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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Hypothesis that Tobin's q captures organizations' debt levels instead of their growth opportunities and intangible assets

Tiago Cardao-Pito¹*

Abstract: The informational content of prices hypothesis in Modialiani and Miller (and Fisher before them) advocates that organizations' market prices could somehow estimate their growth prospects and intangible assets. For this estimation, discounted cash flow models are frequently employed. However, these models require information about monetary flows and discount rates in the long future, which are most difficult to confirm in the moment of the analysis. Thus, Tobin's q or similar procedures as the market-tobook value of the firm have been claimed (and presupposed) as evidence that markets could identify growth prospects and intangible assets. Indeed, Tobin's g tends to be higher for new and/or intangible intensive firms. Nevertheless, we know that for q > 1, less debt tends to imply a higher q, whereas the inverse holds for the less frequent q < 1. To explain this phenomenon, we propose a "mechanical effect hypothesis" describing an automatic relationship between q and capital structures at the variable computation. Accordingly, as intangible-intensive and/or new firms are likely to have q > 1 and less debt, a mechanical effect increases their q-values without requiring growth perspectives, or intangibles. Hence, this new hypothesis disputes Fisher-Modigliani-Miller's utilization of discounted cash flow models to explain markets and prices.

Tiago Cardao-Pito

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This study disproves one of the most used empirical indicators in economics and finance, namely, Tobin's q. Researchers employ Tobin's q to identify firm's intangible assets and growth opportunities. Indeed, q tends to be higher for intangible-intensive firms (e.g., Alphabet, Meta, ByteDance) and new firms. Thus, many studies are quick to presuppose that firms' q can identify their intangible assets and future growth opportunities. Rather, what Tobin's q has been empirically capturing is firms' debt levels. As intangibleintensive firms and new firms tend to have less debt in their capital structures, a mechanical effect in the computation automatically makes them have a higher q every time that q is higher than 1 (common case). No intangible assets or growth opportunities are required. Given this indicator's prominence, these findings raise questions about the capacity of economic and finance theory to understand firms, markets, prices, intangible assets, and performance.





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Subjects: Business & Policy; Business & Company Law; Organizational Theory & Behavior; Economics; Finance; Business, Management and Accounting; Organizational Studies

Keywords: Tobin's q; growth; intangible assets; capital structure; market-to-book

1. Introduction

In practice, Tobin's q makes a simple comparison between a firm's market and book values. A similar comparison is referred to as market to book of the firm, its inverse the book to market of the firm, or intangible capital. However, Tobin's q applicability in economics and related disciplines, such as finance, accounting or management can be quite extraordinary because q is often used to estimate firms' eventual intangible assets and growth prospects (also denoted to as investment opportunities). Erickson and Whited (2006) refer to Tobin's q as the most widely used quantitative regressor in organizational economics, and as a measure of a firm's incentive to invest (see also, Bartlett & Partnoy, 2020). A high Tobin's q value is usually interpreted as indicating a high level of intangible assets, along with a solid overall current and future operating performance. A low q value is used to suggest the opposite condition.¹

To make matters even further complicated, Tobin's q indeed tends to be higher for firms that are intangible intensive and/or relatively new, as if capable of capturing their eventually higher intangible assets and growth prospects. The dominant hypothetical explanation for these associations is an "informational content of prices hypothesis". This hypothesis can already be found in the seminal work of Modigliani and Miller (1958), which was derived from Irving Fisher's work at the beginning of the 20th century (Cardao-Pito, 2021; forthcoming).² It suggests market prices could capture information about intangible assets and/or growth/investment prospects reflected in discounted forecasts of firms' future monetary flows. Accordingly, intangible intensive firms (for instance, Microsoft, Apple, Alibaba, SAP or Fuetrek) and new firms would tend to have a higher q because the indicator would capture their intangible assets and/or growth opportunities. Likewise, firms with high q are interpreted as being reward by markets for having good investments opportunities and/or high level of intangible assets.

In economics and finance, the methodologies to identify firms' intangible assets and growth prospects are generally related to variations of the discounted cash flow model, as suggested by the Fisher-Modigliani-Miller framework and the informational content of prices hypothesis. However, those estimates require projections of future monetary flows and discount rates that are nearly impossible to confirm at the moment of analysis. For instance, for explaining the stock price of a single firm, researchers and analyst can try to foresee the future 20, 30, 40 or more years ahead. These estimates have no factor of comparison nor basis for corroboration in year 0. Nevertheless, Tobin's q has been invoked as evidence for discounted cash flow models and the efficacy of market prices in describing firms' intangible assets and growth prospects. Because Tobin's q tends to be larger for intangible intensive firms and new firms, researchers and analysts were quick to conclude that the difference between market and book values existed mostly because of intangible assets and firm prospects (that would be captured through discounted cash flow models). Nevertheless, firms' market values might be related to many other factors beyond the respective firms. Examples include economic growth, economic policies, institutional structure, international context, business climate, high frequency trading, block trading, environmental concerns, public debt, crises, and so forth.

