 - c_0 - rk\right)\,. \tag{8}$$

Managers who underinvest produce less than $y^*$ while managers who shirk their responsibility to control operating expenses have $c$ exceeding $c_0$. The maximization in equation (7) is

[6] The optimization in equation (7) does not maximize Tobin's q in equation (6). The correlation between Tobin's q, $\frac{M}{B}$, and the difference between its numerator and denominator, $M - B$, is only 0.25.

equivalent to maximizing the net profit in equation (4) minus the rent on capital

$$\frac{\left[y\left(G_0 - \frac{y}{2a}\right) - cy\right] - rky}{r}. \tag{9}$$

As discussed in the introduction, we assume that scale inefficiency arises from underinvestment rather than overinvestment. In other words, we assume that output is the region $(y < y^*)$ where equation (7) is increasing with $y$. This assumption is consistent with empirical evidence on managerial career concerns, monitoring costs, and the quiet life hypothesis. Although investors prefer managers to produce a level of output $y^*$ that sets marginal revenue equal to marginal cost, this optimal output level is too high from the perspective of managers that underinvest by producing below $y^*$.

Using the maximization in equation (7), we propose two operating efficiency measures that proxy for firm performance. The first operating efficiency measure is derived from gross margins while the second measure is derived from operating expenses. In particular, the first operating efficiency measure, $R_y$, isolates scale decisions

$$R_y = \frac{\text{Gross Margin}}{\text{Capital}} = \frac{y\left(G_0 - \frac{y}{2a}\right)}{ky} = \frac{G_0 - \frac{y}{2a}}{k} \geq \frac{G_0 + c_0 + rk}{2k}, \tag{10}$$

with the lower bound being independent of $a$ after invoking $y^*$ from equation (8). This lower bound is not required for empirical tests since the normalization by capital ensures that $R_y$ is a decreasing function of output. Thus, it is not necessary to estimate deviations of $y$ from $y^*$.

Observe that $R_y$ is not affected by the level of cost discipline. Instead, cost discipline is the focus of the second operating efficiency measure, $R_c$, based on the operating expenses that determine $cy$

$$R_c = \frac{\text{Operating Expenses}}{\text{Capital}} = \frac{cy}{ky} = \frac{c}{k} \geq \frac{c_0}{k}. \tag{11}$$

The normalization by capital ensures that $R_c$ is not complicated by management scale decisions. As $R_c$ decreases with better cost-based operating efficiency, estimating deviations between $c$ and $c_0$ is unnecessary.

According to equation (7), the loss in firm value is $\frac{(y^*-y)^2}{2\,a\,r}$ when output is below its optimal level, while this loss is $\frac{y\,(c-c_0)}{r}$ when operating expenses per unit exceed its lower bound. Thus, scale and cost decisions have quadratic and linear implications, respectively, for firm value. Furthermore, as $y^*$, $y$ $c_0$, $c$, and $a$ are not estimated, we cannot determine ex-ante from our framework whether $R_y$ or $R_c$ has a greater impact on Tobin's q.

To clarify, a firm is operating inefficiently if and only if at least one operating efficiency measure is large. Thus, a large value of $R_y$ is evidence of underinvestment.[7] Conversely, if $R_y$ is small, the firm's long-term survival requires $R_c$ to be small since high gross margins are needed to fund unnecessary operating expenses. In general, $y$ and $c$ are chosen simultaneously by management, which implies an interaction between our operating efficiency measures that is examined in the next section.

In general, any capital-adjusted profitability metric is likely to be ambiguous regarding firm performance. For example, when total assets define capital in the denominator of our operating efficiency measures, return on assets (ROA) equals their difference

$$\text{ROA} \quad = \quad R_y - R_c \,, \tag{12}$$

since ROA is defined as the net operating profit in equation (4) normalized by total assets.

While $R_y$ and $R_c$ both decrease with improved operating efficiency, ROA evaluates their difference. Therefore, a high ROA can either be attributed to a high $R_y$ or a low $R_c$ measure, which signify poor and good firm performance, respectively. The similarity between ROA and Tobin's q is a consequence of their common denominator and from the market value in Tobin's q capitalizing the cash flows that define ROA. This conclusions can be easily extended to include riskless debt. Continuing under the assumption of no taxes, when a fraction $0 \leq f < 1$ of the firm's capital is financed by debt, its cash flows are reduced by an interest expense equaling $frky$. The remaining per-period cash flow in equation (4) is therefore reduced by this amount

$$y \left( G_0 - \frac{y}{2a} - c - frk \right) .$$

The above cash flow is obtained from an equity-financed capital investment of $(1-f)ky$. Therefore, the firm's return on equity (ROE) equals

$$\text{ROE} \quad = \quad \frac{y \left( G_0 - \frac{y}{2a} - c - frk \right)}{(1-f)ky} = \frac{R_y - R_c - rf}{1-f} \,, \tag{13}$$

which reduces to the decomposition of ROA in equation (12) when $f = 0$. More important, better operating efficiency does not necessarily increase a firm's return on equity since ROE also involves the difference between $R_y$ and $R_c$.

The reason that Tobin's q is higher for firms that underinvest in our framework parallels its ability to predict investment in Brainard and Tobin (1968) as well as Tobin (1969). Intuitively, each additional unit of capital is worth more than its cost when a firm operates below its optimal scale. Thus, further investment increases firm value net of its cost. However,

[7] Although the underinvestment associated with a large $R_y$ also lowers $R_c$ when sales are in their denominator, the large $R_y$ already identifies the firm as having poor operating efficiency.

instead of assuming that managers maximize firm-value net of capital in the presence of adjustment costs, our framework allows managers to deviate from this maximization through underinvestment and lax cost discipline. In particular, our operating measures can be utilized to study the effectiveness of different governance mechanisms at reducing underinvestment or improving cost discipline.

Despite its simplicity, the next section provides testable implications of our framework involving the operating efficiency measures that are broadly consistent with our empirical results. Moreover, a more complex framework in which cash flow and investment interact through a dynamic relation is unlikely to produce more robust proxies for firm performance that are applicable to a wide cross-section of firms. Indeed, the disadvantages of a more complex framework are apparent from the literature examining the investment implications of Tobin's q. For example, while Fazzari, Hubbard, and Petersen (1988) argue that cash flow predicts investment, Kaplan and Zingales (1997) argue that cash flow itself proxies for investment opportunities. Thus, the sufficiency of Tobin's q at predicting investment in the presence of external financing constraints is inconclusive. The appropriate proxy for financing constraints is also in dispute. For example, Hadlock and Pierce (2010) report that firm size is the best predictor of financing constraints, although our framework demonstrates the endogeneity of firm size. Overall, without a firm foundation, complicating our framework by introducing a dynamic relation between cash flow and investment is unlikely to improve our operating efficiency measures.

## 2.3 Excess Capital and Overinvestment

Excess capital can be utilized to produce a suboptimal amount of output. Thus, underinvestment can simultaneously occur in firms that utilize excess capital. Identifying the inefficiency associated with utilizing excess capital would require a normalization of capital by output to facilitate a comparison of $k$ across firms. However, units of output are not reported in standard financial databases and are difficult to compare across firms. Nonetheless, $R_c$ can capture the implications of excess capital arising from higher operating expenses such as rent, utilities, etc.

In contrast to excess capital, which pertains to $k$ being excessively large, overinvestment occurs if a firm produces more output than is optimal, $y > y^*$. Overinvestment reduces a firm's marginal profit below zero. Nonetheless, managers may temporarily sacrifice their firm's profitability provided the expected long-term gross margin offers sufficiently high compensation. For example, a firm may attempt to deter entry by competitors or build brand equity through overinvestment that coincides with temporary price reductions.

As a lower margin decreases the numerator of $R_y$, overinvestment causes the realized scale-based operating efficiency measure to decline. Conversely, the expectation of high gross margins in the long-term implies that Tobin's q is less sensitive to overinvestment than $R_y$.[8] Consequently, unlike underinvestment, overinvestment does not imply a positive relation between Tobin's q and $R_y$.

To clarify, empire building is distinct from both overinvestment and the utilization of excess capital since empire building involves the assembly of conglomerates. The appropriateness of applying our operating efficiency measures to conglomerates is addressed at the end of this section.

## 2.4 Modified Operating Efficiency Measures with Sales

The book value of assets may offer a poor approximation for a firm's (economic) capital. For example, the book value of assets can be reduced by write-offs that are intended to improve subsequent earnings. The valuation of intangible assets such as patents and brand equity also complicates using the book value of assets as a proxy for capital. Therefore, we investigate an alternative version of our operating efficiency measures that replaces the book value of assets in their denominator with sales, or equivalently that replaces $k$ in their denominator with the unit price $P(y)$. The theoretical justification for these alternative operating efficiency measures is demonstrated below.

