UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Tobin's *q* & Corporate Investment Opportunities in Sweden

A longitudinal study

Bachelor's thesis in Industrial and Financial Management
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Supervisor: Aineas Mallios
Author: Erik Nolander 19900412

Abstract

This paper explores the impact of Tobin's average q as a proxy for corporate investment opportunities on the Swedish market. The study takes a longitudinal approach studying 161 firms over the period 2010–2017. Investments were calculated as growth in net property, plant and equipment. The conclusion echoes the literature in that q is found to be significantly and positively related to the corporate investment rate. Its coefficient, in the linear regression model, is small as well as its correlation coefficient, however, pointing to a rather weak impact on investment. By further exploring the q model and its implications on the Swedish market, this paper contributes to the already existing literature and empirical evidence concerned with Tobin's q as a proxy for investment opportunity. Much more research is still to be done on the Swedish market, exploring Tobin's q and its relationship with corporate investment.

Keywords: Tobin's q, corporate investment, investment opportunity, longitudinal study, Sweden, growth in PPE

Abstrakt

Denna uppsats utforskar Tobins q:s roll som proxyvariabel för företags investeringsmöjligheter på den svenska marknaden. Tillvägagångssättet är en longitudinell studie av 161 företag under perioden 2010–2017. Investeringarna beräknades som tillväxt i netto materiella anläggningstillgångar. Studiens resultat är ense med föregående litteratur genom att visa på att q är väsentligt och positivt relaterad till företags investeringsgrad. Dess koefficient, i den linjära regressionsmodellen, är liten, såväl som dess korrelationskoefficient, vilket pekar så på en svag inverkan av variabeln på investeringar. Genom att ytterligare undersöka q-modellen och dess förklaringskraft på den svenska marknaden bidrar denna studie till redan existerande litteratur och empiri som berör Tobins q och dess roll som proxyvariabel för investeringsmöjligheter. Det finns dock fortfarande mycket forskning kvar att utföra på den svenska marknaden kring Tobins q och dess relation med företagsinvesteringar.

Nyckelord: Tobins q, företagsinvesteringar, investeringsmöjligheter, longitudinell studie, Sverige, tillväxt i PPE

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1. Introduction

1.1 Preamble: Investments & investment opportunities

We all make investment decisions. Everything from smaller decisions, like, choosing to spend Wednesday evenings practicing French at the local language café, to lifechanging ones, like quitting work to start a new business. All these decisions carry with them costs accrued in the present, and expectations of future benefits. The costs can, for example, be sacrifices like time, money or the security that comes from being a full-time employee, while the benefits can be acquired skillsets, financial returns, won legal contracts or employment, to name a few.

What has been discussed above concerning individuals holds true also for corporations where assets are typically being installed and employed for production of commodities and services; assets that can presumably, and alternatively, be used for present consumption, and so, immediate gratification (Lumpkin & Brigham 2011).

It has long been noted that the ability to make temporary sacrifices and delay gratification for the potential of future gains, although uncertain, is what has elevated humankind as a species, and has been a major stepping stone for our civilization (Mischel et al. 1972; Opper & Zimmerman 2003). However, when making investments, we want the circumstances surrounding them to meet certain criteria—that is, assuming we are rational and make rational choices (Amadae & Rogers 2018). These criteria vary in nature, number and complexity, but they all have to do with the relationship between the sacrifice having to be made and the expected benefit: taking into account both its present value and the probability that it indeed will be enjoyed.

The arguably most important criterion, that presupposes all others, is very existence of a real and attractive set of investment opportunities (Lyandres & Zhdanov 2013). It is, after all, first when such investment opportunities have been identified that further evaluations can be performed.

1.2 Background: The need of a corporate investment model

1.2.1 Measuring the impact of negative interest rates

During a period that stretches roughly from the aftermath of the last financial crisis to today, Sweden has been characterized by low to ultra-low, and ever decreasing, interest rates. These rates have been set by the central bank of Sweden in order to stimulate growth through investments (Stockholm Sveriges Riksbank 2017). The idea is, after all, to lower the investment threshold by making capital more available. As we leave these times of even negative rates behind us, it should be of paramount interest to measure the real effect that these policies have had on firms' investment behavior. It is good practice, after all, to continually evaluate the effect of our monetary policies on the real markets. Especially after such extraordinary times. Findings from such evaluations could be of assistance and future reference for policy makers, as well as regulators of the financial markets, when deciding on new monetary policies and creating new tools for market stimuli and tackling financial hardships.

What has been presented above is an example of a situation where the need arises for a corporate investment model: a model describing corporate investment behavior. Such a model would indeed include parameters related to firms' cost of capital, making tests, such as the one proposed above, doable.

1.2.2 Accounting for & identifying investment opportunities

However, as have been mentioned, capital availability is not the sole criterion evaluated by firms before investing. A rational, profit maximizing firm would be expected to only take on projects that have the potential to increase its present value (Berk & DeMarzo 2017). Therefore, there has to exist investment opportunities, meeting this one criterion, for the firm to seize or the financing decision would be redundant. In other words, if a firm cannot identify attractive investments it does not matter how much capital it has at its disposal. Therefore, when investigating the impact that lower interest rates have had on firms' investment behavior, a corporate investment model should be used that makes sure to account for firms' investment opportunities. Only when these opportunity sets can be observed can a weighted and fair evaluation be done of the market's aggregate investment behavior.

Firms would be expected to go about identifying investment opportunities applying qualitative methods since the attributes, or the characteristics, of what would qualify as attractive investments, would most probably be qualitative in nature. In the complex and hard-to-analyze reality in which firms operate, these methods are assumedly quite tedious and costly. For an academic researcher with less incentives and even less resources at hand, applying the same methods as firms would be unpractical. This, especially if the research encompasses larger sets of firms. Rather, a researcher would be left in search for a much more efficient quantitative model.

1.2.3 Tobin's q as proxy for investment opportunities

The problem faced by academics is how to quantify investment opportunities. To accurately predict levels of investment opportunities is no simple task, but over the years, a variety of proxies have been developed that aspire to identify them. One measurement that has been frequently discussed in the literature for a number of decades now is Tobin's q, or simply the q ratio, which is the ratio between the market value of a firm's total assets and their replacement cost (Tobin 1969). The q ratio, which can be calculated for both individual firms as well as for entire markets, should theoretically be able to give an indication of whether a firm is expected to invest in capital or refrain from making investments altogether, or even divest, at any given point in time. The intuition behind q is that, by examining how the market values a company's assets in relation to their replacement cost, the market's expectation on the hidden characteristics behind these assets can be inferred. If the market value of a set of assets exceeds their replacement costs, investing in them would be a good idea since the marginal benefit of installing one more unit of capital would, supposedly, be greater than the marginal cost of production (Hayashi 1982). A firm would thus be expected to invest until marginal benefits equals marginal costs, or, in other words, until q is in equilibrium ($q = 1$).

While q is not considered to drive investments per se, a positive relationship is expected between the market's prognosis of future profits and corporations' investment behavior. In other words, managers are not expected to base their investment decisions on observations of their respective firms' market valuations. Rather, the driving forces are expected to be exogenous ones like market trends and technological shocks causing shifts in demand and supply. These, in turn, will be reflected in changes in market valuations as well as corporate investments. Since the former are expected to precede the latter, q should be able to serve as a proxy for investment opportunities.

1.3 Problem analysis

1.3.1 Demand for further empirical evidence

Based on the reasoning above, the question arises of whether this logic applies to actual firms. Namely, do real firms invest in a way that is consistent with how they, according to q theory, should be investing? As it turns out, when examining previous literature on the subject there is no clear-cut way of telling whether there exists a positive relationship between q and corporations' rate of investment. Results from various studies across different markets have been inconsistent and sometimes conflicting, which means that there are still doubts about the predictive power of q. It would seem that this relationship at least needs to be further verified by empirical evidence before it can be confidently included into a corporate investment model.

Moreover, for a model incorporating q to be applied in studies focusing on specific markets, such as the one suggested under section 1.2.1 above, it would make sense to first test the theory directly on that market to verify the performance of q as proxy for investment opportunities. Additionally, while the majority of research have been heavily focused on the US, or other large markets, it would probably be of interest to also examine other, smaller markets that could still be considered to be relatively unexplored in this regard.

To summarize, there is a need to further provide empirical evidence on the performance of q as proxy for investment opportunities. Furthermore, there is little research done on singular markets and, to the knowledge of this author, nothing performed exclusively on smaller markets, leaving room for further enquire.

1.3.2 Swedish corporations as study subjects

For a market to be considered as a subject in any study, data availability has to be taken into account. Since the firms' market valuations are essential in calculating q, markets with relatively few listed companies would therefore be bad candidates. Moreover, the accounting culture of the market also plays an important role. Proper accounting regulation and standardization in how data are reported are vital when comparing items from firms' balance sheets etc. Thus, compromises in either would impede the reliability of the data. Sweden, while being a smaller economy than those previously studied, does meet the requirements regarding data availability; the Stockholm stock exchange has a relatively large number of firms listed on its exchange and they all have to adhere to the International Financial Reporting Standards (IFRS). Sweden can therefore be considered a viable market candidate in a study seeking to determine the extent to which investments by publicly traded firms can be explained by q theory.

1.3.3 Comments on quantitative models

A major general downside in using quantitative models is that they are expected to be worse at predicting reality the more complex a subject matter is; this, since complexity is best measured using qualitative models (Hammarberg et al. 2016). To tie in with the previous sections on how firms invest, the complexity in the nature of an investment decision forces the firm to examine qualitative aspects of its current state. Aspects such as its current product portfolio, its technological capabilities, customer demand, its financial strength, the nature and status of its competitive environment, current political and legal aspects, etc. Other, more quantitative aspects, while being relevant in a number of ways would not be, as one would have believed, a major determinant in an investment decision; even less of major interest to the decision makers themselves. Examples of such aspects are historical profitability, the magnitude of current cashflows and stockholder sentiment as reflected by significant changes in stock prices.

To remedy this issue to, at least, some degree as pertains to tests of the q model, attempts can be made to catch a fuller picture of reality by including additional and relevant variables. These variables, like q, would function as proxies for corporate investment opportunities capturing aspects ignored by q. These variables will be considered as complements to q in this thesis and will be first discussed under section 2.3 below.