We present an alternative "mechanical effect hypothesis", which no longer requires implausible claims involving an all-seeing and all-knowing market capable of predicting intangible assets and growth opportunities many years ahead:

Mechanical Effect Hypothesis: The proportion of debt in firms' capital structures is mechanically captured in the computation of q. Our new hypothesis suggests a cause-effect relation whereby as an organization's debt levels increase, their q tends to 1. When q > 1, it tends to 1 from above, and when q < 1, from below. In the very rare case where q = 1, this effect does not apply simply because

q is already 1. Debt and q have a partially automatic relation because highly correlated informational inputs associated to debt and/or liabilities are computed both at the q variable's numerator and denominator.

Our new hypothesis may contribute to clarifying puzzling findings, about which our knowledge is far from satisfactory. Furthermore, it might be used to revisit many previous research' conclusions that have been deducted from the dominant hypothesis. Indeed, if this new hypothesis is correct, we may need to question the validity of using discounted cash flow models to explain markets and prices as suggested by the Fisher-Modigliani-Miller foundational framework. If confirmed, the new hypothesis removes Tobin's q as valid evidence for justifying the use of discounted cash flow models to explain firms, values, markets, prices, intangible assets, and future performance.

2. Tobin's q and the capital structure, a puzzling relationship

It is often noted that Brainard and Tobin (1968) and Tobin (1969) formulated the indicator known as Tobin's q without aiming to make considerations about specific firms. Their major endeavor was to make considerations about monetary policy (see for instance, Bartlett & Partnoy, 2020). The key idea is that an investor will want to invest in a firm if its market value is higher than what it would cost the investor to buy the firm's assets and create the same firm for him/herself (i.e., the market value is higher than the replacement cost). An investor would not be interested in investing in a firm if its market value were lower than its replacement cost. Brainard and Tobin (1968) defend that the valuation of investment goods relative to their cost should be the prime indicator and proper target of monetary policy. Research in what is known as q-theory of investment often follow this path of analysis (e.g., Andrei et al., 2019; George et al., 2018; Schiantarelli & Georgoutsos, 1990; Yoshikawa, 1980) whereas, as explained above, research in financial and organizational economics uses q for direct considerations about specific firms.

Nevertheless, the informational content of prices hypothesis is present in Tobin's q since its inception, when the indicator was suggested for economic policy analysis. As Fisher (1906) had suggested, Brainard and Tobin (1968) and Tobin (1969) claim that market prices are explainable by future income and discount rates, that is to say, discounted cash flow models. Moreover, the creators of q criticized accounting for not being capable of identifying investment opportunities as markets did, which is also a common theme in Fisher (1906). Tobin was a known admirer of Fisher's work (see for instance, Dimand & Geanakoplos, 2005; Tobin, 1990, 2005). Certainly, Tobin (1969, 1977) displayed concern with finding a single exogenous or intermediate variable for q that could capture the impact of monetary policies or other financial events. Brainard and Tobin (1968) and Tobin (1977) noticeably denote that their q indicator is connected to the Fisher-Modigliani-Miller framework. Accordingly, firms' market values would be essentially explained by projections of future earnings (income) related to eventual growth prospects. Therefore, the informational content of prices underlies Tobin's q when this indicator is employed both for economic policy and specific firms. In both group of studies, furthermore, the forms for empirical computation of q are relatively similar (see, Section 4).

Nonetheless, McConnell and Servaes (1995) established a curious relationship between q and debt leverage (i.e., the proportion of debt in the capital structure).³ Using a sample of 826 firms listed in the US Stock Exchanges (NYSE and AMEX), they have empirically demonstrated that the q values of "high growth firms" (those with q > 1) and "low growth firms" (those with q < 1) were negatively and positively correlated with leverage, respectively. This relationship between q and debt, which immediately changes according to whether q is lower or higher than 1, is quite puzzling and might pose an empirical anomaly to the dominant informational content of prices hypothesis. However, McConnell and Servaes (1995) have tried to align their findings with an explanation related to intangible assets or growth prospects, as in the as in the informational content hypothesis. They have suggested that the market perceives the firm's debt policy differently depending on whether the firm has large growth prospects. Indeed, McConnell and Servaes's

typology of defining firms as high growth or low growth according to their q is the very application of the informational content of prices hypothesis described earlier.

A few subsequent papers have proposed explanations for this same puzzling phenomenon that also try aligning with the informational content of prices hypothesis (e.g., Lang, Ofek, and Stulz 1996; Moon & Tandon, 2007; Pennman et al., 2007). However, most papers that address Tobin's q (or the firm's market to book) seldom mention that this empirical irregularity exists, let alone that it may have any impact in the dominant informational content of prices hypothesis.⁴ The matter appears thus to be settled in the research literature (see for instance, De la Fuente & Velasco, 2020; Huang et al., 2018 or Luo et al., 2021). Even critics of the "misuse" of Tobin'q as Bartlett and Partnoy (2020) point their criticism towards accounting values in the numerator without raising the possibility that the market value in the numerator might depend on many other factors that are not directly related to the respective firm, its intangible assets or growth prospects. Otherwise, the alternative explanation proposed in this paper suggests that the relationship between debt and Tobin's q (or the firm's market to book) is, indeed, an anomaly to the dominant hypothesis. That is, the empirical association, such as the one found by McConnell and Servaes (1995), can be partially predicted from a mechanical process at the variable computation.