Using sales, defined as $yP(y) = y\,(P_0 - a_p y)$, in the denominator of our scale-based operating efficiency measure alters $R_y$ as follows

$$R_y = \frac{\text{Gross Margin}}{\text{Sales}} = \frac{G_0 - \frac{y}{2a}}{P_0 - a_p y}\,. \tag{14}$$

To demonstrate that $R_y$ is a decreasing function of $y$, applying the quotient rule to the above expression yields its derivative

$$\frac{\partial R_y}{\partial y} = \frac{\frac{-[P_0 - a_p\, y]}{2a} + a_p\left[G_0 - \frac{y}{2a}\right]}{\left[P_0 - a_p\, y\right]^2}\,. \tag{15}$$

The identities $G_0 = P_0 - C_0$ and $a = \frac{1}{2(a_p + a_c)}$ along with the assumption that $P_0$, $C_0$, $a_p$, and $a_c$ are positive imply the above expression equals

$$\begin{aligned} \frac{\partial R_y}{\partial y} &= \frac{-1}{2a\,\left[P_0 - a_p\, y\right]^2}\left(\frac{a_c}{a_p + a_c}\,P_0 + \frac{a_p}{a_p + a_c}\,C_0\right) \\ &= -\left(\frac{a_c\, P_0 + a_p\, C_0}{\left[P_0 - a_p\, y\right]^2}\right) < 0\,. \end{aligned} \tag{16}$$

[8] A later analysis finds firm-level operating efficiency to be highly persistent. This persistence is inconsistent with overinvestment leading to higher future cash flows.

Therefore, as in equation (10), underinvestment lowers our scale-based operating efficiency measure when sales normalize gross margins.

In contrast to using the book value of assets to scale operating expenses, $R_c$ with sales in the denominator is no longer independent of output

$$R_c = \frac{\text{Operating Expenses}}{\text{Sales}} = \frac{c}{P_0 - a_p y}. \tag{17}$$

Instead, conditional on $c$, $R_c$ is an increasing function of $y$. Therefore, when sales normalize operating expenses, a low $R_c$ can signify stringent cost discipline or underinvestment. Consequently, with sales in the denominator, a low $R_c$ is not evidence of better firm performance.

## 2.5 Empire-Building

Mergers and acquisitions can improve operating efficiency through synergies and cost-savings. Graham, Lemmon, and Wolf (2002) challenge the assumption that acquisitions destroy value simply by lowering the combined entity's valuation. Their argument parallels our framework's intuition that optimal managerial decisions decrease marginal profitability towards zero rather than increasing average profitability. Similarly, Gozzi, Levine, and Schmukler (2008) find evidence that international expansion reduces Tobin's q. As illustrated by the simple numerical example in the introduction, a scale decision that reduces Tobin's q can increase firm value.

Conversely, mergers and acquisitions can create a collection of diverse enterprises, each operating at an insufficient scale. Harford and Li (2007) conclude that increases in firm size are often motivated by the desire for greater managerial compensation. This empire building can create large conglomerates that operate at a suboptimal scale in multiple product markets. If enterprises are combined to increase firm size without improving operating efficiency, then our measures identify the conglomerate as having poor firm performance. In particular, as demonstrated below, a conglomerate's operating efficiency is the capital-weighted average of the operating efficiencies of its individual divisions in the absence of synergy gains.

Although our framework investigates a single firm, consider a merger between firms "A" and "B" that forms a new firm by combining their operations. Using firm names as superscripts, the combined entity has a scale-based operating efficiency measure equaling

$$\begin{aligned} R_y^{new} &= \frac{y^A \left( G_0^A - \frac{y^A}{2a^A} \right) + y^B \left( G_0^B - \frac{y^B}{2a^B} \right)}{k^A\, y^A + k^B\, y^B} \\ &= \left( \frac{k^A\, y^A}{k^A\, y^A + k^B\, y^B} \right) \frac{y^A \left( G_0^A - \frac{y^A}{2a^A} \right)}{k^A\, y^A} + \left( \frac{k^B\, y^B}{k^A\, y^A + k^B\, y^B} \right) \frac{y^B \left( G_0^B - \frac{y^B}{2a^B} \right)}{k^B\, y^B} \\ &= \tau\, R_y^A + (1-\tau)\, R_y^B\,, \end{aligned}$$

where $\tau$ is defined as $\frac{k^A\, y^A}{k^A\, y^A + k^B\, y^B}$, the fraction of capital in the combined entity that is contributed by firm A. Therefore, the scale-based operating efficiency measure of the merged firm is the capital-weighted average of the scale-based operating efficiency measures for firm A and firm B. This property implies that our scale-based operating efficiency measure remains valid after a merger.

Similarly, if there are no operational changes, the cost-based measure of operating efficiency for the combined entity equals

$$\begin{aligned} R_c^{new} &= \frac{c^A\, y^A + c^B\, y^B}{k^A\, y^A + k^B\, y^B} \\ &= \left( \frac{k^A\, y^A}{k^A\, y^A + k^B\, y^B} \right) \frac{c^A\, y^A}{k^A\, y^A} + \left( \frac{k^B\, y^B}{k^A\, y^A + k^B\, y^B} \right) \frac{c^B\, y^B}{k^B\, y^B} \\ &= \tau\, R_c^A + (1-\tau)\, R_c^B\,, \end{aligned}$$

which equals the weighted average of the cost-based measures for each firm before the merger. Thus, the cost-based measure for the merged firm is the capital-weighted average of the measures for firm A and firm B. This property implies that our cost-based operating efficiency measure is robust to merger activity.

# 3 Empirical Implementation

We focus our empirical investigation on the relation between Tobin's q and operating efficiency. Annual COMPUSTAT data from 1980 until 2010 is used to construct our operating efficiency measures and Tobin's q. The usual inconsistency between Tobin's average q, which can be estimated from available data, and Tobin's marginal q is not an issue since our framework provides results for Tobin's average q.

Sales minus cost of goods sold (Sales - COGS) is our measure for gross margin in the numerator of $R_y$. Our measure for operating expenses in the numerator of $R_c$ subtracts research and development (R&D) and advertising expenses from sales, general, and administrative expenses (SG&A). R&D and advertising are removed because these expenses can create intangible assets that represent an investment, a potential bias that is examined later in more detail. Missing values for R&D and advertising are set to zero. We estimate three sets of operating efficiency measures by using three different denominators; total assets (TA - preferred proxy for capital), property, plant, and equipment (PPE - another proxy for capital that is less sensitive to intangible assets), as well as sales (Sales - as detailed in Section 2.4).

As detailed in the existing literature, measurement error surrounds the replacement cost of assets, especially intangible assets. Lindenberg and Ross (1981) interpret a Tobin's q above one as an indication of monopoly rents that may be attributable to intangible assets, and pioneer algorithms for alleviating the measurement error inherent in Tobin's q. Although Erikson and Whited (2006) conclude that these algorithms are unsuccessful at improving the measurement quality of Tobin's q, several remedies, including instrumental variables, continue to have their proponents (Erikson and Whited, 2012). This debate is often motivated by the use of Tobin's q as an independent variable in regressions that test the sensitivity of investment to cash flow constraints. In contrast, our focus is on the use of Tobin's q as a dependent variable in tests that evaluate the sensitivity of firm performance to governance. Therefore, we adopt the standard definition of Tobin's q in the empirical governance literature. Specifically, the numerator of Tobin's q is computed as the book value of total assets plus the market value of equity minus the book value of equity, while its denominator is the book value of total assets.[9]

The operating efficiency measures and Tobin's q measures are trimmed at the 99% threshold within each industry to ensure our results are not driven by data errors. Negative values for sales, COGS, SG&A, total assets, PPE, and the book value of equity are removed from the sample. Our framework is sensible when a firm's gross margin, hence $R_y$, is positive. Nonetheless, there exists a small subset of 1,516 firm-year observations where COGS exceeds sales in our sample. Since their inclusion does not alter our results, these observations are not removed from the sample.[10]

Two digit SIC codes are obtained from CRSP to determine industry classifications. Firms in the banking, insurance, real estate, and financial trading industries are removed from our sample as well as industries that have fewer than 40 firm-year observations. The remaining

[9]This is the market value of equity plus the book value of debt. Market values for debt are difficult to estimate but are approximated by their book values.

[10]Firms with negative gross margins have an average stock price of $4.24, and are concentrated in industries (mining, metals, oil & gas extraction) whose irreversible investments are costly to abandon in periods with depressed prices. Firms with negative gross margins remain in the sample for less than 6 years on average, versus 15 years for their counterparts with positive gross margins.

62 industries are used in later empirical tests.

Table 1 reports summary statistics for our operating efficiency measures and Tobin's q. Panel A reports univariate statistics and Panel B reports on their correlations. The correlations are based on firm-year observations and are computed as the average within-industry correlation. Specifically, correlation matrices are first computed within each industry and then averaged across industries to form the correlation matrix in Panel B.

## 3.1 Does Better Operating Efficiency Increase Tobin's q?

Our theoretical framework highlights an ambiguous relation between Tobin's q and firm performance: improving scale efficiency reduces Tobin's q while improving cost discipline increases Tobin's q. Our empirical analysis documents that both channels are important but poor scale efficiency is statistically more significant, which is difficult to reconcile with a higher Tobin's q signifying better firm performance.