1.3.4 Summary of the problem analysis

In summary, there is, indeed, a need for a reliable quantitative model predicting corporate investment. Such a model would aim to quantify and measure investment opportunities among firms. To do that in a complex world is trying to solve an ill structured and complex problem with many moving parts and variables. Intuition has it that a model, such as the one theorized above, has to take into account the many idiosyncrasies to be expected across the different countries, sectors, industries and firms to be studied. At the same time, it should at least consider including many of those different variables that have been discovered, throughout the literature, to influence corporate investment.

1.4 Aim, research question & scope of research

The aim of this thesis is to examine how potential investment opportunities for firms can be identified and measured on the Swedish market using Tobin's q, and to study the relationship between this indicator and actualized corporate investments. Such an examination would contribute to the literature on investment opportunities and suggest a framework within which future research on firms' investment behavior could be performed. With this in mind, the following research question have been formulized:

> How well has Tobin's q performed as an indicator for the existence of investment opportunities for Swedish firms?

In order to answer the research question, a panel consisting of 161 non-financial Swedish firms have been studied over the period 2010–2017. For further details on limitations and other details concerned with the methodology of this thesis, see section 3 below.

2. Literature review

2.1. Corporate investment and Tobin's q

2.1.1 Introducing q

One of the most fundamental ideas of corporate investment is that firms undertake investments to maximize their present value, and that firms should only invest in ways that lead to an increase in shareholder value. This idea is reflected in investment opportunities, where certain conditions indicate that such investments could be made. Throughout the past decades, a large body of research has been conducted on the topic of the factors that could potentially act as indicators for investment opportunities, but there is still no clear consensus regarding what indicators should be used to most accurately proxy for and evaluate those opportunities. Among these different indicators, Tobin's q is one of the more frequently studied ever since the introduction and establishment of the q theory (Tobin 1969; Hayashi 1982). Originally known as the *valuation ratio*, or simply v (Kaldor 1966), the ratio of the market value of a firm's assets and their replacement cost is today more commonly known as Tobin's q. This stems from the fact that it was through the work of James Tobin that the q theory was established, providing a foundation for further application and development (Tobin 1969).

The q ratio, in its original form, is defined as:

$$q = \frac{Market\ value\ of\ firm}{Replacement\ cost\ of\ the\ firm's\ total\ assets}. \tag{1}$$

Since q measures the ratio of two different valuations of the same assets, one could argue that, intuitively, given perfect information and transparency, the market value of the assets should be equal to their total replacement cost, giving a q value of 1. Based on this idea, a firm is said to be undervalued or overvalued in the market if q is less than one or more than one, respectively. Brainard and Tobin (1977) state that the normal equilibrium value for the q ratio should be 1 for reproducible assets that are being reproduced, and less than 1 for others.

According to the theory, the q ratio also has implications for the firm's investment decisions, as it gives an indication of how the firm ought to be investing. Typically, a high value ($q > 1$), signals that a firm should invest in capital and also indicates the relative magnitude of those investments; higher values of q call for greater investments. This, while a low value ($q < 1$) should discourage investments (Brainard & Tobin 1977). It could therefore be expected that higher values of q would encourage firms to invest more as these investments would be worth more to the firms than their costs.

2.1.2 Calculation of q

Despite being a seemingly straightforward valuation tool, the application of q is not entirely unproblematic. The first issue is the difficulty of properly calculating the replacement cost of a firm's assets. However, this issue can be remedied by simply approximating the replacement value. One common way to do this would be to instead use the recorded book value of the assets, which has the benefit of being directly observable. The equation for this modified version of the q ratio can be written as:

$$q = \frac{Market\ value\ of\ firm}{Book\ value\ of\ \text{the firm's}\ total\ assets}. \tag{2}$$

This approximation is further discussed under section 3.3 below.

Lindenberg and Ross (1981) proposes, and Chappell and Cheng (1984) more clearly presents, a method for calculating the replacement cost of assets. First it divides the assets into three categories: property, plant and equipment (PPE), inventory assets, and other assets; the last one including liquid assets, land, and intangibles. The replacement cost for PPE is then adjusted for inflation, depreciation, and new investment. Inventory assets are adjusted for discrepancies due to differences in accounting practices among firms. They are also adjusted for inflation if it has been high enough to significantly affect prices in the short term. The replacement costs of other assets are assumed to take on their recorded book values.

2.1.3 Marginal q

In his seminal work, Hayashi (1982), often viewed as one of the main contributors to the q theory, formalizes the idea behind Tobin's supposition and the modified neoclassical theory of investments. He shows, in logical steps, that the optimal rate of investment can be derived for any given firm by observing q and through knowledge of its installation function—the adjustment cost of installing I units of capital to the existing capital stock K:

$$\frac{I}{K} = f(q; t) \tag{3}$$

Here, q is derived from Tobin's marginal q measured at time t, the market value of one additional unit of capital to its replacement cost. Since marginal q is unobservable, average q—which captures the value of *existing* capital and is analogous with the q ratio discussed so far in this article—can be used to proxy for the former. First, however, the following must be taken into consideration:

"If the firm is a price-taker with constant returns to scale in both production and installation, then marginal q is equal to average q. If the firm is a price-maker, then average q is higher than marginal q by what is legitimately called monopoly rent." (Hayashi 1982, p. 214)

Thus, for researchers to infer the optimal investment rate of firms by using average q as a proxy for investment opportunity, certain assumptions must initially be made concerning the production and cost structure of firms, as well as the markets they operate in.

2.2 The performance of q in previous research

2.2.1 Instances of satisfactory performance

Since the introduction of q theory, a variety of studies examining the performance of q as an investment opportunity proxy, have been conducted. An early example where the performance of q has been found to be satisfactory is the study by Malkiel et al. (1979). The authors conclude that changes to q appear to have an impact on investment, while changes in output relative to trend and changes in capacity utilization do not show statistical significance. Another case providing evidence for the performance of q was is a study of UK manufacturing firms, where the ratio was found to have a significant effect on investment, although this effect was small (Blundell et al. 1992). The authors also concluded that, although q was shown to influence investment decisions, firms generally seemed unresponsive to variations in equity valuation regarding investment in the short run.

In a different study of UK firms by Cuthbertson and Gasparro (1995), the authors examine the investment decisions in manufacturing firms for the period 1968-1990. Here average q is included alongside capital gearing, or financial leverage, and manufacturers output in their final model for investment expenditure, which is found to adequately measure these investments. It is, however, worth noting that although their model proved to be adequate, their study clearly shows that q alone is not sufficient for measuring investments (Cuthbertson & Gasparro, 1995), indicating that different variables need to be incorporated into the q model in a similar manner. This is consistent with previous findings, that it should be considered good practice to include additional variables in these investment models (von Furstenberg et al. 1977). Furthermore, in a more recent study by Hsiao and Li (2012) a number of investment rate proxies were tested against a collection of benchmark variables among most were proxies for investment opportunity. These benchmarks, including q, showed varying degrees of correlation with the different proxies for investment rate and could potentially be incorporated into a model for investment.

Findings along the same lines include those by Adam and Goyal (2008). They used a real options approach to evaluate proxy variables for investment opportunities and found the market-to-book assets ratio to have the highest information content compared with all other variables tested—the market-to-book equity ratio, the earnings-price ratio and the ratio of capital expenditures to property, plant and equipment. Since the market-to-book assets ratio is characteristically similar to q, with the former, as already mentioned, sometimes acting as a proxy for the latter for simplification, this provides some additional interesting insight regarding the performance of the ratio. When instead looking at the book-to-market ratio, the inverse of equation 2, it turns out that empirical evidence has been presented for a relationship between this valuation and investment as well. More precisely, firms with a low book-to-market ratio has been shown to increase capital investment, while the effect was precisely the opposite for firms with a high book-to-market ratio (Anderson & Garcia-Feijóo 2006).

In a recent study from 2017 of US firms, it was shown that the neoclassical q theory (Hayashi 1982) still holds for intangible assets, which tend to move together with physical assets. It could thus be concluded that the degree to which q explains investment should be roughly the same for tangible and intangible assets (Peters & Taylor 2017). Looking at their results in greater detail, it was shown that intangible investments were slightly better explained by the q ratio than tangible ones; better explained still were total investments, or the sum total of tangible and intangible investments together.

In this study, a somewhat different variant of the q ratio, which the authors referred to as total q (q_{tot}), was introduced and tested alongside average q. The main difference between the two was that q_{tot} made a distinction between tangible and intangible assets in the denominator. In every test performed in the study q_{tot} was found to outperform regular q in terms of explaining investment, regardless of the nature of the investments (Peters & Taylor 2017). To further explore the implications of this modified version of average q could be a step in the right direction when examining corporate investment decisions.

2.2.2 Criticism & inconsistencies

Despite the strong presence of q theory in the literature, it has been repeatedly under scrutiny. Among the most notable sources of criticism is a comprehensive study by Blanchard et al. (1993). Based on 90 years of data (1900–1990), they were able to prove that the role of market valuation in determining investment decisions is limited. The authors also claim that even though managers' valuation of a marginal project will coincide with q, which means that investment will move together with the market valuation, the market valuation alone will not cause investment. And despite the existence of evidence for the performance of q, the ratio has shown inconsistencies in different studies across different markets. An example of such an inconsistency has been found when comparing aggregate q for young and for established firms in a relatively recent study. Here a positive relationship between q and investment rate could be observed for younger firms while for larger, more established firms, the relationship was instead negative (Jovanovic & Rousseau 2014).

Instances where the performance of average q has been found to be poor include a study of the Japanese market for the period 1969-1991 where it is compared to estimations of marginal q and the authors observe a divergence between the two (Ogawa & Kitasaka 1999). Their conclusions are, similar to those of Blanchard et al. (1993), that market valuation, as incorporated in average q, fails to properly explain corporate investment decisions. A different observation is that q serves as a particularly poor indicator of current investment opportunities for younger firms with high growth potential, the reason being that the value of q reflects the long-term growth potential and investment opportunities for those firms (Alti 2003). Because of this, should the q model be tested for a sample including firms with the characteristics just described, the effect observed might be lower than anticipated, or it might be concluded that these firms appear to be underinvesting.

Also, Abel and Blanchard (1986) in their study on variations in marginal profit and investments, further discussed under section 2.3.3, observed marginal q to perform weakly in its predictions.