3. Methodology

This paper develops and formalizes a new hypothesis that disputes the informational content of prices hypothesis. In most previous research, the latter is the underlying interpretation for Tobin's q (market to book of the firm). The mechanical effect hypothesis is formulated through the analytical inspection of the manner Tobin's q is computed. It takes also in consideration previous research findings that are not consistent with the informational content of prices hypothesis.

Evidence for the new hypothesis is provided in two manners. First, through a numerical simulation. Second, through the examination of a large 8-country sample with 20 years [2000–2019] of observations.

4. Mechanical effect hypothesis

Our new hypothesis explains why q is negatively correlated to debt when q > 1, and positively correlated to debt when q < 1. As defined by Tobin (1969), q is the market value of a firm's capital goods (necessary for production), divided by the price of their replacement cost:

$$Tobin's q = \frac{Market Value of Capital Goods}{Replacement Cost of Capital Goods}$$
(1)

Still, both these inputs are unknown. Hence, proxies must be used to identify the market and book values of capital goods in the absence of the direct observation of relevant variables (Tobin, 1969, p. 29). The denominator in Eq. 1 is typically replaced with the book value of equity plus some additional value *y*. The numerator is replaced with the market value of equity plus some additional value *x*. As they are used to help describe a firm's capital goods involved in the productive process, both *x* and *y* are necessarily connected to the assets, due to the fundamental equation in accounting. As a result, *x* and *y* are linked to items in the debit and credit sides of the final balance sheet for each accounting period, wherein the sum of assets must be equal to the sum of equity (including net income) and liabilities (including debt). These substitutions yield the following ratio for q:

$$q^{proxy} = \frac{\text{Market Value of Capital Goods}}{\text{Replacement Cost of Capital Goods}}$$

$$= \frac{e_{MV} + x}{e_{BV} + y}$$
(2)

In (2), e is the shareholders' equity value at either market value (MV) or accounting book value (BV). The values of x and y are either total liabilities (l) or a proportion of it. The value of a firm's total assets is equal to the sum of equity (e) and total liabilities (l). We will not accommodate a speculation on how q could be better computed. Our study is focused on how q (and the firm's market to book) has undeniably been computed in financial and economic research. When the total assets are studied, x and y must be equal to 100% of the total liabilities; whereas when only some assets (e.g., property, equipment, plant, total money, etc.) are studied, x and y must be less than 100% of the total liabilities. The market and book values of total liabilities are considered to be (and, indeed, might be) similar in magnitude. Debt is of course a proportion of total liabilities. However, not all debt commitments are traded in financial markets in the form, for instance, of bonds or commercial paper. In fact, no liquid markets exist that could recurrently produce market values for items such as most bank loans, commitments towards suppliers or the government, or other items. Moreover, there are good reasons for these items to be at historical values in the balance sheet because they describe the firm's pledges to their creditors, which are, incontestably, highly relevant as financial information. Hence, with x and y as a proportion of total liabilities, we have:

$$\begin{cases} x = pl & \text{where } 0 \le p \le 1\\ y = ql & \text{where } 0 \le q \le 1\\ l_{MV} \approx l_{BV} \end{cases}$$
(3)

The classic market-to-book value of shareholder equity (*MBE*) may be an extreme form of q when the firm has no external financing because it is fully financed by the shareholders' equity. In other words, *MBE* is Tobin's q for the case in which x and y are equal to zero:

$$MBE = \frac{e_{MV}}{e_{BV}}$$
(4)

The mechanical effect we are describing does not apply to the (*MBE*). Nevertheless, by definition, the *MBE* cannot be q or the market to book of the firm when the firm has other sources of financing beyond equity. Q is related to all capital goods. Likewise, the market to book of the firm variable is related to all assets, regardless of how they are financed. When the liabilities are not zero, *MBE* does not capture all capital goods and/or all assets. Furthermore, the analysis regarding the informational content of price hypothesis in Modigliani and Miller (1958, p. 268–271) is based on the full firm, as clearly stated at their Propositions I and II. Proposition I involve the full firm's market value, and Proposition II the full firm's average cost of capital. To use *MBE* has a proxy for q or market to book of the firm would be a violation of these Modigliani and Miller's propositions.