We implement two distinct empirical specifications; a panel regression that incorporates all available data as well as a cross-sectional regression to address several econometric issues confronting the panel regression. With the book value of total assets in their denominator, the definition of $R_y$ and $R_c$ in equation (10) and equation (11), respectively, enables Tobin's q to be decomposed as follows

$$q(y,c) \;=\; \frac{y\left(G_0 - \frac{y}{2a}\right) - cy}{rky} = \frac{R_y \,-\, R_c}{r}\,, \tag{18}$$

since the market value in its numerator equals the present value of the difference between the numerators of $R_y$ and $R_c$. One disadvantage of using PPE or sales in their denominator is the loss of this intuitive decomposition.

With cash flows being a martingale and capital being fixed, the decomposition in equation (18) satisfies the following equality in expectation

$$q(y,c) \;=\; \frac{1}{r}\left(\frac{E\left[y\,\left(G_0 - \frac{y}{2a}\right) - cy\right]}{ky}\right) = \frac{E\left[R_y\right] - E\left[R_c\right]}{r}\,. \tag{19}$$

Therefore, the panel regression

$$q_{i,t} \;=\; \beta_y\, R_{y,i,t} + \beta_c\, R_{c,i,t} + \gamma\, X + \epsilon_{i,t}\,, \tag{20}$$

has an errors-in-variables problem because the correct regressors $E\left[R_y\right]$ and $E\left[R_c\right]$ are replaced by their noisy respective counterparts $R_y$ and $R_c$. In a univariate regression, this problem biases the regression coefficients toward zero. In our multivariate setting, a covariate measured with relatively less noise could proxy for a correlated covariate measured with more noise, which is a qualitatively different source of bias.[11]

The market value in the numerator of Tobin's q can reflect long-term cash flows that differ across industries. Thus, industry fixed effects are included in $X$, along with year fixed effects. Furthermore, the standard errors of the coefficients in equation (20) are clustered at the industry-level. Total assets and sales are not included in the above panel regression since these variables are endogenous.

Under the null hypothesis that Tobin's q is a valid proxy for firm performance, variation in Tobin's q across firms is driven entirely by differences in cost discipline. Thus, the use of Tobin's q as a proxy for firm performance is justified by $\beta_c < 0$ and $\beta_y = 0$. In contrast, a positive $\beta_y$ coefficient indicates that underinvestment is increasing Tobin's q, which contradicts the prior literature's assumption that a high Tobin's q is necessarily evidence of good firm performance. Specifically, the decomposition of Tobin's q in equation (18) predicts $\beta_y = 1/r$ and $\beta_c = -1/r$ when the book value of total assets is the denominator of the operating efficiency measures.

Table 2 reports the coefficient estimates from the panel regression in equation (20). Observe that the $\beta_y$ coefficients are positive regardless of $R_y$'s denominator (total assets, sales, PPE). For example, with the book value of total assets as the proxy for capital, the $\beta_y$ coefficient equals 0.6942 ($t$-statistic of 3.64). Similarly, the $\beta_y$ coefficient is positive, equaling 0.0193 ($t$-statistic of 2.92), when PPE is the denominator of $R_y$. These positive $\beta_y$ coefficients are consistent with underinvestment inflating Tobin's q.

A negative but insignificant $\beta_c$ coefficient equaling -0.0199 ($t$-statistic of -0.08) is obtained when total assets normalize operating expenses. Recall that our framework does not have a clear prediction regarding the sign of $\beta_c$ with sales in the denominator of $R_c$. Overall, with total assets in the denominator of our operating efficiency measures, the positive $\beta_y$ and negative $\beta_c$ coefficients reported in Table 2 support our framework's predictions. However, their magnitudes are smaller than one might reasonably expect for $1/r$ and $-1/r$, respectively.

The deviations from our framework's predictions may be explained by three econometric complications that are addressed by a later cross-sectional analysis. The panel regression's first econometric complication arises from the errors-in-variables defined by $R_y - E[R_y]$ and

[11] To clarify, our framework is designed to produce operating efficiency measures that replace Tobin's q as a dependent variable in empirical tests that examine the impact of corporate governance on firm performance, as in equation (22). In this intended specification, where our operating efficiency measures serve as a dependent variable, the errors-in-variables associated with $R_y$ and $R_c$ does not bias the coefficients. Indeed, our framework is not developed to facilitate explicit hypothesis tests regarding $\beta_y$ and $\beta_c$ in equation (20).

$R_c - E[R_c]$. The appendix illustrates that the $\beta_y$ and $\beta_c$ coefficients are biased towards zero and may proxy for each other depending on the relative variability of these errors. A second econometric complication arises from variation in $E[R_y]$ and $E[R_c]$ over time, which may indicate a violation of the assumption that cash flows are a martingale. A third econometric complication arises from investment frictions that create deviations between observed and optimal operating efficiency. These investment frictions imply that immediately remedying a scale or cost inefficiency is not optimal.

## 3.2 Long-Term Operating Performance

To mitigate the econometric complications of the panel regression, we estimate a cross-sectional regression using the time series average of $R_y$ and $R_c$ at the firm-level. These firm-level time series averages mitigate the errors-in-variables problem and provide more robust estimates since cash flow in a single period is replaced by its long-term average. Temporary deviations from optimality induced by investment frictions are also addressed by using firm-level time series averages. To ensure these averages at the firm-level are meaningful, we limit our analysis to firms with at least 10 annual observations. This reduces our sample to approximately 30% of the original firms, which have approximately 70% of the original firm-year observations.[12]

In the following cross-sectional regression, firm-level time series averages are denoted by bar superscripts

$$\bar{q}_i = \beta_y \bar{R}_{y,i} + \beta_c \bar{R}_{c,i} + \epsilon_i \,. \tag{21}$$

A positive $\beta_y$ coefficient in this specification demonstrates the robustness of our conclusion that underinvestment inflates Tobin's q.

The discounted expected aggregate cash flow in equation (5) is the appropriate numerator for Tobin's q. This aggregate discounted expectation can be approximated by a linear combination of $R_y$ and $R_c$ plus a constant term. Thus, our earlier panel regression contained industry fixed effects. However, as the firm-level time series averages are closer to long-term average discounted expectations, these fixed effects are unnecessary in the cross-sectional regression.

The $\beta_y$ coefficients for $\bar{R}_y$ in Table 3 are consistently positive across all three denominators. Specifically, with total assets in the denominator of our operating efficiency measures,

[12]Because the filter eliminates firms with fewer than ten observations and retains those with more observations, the proportionate reduction in the number of firm-year observations is far less than the proportionate reduction in the number of firms. By conditioning on the number of observations available during the entire sample period, this filter may induce a slight "forward-looking" bias.

the $\beta_y$ coefficient equals 5.3990 ($t$-statistic of 16.36), which is closer to a reasonable estimate of $1/r$. For example, as a 20% cost of capital implies that 1/r equals 5, the 5.3990 coefficient indicates that the cross-sectional regression mitigates the econometric complications associated with the panel regression. Furthermore, with total assets and PPE in the denominator of $\bar{R}_c$, the $\beta_c$ coefficients are also negative. In particular, with total assets in the denominator, $\beta_c$ equals -2.8271 ($t$-statistic of -4.57).

Our framework is not intended to provide a complex structural model that perfectly describes the impact of managerial decisions regarding scale and cost discipline on Tobin's q. Moreover, our estimation is based on 10 to 30 years of annual data, not an infinite amount of data, and the cross-sectional regression is also subject to econometric issues such as selection bias. Nonetheless, despite its simplicity, our theoretical framework allows us to confidently conclude that underinvestment inflates Tobin's q based on the positive $\beta_y$ coefficients. A more complicated framework with dynamic cash flows and capital accumulation would not enable Tobin's q to escape our critique. Instead, incorporating these dynamics into our framework would produce operating efficiency measures that are more complicated to estimate and very sensitive to the exact specification of these dynamics.

Overall, the coefficients in Table 3 from the cross-sectional regression are more consistent with our framework's predictions than the panel regression coefficients in Table 2. This improvement suggests that deviations between the panel regression coefficients and the predictions of our framework can be attributed to errors-in-variables, cash flow dynamics, and investment frictions; all of which are mitigated by using firm-level time series averages in lieu of firm-year observations.

Further evidence that we have identified the sources of the bias can be found by examining firm-level persistence in operating efficiency relative to a firm's industry peers. Every year, firms are sorted into poor, average, or good operating efficiency portfolios according to whether their $R_y$ (or $R_c$) measure is in the top, middle, or bottom tercile, respectively, relative to their industry peers. Consecutive transitions among these relative scale efficiency portfolios are then computed and summarized in a transition matrix.