2.3 Other investment proxies

When analyzing investment opportunities, a number of different measurements could potentially be used as indicators and be included in the q model, as the ratio alone generally will not be able to sufficiently explain investment decisions (von Furstenberg et al. 1977). When looking at the different q models used in previous studies they do tend to show some variation in terms of the other variables chosen to be included in the model.

2.3.1 Return on assets & growth in sales

In the aforementioned study by Hsiao and Li (2012) several commonly used "benchmarks", or indicators for investment, were tested for different investment proxies to explore the relationship between those variables. Among those tested and shown to be correlated with the various investment proxies were, alongside q, return on assets and the 3-year growth in sales. The results of their study greatly inspired the choices of potential variables tested in my preliminary regression model, both independent and dependent ones. The topic of the model and variables used in this thesis will be discussed further in sections 3.2.1 through 3.2.4.

2.3.2 Cash flow

Apart from these variables, one of the most commonly used alongside q is cash flow (CF). The relationship between CF and corporate investment, including when CF is incorporated in models alongside q, is strongly supported by research evidence (Vogt 1994; Blundell et al. 1992) and it is therefore generally considered a natural choice to include CF in models seeking to explain investment decisions. However, as is pointed out by Chen and Chen (2012), the relationship between firms' investments and their cash flow seem to have been declining in recent times. Not even during the credit crunch of 2007–2009 could financial constraints be explained by the investment-cash flow sensitivity. Their conclusion was that neither sample composition, corporate governance, nor market power could explain for this discrepancy, and that this issue remains a puzzle.

2.3.3 Cost of capital

Intuition has it, that the cost of capital should have a negative impact on corporate investment, and it has been acknowledged that this would indeed be the case in a standard q model. Abel and Blanchard (1986) found that the cost of capital explained the greater part of the cyclical variability in marginal q. Their second finding, that q performed rather poorly as a proxy for investment, undercut their first conclusion though. Later, however, their findings found support in the research of Frank and Shen (2016). It was observed that the cost of debt indeed was consistent with the q model. Also cost of equity was found to be consistent though there were some discrepancies that came up in connection with its method of measurement.

Moreover, it has also been empirically shown that there is a close relationship between corporate investment opportunities, as measured by real options, and the cost of capital as well as corporate cash holdings (Ramezani 2011). Firms with higher weighted average cost of capital tend to hold more cash than firms with lower cost of capital. This shows that the cost of external financing constrains the investment decision (Myers & Majluf 1984) since "firms whose investment opportunities outstrip operating cash flows, and which have used up their ability to issue low-risk debt, may forego good investments rather than issue risky securities to finance them" (Myers & Majluf 1984, p. 219).

2.3.4 Bond market's q

In their paper "Investment, Tobin's q, and interest rates" Lin et al. (2016) studies the impact of interest rates and capital illiquidity on corporate investment. They do this utilizing bond q, a q model incorporating credit risk. They reason that the volatility in market equity prices introduces issues when measuring average q in empirical measurements, and that a q model based on debt pricing, therefore, is more accurate in its predictions. In a similar research, Philippon (2009) explores his version of q derived from the bond market and finds it to perform six times better than q also based on equity valuation.

2.3.5 Lagged investment rate

It has long been observed that lagged investment is the best predictor of current investment. Eberly, Rebelo and Vincent (2012) explain why using a model developed by Christiano, Eichenbaum and Evans (2005). Their model was first used to explain for observed inertia in inflation and persistence in aggregate output and is used here to analyze inertial effects in corporate investment (Eberly, Rebelo & Vincent 2012). The authors conclude in line with Christiano, Eichenbaum and Evans that the predictive power of lagged investment can be accounted for by the presence of investment adjustment costs. Here Matsuyama (1984) provides the interpretation that firms have to learn how to implement a given rate of investment. Eberly, Rebelo and Vincent (2012) observes that this interpretation is consistent with the findings made by Bloom et al. (2009), that investment budget proposals, provided by senior managers, are by default set to equal previous year's budget. Suggested revisions of the proposals are, in their turn, met by greater resistance the farther they stray from their original versions.

2.3.6 Summary of other investment proxies

In summary, there are several proxies used in the literature; sometimes complementing q and sometimes acting as substitutes. As was mentioned under sections 1.3.3 and 1.3.4, in order to more comprehensively capture the reality surrounding corporate investments other proxies inhibiting content information not covered by q should be considered in an investment model. The ones described here have all been recognized as candidate proxies in the literature and have, for that reason, come under further consideration in this study.

2.4 Summary of the literature review & hypothesis

The literature on q spans over several decades. Many different approaches to the q model have been theorized and tested. The empirical evidence varies and there is great contention around whether the theory is valid for real firms and markets. Moreover, several alternative proxies for investment opportunities have been proposed and empirically tested suggesting that there is important information not incorporated in q.

Based on the findings from the literature review, a hypothesis was constructed in order to verify whether such a relationship appears to exist:

> H_0: There exists no significant positive relationship between q and actualized corporate investment on the Swedish market during the period of 2010–2017.
>
> H_a: There exists a significant and positive relationship between q and actualized corporate investment on the Swedish market during the period of 2010–2017.

3. Methodology

3.1 Research approach

To answer the research question, a quantitative longitudinal study was conducted, where quarterly data for Swedish publicly traded firms included in the OMXSPI index was collected and analyzed over the period 2010–2017. In a longitudinal study multiple, repeated observations for the same sample within a given time period are used in order to capture changes in the data set (Bryman & Bell 2013).

As the objective of this thesis was to determine the existence of a potential relationship, namely, the relationship between q and actualized investment, a deductive research approach was chosen.

3.2 Linear regression model & variables

To test the hypothesis, GLS regressions were performed on a sample consisting of Swedish firms extracted from the OMXSPI index. GLS, or generalized least squares, is a technique in statistics introduced by Aitken (1934). It is used to estimate parameters in linear regression models where other techniques, like ordinary least squares (OLS), are insufficient because of serious correlation among the residuals. Since the data used in this study might suffer from both serial correlation or model misspecification, GLS has been deemed a suitable technique. GLS is also commonly used to correct for autocorrelation and heteroscedasticity.

The full linear regression model, which was developed on Hayashi's (1982) model as referenced in equation 3, is presented below:

$$y_{it} = \alpha_0 + \alpha_1 y_{i,t-1} + \alpha_2 Q_{i,t-1} + \alpha_3 ROA_{i,t-1} + \alpha_4 SGRO_{i,t} + \alpha_5 WACC_{i,t-1} + \alpha_6 TR_{i,t} + \alpha_7 Beta_{i,t} + \mathrm{s}_j + \varepsilon_{i,t}, \tag{4}$$

where $y_{i,t}$, the dependent variable, is company i's rate of investment in time t, s_j is a set of sector dummies, and $\varepsilon_{i,t}$ is the error term. The lagged dependent variable (y_{t-1}) was included to measure the effect of past investment on decisions to invest today. Tests were also done on models excluding y_{t-1} to test for bias that could potentially be introduced when including it (Keel & Kelly 2006). Care was also taken in tests using the fixed effects estimator since lagged dependent variables, in such cases, can lead to severe bias.

To assist in the analysis, the statistical software Stata 15.1 by StataCorp LLC was used to process the data and perform the regressions.

3.2.1 Dependent variables

To capture a more complete picture of the performance of q, it was tested against four different dependent variables measuring different aspects of corporate investment: capital expenditure scaled by total assets ($CAPX/A$) and property, plant and equipment ($CAPX/P$), growth in net property, plant and equipment ($PPEGRO$), and research and development scaled by total assets ($R\&D/A$). However, since preliminary samplings clearly revealed that both $CAPX$ and $R\&D$ were poorly represented in the Swedish data, $PPEGRO$ would eventually become the main investment rate proxy of interest. Regressions were performed on the other two variables anyway for the sake of completeness and control. $PPEGRO$ was calculated from period $t-4$ to t as presented in the following equation:

$$PPEGRO = \frac{PPE_t}{PPE_{t-4}}. \tag{5}$$

Despite being based on simple accounting information, the growth in PPE was found by Hsiao and Li (2012) to be highly correlated with q and outperformed a number of more widely used investment rate proxies such as those based on capital expenditure.

The reasons for measuring growth annually rather than quarterly were to eliminate seasonal effects as well as minimizing other effects due to budgeting and accounting practices.

The two measures of capital, mentioned above, used to scale $CAPX$ are both commonly used as deflators alongside the investment measure. The same goes for $R\&D$ and the book value of total assets. These deflators were all measured in the beginning of the period; their respective equations are as follows:

$$\frac{CAPX}{A} = \frac{CAPX_t}{Total\ assets_{t-1}}, \tag{6}$$

$$\frac{CAPX}{P} = \frac{CAPX_t}{PPE_{t-1}}, \tag{7}$$

$$R\&D/A = \frac{R\&D_t}{Total\ assets_{t-1}}. \tag{8}$$

3.2.2 Independent variables

The variables included in this study to explain investment rate, beside lagged investment rate and q, were return on assets (ROA), past sales growth ($SGRO$), weighted average cost of capital ($WACC$), total stock return (TR) and company beta ($Beta$). q, ROA, $SGRO$, and $WACC$ were all used as proxies for investment opportunity. The rationale behind the first three is that they all should be positively correlated with actualized investments since increases in all the above variables should increase incitement to boost investment. $WACC$ should be negatively correlated with corporate investment since increases in the cost of capital should decrease the incitement to invest. Sales growth was calculated over four periods (one year) to properly account for short-term, seasonal variations. In order to account for the effects of risk on the investment decision, the decision was to include the company beta as a volatility measure. This while TR was introduced to control for fluctuations in stockholders' expectations. All of the regressors were measured as lagged variables except for TR, $Beta$ and $SGRO$.

3.2.3 Sector dummies

To control for differences across different industries, sector dummies were included in the model. These dummies were created using the ICB industry classification at the top level; ten industries in all.

All relevant variables are summarized in Table 1 below.