Yet, liabilities and debt are captured both in *x* and *y*. The mechanical effect in q kicks in as soon as the q equation includes an *x* and an *y* that are either identical or highly correlated. It is not even required that *x* be equal to *y*. What is required is that the book and market value of equity differ, as occurs in most situations. Thereby, increasing the debt level will make q tend to 1, whenever q is not already 1. We are now able to further investigate our new hypothesis:

'The mechanical effect hypothesis regarding Tobin's q (or the market to book of the firm)': The proportion of debt in firms' capital structures is mechanically captured in the computation of q. Our new hypothesis suggests a cause-effect relation whereby as an organization's debt levels increase, their q tends to 1. When q>1, it tends to 1 from above, and when q<1, from bellow.n the very rare case where q=1, this effect does not apply simply because q is already 1. Debt and q have a partially automatic relation because highly correlated informational inputs associated to debt and/or liabilities are computed both at the q variable's numerator and denominator.

This hypothesis encompasses the different methods employed in past research to compute Tobin's q or the firm's market to book (e.g., with simple end-of-the-year book values, historical averages, book

Panel A- case where q > 1						
Step						
	1	2	3	4	5	
Market Equity	148	148	148	148	148	
Book Equity	40	40	40	40	40	
Book Debt	0	8	64	512	4 096	
Book Leverage	0%	17%	62%	93%	99%	
Market to Book of Equity	3.70	3.7	3.7	3.7	3.7	
Tobin's q	3.70	3.25	2.04	1.20	1.03	
Panel B- Case where q < 1						
	1	2	3	4	5	
Market Equity	75	75	75	75	75	
Book Equity	100	100	100	100	100	
Book Debt	0	8	64	512	4096	
Book Leverage	0%	17%	62%	93%	99%	
Market to Book of Equity	0.75	0.75	0.75	0.75	0.75	
Tobin's q	0.75	0.77	0.85	0.96	0.99	

Table 1. Numerical examples of the mechanical effect hypothesis*

*Notes: In this example, Tobin's q is computed through book debt. After step 2, book debt is simply multiplied by 8. Ceteris paribus, as debt increases, the market to book of shareholders' equity ratio remains constant, while Tobin's q converges to 1.

values predicted from regressions, and so forth). Furthermore, it is applicable to different variables used as proxies for *x* and *y* when computing q, including total liabilities, book debt, liabilities less inventories, long-term debt, and long-term liabilities, and so forth. As we know from past research, even elaborate q proxies provide results that are highly correlated to results with less-detailed q proxies. A simplified version of Tobin's q can explain 96% of the variance in the more sophisticated proxy (Lindenberg and Ross, 1981, Chung & Pruitt, 1994, Perfect and Wiles, 1996; Wang et al., 2016). Therefore, the concrete proxy used to infer Tobin's q is not of relevance for the new hypothesis.

5. Demonstrating the new hypothesis

We can demonstrate the new hypothesis with a simple numerical example, which appear also in Table 1 and Figure 1. Suppose that firm J has a market value of equity MV[E] = \$7.5 billion and a book value of equity BV[E] = 2.5. Its market to book of equity is thus MB[E] = 3. Now suppose that this firm has market and book value of debt of MV[D] = BV[D] = 2.5, and that debt is used to compute its q (or market to book of the firm). Thus, the firm has a q[A] = 2 = [(MV[E]+MV[D])/(BV[E] + BV[D]). Assume that the same firm issues \$2.50 in debt and puts it into treasuries. All else remaining the same (ceteris paribus), the firm has now a MV[A] = \$10+\$2.50, and <math>BV[A] = \$7.50. Its q, however, has just gone down to q[A] = 1.7 due to the modification in the debt level suggested by the new hypothesis. Yet, the market to book of equity remains MB[E] = 3.

Now, suppose that another firm K has MV[E] = \$2.5 and BV[E] = \$5, thus MB[E] = 0.5. If this other firm has the same amount of debt as the previous firm (MV[D] = BV[D] = 2.5), then its q would be lower than 1 at q[A] = 0,67. Ceteris paribus, if firm K also issues \$2.50 in debt and puts it into treasuries, its q now goes up to q[A] = 0,75, while its MB[E] remains 0.5. Table 1 provides several more numerical examples exhibiting that, both when q is higher and lower than 1, q tends to 1 when debt increases. However, the market to book of equity remains the same. We can do this demonstration without involving considerations about future monetary flows, growth, or intangible assets. The essence of the mechanical effect hypothesis is, precisely, that both when q is lower

Figure 1. Numerical examples of the mechanical effect hypothesis

Notes: This figure portrays the example in Table 1. As exhibited, Tobin's q converges to 1 by increasing the debt leverage. When q > 1, it converges from above, and when q < 1, it converges from bellow.

Panel A- Case where q>1



Panel B- Case where q<1



and higher than 1, q tends to 1 as debt levels increases. Naturally, a change in debt might also affect other variables, including market values. However, these ceteris paribus examples demonstrate that debt levels impact q regardless of future projections and intangible assets.