Both $R_y$ and $R_c$ are persistent since the diagonal elements of the transition matrices are close to 1 in Panel A and Panel B of Table 4, respectively. This persistence is consistent with using firm-level time series averages to mitigate the econometric complications confronting our earlier panel regression.[13] For example, with errors-in-variables, the transitions

[13]The persistence of firm-level operating efficiency is compatible with our intention to provide firm performance proxies for tests involving corporate governance proxies that are also persistent at the firm level. Indeed, the persistence of firm-level governance proxies, such as the G index, justifies using long-term average operating efficiency when studying the relation between governance and firm performance.

are attributable to statistical variation around long-term average operating efficiency. Alternatively, with investment frictions, the transitions result from temporary shocks to the firm's optimal scale or cost discipline that the firm correctly ignores. Although the transition matrices are unable to distinguish between the effects of different econometric complications, the transition matrices confirm the bias inherent in the panel regression coefficients.

## 3.3 Are the Operating Efficiency Measures Distinct?

Having two types of operating efficiency measures instead of one has both advantages and disadvantages. Although a single measure might lead to more definite statements regarding the impact of governance on firm performance, having multiple measures allows researchers to determine whether a particular governance change improves one aspect of firm performance more than another. Nonetheless, whether the scale-based and cost-based operating efficiency measures convey distinct information regarding firm performance, or alternatively can be aggregated into a single measure, is an interesting question.

In theory, there is no general method for aggregating the scale-based and cost-based operating efficiency measures. Recall from the previous section that the firm value lost to underinvestment is quadratic in $y - y^*$ but linear in $c - c_0$. As these parameters (along with $a$) are unknown, the sum of $R_y$ and $R_c$ does not create a measure of "total" inefficiency.

Our empirical findings also offer an interesting perspective on the distinctiveness of $R_y$ versus $R_c$. In Panel B of Table 1, the correlation between these operating efficiency measures (with the book value of total assets in their denominator) is reported as 0.719. Although one might conclude that both these proxies indicate the same approximate level of firm performance, the distinction between feasible inefficiency versus managerial decisions to be inefficient is relevant. A firm's survival requires that $R_y \geq R_c$ over the long term. If $R_y$ is low, then a high $R_c$ measure is infeasible, or at least unsustainable in the long term.[14] Thus, a low $R_y$ is likely to coincide with a low $R_c$, and induce a positive correlation between the two operating efficiency measures. Conversely, weak product market competition and valuable intangible assets can increase a firm's gross margin and enable its managers to be less disciplined at controlling costs. Therefore, while the positive correlation may seem to imply that $R_y$ can proxy for $R_c$, the correlation actually captures the feasibility of having lax cost discipline.

Although certain managers could choose to operate at an inefficient scale in order to

[14] After applying the filter that requires at least 10 years of data, there are only 13 violations of the $\bar{R}_y > \bar{R}_c$ inequality based on firm-level time series averages out of 5,016 firms, with these violations arising from a negative time series average for scale efficiency.

exert less effort at controlling costs, the feasibility constraint affects low margin firms rather than high margin firms. Therefore, we estimate equation (20) within portfolios formed by sorting firms according to $R_y$ (gross margin scaled by the book value of total assets). According to the feasibility constraint, the range of $R_c$ (and $R_y$, which is positive) is narrow when $R_y$ is small. Thus, the severity of the errors-in-variables problem can vary across the portfolios. Furthermore, $R_c$ can proxy for $R_y$ when $R_y$ is small. The appendix demonstrates this possibility depending on the relative variability of the errors associated with $R_c$ and $R_y$.

The panel regression results in Panel A of Table 5 indicate that the signs of $\beta_y$ and $\beta_c$ in the low margin portfolios are the opposite of those predicted by our framework (or insignificant). However, the $\beta_y$ coefficients increase monotonically from the low to high gross margin portfolios. Indeed, as predicted by our theoretical framework, the positive relation between $R_y$ and Tobin's q is significant among all but low gross margin firms, while the negative relation between $R_c$ and Tobin's q predicted by our framework applies to firms with sufficiently high gross margins to sustain lax cost discipline. Intuitively, stringent cost discipline does increase Tobin's q when lax cost discipline is feasible.

Consistent with the cross-sectional regression specification mitigating the econometric complications confronting the panel regression, the results in Panel B of Table 5 indicate that $\beta_y$ increases monotonically and $\beta_c$ decreases monotonically from the low to high margin portfolio.[15] With total assets in the denominator of the operating efficiency measures, the $\beta_y$ coefficients vary from 4.6110 to 5.5216, which is consistent with their predicted value of 1/r, while $\beta_c$ is -3.7862 in the high margin portfolio. Indeed, high margin firms, with the largest values of Tobin's q, conform closely to the predictions of our framework.

Furthermore, the $\beta_y$ coefficients are non-negative in every specification. While $\beta_c$ continues to be positive in the low margin portfolios, this coefficient is negative and close to $-\beta_y$ in the high margin portfolios (with the usual caveat that $\beta_c$ cannot be interpreted with sales in the denominator of the cost-based operating efficiency measure). Recall that $R_c$ can proxy for $R_y$ in the low margin portfolio.

Overall, we find no evidence that Tobin's q is a valid proxy for firm performance. The use of Tobin's q as a proxy for firm performance requires the inverse relation between cost-based efficiency and Tobin's q to dominate the relation between scale-based efficiency and Tobin's q. In contrast, our empirical evidence demonstrates that the impact of scale decisions cannot be ignored as underinvestment inflates Tobin's q in nearly all specifications.

[15] The requirement that firms have at least 10 annual observations eliminates firms that violate the feasibility constraint and firms operating in industries that consolidate in order to reduce overinvestment.

## 3.4 Robustness Tests

Our first robustness test analyzes the relation between Tobin's q and scale-based operating efficiency across firms with different levels of intangible assets normalized by total assets. This robustness test addresses the possibility that measurement error surrounding the valuation of intangible assets is driving our results. For example, $R_y$ is larger when intangible assets on the balance sheet are undervalued. However, market participants may assign higher valuations to intangible assets, and increase Tobin's q as a consequence. Thus, the undervaluation of intangible assets due to accounting conservatism can induce a positive relation between $R_y$ and Tobin's q.

Financing constraints can also induce the appearance of underinvestment. A separate robustness test sorts firms into high, medium, and low portfolios depending on the average credit rating of their long-term debt. The thresholds for high and low are BBB+ and BB, respectively, as 33.95% and 66.68% of firms have a credit rating equal or above these thresholds. Firms in the high credit rating portfolio are less financially constrained than those in the low credit rating portfolio. Firms with higher credit ratings are also less likely to have experienced asset write-downs that can potentially induce the spurious appearance of underinvestment.

The results in Panel A of Table 6 indicate that the $\beta_y$ coefficients are positive across portfolios with different levels of intangible assets normalized by total assets. The $\beta_y$ coefficients exhibit a similar pattern when sales normalize gross margins. Overall, the impact of underinvestment on Tobin's q does not appear to be driven by intangible assets. In particular, the impact of scale-based operating efficiency on Tobin's q is not limited to firms with high intangible assets whose intellectual property (patents for example) provides monopoly rents. Furthermore, a positive $\beta_y$ coefficient is obtained in the low intangible asset portfolio, which mitigates the concern that the positive relation between $R_y$ and Tobin's q is the result of accountants valuing intangible assets more conservatively than investors.

Panel B of Table 6 indicates that firms with low debt ratings, hence financially constrained firms, are not responsible for the positive relation between $R_y$ and Tobin's q. In contrast to the financing constraint hypothesis, firms with high credit ratings have larger $\beta_y$ coefficients than their counterparts with low credit ratings. Specifically, when total assets normalize gross margins, the $\beta_y$ coefficient is 6.2904 ($t$-statistic of 12.60) in the portfolio of firms with high credit ratings versus 1.8515 ($t$-statistic of 5.02) in the low credit rating portfolio. Firms without credit ratings are included in the "No" column. Underinvestment in these unrated firms, which are likely to be the most financially constrained, exerts the weakest impact on Tobin's q.

Similarly, the $R^2$ measures decline from 0.511 to 0.107 across the high to no credit rating portfolios. Thus, poor scale efficiency explains more variation in Tobin's q among firms with a high credit rating than in firms with a low credit rating or no credit rating. These findings are confirmed with sales in the denominator of the operating efficiency measures. The empirical evidence in Panel B is consistent with John and Litov (2010)'s conclusion that high credit ratings partially reflect managerial conservatism regarding investment.

Our next analysis estimates the cross-sectional regression in equation (21) within each intangible asset and debt rating portfolio. The results in Panel C and Panel D, respectively, provide further support for our framework's theoretical predictions. Specifically, with total assets in the denominator of our operating efficiency measures, the $\beta_y$ coefficients are consistently positive for the time series averages of $R_y$, while the $\beta_c$ coefficients for the time series averages of $R_c$ are consistently negative. In particular, with total assets in the denominator of our operating efficiency measures, Panel C indicates that $\beta_y$ ranges from 5.7368 to 5.9005 across the intangible asset portfolios while $\beta_c$ ranges from -3.0329 to -3.7347. Thus, $\beta_y$ and $\beta_c$ are both close to the absolute value of 1/r. Similarly, Panel D indicates that $\beta_y$ ranges from 5.3336 to 8.6150 across the debt rating portfolios, with $\beta_c$ being closer to $-\beta_y$ than in the panel regression.