Table 1. Variable definitions

Variable name	Abbr.	Frequency	Definition & source
Market capitalization		Quarterly	Market value of common equity. Market price-Year End (Quarter End) * Common shares outstanding. (Worldscope, WC08001A)
Total assets		Quarterly	The sum of total assets, long term receivables, investment in unconsolidated subsidiaries, other investments, net PPE and other assets. (Worldscope, WC02999A)
Total liabilities		Quarterly	All short- and long-term obligations expected to be satisfied by the company. Includes (but is not limited to) current liabilities, long term debt, deferred taxes, deferred income, other liabilities. Excludes minority interest, preferred stock equity, common stock equity, non-equity reserves. (Worldscope, WC03351A)
Tobin's q	q	Quarterly	(Market capitalization + total liabilities) / total assets in period t – 1
Return on assets	ROA	Quarterly	Interim Time Series (these calculations use restated data for last year's values where available): Trailing 12 Months Net Profit + Trailing 12 Months Expense on Debt * (1 – Tax Rate) (Worldscope, WC08326A)
Sales		Quarterly	Gross sales and other operating revenue less discounts, returns and allowances. (Worldscope, WC01001A)
1yr sales growth	SGRO	Quarterly	(Revenue / Revenue in period t – 4) – 1
Weighted average cost of capital	WACC	Quarterly	Weighted average cost of capital (Bloomberg, WACC)
Total stock return	TR	Quarterly	Theoretical growth in value of a share holding, assuming dividends are reinvested to purchase additional units of equity at the closing price applicable on the ex-dividend date. The percentage change was retried by the Datastream PCH formula. (Worldscope, RI, PCH#)
Company beta	Beta	Quarterly	A measure of market risk which shows the relationship between the volatility of the stock and the volatility of the market. This coefficient is based on between 23 and 35 consecutive month end price percent changes and their relativity to a local market index. Company beta was retrieved by the Datastream REGB formula. (Worldscope, REGB#)
Capital expenditure	CAPX	Quarterly	Additions to fixed assets other than those associated with acquisitions. Includes but is not limited to additions to PPE, investments in machinery and equipment. (Worldscope, WC04601A)
Rate of CAPX, PPE	CAPX/P	Quarterly	Capital expenditure / Net PPE in period t – 1
Rate of CAPX, total assets	CAPX/A	Quarterly	Capital expenditure / Total assets in period t – 1
Expenditure on research and development	R&D	Quarterly	All direct and indirect costs related to the creation and development of new processes, techniques, applications and products with commercial possibilities. (Worldscope, WC01201A)
Rate of R&D	R&D/A		R&D expenditure / Total assets in period t – 1
Net property, plant and equipment	PPE	Quarterly	Gross PPE less accumulated reserves for depreciation, depletion and amortization. (Worldscope, WC02501A)
1yr growth in net PPE	PPEGRO	Quarterly	(Net PPE / Net PPE in period t – 4) – 1
ICB industry name		Static	The name of the ICB industry under which the equity is classified. (Worldscope, WC07040)

3.3 Calculating *q*

In my calculations, the market value of equity, along with the book value of total liabilities and total assets, were used to approximate q (see equation 2). Thus, q was calculated with total assets in the denominator as an approximation of the replacement cost of assets. This is possibly the greatest limitation in this study. Although this method has been a common practice for some time, it is not entirely unproblematic. The book value of assets is determined by accounting standards regulated by law and good accounting practice. These standards are not developed with the primary purpose of representing real values as they would be had, for example, in the market place. Rather, they have to adhere to tax laws and limitations set for regulation purposes, and so, does often poorly in generating numbers representing the true replacement costs of assets. A number of examples are presented below.

First, depreciation as recorded in the balance sheet, follow a flat-rate, or some other predetermined model, and cannot hardly represent costs related to any real wear and tear. Another example is that the recorded book values do not take into consideration inflation and technological advancement that heavily influence prices in the real markets. A third problem is how to take into account those immaterial assets that, by law, are not allowed to be put down in the official records. For many firms are these assets, like brand and employee value, substantial and exert great influence on the firms' market valuation.

While several considerably more sophisticated models offering a more accurate approximation of q can be found in the literature, with the issues regarding data availability for the Swedish market, which will be discussed in section 3.5, the attempted use of a more complex model was decided against. Although these calculations more often offer a closer estimate of the true value of q, the results from more basic calculations give roughly the same results and tend to be widely used in different studies (Hsiao & Li 2012; Pietrovito 2016; Wolfe 2005). Therefore, the chosen method was considered to provide a close enough approximation of q.

3.4 The dependent variables & generalizability

For the rate of corporate investment, a number of different proxies may be used. Among these, the most commonly used would be $CAPX$ scaled by some deflator, such as the total value of assets. However, Hsiao and Li (2012) found that the more commonly used investment proxies tend to be outperformed by proxies based on accounting statistics, such as $PPEGRO$ when tested against various proxies for investment opportunity. It was therefore considered an important decision to include this investment measure in the list of dependent variables to be tested against the q model.

$R\&D$ is a different kind of investment measure with limited generalizability, but that could nonetheless be of interest when testing the final q model. The lack of generalizability stems from the fact that $R\&D$ is only undertaken and reported by a fraction of firms, which in turn means that test samples for $R\&D$

would usually tend to be smaller than those for different, more general investment proxies. In this case, this would mean that in order to test the q model for $R\&D$, only a fraction of the full data sample could be studied. This could however still prove meaningful as it would provide insight into how this particular form of investment can be affected by q. The activities and costs included in $R\&D$ may vary between different sectors, but generally the purpose of these undertakings is to increase profitability in the long run through the innovation and enhancement of products and processes.

Despite the fact that all three measures capture investment by some definition, the nature of those investments is different from one another and it is therefore difficult to make generalizations based on the result of a certain form of investment. It is therefore important to specify what is actually included in those investment measures, and what is not, to be able to accurately interpret the results.

In this sense, both $CAPX$ and $PPEGRO$ can be seen as relatively straightforward, as they both, in one way or another, measure investments that are strictly tangible. Historically, the tangible forms of investment have been the main focus of research, but with the changing business climate comes an increasing emphasis on intangible investment. It could therefore be expected that the already somewhat limited need to proxy for strictly tangible investments will become increasingly limited, as intangible investments might be more important for an increasing number of firms. However, as there are still industries which rely heavily on physical assets, such as manufacturing, the rate of tangible investment continues to serve as an accurate proxy for those particular industries.

$R\&D$ is limited to firms or sectors where significant investments in $R\&D$ are common. Unsurprisingly and in line with what might be expected, Hsiao and Li (2012) found $R\&D$ to be a valid investment proxy for certain industries, but otherwise a rather poor one. Therefore, the results from tests with $R\&D$ as the dependent variable will be neither representative nor generalizable for other industries than those represented in the test sample. For the industries where firms do tend to invest in $R\&D$, such as the pharmaceutical industry, this could be considered a valid investment proxy.

Despite the apparent issue concerning generalizability, no consideration could be taken, however, due to the fact that it would have required a rigorous filtering process outside the scope of this study. Moreover, such an undertaking would also significantly limit the total number of observations. Along with the issue regarding the approximation of the replacement costs in q's denominator, this could be one of the more serious limitations of this study and is important to keep in mind when interpreting the results. An alternative in future studies could be using a model combining tangible and intangible investments like q_{tot} described under section 2.2.1.

3.5 Data selection & evaluation

3.5.1 Sampling process

The research presented in this thesis almost exclusively relies on secondary data from Worldscope, collected through the service Thomson Reuters' Datastream. As Datastream typically offers multiple options for a given type of data, all the various datatypes that could potentially be used for the tests were evaluated before finally proceeding with the process of downloading the data. This was to ensure that the datatypes selected were the ones that provided the best available data, both in terms of accuracy as well as quantity. Since the decision had been made to use quarterly data in order to increase the number of observations, one requirement was that all the chosen datatypes were reported on a quarterly basis. The decision to collect quarterly data instead of annual was made to avoid errors attributed to small sample sizes, but with this decision came the restriction of not being able to use certain datatypes that were not reported quarterly such as gross PPE. However, as quarterly data was available for plenty of datatypes, this did not prove to be a major issue over all. Additionally, the data for the weighted average cost of capital, or $WACC$, was gathered from Bloomberg.

3.5.2 Additional comments on data

As can be expected from utilizing large, international databases, data from small markets, such as Sweden, can be severely limited. When attempting to put together sufficiently large samples for preliminary tests the test samples ended up missing large portions of data for periods where those firms were indeed active. While a slightly unbalanced sample generally would not be an issue, the fact a large proportion of data was missing for no evident reason was considered highly problematic as this could potentially have a significant effect on the result of the regression. To try to counter this issue the focus was shifted to examine the different indices for the Swedish stock market, for which data availability proved more satisfactory. Additionally, these indices have the benefit of generally being seen as representatives for the market from which they are derived. For the final sample the list of firms from the OMXSPI index was used, and, in contrast to previous samples, a much smaller fraction of firms needed to be eliminated for this specific reason. Further motivations for choosing this particular index are presented under section 3.6.1 below.

Another issue previously mentioned, was the fact that, for a significant number of firms, no reported data could be found for $CAPX$. Whereas this was somewhat expected in the case of $R\&D$, with this only being reported by a fraction of the total sample, the same could not be said in the case of $CAPX$. This ultimately left no other option than to use a significantly smaller sample than anticipated in the case of this particular variable. At a later stage of the data collection, the timespans for the data sets of $CAPX$ and $R\&D$ were extended three quarters to include Q1 2009 through Q3 2009.

3.6 Limitations & critical discussion

3.6.1 Choice of firms

The OMXSPI index includes all securities traded on the Stockholm Stock Exchange's main market. Limiting the sample by excluding firms traded on the alternative stock markets improved the quality of the data since firms listed there have limited reporting requirements. Evaluations of samples including firms from Nasdaq First North was able to confirm that fact. Thus, by exclusively sampling firms included in the OMXSPI index, it was possible to affirm both the quantity and the quality of the data.

The fact that only firms still active by December 11th, 2018 were studied implies the introduction of survivorship bias in the data. This issue can be assessed to have negligible impact on the outcome of the regressions since what is measured is arguably not that strongly related to the actual performance of the firms. Moreover, initial tests were performed including delisted firms with similar results as the ones presented below.

3.6.2 Choice of time span

The time span 2010–2017 was chosen because of two reasons: One, including the years of the great recession (2007–2009) could potentially have introduced noise in the data making it harder to analyze. Two, a longer time span, while increasing the number of observations by extending the time series, would decrease the number of cross-sectional observations as more firms would have had to be excluded because of inactivity. Thus, the total number of observations would have decreased. An alternative would have been to study separate panels covering a number of different time periods. This, however, was deemed to fall outside the scope of this particular study.