6. Formalizing the mechanical effect hypothesis on Tobin's **q** and market to book of the firm

The effect of x and y on Tobin's q (as described in Eq. 2) can be identified by using partial derivatives. The following results hold for any proxy of q when equity is higher than 0. They can be derived from the definition of q. The total differential of the effects of x and y in Eq. 2 can be approximated as follows:

$$\frac{\partial q}{\partial x}\Delta(x) + \frac{\partial q}{\partial y}\Delta(y) = \frac{1}{e_{BV} + y}\Delta(x) + \frac{-(e_{MV} + x)}{(e_{BV} + y)^2}\Delta(y)$$
(5)

where Δ denotes change. Furthermore, the effect of a difference between x and y can be identified. For example, if the market value of x is equal to the book value of y plus a quantity for the differential between them (λ), we have:

$$\frac{\partial q}{\partial (y+\lambda)} \Delta(y+\lambda) + \frac{\partial q}{\partial y} \Delta(y) = \frac{1}{e_{BV} + y} \Delta(y+\lambda) + \frac{-(e_{MV} + y + \lambda)}{(e_{BV} + y)^2} \Delta(y)$$

$$= \frac{-e_{MV} + e_{BV}}{(e_{BV} + y)^2} \Delta(b) + \frac{-\lambda}{(e_{BV} + y)^2} \Delta(b) + \frac{1}{e_{BV} + y} \Delta(\lambda)$$
(6)

Therefore, by definition, Tobin's q variable will capture the manner through which firms obtain external capital by means of equity or debt. The other two components correspond to the effect of a difference between the values of *x* and *y*. In most cases, *x* corresponds to *y* in Tobin's q, or similar procedures as the market-to-book value of the firm's computations (e.g., McConnell & Servaes, 1995; Rajan & Zingales, 1995).

When λ is equal to 0, only the first part of the expression above will affect Tobin's q, as follows:

$$Lim_{x \to y} \frac{\partial q}{\partial x} \Delta x = Lim_{x \to y} \frac{\partial \left[\frac{e_{MV} + x}{e_{BV} + y}\right]}{\partial x} \Delta x = \frac{-e_{MV} + e_{BV}}{\left(e_{BV} + y\right)^2} \Delta y$$
(7)

Nonetheless, Eq. A.2 demonstrates that even if a differential between the market and book values of external capital (all capital that does not include equity) exists, by definition, q will always mechanically capture x and y.

Moreover, for cases in which *x* tends to *y*, the following conclusions can be deduced from the mathematical definition of q: i) if the market value of equity is greater than the book value of equity, then q decreases with increasing leverage (i.e., more debt in the capital structure); ii) if the market value of equity () is less than the book value of equity, then q increases with increasing leverage; iii) when market value of equity differs from the book value of equity q tends to 1 as leverage increases; and iv) when q is one, it no longer can tend to one. This analytical reasoning describes the same correlations observed by McConnell and Servaes (1995) and Rajan and Zingales (1995) in their samples. The debt level in the capital structure has an impact on q for every case in which the market value of equity differs from the book value.

7. Empirical analysis of the two hypotheses

7.1. Variables for testing the two hypotheses

To compare the mechanical effect hypothesis with the informational content of prices hypothesis, the three key variables are Tobin q (also known as the market to book value of the firm), the market to book value of equity, and the debt leverage. These three variables are defined as follows:

1) *TOBINQ* (or market to book of the firm): To produce this variable, the ratio containing the market value of equity and the book value of liabilities in the numerator, and the book value of equity and liabilities (equal to the total assets) in the denominator was computed. Other specifications for this variable were also tested. However, as explained before, the particular methodology for computing Tobin's is not entirely relevant. Previous studies have demonstrated that a simplified version of Tobin's q can explain 96% of the variance in the more sophisticated proxies for the same variable (Lindenberg and Ross, 1981; Chung & Pruitt, 1994; Perfect and Wiles, 1994; Wang et al., 2016);

2) MARKETTOBOOK[Equity]: the market to book value of shareholders' equity; and

3) DEBTLEVERAGE: the proportion of debt in the capital structure.

If the mechanical effect hypothesis is correct, then the empirical findings should demonstrate that Tobin's q tends to 1 when the debt level increases. When q > 1, it should tend to 1 from above,

Table 2. 8 country sample obtained at the Refinitiv Eikon-Datastream Database						
	Firms	Yearly observations				
		Total	With <i>q</i> higher than 1	With <i>q</i> equal to 1	With <i>q</i> lower than 1	
Canada Sample	2 980	19 886	13 482	74	6 330	
China Sample	3 502	35 003	33 620	67	1 316	
France Sample	1 289	12 149	8 396	59	3 694	
Germany Sample	1 354	12 441	9 213	53	3 175	
Italy Sample	546	4 797	3 221	12	1 564	
Japan Sample	5 306	70 164	31 983	416	37 765	
UK Sample	3 804	28 711	18 413	170	10 128	
US Sample	13 782	109 818	85 150	478	24 190	
Total	32 563	292 969	203 478	1 329	88 162	
Percentage			0.69	0.00	0.30	

and when q < 1, from bellow. In the very rare case where q = 1, this effect does not apply simply because q is already 1. According to this new hypothesis, the market to book of equity has no reason to display a similar empirical behavior. On the other hand, if the informational content of prices hypothesis is correct, the empirical behavior of Tobin's q (market to book of the firm) and market to book of equity should be similar because they both convey the same market information regarding intangible assets and future growth prospects.