## 3.5 Is Operating Efficiency Different From Tobin's q?

Besides documenting a problem with the traditional use of Tobin's q as a proxy for firm performance, we have proposed new proxies for firm performance that are theoretically motivated. However, the question remains: does it matter whether one uses Tobin's q or our operating efficiency measures as a proxy for firm performance when investigating its relation with governance? Our next analysis demonstrates that the chosen proxy for firm performance does matter.

Tobin's q is often used as a proxy for firm performance in the corporate governance literature. Yermack (1996) analyzes board performance using Tobin's q while Anderson and Reeb (2003) employ Tobin's q to examine the governance of family firms. To assess the economic importance of the operating efficiency measures, we examine whether the relation between the G index of Gompers, Ishii, and Metrick (2003) and firm performance is sensitive to replacing Tobin's q with these theoretically-motivated proxies for firm performance.

To clarify, our critique of Tobin's q pertains to its use as a proxy for firm performance, hence as a dependent variable in regressions that have proxies for corporate governance as independent variables. The errors-in-variables problem is not an issue when our operating efficiency measures are used as dependent variables in studies of corporate governance since their errors are captured by the regression's error terms.

The G index is obtained from the Investor Responsibility Research Center (IRRC) starting in 1990 every three years until 1998 when it becomes available every two years. The G index assigns firms a score between zero and twenty-four by counting the number of their charter provisions that inhibit the replacement of management. Therefore, a higher G index corresponds to greater managerial entrenchment.[16]

We evaluate the influence of the G index on $R_y$ using the following panel regression

$$R_{y,i,t} \quad = \quad \alpha\, \mathrm{G}_{i,t} + \gamma\, X + \epsilon_{i,t}\,, \tag{22}$$

where the $X$ vector contains industry and year fixed effects. Standard errors are clustered at the industry-level. Besides $R_y$, this regression is also estimated with Tobin's q as the dependent variable, as in Gompers, Ishii, and Metrick (2003), and $R_c$ as the dependent variable.

For emphasis, our framework does not specify an explicit function between governance and output. Moreover, conclusions based on equation (22) are derived from a joint hypothesis involving the ability of the G index to adequately proxy for corporate governance.[17] While our operating efficiency measures circumvent the endogeneity confounding Tobin's q, Hermalin and Weisbach (2003) document the endogeneity of corporate governance mechanisms. For example, board characteristics and firm performance can be linked through their common dependence on past performance (Hermalin and Weisbach, 1988).

Table 7 reports on the coefficient estimates from equation (22). To begin with, the inverse relation between Tobin's q and the G index reported in Gompers, Ishii, and Metrick (2003) is present in our sample since the $\alpha$ coefficient is -0.0236 ($t$-statistic of -4.62).

With our operating efficiency measures as the dependent variable, positive $\alpha$ coefficients are consistent with the hypothesis that a higher G index (more entrenchment) corresponds to worse operating efficiency. However, when $R_y$ replaces Tobin's q as the dependent variable, the $\alpha$ coefficients are found to be insignificant or negative. Thus, a higher G index (more entrenchment) is not associated with worse operating efficiency. Specifically, the coefficient

[16] Although the G index fails to capture external governance mechanisms such as the market for corporate control (Shleifer and Vishny, 1986), Giroud and Mueller (2011) highlight the 0.68 correlation between the G index and the takeover index of Cremers and Nair (2005). Giroud and Mueller (2011) also document the 0.71 correlation between the G index and the simplified governance index of Bebchuk, Cohen, and Ferrell (2009) that is based on a subset of six charter provisions.

[17] Bates, Becher, and Lemmon (2008) report that classified boards, a charter provision included in the G index, exert an insignificant influence on the market for corporate control. Thus, external governance is not necessarily inhibited by a higher G index. Furthermore, Low (2009) reports that managerial entrenchment can be partially overcome through additional stock options.

is insignificant ($t$-statistic of -1.11) when the book value of total assets normalize gross margins but negative when sales ($t$-statistic of -3.82) or PPE ($t$-statistic of -4.04) are in the denominator of $R_y$.

Replacing $R_y$ with $R_c$ as the dependent variable produces an insignificant $\alpha$ coefficient whose $t$-statistic is -0.25 when total assets is the denominator. Therefore, while a negative relation between Tobin's q and $R_c$ justifies the use of Tobin's q as a proxy for firm performance, $R_c$ itself is not sensitive to governance. Moreover, the -0.0521 coefficient for $R_c$ with PPE in the denominator ($t$-statistic of -3.35) indicates that greater managerial entrenchment improves instead of weakens cost discipline. Nonetheless, the coefficients for $R_y$ are at least twice as large as those for $R_c$.

In conjunction with the positive relation between Tobin's q and $R_y$, the negative $\alpha$ coefficients in equation (22) suggest that using Tobin's q as a proxy for firm performance induces a spurious conclusion that firms with lower G indices have better firm performance. Specifically, while a lower G index is associated with a higher Tobin's q, the higher Tobin's q is attributable to greater underinvestment. Intuitively, managers may be more willing to expand output until firm value is maximized if they are afforded certain protections against their replacement. These protections are especially important if investors cannot differentiate between negative demand shocks and poor management. By reducing the career concerns of management, Aghion, Van Reenen, and Zingales (2013) find that institutional investors encourage innovative ("risky") investments, which may increase a firm's scale. Furthermore, facets of governance such as the market for corporate control and managerial incentive compensation that are not captured by the G index can also influence operating efficiency.

However, the interpretation of the coefficients in Table 7 is not central to our analysis. Instead, we use a prominent proxy of governance quality to demonstrate that the relation between corporate governance and firm performance is sensitive to replacing Tobin's q as a proxy for firm performance with our operating efficiency measures.

# 4 Conclusion

We provide a simple theoretical framework to demonstrate that underinvestment confounds the relation between Tobin's q and firm performance. In particular, firm performance has an ambiguous impact on Tobin's q. Better firm performance can either decrease or increase Tobin's q depending on the relative importance of scale decisions versus cost discipline, respectively. In contrast, the existing literature's assumption that a higher Tobin's q is evidence of better firm performance ignores the impact of managerial scale decisions. In particular, the existing literature does not account for the possibility that underinvestment is inflating Tobin's q.

Our framework develops two theoretically-motivated measures of operating efficiency that provide unambiguous proxies for firm performance. The first measure assesses managerial decisions regarding scale, while the second measure assesses managerial cost discipline. These operating efficiency measures are derived from the maximization of firm value net of invested capital, hence the maximization of a firm's net present value.

Our empirical results indicate that better firm performance is not associated with a higher Tobin's q. This finding is consistent with underinvestment's ability to inflate Tobin's q, and contradicts the prior literature's assumption that a higher Tobin's q is evidence of better firm performance. The positive impact of poor scale decisions on Tobin's q is robust to controls for lax cost discipline, intangible assets, financial constraints, and investment frictions as well as cash flow and investment dynamics. In summary, our statistical tests caution that a higher Tobin's q is not evidence of better firm performance.

Regarding our framework's economic importance, the inverse relation in Gompers, Ishii, and Metrick (2003) between their G index and Tobin's q can be attributed to underinvestment being more severe in firms with lower G indices. Therefore, the relation between firm performance and corporate governance is sensitive to the chosen proxy for firm performance.

Important questions remain for future research. The prior literature often uses Tobin's q (as well as return on assets and return on equity) as a proxy for firm performance. A re-examination of these results using our operating efficiency measures may be warranted based on our theoretical framework and empirical results. Furthermore, our most reliable empirical results are based on the time-series averages of these measures, which raises an important question regarding the delayed impact of managerial decisions on future cash flows. Specifically, when to evaluate firm performance is an important question, which is common to most studies that examine reactions to a change.

In summary, the relation between governance and firm performance remains an important topic for future research that can only be addressed with appropriate proxies for firm performance. Our contribution is to provide theoretically-motivated proxies for firm performance that facilitate this future research.