3.6.3 Excluding financial firms

Since the idiosyncrasies between different industries must be taken into consideration when observing their investment decisions, the decision to exclude all firms listed as financials, including those listed under real estate, was therefore made, as is custom for this kind of study. This is due to the nature of those firms and, more specifically, their investment patterns, which differ substantially from those of firms from the categories included in the analysis. The inclusion of these firms could, and most likely would, affect the result of the regression in a way such that it would no longer be representative for the market.

3.6.4 Multiple panels

It would have been preferable to, instead of having a different data sets for each of the dependent variables, have one dataset encompassing all of them. With such a data set comparison would have been more fair and additional tests could have been performed such as calculating the correlation among the different investment rate measures. Such a test would have been instrumental in the validation of the data since strong correlation among the dependent variables would have been expected.

3.6.5 Excluding operating cash flow

The data on operating cash flow on the Swedish firms were insufficient. Having to include the variable would simply have meant discarding too many observations. Tests on a smaller dataset including CF were conducted and confirmed that it was insufficient for the purpose of this study.

3.6.6 Comments on endogeneity

Concerning endogeneity, all regressors used in the analysis have been treated as exogenous variables previously in the literature, although there have been exceptions. This was the main argument for assuming exogeneity among the regressors in this study.

As was previously mentioned under section 1.3.1, there are underlying forces in the market influencing both corporate investment and q. These confounding variables are often unobservable or difficult to measure. The decision to include the other regressors was largely due to this issue. As was discussed under section 2.3, ROA, $SGRO$ and $WACC$ have all been identified in the literature to influence corporate investment. These variables are also under close observation by the financial markets and key parameters in models estimating future cash flow, indirectly affecting firm valuation and q.

Another source of endogeneity are measurement errors related to potential inaccuracies in the recorded book values. Since the error term is not directly observable, the impact of the resulting noise on the model is difficult to assess.

Moreover, total stock return and company beta were introduced into the model with the primary purpose of accounting for exogenous shocks that might influence decision-making within firms.

3.6.7 Robustness analysis

Finally, several robustness tests were performed throughout the study where extreme outliers, missing values and other issues related to the data, or the statistical model, were tested for and discussed, and addressed when needed. These can be found, along with further comments, under sections 4.1 and 5.4.

4. Results

4.1 Data summary

4.1.1 Sample description

As of December 11th, 2018, the Stockholm All-Share Index consisted of 362 components. After filtering for all primary and major stocks and excluding banks, providers of financial services and insurance and real estate firms, a list comprising 255 companies was generated. Then, in order to maintain the quality of the sample data, firms were excluded where data was insufficient, either because of inactivity on the part of the firms or simply because of limitations to the Worldscope database. The final sample consisted of 161 companies and an unbalanced panel of 5’098 observations (time/id pairs), covering a period from Q4 2009 to Q4 2017.

As can be seen in Table 2, Industrials are heavily overrepresented in the sample with close to 40% of the firms belonging to that sector. This was expected due to the nature of the Swedish market and the fact that industrials constitute the, by far, largest sector. Another driving factor for why the distribution looks like it does is that the sample have been filtered for firms that have fixed assets to record; this due to the nature of the study. The vast majority of firms traded on the Stockholm Stock Exchange are smaller companies, among which many can be expected to be prone to, for example, rent or lease their facilities and machines. These firms are more likely to be members of other sectors like the technology or health care sectors.

Table 2. Sector frequency

Sector[1]	Frequency, firms	Percentage, firms	Frequency, observations	Percentage, observations
Basic materials	13	8,97	356	7,00
Consumer goods	20	12,42	667	13,08
Consumer services	23	14,29	701	13,75
Health care	17	10,56	568	11,14
Industrials	61	37,89	1’865	36,58
Oil & gas	2	1,24	62	1,22
Technology	21	13,04	747	14,65
Telecommunications	3	1,86	99	1,94
Utilities	1	0,62	32	0,63
Total	161	100	5’098	100

1. The sectors are classified using the top-tier level in the Industrial Classification Benchmark (ICB). In total there are 10 sectors (or industries as ICB refers to them) with nine represented here. Financials are excluded from the sample.

4.1.2 Descriptive statistics

In Table 3 is a summary of the descriptive statistics. Overall, the statistics take on expected values. The mean of $PPEGRO$ is almost identical with the one reported by Hsiao and Li (2012) which is encouraging considering the much smaller sample size of this study. Their standard deviation, for the same variable, is somewhat smaller though (0,722). Notable is that the means for $PPEGRO$, $PPEGRO_{t-1}$ and $SGRO$ are greater than the 75th percentiles. This indicates that there are still significant outliers despite winsorization. The same is the case for Hsiao and Li (2012) when it comes their recorded values for both q and $SGRO$. Still, it is something to be aware of during the analysis.

Moreover, the SD of TR is also very high but not surprising considering the nature of the volatility of stock returns in general. The other variables take on expected values for SD when compared to other studies and when taking into account the time span applied.

4.1.3 Missing data

In Table 4 are statistics on the missing data reported. ROA sticks out with 6,85% of its values missing. The problem with the missing data was remedied by telling Stata to fill in the blanks through interpolation. While this was done automatically, the windows of values missing was first manually examined for their size and whether interpolation would result in inaccurate estimations. Companies with insufficient data, due to e.g. too many missing values, were removed from the sample. In some cases, a company's time series would be partially kept if it was still extensive enough after an insufficient portion had been removed. It was deemed more necessary to sustain the number of observations above keeping the panel balanced.

Concerning the other variables, the problem with missing data was negligible since less than 1% of the

Table 3. Summary statistics

Variable	Observations[1]	Mean	SD	25th percentile	Median	75th percentile
PPEGRO	4'454	0,199	1,399	-0,078	0,020	0,163
PPEGRO $_{t-1}$	4'293	0,196	1,352	-0,078	0,019	0,165
q $_{t-1}$	4'937	2,153	2,056	1,174	1,559	2,271
ROA $_{t-1}$	4'937	0,042	0,150	0,016	0,058	0,100
SGRO	4'454	0,248	2,453	-0,024	0,058	0,183
WACC $_{t-1}$	4'937	0.074	0.025	0,058	0.073	0,089
TR	4'937	0,033	0,196	-0,083	0,016	0,131
Beta	5'098	1,166	0,651	0,740	1,140	1,530

For variable definitions, see Table 1. The statistics are all observed after interpolation, filling in missing data, and winsorization of extreme outliers. ROA's, WACC's and R's values are given as decimals. 1. The differences between the variables concerning the number of observations reported are due to the data points excluded when lagging variables or calculating growth over multiple periods.

Table 4. Missing values

Variable	Missing	Total	Percent missing (%)
PPE	19	5,098	0,37
Market cap	14	5,098	0,27
Total assets	12	5,098	0,24
Total liabilities	12	5,098	0,24
ROA	349	5,098	6,85
Sales	11	5,098	0,22
WACC	3	5,098	0,00
TR	12	5,098	0,24
Beta	23	5,098	0,45

For variable definitions, see Table 1.

data was missing for each and every of the rest of the variables. Here too, the blanks were filled with interpolated values in accordance with good practice.

In broad strokes, the same as what has just been mentioned above could be said about the data sets for the $CAPX$ and $R\&D$ tests. In the latter one, $R\&D$ has 4 missing values of 1'702 (0,28%) and 6,15% of ROA's data is missing. In the $CAPX$ test, $CAPX$ misses close to 9,26% of its data, with 8,15% of ROA's values missing. It is especially troubling to see that $CAPX$ is so misrepresented in the data set. The same care was taken, as was taken in the clean-up of the main data set, and, except for the regrettable sizes of both panels, the data should be good enough for its purpose of control.

4.1.4 Outliers

To further optimize the data by limiting the effect of possibly spurious outliers, it was decided that extreme outliers should be winsorized by replacing values smaller than the first percentile with the value of the first percentile, and similarly with the values greater than the 99th percentile.

4.2 Regression results

4.2.1 Lag *t–1*

The relationship between Tobin's q and corporate investments is being tested. A GLS regression is performed on the model represented by equation 4, introducing a number of variables the literature has identified as proxies for investment opportunity. These additional regressors are added for the sake of the robustness of the model. To these, total return and company beta are added to account for changes in investor attitude and risk. The initial results are reported in Table 5 below.

The overall models are fine, reporting chi square values (χ^2) well above the 1% significant level. The coefficients of determination (R^2) for the first two models are small but are generally difficult to interpret and draw conclusions from after a GLS estimation. The main estimators are all significant to various degrees with expected signs. Neither TR nor $Beta$ are significant in the full model, however.

The GLS regression, without control for additional explanatory variables, estimates the coefficient of Tobin's q to be positive and significant at a 1% level. The model, introducing additional regressors, continues to show a positive relationship between q_{t-1} and $PPEGRO$, still significant at 1%. Moreover, ROA_{t-1}, $SGRO$ and $WACC_{t-1}$ are all significant. ROA_{t-1} and $SGRO$ with positive coefficients at 1% and $WACC_{t-1}$ with a negative coefficient at 5%. As previously mentioned, the negative relationship between cost of capital and corporate investment is expected since increases in financial costs is expected to lead to decreases in firm investment.

In Table 6, the correlations between the different variables are reported. q_{t-1} has a positive but weak correlation with the investment rate measure. $SGRO$, however, seem to be even more correlated with

Table 5. Regression output: t-1

PPEGRO	*q* as sole regressor	Without lagged PPEGRO	Full model
$PPEGRO_{t-1}$			0,7501 *** (0,000)
q_{t-1}	0,0663 *** (0.000)	0,0294 *** (0,004)	0,0150 ** (0,045)
ROA_{t-1}		0,0137 *** (0,000)	0,0024 ** (0,016)
SGRO		0,0844 *** (0,000)	0,0582 *** (0,000)
$WACC_{t-1}$		-0,0206 ** (0,045)	-0,0115 * (0,079)
TR		-0,0017 * (0,083)	0,0008 (0,319)
Beta		0,0653 (0,152)	-0,0077 (0,750)
Observations	4'454	4'454	4'293
R^2, within	0,0033	0,0429	0,4677
R^2, between	0,0447	0,0024	0,9358
R^2, overall	0,0113	0,0303	0,5451
Prob. > χ^2	21,13 (0,0000)	180,81 (0,0000)	5134,30 (0,0000)
Estimation method	GLS	GLS	GLS

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level. The sample is comprised of 161 Swedish firms from Q4 2009 to Q4 2017. The regression coefficients are reported as absolute values while the R^2 values are given in decimal form.