7.2. Sample

The sample is described in Table 2. It contains the large sub-samples of 8 countries, namely, Canada, China, France, Germany, Italy, Japan, United Kingdom and United States. Furthermore, a relatively long period of 20 years was investigated [2000–2019]. As these countries are very different, each sub-sample was studied separately.

The source for this sample was the Refinitiv Eikon-Datastream Database. Table 3 describes the specific mnemonics at the source for computing the variables required for this study. To avoid the possibility that extreme observations could drive the results, the primary results described here are computed without outlier observations, Furthermore, the observations where *TOBINQ* and *DEBTLEVERAGE* are lower than zero have been deleted. There might be errors in the database generating spurious extremely high values or illogical values, which could drive results. The Refinitiv database was produced by importing company reports' data, in some cases manually, which may lead to inaccuracies. Thus, the 0.005 of the highest value observations for the key variables in this study have been deleted, namely, *TOBINQ, MARKETTOBOOK(Equity)* and *DEBTLEVERAGE*.

Table 1 describes the final sample, segmented by the 8-country sub samples. It comprises292969yearly observations for32563firms listed in stock markets. The number of observations with *TOBINQ* and *MARKETTOBOOK[Equity]* higher than 1 are 203478 (percentage of 0.69). According to the informational content of prices hypothesis, these observations should indicate positive growth prospects and intangible assets unreported by accounting. The observations that according to informational content of prices hypothesis denote the opposite are those with *TOBINQ* and *MARKETTOBOOK[Equity]* lower than 1. They sum up to88162observations (0.30). The number of observations where *TOBINQ* and *MARKETTOBOOK[Equity]* equal to 1 is indeed very small, and thus, negligible. It involves merely 1 329 observations (0.005).

Table 3. Computing the variables at Refinitiv Eikon-Datastream Database					
Variable	Description	Data mnemonics in the database			
TOBINQ	Ratio containing the market value of equity and the book value of liabilities in the numerator, and the book value of equity and liabilities (equal to the total assets) in the denominator. Thus, in Eq. (4), x and y are equal to book liabilities. This variable is the same as the q variable used in McConnell and Servaes (1995) and the Market to Book (of the firm) variable used in Rajan and Zingales (1995).	((WC03351+ WC03501*MTBV)/ (WC03351+ WC03501))			
MARKETTOBOOK[Equity]	Market value divided by the book value per equity shares at close date. Thus, in Eq. (2), x and y are equal to zero.	(MTBV)			
DEBTLEVERAGE	Book value of total liabilities divided by the sum of the book values of shareholders' equity and total liabilities. In the robustness procedures, this variable is computed by using only debt instead of liabilities.	(WC03351)/(WC03351+ WC03501)			

7.3. Quintile analysis

Several procedures were implemented to test the two hypotheses and they have obtained similar findings in the 8 countries subsamples. Here, the results from quintile analysis are reported. Quintile and decile analyses are well-established methodology in prior research. After each country subsample has been divided between observations with q higher or lower than 1, the quintiles in each of the 8 country subsamples were produced as follows. First, it was computed the mean *DEBTLEVERAGE* for each firm. After that, the five quintiles were created according to the mean *DEBTLEVERAGE* for each firm. At each country sub-sample, each quintile has a similar number of firms. After a firm has been classified into a quintile, all its observations are classified in that same quintile.

The entire country subsample is therefore subdivided into ten sets (five times two) according to q being higher or lower to 1. Firms with analogous mean *DEBTLEVERAGE* are grouped together. Quintile 1 includes firms with relatively less debt in their capital structure at each country sample. Decile 2 includes the 20% of firms with, on average, more debt than firms in quintile 1 and less debt than all other firms. This pattern is followed until quintile 5, which contains firms with relatively more debt in their capital structure.

The findings are described in Figure 2. For greater detail, Figure 2 also documents the means values for the three variables under study by country and quintile. Remarkably, the pattern of values by quintile in the 8-country sample closely replicates the numerical example deducted in Table 1 and Figure 1. As predicted by the mechanical effect hypothesis, from quintile 1 (firms with the least debt) to quintile 5 (firms with the most debt), the mean *TOBINQ* move towards 1 in the five country samples. This movement is from above when *TOBINQ* is higher than 1 (Panel A), and from bellow when *TOBINQ* is lower than 1 (Panel B).

On the contrary, a similarly discernible empirical behavior cannot be observed for the variable *MARKETOTBOOK[Equity]*. This variable expected value has much less variability among quintiles. Moreover, both when q is higher and lower than 1, it does not appear to move towards a specific value as the debt leverage quintile increases. As exhibited in Figure 2 Panel A, while in some countries the mean market to book of equity by quintile grow with leverage, in others decreases.