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# Appendix

Tobin's q is defined in equation (19) as

$$q \;=\; \frac{1}{r}\left(E\left[R_y\right]-E\left[R_c\right]\right). \tag{23}$$

Assume the following variance-covariance matrix for expected operating efficiency

$$\mathrm{COV}\left(E\left[R_y\right],E\left[R_c\right]\right)=\begin{pmatrix}\sigma_y^2 & \sigma_{y,c}\\ \sigma_{y,c} & \sigma_c^2\end{pmatrix}.$$

Further assume the following variance-covariance matrix for the "errors" in the independent variables of the panel regression in equation (20)

$$\mathrm{COV}\left(R_y-E\left[R_y\right],R_c-E\left[R_c\right]\right)=\begin{pmatrix}\nu_y^2 & \nu_{y,c}\\ \nu_{y,c} & \nu_c^2\end{pmatrix}.$$

The covariance matrix for Tobin's q and the observed operating efficiency measures equals

$$\mathrm{COV}\left(q,R_y,R_c\right) \;=\; \begin{pmatrix}\frac{\sigma_y^2+\sigma_c^2-2\,\sigma_{y,c}}{r^2} & \frac{\sigma_y^2-\sigma_{y,c}}{r} & \frac{-\sigma_c^2+\sigma_{y,c}}{r}\\ \frac{\sigma_y^2-\sigma_{y,c}}{r} & \sigma_y^2+\nu_y^2 & \sigma_{y,c}+\nu_{y,c}\\ \frac{-\sigma_c^2+\sigma_{y,c}}{r} & \sigma_{y,c}+\nu_{y,c} & \sigma_c^2+\nu_c^2\end{pmatrix}. \tag{24}$$

The errors-in-variables problem arises from conditioning on $R_y$ and $R_c$ instead of $E\left[R_y\right]$ and $E\left[R_c\right]$, respectively. Ignoring industry and time fixed effects, the $\beta$ vector implied by the variance-covariance matrix in (24) equals

$$\begin{aligned}\beta \;&=\; \begin{pmatrix}\sigma_y^2+\nu_y^2 & \sigma_{y,c}+\nu_{y,c}\\ \sigma_{y,c}+\nu_{y,c} & \sigma_c^2+\nu_c^2\end{pmatrix}^{-1}\begin{pmatrix}\frac{\sigma_y^2-\sigma_{y,c}}{r}\\ \frac{-\sigma_c^2+\sigma_{y,c}}{r}\end{pmatrix}\\ &=\; \frac{1}{D}\begin{pmatrix}\sigma_c^2+\nu_c^2 & -\left(\sigma_{y,c}+\nu_{y,c}\right)\\ -\left(\sigma_{y,c}+\nu_{y,c}\right) & \sigma_y^2+\nu_y^2\end{pmatrix}\begin{pmatrix}\frac{\sigma_y^2-\sigma_{y,c}}{r}\\ \frac{-\sigma_c^2+\sigma_{y,c}}{r}\end{pmatrix},\end{aligned}$$

where

$$D \;=\; \left(\sigma_y^2+\nu_y^2\right)\left(\sigma_c^2+\nu_c^2\right)-\left(\sigma_{y,c}+\nu_{y,c}\right)^2. \tag{25}$$

Thus, the individual $\beta_y$ and $\beta_c$ coefficients are

$$\beta_y \;=\; \frac{\left(\sigma_c^2+\nu_c^2\right)\left(\sigma_y^2-\sigma_{y,c}\right)+\left(\sigma_{y,c}+\nu_{y,c}\right)\left(\sigma_c^2-\sigma_{y,c}\right)}{rD} \tag{26}$$

$$\beta_c \;=\; \frac{-\left(\sigma_y^2+\nu_y^2\right)\left(\sigma_c^2-\sigma_{y,c}\right)-\left(\sigma_{y,c}+\nu_{y,c}\right)\left(\sigma_y^2-\sigma_{y,c}\right)}{rD}. \tag{27}$$

Observe that the $\beta_y$ and $\beta_c$ coefficients equal $1/r$ and $-1/r$, respectively, in the absence of the errors-in-variables problem ($\nu_y^2 = \nu_c^2 = \nu_{y,c} = 0$). The inconsistency of the $\beta$ coefficients due to their bias towards zero is known as the attenuation bias. Equation (26) implies that the inequality $\beta_y \leq 1/r$ is equivalent to

$$\nu_y^2\sigma_c^2 + \nu_c^2\sigma_{y,c} + \nu_y^2\nu_c^2 \quad \geq \quad \nu_{y,c}\sigma_c^2 + \nu_{y,c}\sigma_{y,c} + \nu_{y,c}^2 \,. \tag{28}$$

The variance-covariance matrix for the errors requires $\nu_{y,c} \leq \nu_y\nu_c$, which reduces equation (28) to

$$\nu_y^2\sigma_c^2 + \nu_c^2\sigma_{y,c} \quad \geq \quad \nu_{y,c}\sigma_c^2 + \nu_{y,c}\sigma_{y,c} \,. \tag{29}$$

The properties $\nu_{y,c} \leq \nu_c^2$ and $\nu_{y,c} \leq \nu_y^2$ imply the inequality in equation (29) is satisfied. Furthermore, the greater the variance of the $R_y - E[R_y]$ and $R_c - E[R_c]$ errors, the more $\beta_y$ is biased toward zero.

If the errors in the independent variables are uncorrelated, $\nu_{y,c} = 0$, equation (28) is satisfied provided the covariance, $\sigma_{y,c}$, is positive. This covariance is expected to be positive since firms with lower gross margins require more stringent cost discipline to survive.

Similarly, the inequality $\beta_c \geq -1/r$ that implies $\beta_c$ is biased toward zero is satisfied provided

$$\nu_c^2\sigma_y^2 + \nu_y^2\sigma_{y,c} \quad \geq \quad \nu_{y,c}\sigma_y^2 + \nu_{y,c}\sigma_{y,c} \,. \tag{30}$$

The same properties $\nu_{y,c} \leq \nu_c^2$ and $\nu_{y,c} \leq \nu_y^2$ continue to imply the inequality in equation (30). Once again, with independent errors, $\beta_c$ is biased toward zero when $\sigma_{y,c}$ is positive.

Table 1: Summary Statistics and Correlations

Panel A of this table reports summary statistics for the distribution of our operating efficiency measures, $R_y$ and $R_c$, as well as Tobin's q. Tobin's q and the operating efficiency measures are constructed using COMPUSTAT data. The numerator of Tobin's q is computed as the book value of total assets plus the market value of equity minus the book value of equity. The denominator of Tobin's q is the book value of total assets. The numerator of $R_y$ and $R_c$ are gross margins, defined as sales minus cost of goods sold, and operating expenses, respectively. Operating expenses are defined as sales, general, and administrative expenses minus advertising and R&D expenditures. The denominator of the operating efficiency measures is either the book value of total assets (TA), sales, or property, plant, and equipment (PPE). Cross-sectional correlations between our operating efficiency measures and Tobin's q are reported in Panel B. These correlations represent average within-industry correlations. Specifically, the correlation matrix is first computed within each industry and then averaged element-by-element across all the industries.

Panel A: Summary statistics

| | | | Percentiles | | | |
|---|---|---|---|---|---|---|
| | Mean | 25th | 50th | 75th | Std. Dev. | Observations |
| $R_y$ TA | 0.396 | 0.219 | 0.356 | 0.528 | 0.250 | 133,474 |
| $R_y$ Sales | 0.368 | 0.239 | 0.352 | 0.506 | 0.506 | 133,474 |
| $R_y$ PPE | 3.238 | 0.615 | 1.595 | 3.630 | 5.015 | 133,474 |
| $R_c$ TA | 0.266 | 0.108 | 0.213 | 0.361 | 0.215 | 133,474 |
| $R_c$ Sales | 0.314 | 0.122 | 0.204 | 0.316 | 0.907 | 133,474 |
| $R_c$ PPE | 2.414 | 0.328 | 1.002 | 2.582 | 4.642 | 133,474 |
| Tobin's q | 1.759 | 1.025 | 1.346 | 1.999 | 1.249 | 133,474 |

Panel B: Correlations

| | $R_y$ TA | $R_y$ Sales | $R_y$ PPE | $R_c$ TA | $R_c$ Sales | $R_c$ PPE | Tobin's q |
|---|---|---|---|---|---|---|---|
| $R_y$ TA | 1 | | | | | | |
| $R_y$ Sales | 0.434 | 1 | | | | | |
| $R_y$ PPE | 0.459 | 0.192 | 1 | | | | |
| $R_c$ TA | 0.719 | 0.210 | 0.388 | 1 | | | |
| $R_c$ Sales | 0.186 | 0.351 | 0.142 | 0.532 | 1 | | |
| $R_c$ PPE | 0.323 | 0.087 | 0.819 | 0.533 | 0.360 | 1 | |
| Tobin's q | 0.177 | 0.159 | 0.140 | 0.090 | 0.088 | 0.076 | 1 |

Table 2: Panel Regression of Tobin's q on Operating Efficiency

This table reports on the relation between Tobin's q and operating efficiency by recording the panel regression coefficients from equation (20), $q_{i,t} = \beta_y R_{y,i,t} + \beta_c R_{c,i,t} + \gamma X + \epsilon_{i,t}$. The $X$ vector represents industry and year fixed effects. A positive $\beta_y$ coefficient indicates that underinvestment increases Tobin's q. Below each regression coefficient, $t$-statistics are reported in italics with standard errors clustered at the industry-level. Lower values of $R_y$ with $R_c$ correspond to better operating efficiency, hence better firm performance. COMPUSTAT data is used to construct our operating efficiency measures and Tobin's q. The numerator of Tobin's q is computed as total assets plus the market value of equity minus the book value of equity. The denominator of Tobin's q is the book value of total assets while the denominator of the operating efficiency measures is either the book value of total assets (TA), sales, or property, plant, and equipment (PPE). The numerator of $R_y$ and $R_c$ are gross margins, defined as sales minus cost of goods sold, and operating expenses, respectively. Operating expenses are defined as sales, general, and administrative expenses minus advertising and R&D expenditures.