Table 6. Correlation matrix: t-1

Variable	PPEGRO	$PPEGRO_{t-1}$	q_{t-1}	ROA_{t-1}	SGRO	$WACC_{t-1}$	TR	Beta
PPEGRO	1							
$PPEGRO_{t-1}$	0,7298 ***	1						
q_{t-1}	0,1061 ***	0,0980 ***	1					
ROA_{t-1}	0,0562 ***	0,0448 ***	0,1486 ***	1				
SGRO	0,1752 ***	0,1000 ***	0,1093 ***	-0,0185	1			
$WACC_{t-1}$	-0,0214	-0,0080 ***	0,1675 ***	0,1502 ***	-0,0090	1		
TR	0,0015	-0,0182	0,0006	0,0786 ***	0,0255 *	-0,0201	1	
Beta	-0,0749 ***	-0,0836 ***	-0,1435 ***	-0,1035 ***	-0,0443 ***	0,2353 ***	0,0087	1

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level.

the investment rate compared with q_{t-1}. All explanatory variables take on the signs expected. The signs of both $WACC_{t-1}$ and TR cannot be ascertained even at the 10% significance level, however.

4.2.2 Lag *t–2*

In order to account for the fact that $PPEGRO$ is measured over four periods (four quarters) it would make sense to test extending the lag of the explanatory variables. In that way, the model would be allowed to further capture the influence of the regressors on the dependent variable. In Table 7 below are the GLS regressions reported where q_{t-2}, ROA_{t-2} and $WACC_{t-2}$ as well as $PPEGRO_{t-2}$ are lagged an additional period. To extend the variables' lag even further runs the risk of capturing effects not related to what the model tries to estimate. $SGRO$ is maintained since the growth in sales are already calculated over the past four periods. TR and $Beta$ are controlling for non-essential parts of the model and are quite volatile variables that might skew the model and make the regression output difficult to interpret. Therefore, it could be potentially hazardous to lag them in either of the models.

Overall, before introducing the lagged dependent variable, the model improves after extending the lag. χ^2 goes from 21,13 to 33,04 and 180,81 to 223,36 before and after introducing additional regressors respectively. Even the overall R^2 improves, all but marginally, from 0,0113 to 0,0136, mainly due to an increase in the R^2 explaining for the within variation. The coefficients in all main regressors have, more or less, increased (or decreased in the case of $WACC_{t-2}$) and all are now significant at 1%. Most notable is the change in q_{t-2}'s coefficient which is closing in on a half base point. After including the two-period lagged variable for growth in PPE ($PPEGRO_{t-2}$), the comparison changes with a steep

Table 7. Regression output: t-2

PPEGRO	No control	With control	Full model
$PPEGRO_{t-2}$			0,4393 *** (0,000)
q_{t-2}	0,0837 *** (0,000)	0,0412 *** (0,005)	0,0364 *** (0,001)
ROA_{t-2}		0,0172 *** (0,000)	0,0067 *** (0,000)
SGRO		0,0847 *** (0,000)	0,0922 *** (0,000)
$WACC_{t-2}$		-0,0310 *** (0,002)	-0,0251 *** (0,007)
TR		-0,0012 (0,220)	0,0004 (0,723)
Beta		0,0840 * (0,065)	-0,0062 (0,863)
Observations	4'454	4'454	4'132
R^2, within	0,0059	0,0541	0,1343
R^2, between	0,0447	0,0010	0,7191
R^2, overall	0,0136	0,0333	0,2242
Prob. > χ^2	33,04 (0,0000)	223,36 (0,0000)	1048,95 (0,0000)
Estimation method	GLS	GLS	GLS

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level. The sample is comprised of 161 Swedish firms from Q4 2009 to Q4 2017. The regression coefficients are reported as absolute values while the R^2 values are given in decimal form.

Table 8. Correlation matrix: t-2

Variable	PPEGRO	PPEGRO $_{t-2}$	q $_{t-2}$	ROA $_{t-2}$	SGRO	WACC $_{t-2}$	TR	Beta
PPEGRO	1							
PPEGRO $_{t-2}$	0,4353 ***	1						
q $_{t-2}$	0,1164 ***	0,0986 ***	1					
ROA $_{t-2}$	0,0700 ***	0,0484 ***	0,1395 ***	1				
SGRO	0,1752 ***	0,0203	0,1178 ***	-0,0330 **	1			
WACC $_{t-2}$	-0,0308 **	-0,0094	0,1673 ***	0,1498 ***	-0,0052	1		
TR	0,0015	-0,0310 **	-0,0065	0,0409 ***	0,0255 *	-0,0199	1	
Beta	-0,0749 ***	-0,0899 ***	-0,1473 ***	-0,0996 ***	-0,0443 ***	0,2442 ***	0,0087	1

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level.

decrease in χ^2, from 5134,30 to 1048,95, which is expected since the relationship between the dependent variable and any lagged dependent variable would be stronger the closer in proximity in time they are.

Another major difference can be seen as $WACC_{t-2}$'s coefficient more than doubles in magnitude, from -0,0115 to -0,0251, and from a 10% degree of certainty to 1%. This puts its estimated effect on the dependent variable on par with both q_{t-2} and $SGRO$.

To summarize, lagging the regressors one additional time period seem to improve the model. It is good practice, however, to be careful when interpreting the results in these kinds of situations.

4.3 Additional findings

The output of the regressions, using scaled versions of capital expenditure and research and development as dependent variables, is reported in appendices A, B and C. These results will be further discussed under sections 5.2.1 and 5.2.2.

4.3.1 Regressions on capital expenditure

All regressors in the $CAPX/A$ models (see Appendix A) have very small coefficients, except for lagged $CAPX/A$ in the full model. q's is significant in the first two, but nothing substantial can be retrieved from these tests. From the $CAPX/P$ model (see Appendix B) the coefficients seem to increase with around one order of magnitude in average from the previous model. They are still quite small, however. q is significant to various degrees in all three models. Overall, all models have relatively low R^2 and χ^2 values, except for the models incorporating lagged investment rate.

In summary, q cannot be determined to be significantly correlated with $CAPX/A$ and no other strong relationship can be established among any of the other regressors and the dependent variable. In the case of $CAPX/P$, q is significantly (1%) correlated with the investment rate measure, but only a weak positive relationship (0,09) can be established. Moreover, both $WACC$ and $Beta$ are significantly and negatively correlated with $CAPX/P$.

4.3.2 Regressions on R&D

In Appendix C, the results from the regression on $R\&D/A$ are presented. In contrast to the tests done on $CAPX$, all three models have high and χ^2 and R^2 values. When looking at the coefficients, however, they have really small values, although significant. All variables, in the "With control" model, are significant at the 1% level. A couple of the coefficients take on unsuspected signs, with both return on assets in negative and $WACC$ in positive territory. They are, as mentioned, rather small, so nothing substantial could be read into them. When introducing lagged $R\&D/A$, $WACC$'s sign is flipped to the more expected, negative one, but cannot be established to be non-zero even with 10% certainty. Neither are $SGRO$'s, TR's nor $Beta$'s coefficients determined to be significant any more. Moreover, q's coefficient, in the full model, is the only one, except for lagged $R\&D/A$, that is both still significant (1%) and takes the expected, positive sign.

These findings above will be contributing to this study by acting as control for the primary tests done on $PPEGRO$, and will, to that end, be discussed in a concise manner in the analysis.

4.3.3 Regression with sector dummies

When running a fixed effects GLS estimation on the above-mentioned models, including dummies for ICB's 10 top-level sector classification, resulted in all of the dummies being omitted from the model. Hence no effect could be seen across industries on the Swedish market given the historical observations studied. This result is discussed in a short manner under section 5.2.3.

5. Analysis

5.1 Interpreting the model

The overall interpretation of the results has to be done in light of the conclusions of previous studies. As will be shown below, there are many similarities between the outcome of this study and others, leaving little room for surprise.

5.1.1 Overall model & q

There are several indicators pointing to the fact that Tobin's q is performing on the Swedish market as it has been discovered, in other studies, to perform on other markets. The first is a positive but weak correlation of q with corporate investment. The second is a positive and significant, all but small, coefficient. Neither finding point to q being an accurate proxy for a firm's investment level. This reflects the literature well (Blundell et al. 1992; Pietrovito 2016; Abel & Blanchard 1986; Eberly, Rebelo & Vincent 2012). Rather, testing additional parameters in the model, shows that q far from stands out. As was pointed out under section 4.2.1, both sales growth and the weighted average cost of capital exert about the same amount of influence on the dependent variable as q. Although the absolute meaning behind the outcome of the GLS estimation is difficult to interpret, these relative comparisons do point to that fact. The fact that q does not perform well as a sole estimator is not unexpected and a fact well reflected in the literature (Cuthbertson & Gasparro 1995; von Furstenberg et al. 1977).

Now let's consider a more direct interpretation of the results of the full model, as represented in Table 5, by applying standardized interpretation. Keeping all other regressors constant at their respective means, one standard deviation (2,056) increase in q implies an increase in the investment rate of 3,078%. Considering the relatively high standard deviation, the impact of q on $PPEGRO$ is negligible.

For example, say that a firm A's market value at time t equals the replacement costs of its assets ($q = 1$). At time $t + 1$, the firm's market value experiences a dramatic increase of 200%. Everything else equal, this would mean an increase in q with approximately one standard deviation so that q equals three. According to the findings of this study, firm A would now be expected to accelerate its investments in its fixed assets by three percent. Considering that firm A's size just tripled in terms of its market valuation, the three percent increase in its investment rate have to be regarded as incremental.