Figure 2. Empirically comparing the mechanical effect hypothesis and the informational content of prices hypothesis Panel A: Sub sample with TOBINQ and MARKETTOBOOK[Equity] higher than 1



Panel A: Sub sample with TOBINQ and MARKETTOBOOK[Equity] higher than 1

Mean Market to Book of Equity



1.50 -

1 00					
1.00	Debt Quintile 1	Debt Quintile 2	Debt Quintile 3	Debt Quintile 4	Debt Quintile 5
	3.09	3.19	3.39	3.09	3.90
	4.06	3.77	3.71	4.01	3.83
	2.78	2.66	2.58	2.94	3.22
Germany Sample	3.17	3.00	2.90	3.00	3.40
-O-Italy Sample	2.54	2.28	2.48	3.11	2.65
-O-Japan Sample	2.45	2.30	2.18	2.14	2.24
	2.93	3.24	3.16	3.46	4.15
	3.82	3.83	3.76	4.05	3.18

Figure 2. Continued.

Panel B: Sub sample with TOBINQ and MARKETTOBOOK[Equity] lower than 1



0 50					
0.50	Debt Quintile 1	Debt Quintile 2	Debt Quintile 3	Debt Quintile 4	Debt Quintile 5
Canada Sample	0.64	0.70	0.76	0.81	0.90
China Sample	0.86	0.89	0.90	0.93	0.96
	0.77	0.83	0.87	0.89	0.94
Germany Sample	0.75	0.79	0.86	0.88	0.94
	0.76	0.84	0.89	0.93	0.97
-O-Japan Sample	0.70	0.76	0.82	0.87	0.94
	0.78	0.77	0.78	0.83	0.89
	0.71	0.78	0.84	0.91	0.97



0.50					
0.50	Debt Quintile 1	Debt Quintile 2	Debt Quintile 3	Debt Quintile 4	Debt Quintile 5
	0.61	0.61	0.62	0.62	0.65
	0.82	0.81	0.80	0.80	0.79
-O-France Sample	0.69	0.68	0.69	0.66	0.61
Germany Sample	0.69	0.68	0.70	0.65	0.66
-O-Italy Sample	0.64	0.64	0.67	0.73	0.61
-O-Japan Sample	0.61	0.60	0.62	0.62	0.63
	0.77	0.72	0.67	0.67	0.65
	0.64	0.64	0.65	0.65	0.70

Additionally, in other countries, the latter remains relatively stable with changes in the debt level (this stability of the mean market to book of equity relatively to debt is generally the case when q < 1 but happens also in the China and Japan sub-samples when q > 1). These findings are compatible with the hypothetical prediction that Tobin's q captures the debt level in the capital structure and that the market value may not be an adequate indicator for firms' intangible assets and/or growth prospects contrarily to what is advocated by the informational content of prices hypothesis.

7.4. Robustness procedures

The results are robust with respect to other empirical models, such as models with the individual effects identified in regressions with clustered standard errors by firm; models with random effects implemented through general least squares or maximum likelihood estimators; and Pearson's or Spearman's correlation tests between Tobin's q variables and identifier variables. Fama and Macbeth's (1973) regressions were also computed, with standard errors corrected by the Newey-West (1983) approach to control for serial correlation. Similar findings have been obtained using these alternative specifications. Thus, these robustness procedures further support the mechanical effect hypothesis. The findings reported are preliminary evidence for the new hypothesis, which could gain to be retested and reconfirmed in future research.

8. Relation among q, intangible intensive firms, and new firms

This new hypothesis may help us better understand the relation among q, intangible intensive firms, and new firms. Financial economic theory places foremost importance to these associations because it would provide evidence that markets would be capable of predicting firms' intangible assets and investment growth prospects, via the continuous computation of discounted forecasts of firms' future monetary flows. However, if the new hypothesis is correct, Tobin's q cannot be immediately used in this manner. Instead, the ability of q to identify intangibility might partially occur because these firms tend to have less debt in their capital structures and q > 1 (e.g., Bah & Dumontier, 2001; Cardao-Pito, 2017, 2021; Cardão-Pito et al., 2021; Falato et al., 2020; Mantell, 2005). Likewise, although a high value of q for new firms is commonly interpreted as describing future growth opportunities, many start-ups are financed primarily by equity (Cumming & Groh, 2018; Denis, 2004; Lerner & Nanda, 2020). Hence, as they generally have q > 1, they also tend to have higher Tobin q due to the hypothesized mechanical effect.

9. Conclusion

Already described in the Fisher-Modigliani-Miller framework, the informational content of prices hypothesis sustains that market prices are explainable by information reflected upon discounted expectations of future cash flows. These projections would capture growth prospects and intangible assets. Nevertheless, for calculating discounted cash flow models, researchers and analysts make projections of future monetary flows and discount rates that are nearly impossible to confirm. For example, these forecasts may go several decades ahead in the future. Therefore, these conjectures have no factor of comparison nor basis for corroboration in the moment of analysis. Because Tobin's q (market to book of the firm) tends to be higher for new and intangible intensive firms, many researchers and analysts have assumed that the difference between market and book values existed mostly because of intangible assets and firm prospects, which could be captured in discounted cash flow models.