| | | | | |
|---|---|---|---|---|
| $R_y$ | TA | 0.6942*** | | |
| | | *3.64* | | |
| $R_c$ | TA | -0.0199 | | |
| | | *-0.08* | | |
| $R_y$ | Sales | | 0.2554 | |
| | | | *1.60* | |
| $R_c$ | Sales | | 0.1768* | |
| | | | *1.99* | |
| $R_y$ | PPE | | | 0.0193*** |
| | | | | *2.92* |
| $R_c$ | PPE | | | 0.0030 |
| | | | | *0.35* |
| Observations | | 133,474 | 133,474 | 133,474 |
| Adj. $R^2$ | | 0.111 | 0.114 | 0.104 |

Table 3: Cross-Sectional Regression of Tobin's q on Operating Efficiency

This table records the results from a cross-sectional regression based on firm-level time series averages for Tobin's q, $R_y$, and $R_c$. The long-term relation between Tobin's q and operating efficiency is estimated using equation (21), $\bar{q}_i = \beta_y \bar{R}_{y,i} + \beta_c \bar{R}_{c,i} + \epsilon_i$, based on these time series averages. Each firm in this cross-sectional regression is required to have at least ten years of annual data. A positive $\beta_y$ coefficient indicates that underinvestment is increasing Tobin's q. Below each regression coefficient, $t$-statistics are reported in italics with standard errors clustered at the industry-level. Lower values of $R_y$ and $R_c$ correspond to better scale-based and cost-based operating efficiency, respectively, hence better firm performance. COMPUSTAT data is used to construct our operating efficiency measures and Tobin's q. The numerator of Tobin's q is computed as the book value of total assets plus the market value of equity minus the book value of equity. The denominator of Tobin's q is the book value of total assets. The book value of total assets (TA), sales, or property, plant, and equipment (PPE) normalize the gross margins, defined as sales minus cost of goods sold, in the numerator of $R_y$. The numerator of $R_c$ is operating expenses minus expenditures on R&D and advertising.

| | | | | |
|---|---|---|---|---|
| $\bar{R}_y$ | TA | 5.3990*** | | |
| | | *16.36* | | |
| $\bar{R}_c$ | TA | -2.8271*** | | |
| | | *-4.57* | | |
| $\bar{R}_y$ | Sales | | 3.0046*** | |
| | | | *11.04* | |
| $\bar{R}_c$ | Sales | | 1.6298*** | |
| | | | *4.34* | |
| $\bar{R}_y$ | PPE | | | 0.3309*** |
| | | | | *5.44* |
| $\bar{R}_c$ | PPE | | | -0.1301* |
| | | | | *-1.97* |
| Observations | | 5,016 | 5,016 | 5,016 |
| Adj. $R^2$ | | 0.742 | 0.814 | 0.426 |

Table 4: Transition Matrices for Operating Efficiency

Panel A reports transition matrices for scale-based operating efficiency ($R_y$) to assess its persistence at the firm level. Every year, within each industry, firms are sorted into poor, average, or good operating efficiency portfolios according to their $R_y$ measure. Consecutive transitions between these relative scale efficiency portfolios are then computed and summarized in a transition matrix from each row to column. Panel B reports these transition matrices for cost-based operating efficiency ($R_c$) to assess its persistence from row to column. COMPUSTAT data is used to construct our operating efficiency measures. The book value of total assets (TA), sales, as well as property, plant, and equipment (PPE) provide three proxies for capital in the denominator of our operating efficiency measures. Gross margin, defined as sales minus cost of goods sold, is the numerator of $R_y$. The numerator of $R_c$ is operating expenses minus expenditures on R&D and advertising. Lower values of $R_y$ and $R_c$ correspond to better scale-based and cost-based operating efficiency, respectively, hence better firm performance.

Panel A: Transition matrices for scale efficiency

| | $R_y$ TA | | | $R_y$ Sales | | | $R_y$ PPE | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poor | Average | Good | Poor | Average | Good | Poor | Average | Good |
| Poor | 78.94% | 18.54% | 2.52% | 86.10% | 12.54% | 1.36% | 83.41% | 15.03% | 1.56% |
| Average | 19.03% | 64.93% | 16.03% | 12.96% | 76.59% | 10.45% | 14.36% | 71.44% | 14.20% |
| Good | 3.07% | 17.20% | 79.72% | 1.38% | 10.78% | 87.85% | 1.92% | 13.68% | 84.41% |

Panel B: Transition matrices for cost efficiency

| | $R_c$ TA | | | $R_c$ Sales | | | $R_c$ PPE | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poor | Average | Good | Poor | Average | Good | Poor | Average | Good |
| Poor | 85.96% | 12.98% | 1.06% | 87.57% | 11.30% | 1.13% | 89.10% | 10.38% | 0.52% |
| Average | 13.02% | 73.17% | 13.81% | 10.86% | 76.27% | 12.86% | 9.46% | 79.15% | 11.39% |
| Good | 1.36% | 13.61% | 85.03% | 1.04% | 12.34% | 86.62% | 0.85% | 10.41% | 88.73% |

Table 5: Interaction between Operating Efficiency Measures

This table examines the interaction between the operating efficiency measures. COMPUSTAT data is used to construct our operating efficiency measures and Tobin's q. The numerator of Tobin's q is computed as the book value of total assets plus the market value of equity minus the book value of equity. The denominator of Tobin's q is the book value of total assets, while the denominator of the operating efficiency measures is either the book value of total assets (TA), sales, or property, plant, and equipment (PPE). The numerator of $R_y$ and $R_c$ are gross margins, defined as sales minus cost of goods sold, and operating expenses, respectively. Operating expenses are defined as sales, general, and administrative expenses minus advertising and R&D expenditures. Panel A repeats the panel regression in equation (20) within portfolios formed according to the time series average of each firm's scale-based operating efficiency measure, with the book value of total assets in the denominator. This portfolio-level analysis examines the interaction between our scale-based and cost-based operating efficiency measures in firms with high, medium, and low gross margins (scaled by total assets). The results in Panel B repeat this portfolio-level analysis using the cross-sectional regression in equation (21). Below each regression coefficient, $t$-statistics are reported in italics with standard errors clustered at the industry-level.

Panel A: Panel regression

| | | $R_y$ TA | | | $R_y$ Sales | | | $R_y$ PPE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | Medium | High | Low | Medium | High | Low | Medium | High |
| $R_y$ | TA | -1.2522*** | 1.3387*** | 2.5986*** | | | | | | |
| | | *-2.82* | *8.13* | *11.53* | | | | | | |
| $R_c$ | TA | 2.5533*** | -0.0886 | -2.3267*** | | | | | | |
| | | *12.01* | *-0.37* | *-10.35* | | | | | | |
| $R_y$ | Sales | | | | 0.0852 | 1.5774*** | 3.3997*** | | | |
| | | | | | *1.33* | *6.55* | *11.42* | | | |
| $R_c$ | Sales | | | | 0.1366* | 0.1997 | -2.1924*** | | | |
| | | | | | *1.84* | *1.26* | *-6.34* | | | |
| $R_y$ | PPE | | | | | | | -0.0230** | 0.0262** | 0.0942*** |
| | | | | | | | | *-2.48* | *2.65* | *5.85* |
| $R_c$ | PPE | | | | | | | 0.0349*** | -0.0076 | -0.1159*** |
| | | | | | | | | *3.09* | *-0.61* | *-5.38* |
| Observations | | 44,492 | 44,491 | 44,491 | 44,492 | 44,491 | 44,491 | 44,492 | 44,491 | 44,491 |
| Adj. $R^2$ | | 0.179 | 0.105 | 0.175 | 0.135 | 0.149 | 0.189 | 0.125 | 0.106 | 0.133 |

Panel B: Cross-sectional regression

| | | $\bar{R}_y$ TA | | | $\bar{R}_y$ Sales | | | $\bar{R}_y$ PPE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | Medium | High | Low | Medium | High | Low | Medium | High |
| $\bar{R}_y$ | TA | 4.6110*** | 5.1533*** | 5.5216*** | | | | | | |
| | | *13.77* | *15.81* | *19.45* | | | | | | |
| $\bar{R}_c$ | TA | 4.0322*** | -1.2177* | -3.7862*** | | | | | | |
| | | *6.83* | *-1.85* | *-8.34* | | | | | | |
| $\bar{R}_y$ | Sales | | | | 2.6236*** | 3.8419*** | 4.4937*** | | | |
| | | | | | *9.59* | *14.39* | *14.19* | | | |
| $\bar{R}_c$ | Sales | | | | 1.7076*** | 0.7320** | -0.5462 | | | |
| | | | | | *5.02* | *2.47* | *-1.26* | | | |
| $\bar{R}_y$ | PPE | | | | | | | 0.0981 | 0.4066*** | 0.4217*** |
| | | | | | | | | *0.84* | *4.82* | *6.36* |
| $\bar{R}_c$ | PPE | | | | | | | 0.1804** | -0.1751* | -0.2779*** |
| | | | | | | | | *2.11* | *-1.86* | *-3.58* |
| Observations | | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 |
| Adj. $R^2$ | | 0.781 | 0.842 | 0.821 | 0.735 | 0.852 | 0.853 | 0.201 | 0.479 | 0.555 |