5.1.2 Accounting for past investments

As I introduce the lagged dependent variable, and so allow the model to take into account the effect of past investments on current ones, the explanatory power of the rest of the regressors decreases. This, while lagged $PPEGRO$ stands out with a coefficient several orders of magnitude greater than the rest. This was indeed expected in light of previous findings (Pietrovito 2016; Blundell et al. 1992; Eberly, Rebelo & Vincent 2012), but also from the expectation that inertia should play a major role in firms' decision-making processes. $PPEGRO$ is naturally strongly correlated (0,73) with its lagged version. All this points to the fact that investments made in the past should not be ignored when trying to explain the firms' investment behavior.

Now, while the explanatory power decreases for the rest of the regressors, it is still important to note that the main regressors are still statistically significant. q's (0,0150) and $SGRO$'s (0,0582) coefficients still stick out, determined at 5% and 1% levels of significance respectively. This means that, even with the model taking into account the impact of investments made in the past, there are still variations in corporate investments being explained by investment opportunities.

5.1.3 Accounting for future investment opportunities

Now, let us turn to the other variables trying to explain for the impact of future investment opportunities on current investment. First, whether a firm is able to sell their produce should be a major factor of whether it is willing to further expand its operations or add similar or complementary products to its already established portfolio. To measure an incentive related to sales through growth in sales makes sense since past growth in sales often prove to be a good indicator of the potential for future growth. Sales growth can be established to have a significant (1%) impact on future investment that exceeds that of q's.

Second, while sales and revenue streams are important, to get a picture of a firm's performance, the profitability of the firm has to be taken into consideration. Return on assets, taking into account both total costs and the absolute book value or, if you will, the recorded size of the firm, is communicating how much profit has been generated by the installed capital. This ratio is expected to be a predictor of investment, since, an already high ROA could be an indicator that installing more capital could lead to even more lucrative outcomes. Relative to q and $SGRO$, ROA cannot be shown to impact corporate investment to any greater extent.

Now, return on assets can be interpreted to be more of a benchmark for past investments rather than an incentive to make new ones. After all, shortsighted thinking would reason that installing more capital, while not guaranteeing even more profitable outcomes, will, at least in the short term, dilute the returns and make the firm less profitable. Thus, a less progressive strategist might suggest investments retaining the current capital stock, rather than expanding it.

Also worth noting is that it has been previously found that ROA is weakly correlated with $PPEGRO$ (Hsiao & Li 2012).

Thirdly, as was previously pointed out in the introduction of this paper (see section 1.2), and also discussed in the literature review (see section 2.3.3), the cost of capital would be expected to be negatively related to corporate investments. Financial constraints on firms limit their freedom in choosing future projects due to added costs related to the financing decisions (Lin et al. 2016; Ramezani 2011). This reasoning holds to be true for the data studied in this paper since $WACC$ is registered to have a negative coefficient in the linear regression model. The correlation coefficient, however, although significantly negative (5%), is surprisingly small (-0,02). One reason for this could be that the changes in the cost of capital is too incremental in the time scale applied. Perhaps, observing changes in $WACC$, and its effect on corporate investment, over longer time periods, using larger time steps, could change the outcome. More probable, however, is that the period 2010–2017 itself is ill suited for studying $WACC$ due to unique factors like the historically low interest rates.

5.1.4 Stock return

Although stock return and company beta were added for the purpose of control, a few comments will be added here related to these variables. As this paper is unable to observe any relationship between $PPEGRO$ and TR, it somewhat concurs with Blanchard et al. (1993) who stated that market valuation—and by close relation, changes in stock price—should not cause investment. Their statement was, however, related to criticism of q, with its numerator being the market capitalization. The market capitalization is not the same as the market value of equity, though, since it includes the market value of debt. And also, the fact that the q ratio is the market value of the firm scaled by its book value, it may not be unreasonable to say that it is unfair to compare q and TR with each other.

In conclusion, neither TR nor $Beta$ was found to exert any significant influence on $PPEGRO$, as was expected. That being the fact, it is interesting to see that all other variables included indeed were significant.

5.1.5 Extending the lag

As mentioned under section 4.2.2, lagging the proper regressors one additional period did further improve the overall outcome. Now all main predictors are significant to a 1% level of certainty. The overall statistics are worse due to the extended lag of the independent variable, the reason of which is also mentioned under section 4.2.2 above.

$SGRO$'s coefficient grows from 0,0582 to 0,0922, closing in on one base point. This is not due to any change in the variable itself but due to improvements of the overall model. Greatest relative change, however, is experienced by the other three primary regressors. Their coefficients more than double with q's now at 0,0364. As discussed above, these improvements are due to giving the model a chance to account for delayed effects in the variables on $PPEGRO$ which is calculated over the full period of a year.

5.1.6 Interpreting the full model

In summary, the full model, in the tests done lagging the variables one period, looks pretty good considering the data given. All main predictors are non-zero to a degree of certainty of, at least, 10%. All coefficients take on the expected signs; all are positive except $WACC$. Extending the lag one additional period improved the model further and contributes for a fuller picture of the regressors impact on corporate investment as calculated in these tests.

The results from both tests were controlled for possible bias that could have been introduced when the lagged version of $PPEGRO$ was included. This was done by comparing both models with the ones excluding the lagged dependent variable.

The full model is by no means a complete one. It shows, however, that historical investments far outperform any proxy for investment opportunity. Further, the primary explanatory variables cannot be rejected on the basis of the statistical results of these tests. No major impact can be attributed to them though, including Tobin's q in the form it has taken in this study.

5.2 Comments on the additional regressions

5.2.1 Discussion on capital expenditure

The decision to extend the timespans and include additional firms, not included in the current (as of December 11th, 2018) OMXSPI index, did improve the outcome of the estimation. This, especially in the case of $R\&D$.

q proved to work better with $CAPX/P$ than with $CAPX/A$ from what could be gathered from the data. This echoes the findings by Hsiao and Li (2012). In the correlation matrix in Table 13 q, $Beta$ and $WACC$ were the only ones found to be correlated with $CAPX/P$, ignoring its lagged version. Although all three take on the expected signs, no strong relationship can be ascertained between them.

Doing a comparison between the models on $PPEGRO$ and scaled $CAPX$, the overall statistics would point to the advantage of using $PPEGRO$ in tandem with the chosen explanatory variables. Comparing the models, however, might not be entirely fair since differences in the data between the tests have to be taken into account. Still, if a comparison had been fair to make, an explanation would be demanded for why the models and, more significantly, q is such a bad predictor of scaled $CAPX$.

5.2.2 Discussion on R&D

Firms that tend to report $R\&D$, on the Swedish market, might, to a greater degree, be firms whose sales and income data are more sporadic and volatile, like firms in the high technology and pharmaceutical sector and less established firms in their startup phase. If not for the rather small sample size, this might be the reason why, doing these kinds of tests in Sweden using $R\&D$ as proxy for investment, is difficult together with the variables included in this study.

In conclusion, the one explanatory variable, among the ones tested in this study, that seem to best describe investment as measured by $R\&D$ and $CAPX$ is q. In all six tests done on $CAPX/P$ and $R\&D$, q is shown to be positively related with the dependent variable to a certainty of, at least, 10%. q was also proven to be the one most strongly correlated with investment rate among the regressors included. Also, in the test on $CAPX/A$, q seems to show the best results. No significant correlation was detected here, however.

5.2.3 Sector dummies

The fact that no variation in the dependent variables could be explained by the sector dummies could very well be attributed to limitations in the data. After all, and as mentioned previously, it would be highly expected that idiosyncrasies across different industries would affect the impact of q on corporate investment. It could also be that variations among firms' activities within each industry might be too great, implying that exploring narrower industry categories might yield more significant results.

Another issue could be the imbalance between the industries as presented by the data in Table 2. Tests could be done on more equally weighted data sets only including the industries most represented on the Swedish market. It is not within the scope of this study to make any such tests, though.

Concerning the study as it is, the fact that the sample consists of such an unbalanced sample, and that industrials are so heavily represented, could potentially have introduced bias in the results. This is difficult to remedy since sacrificing as many observations, as would have been needed to balance the sectors, would have instead introduced errors attributed to a smaller sample size.

5.3 Additional comments on the test results

As has been pointed out before, most primarily under section 3.3, to accommodate for the discrepancies between the q theory and the results found both in this study and in others, a critical stance should be taken against the way q is calculated, or, more specifically, the replacement cost of capital.

Another reason for the poor results attributing q with such weak predictive power can be the data availability in Sweden. As has been explained under section 4.1.1 above, assuring the quality of the data while trying to maintain a sufficient quantity of observations, and, at the same time keeping it relatively balanced, has been difficult. Although the data has proven to be sufficient, there is more to be gained from even larger panels. This has been clear throughout the study since the improvements of the statistical outcomes have not been shown to stagnate even at marginal increases of observations. Especially the tests using $R\&D$ and capital expenditure as corporate investment proxies have much to gain from larger data sets since both, but more notably $R\&D$, are ill represented parameters in corporate Sweden (see sections 3.4 and 3.5.2). In countries, such as the United States, where there is an abundance of large organizations more prone to report $R\&D$ etc., data is more readily available. This in contrast to Sweden where firms belonging to the classification *large cap* are merely in the double figures.

For a full discussion on the robustness of the model, see section 5.4 directly below.

5.4 Robustness

5.4.1 Heteroscedasticity & autocorrelation

To test for the presence of heteroscedasticity, Stata's post-estimation test *hettest* was utilized. These tests were done on OLS estimations performed on all models also estimated by GLS in this study. All tests established that the assumption of homoscedasticity was violated. This was to be expected considering the nature of the data and the relatively frequent occurrence of this issue within econometrics.

Similarly, a post-estimation test, applying Stata's *xtserial* function, found the assumption of no autocorrelation within the panel to be violated.

Both of these issues were remedied by utilizing the generalized least squares during the analysis of the panel data.

5.4.2 Multicollinearity & endogeneity

Performing a GLS estimation with fixed effects did not result in any omitted variables, hence pointing to the fact the there are no multicollinearity issues within the model.

Finally, a Durbin-Wu-Hausman test[1] was performed using instrumental-variables estimation and an OLS estimation. The null hypothesis of exogeneity could not be rejected based on those results. The test was not an extensive one and further inquiry could have been made using more data on other variables not included in this study but otherwise discussed in the literature.

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[1] A Durbin–Wu–Hausman test, a test for model misspecification, was performed on two sets of GLS estimations; one using a fixed effects estimator and the other a random. The conclusion was to not reject the null hypothesis; that there is no systematic difference between the coefficients. Therefore, to use the random effects estimator was preferred in all tests in this study, due to efficiency.