Nevertheless, previous research has found that when Tobin's q (market to book of the firm) is higher than 1, less debt tends to imply a higher value of q, whereas the inverse relation holds for the less frequent case in which q is less than 1. A few studies have tried to accommodate the variable's empirical behavior with the dominant informational content of prices hypothesis. However, far more studies have kept employing q while ignoring this strange phenomenon.

Our new hypothesis sustains that this phenomenon might be a serious challenge to the informational content of prices hypothesis. Although we cannot claim that growth prospects or intangible assets are not negatively associated with leverage on the margin, the provided interpretation of the association of debt leverage to q (market to book) can be explained by and seems more consistent with a near-mechanical effect of the computational process that debt leverage has on q. There seems to be a mechanical relation between Tobin's q and the capital structure that can be explained through the computation of the variable. Thus, the variable behavior might be partially described without requiring previous economic theory, intangible assets, or growth prospects.

The empirical behavior of the market-to-book ratio for equity does not suffer from the same computational effect as q or the market to book of the firm. However, there are good reasons to not use the market to book of equity as a proxy for q (or the firm's market to book). When the firm has other forms of financing, the market to book of equity does not represent assets nor capital goods, and to use it in this context would represent a violation of Proposition I and II in Modigliani and Miller (1958).

Given that Tobin's q is one of the most used empirical indicators in the social sciences, our new hypothesis opens the opportunity to revisit many studies that might have been too quick in assuming that Tobin's q could be used as a valid indicator for intangible assets and investment opportunities, or that we could completely understand markets and prices. If correct, the mechanical effect hypothesis disputes the validity of using discounted cash flow models to explain firms, values, markets, prices, intangible assets, and future performance. Given the prominence of the Fisher-Modigliani-Miller framework, these findings raise questions about the capacity of economic and finance theory to understand these phenomena.

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Notes

- 1. Many studies employ this interpretation of Tobin's g (e.g., Tobin and Brainard, 1977, Wernerfelt & Montgomery, 1988; Morck et al., 1989; Chen & Lee, 1995; Canibano et al., 2000; Lockett & Thompson, 2001; Mahoney, 2001; García-Ayuso, 2003, Gietzmann and Ostaszewskia, 2004; Ng, 2005; Wyatt, 2005, Fanelli and Grasselli, 2006; Abeysekera, 2008; Ceccagnoli, 2009; McClelland et al., 2010; Surroca et al., 2010; Alcaniz et al., 2011; Zéghal & Maaloul, 2011; Khallaf, 2012; Chen, 2013; Zhang, 2013; Wang et al., 2016; Ray et al., 2013, Servaes and Tamayo, 2014; Castilla-Polo & Gallardo-Vázquez, 2016; Biswas et al., 2017; Galant & Cadez, 2017; Gupta et al., 2017; Kabukcuoglu, 2017; Girod & Whittington, 2017; Peters & Taylor, 2017; Entezarkheir & Moshiri, 2018; Muchtar et al., 2018; Feng & Chan, 2018; Paugam et al., 2018; Lian & Wang, 2019; Lim et al., 2020, Nemlioglu, and Mallick, 2020; Agyei-Boapeah et al., 2020; Cheong and Hoang, 2021; Sagliaschi & Savona, 2021).
- On this theme, you may also see, Baker (2018), Bryer (2013), Cardao-Pito and Ferreira, (2018 a b), Dempsey (2014), Cardao-Pito (2020), Markarian (2018), and Mouck (1995).
- McConnell and Servaes' (1995) q variable is identical to the firm's market-to-book value variable used by many other studies (e.g., Rajan & Zingales, 1995)
- Many research papers employ the Tobin's q variable without mentioning this empirical phenomenon (e.g., Tobin and Brainard, 1977, Wernerfelt & Montgomery, 1988; Morck et al., 1989; Chen & Lee, 1995; Canibano

et al., 2000; Lockett & Thompson, 2001; Mahoney, 2001; García-Ayuso, 2003, Gietzmann and Ostaszewskia, 2004; Ng, 2005; Wyatt, 2005, Fanelli and Grasselli, 2006; Abeysekera, 2008; Ceccagnoli, 2009; McClelland et al., 2010; Surroca et al., 2010; Alcaniz et al., 2011; Zéghal & Maaloul, 2011; Khallaf, 2012; Chen, 2013; Zhang, 2013; Wang et al., 2016; Ray et al., 2013, Servaes and Tamayo, 2014; Castilla-Polo & Gallardo-Vázquez, 2016; Biswas et al., 2017; Galant & Cadez, 2017; Gupta et al., 2017; Kabukcuoglu, 2017; Girod & Whittington, 2017; Peters & Taylor, 2017; Entezarkheir & Moshiri, 2018; Feng & Chan, 2018; Paugam et al., 2018; Xiang & Qu, 2018; Lian & Wang, 2019; Lim et al., 2020, Nemlioglu, and Mallick, 2020; Agyei-Boapeah et al., 2020; Sagliaschi & Savona, 2021).

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