Table 6: Robustness Tests

This table examines the robustness of the relation between Tobin's q and underinvestment across different firms. The panel regression coefficients are from equation (20). A positive $\beta_y$ coefficient indicates that underinvestment is increasing Tobin's q. Panel A examines firms with high, medium, and low levels of intangible assets, which are normalized by the book value of total assets. Firms with non-positive intangible assets are removed from the sample. Panel B examines portfolios formed according to the long-term debt ratings of individual firms. The low and high thresholds are determined by BBB+ and BB thresholds, respectively. Below each regression coefficient, *t*-statistics are reported in italics with standard errors clustered at the industry-level. Lower values of $R_y$ and $R_c$ correspond to better scale-based and cost-based operating efficiency, respectively, hence better firm performance. COMPUSTAT data is used to construct our operating efficiency measures and Tobin's q. The numerator of Tobin's q is computed as the book value of total assets plus the market value of equity minus the book value of equity. The denominator of Tobin's q is the book value of total assets. The book value of total assets (TA), sales, or property, plant, and equipment (PPE) normalize the gross margins, defined as sales minus cost of goods sold, in the numerator of $R_y$. The numerator of $R_c$ is operating expenses minus expenditures on R&D and advertising. The results in Panel C and Panel D, replicate the portfolio methodology using the cross-sectional regression in equation (21) based on the time series averages of each variable for firms with at least ten observations.

Panel A: Panel regression within intangible asset portfolios

| | | Intangible assets | | | Intangible assets | | |
|---|---|---|---|---|---|---|---|
| | | Low | Med | High | Low | Med | High |
| $R_y$ | TA | 0.6158** | 0.9033*** | 0.6161*** | | | |
| | | *2.11* | *3.75* | *4.22* | | | |
| $R_c$ | TA | -0.0028 | -0.2495 | 0.2442 | | | |
| | | *-0.01* | *-0.71* | *1.06* | | | |
| $R_y$ | Sales | | | | 1.1371*** | 1.5126*** | 0.8899*** |
| | | | | | *3.76* | *5.74* | *9.02* |
| $R_c$ | Sales | | | | 0.2653*** | 0.3249*** | 0.3226*** |
| | | | | | *3.29* | *7.36* | *8.41* |
| Observations | | 24,707 | 24,707 | 24,707 | 24,707 | 24,707 | 24,707 |
| Adj. $R^2$ | | 0.133 | 0.122 | 0.094 | 0.164 | 0.169 | 0.117 |

Panel B: Panel regression within debt rating portfolios

| | | Debt ratings | | | | Debt ratings | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | High | Med | Low | No | High | Med | Low | No |
| $R_y$ | TA | 6.2904*** | 3.6370*** | 1.8515*** | 0.5268** | | | | |
| | | *12.60* | *9.36* | *5.02* | *2.49* | | | | |
| $R_c$ | TA | -5.6408*** | -3.5361*** | -1.8795*** | 0.0507 | | | | |
| | | *-9.40* | *-7.35* | *-3.63* | *0.20* | | | | |
| $R_y$ | Sales | | | | | 3.4460*** | 1.822** | 0.5409** | 0.2306 |
| | | | | | | *3.96* | *2.64* | *2.41* | *1.56* |
| $R_c$ | Sales | | | | | -2.1893** | -0.8319 | 0.2901*** | 0.1672* |
| | | | | | | *-2.62* | *-1.55* | *3.62* | *1.95* |
| Observations | | 6,841 | 6,594 | 6,714 | 113,325 | 6,841 | 6,594 | 6,714 | 113,325 |
| Adj. $R^2$ | | 0.511 | 0.299 | 0.192 | 0.107 | 0.347 | 0.186 | 0.166 | 0.113 |

Panel C: Cross-sectional regression within intangible asset portfolios

| | | Intangible assets | | | Intangible assets | | |
|---|---|---|---|---|---|---|---|
| | | Low | Med | High | Low | Med | High |
| $\bar{R}_y$ | TA | 5.7368*** | 5.9005*** | 5.8275*** | | | |
| | | *10.18* | *13.09* | *17.16* | | | |
| $\bar{R}_c$ | TA | -3.4340*** | -3.7347*** | -3.0329*** | | | |
| | | *-3.43* | *-4.88* | *-5.43* | | | |
| $\bar{R}_y$ | Sales | | | | 3.5137*** | 3.6877*** | 3.6183*** |
| | | | | | *16.78* | *12.97* | *31.59* |
| $\bar{R}_c$ | Sales | | | | 1.4225*** | 0.8040** | 0.5612*** |
| | | | | | *5.09* | *2.20* | *2.82* |
| Observations | | 793 | 900 | 894 | 793 | 900 | 894 |
| Adj. $R^2$ | | 0.766 | 0.790 | 0.823 | 0.831 | 0.829 | 0.855 |

Panel D: Cross-sectional regression within debt rating portfolios

| | | Debt ratings | | | | Debt ratings | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | High | Med | Low | No | High | Med | Low | No |
| $\bar{R}_y$ | TA | 8.1216*** | 8.5196*** | 8.6150*** | 5.3336*** | | | | |
| | | *6.24* | *17.45* | *9.89* | *16.03* | | | | |
| $\bar{R}_c$ | TA | -6.7695** | -8.2510*** | -8.3774*** | -2.7323*** | | | | |
| | | *-2.83* | *-13.66* | *-6.77* | *-4.40* | | | | |
| $\bar{R}_y$ | Sales | | | | | 3.6897*** | 3.8707*** | 3.0105*** | 3.0090*** |
| | | | | | | *4.76* | *4.37* | *10.19* | *10.89* |
| $\bar{R}_c$ | Sales | | | | | -0.9933 | -0.5386 | 1.4150* | 1.6306*** |
| | | | | | | *-0.64* | *-0.36* | *1.98* | *4.31* |
| Observations | | 32 | 29 | 74 | 4,881 | 32 | 29 | 74 | 4,881 |
| Adj. $R^2$ | | 0.896 | 0.925 | 0.879 | 0.740 | 0.877 | 0.867 | 0.839 | 0.813 |

Table 7: Operating Efficiency Versus Tobin's q

This table reports the influence of the G index (Gompers, Ishii, and Metrick, 2003) on our operating efficiency measures as well as Tobin's q. A lower G index is associated with less managerial entrenchment. Coefficients from the panel regression in equation (22) are reported, $R_{y,i,t} = \alpha \, \mathrm{G}_{i,t} + \gamma \, X + \epsilon_{i,t}$, where the $X$ vector represents industry and year fixed effects. This regression is also repeated with $R_c$ and Tobin's q replacing $R_y$ as the dependent variable. COMPUSTAT data is used to construct our operating efficiency measures and Tobin's q. The numerator of Tobin's q is computed as the book value of total assets plus the market value of equity minus the book value of equity. The denominator of Tobin's q is the book value of total assets. The book value of total assets (TA), sales, or property, plant, and equipment (PPE) normalize the gross margins, defined as sales minus cost of goods sold, in the numerator of $R_y$. The numerator of $R_c$ is operating expenses minus expenditures on R&D and advertising. Lower values of the operating efficiency measures correspond to better operating efficiency, hence better firm performance. Below each regression coefficient, $t$-statistics are reported in italics, with standard errors clustered at the industry-level. Positive coefficients for $R_y$ and $R_c$ indicate that less managerial entrenchment, according to the G index, is associated with better operating efficiency.

| | $R_y$ TA | $R_y$ Sales | $R_y$ PPE | $R_c$ TA | $R_c$ Sales | $R_c$ PPE | Tobin's q |
|---|---|---|---|---|---|---|---|
| | ↓ better operating efficiency | | | | | | |
| G index | -0.0016 | -0.0048*** | -0.1142*** | -0.0003 | -0.0022** | -0.0521*** | -0.0236*** |
| ↑ greater entrenchment | *-1.11* | *-3.82* | *-4.04* | *-0.25* | *-2.40* | *-3.35* | *-4.62* |
| Observations | 7,334 | 7,334 | 7,334 | 7,334 | 7,334 | 7,334 | 7,334 |
| Adj. $R^2$ | 0.355 | 0.345 | 0.279 | 0.408 | 0.152 | 0.311 | 0.129 |