6. Conclusions

6.1 Conclusions drawn from the analysis

This paper has reported the findings of a longitudinal study done on Swedish firms covering the period 2010–2017. A model for predicting corporate investment has been tested on 161 companies using a set of proxies for investment opportunities. The primary goal has been to measure the performance of Tobin's q on the Swedish market using growth in property, plant and equipment as the primary measure for past investments.

From analyzing the sample data, the decision was to reject the null hypothesis on the basis that it points to q having a significant, positive relationship with corporate investment in Sweden over the period studied, as measured in growth in property plant and equipment. Consequently, this study concurs with previous findings concerning q's performance as a proxy for investment opportunity. However, although significant, q cannot be assessed to solely be a well performing predictor of corporate investments in Sweden given the full picture described by the model applied. This, of course, assumes the version of q as it has been applied in this study.

Other proxies were found to be just as relevant as q in predicting corporate investment. Among the ones tested in this study, weighted average cost of capital and growth in sales were found to be the most interesting. Although no strong correlation could be established, the latter was found to be the most correlated with $PPEGRO$.

Although average q, as it has been calculated in the above tests, does not consider more recent ideas, suggested by the literature, on how to approximate the replacement costs of firms' total assets, the market-to-book value approach of this study is, at least, directly comparable to a number of other studies done on other markets. This has, after all, been one of the main objects of this study.

6.2 Contribution

This paper contributes to the literature covering corporate investment, investment opportunity, and, more specifically, the literature dealing with Tobin's q. How corporations invest is a matter of great complexity. There are a lot of parameters going into the decision-making process on how to accrue and install capital, and only a fraction of them can be expected to be measured to a reasonable degree of certainty using quantitative data. In this thesis, the performance on a number of these parameters, and primarily Tobin's q, have been tested on the Swedish market. The apparent lack of studies applying the q model exclusively on Swedish firms, suggest that this paper is merely the first installment of similar studies still to be performed in the future.

Potential implications of the findings reported in this thesis can be deemed to be purely academic since it is unlikely that a quantitative model, such as the one theorized and tested above, would find any application within the corporate sphere. Rather, this paper set out to provide an initial test of Tobin's average q in Sweden and, thus, provide a framework within which future research may be performed and against which future findings may be compared.

To fall back on what was discussed in the introduction, a more direct example of how to apply an investment opportunity model would be to include it in research setting out to measure the impact of other variables on corporate investment, like government interest rates and the like. However, before we start evaluation our governments monetary policies, there is more research having to be done within this field.

6.3 Future research

There is much room for future studies in this field as pertaining to the Swedish market. Greater data sets may be constructed using larger time frames than the one applied in this study. More parameters may be explored such as the operating cash-flow rate, P/E ratio (Pietrovito 2016), value of growth as defined in Richardson (2002), firm specific risk (Panousi & Papanikolaou 2012) or growth in gross PPE (Hsiao & Li 2012).

More direct, and probably even more pressing, is applying other methods of approximating q. Most of the work waiting to be done in this area has to do with discovering appropriate methods for approximating the replacement costs of a firm's assets. There are already models introduced in the literature attempting to do this (Hayashi 1982; Peters & Taylor 2017). It would be interesting to see these tested on the Swedish market as well. First, however, the data availability has to be evaluated with this purpose in mind.

Another, rather different, approach would be to explore the bond market's q (Philippon 2009; Lin et al. 2018). It could be that this version of Tobin's q would perform better since the relatively large share of small cap firms on the Stockholm stock exchange makes the Swedish stock market to be quite volatile. Bond q would expectedly, eliminate errors related to that issue.

Seeing that $WACC$ and $SGRO$ performed relatively well in this study, exploring different but related variables, like cost of debt, weighted average return on invested capital, or different sales rate measures, would be interesting. Also, seeing that return on assets performed relatively poorly, other profitability variables, like return on equity (ROE), could be tested. Perhaps ROE is a profitability ratio more likely to be monitored by decision makers inside firms.

Sector specific effects on the model were expected, but the data clearly did not support any such finding. More could be done here in terms of trying out several alternative models or categorizing firms using a deeper level of industry classification. Time and firm fixed effects are also aspects left to explore in future studies. Also interesting would be to take into consideration the effect of firm size and age on the model. This, especially, since some previous studies have discovered that q's impact on investment differs, not only in magnitude but in direction, depending on these characteristics (Jovanovic & Rousseau 2014; Alti 2003).

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Appendix A: Regression on CAPX/A

Table 9. Summary statistics

Variable	Observations[1]	Mean	SD	25th percentile	Median	75th percentile
CAPX/A	2’733	0,011	0,017	0,003	0,006	0,012
CAPX/A $_{t-1}$	2’657	0,011	0,017	0,003	0,006	0,012
q $_{t-1}$	2’733	2,102	2,114	1,178	1,542	2,193
ROA $_{t-1}$	2’733	0,056	0,135	0,019	0,057	0,099
SGRO	2’505	0,144	1,308	-0,027	0,054	0,157
WACC $_{t-1}$	2’733	0,073	0,024	0,058	0,072	0,087
TR	2’809	0,044	0,196	-0,076	0,023	0,141
Beta	2’809	1,210	0,669	0,790	1,230	1,640

For variable definitions, see Table 1. The statistics are all observed after interpolation, filling in missing data, and winsorization of extreme outliers. ROA’s, WACC’s and TR’s values are given as decimals. 1. The differences between the variables concerning the number of observations reported are due to the data points excluded when lagging variables or calculating growth over multiple periods.

Table 10. Correlation matrix

Variable	CAPX/A	CAPX/A $_{t-1}$	q $_{t-1}$	ROA $_{t-1}$	SGRO	WACC $_{t-1}$	TR	Beta
CAPX/A	1							
CAPX/A $_{t-1}$	0,6700 ***	1						
q $_{t-1}$	-0,0208	-0,0271	1					
ROA $_{t-1}$	-0,0589 ***	-0,0467 **	0,2848 ***	1				
SGRO	-0,0110	-0,0067	0,0351 *	-0,0587 ***	1			
WACC $_{t-1}$	-0,0171	-0,0427 **	0,1094 ***	0,1767 ***	0,0084	1		
TR	-0,0226	-0,0214	0,0003	0,0624 ***	0,0027	-0,0592 ***	1	
Beta	-0,0736 ***	-0,0755 ***	-0,2353 ***	0,0991 ***	-0,0559 ***	0,2632 ***	0,0628 ***	1

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 11. Regression output

CAPX/A	No control	With control	Full model
CAPX/A $_{t-1}$			0,6397 *** (0,000)
q $_{t-1}$	0,0005 *** (0,000)	0,0005 *** (0,007)	0,0000 (0,938)
ROA $_{t-1}$		-0,0000 * (0,079)	-0,0000 ** (0,019)
SGRO		-0,0000 (0,821)	-0,0001 (0,498)
WACC $_{t-1}$		0,0003 * (0,053)	0,0002 (0,125)
TR		-0,0000 (0,408)	-0,0000 (0,726)
Beta		-0,0016 *** (0,009)	-0,0006 (0,203)
Observations	2’733	2’505	2’505
R^2, within	0.0036	0.0088	0,1617
R^2, between	0.0107	0.0000	0,9926
R^2, overall	0.0004	0.0021	0,4249
Prob. > χ^2	7.64 (0,0057)	20,27 (0,0025)	1844,52 (0,0000)
Estimation method	GLS	GLS	GLS

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level. The sample is comprised of 76 Swedish firms from Q1 2009 to Q4 2017. The regression coefficients are reported as absolute values while the R^2 values are given in decimal form.

Appendix B: Regression on CAPX/P

Table 12. Summary statistics

Variable	Observations[1]	Mean	SD	25th percentile	Median	75th percentile
CAPX/P	2’733	0,131	0,351	0,029	0,055	0,108
CAPX/P $_{t-1}$	2’657	0,129	0,352	0,029	0,054	0,108
q $_{t-1}$	2’733	2,102	2,114	1,178	1,542	2,193
ROA $_{t-1}$	2’733	0,056	0,135	0,019	0,057	0,099
SGRO	2’505	0,144	1,308	-0,027	0,054	0,157
WACC $_{t-1}$	2’733	0,073	0,024	0,058	0,072	0,087
TR	2’809	0,044	0,196	-0,076	0,023	0,141
Beta	2’809	1,210	0,669	0,790	1,230	1,640

For variable definitions, see Table 1. The statistics are all observed after interpolation, filling in missing data, and winsorization of extreme outliers. 1. ROA’s, WACC’s and TR’s values are given as decimals. The differences between the variables concerning the number of observations reported are due to the data points excluded when lagging variables or calculating growth over multiple periods.

Table 13. Correlation matrix

Variable	CAPX/P	CAPX/P $_{t-1}$	q $_{t-1}$	ROA $_{t-1}$	SGRO	WACC $_{t-1}$	TR	Beta
CAPX/P	1							
CAPX/P $_{t-1}$	0.5567 ***	1						
q $_{t-1}$	0.0869 ***	0.0887 ***	1					
ROA $_{t-1}$	-0.0184	0.0001	0,2848 ***	1				
SGRO	0.0153	0.0128	0,0351 *	-0,0587 ***	1			
WACC $_{t-1}$	-0.0803 ***	-0.0877 ***	0,1094 ***	0,1767 ***	0,0084	1		
TR	0.0116	0.0261	0,0003	0,0624 ***	0,0027	-0,0592 ***	1	
Beta	-0.0689 ***	-0.0432 **	-0,2353 ***	0,0991 ***	-0,0559 ***	0,2632 ***	0,0628 ***	1

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 14. Regression output

CAPX/P	No control	With control	Full model
CAPX/P $_{t-1}$			0,5582 *** (0,000)
q $_{t-1}$	0,0116 *** (0,003)	0,0076 * (0,075)	0,0071 ** (0,019)
ROA $_{t-1}$		0,0017 *** (0,004)	-0,0008 * (0,091)
SGRO		-0,0032 (0,480)	0,0010 (0,821)
WACC $_{t-1}$		0,0024 (0,443)	-0,0038 (0,145)
TR		0,0002 (0,509)	0,0004 (0,870)
Beta		-0,0362 *** (0,007)	-0,0 (0,153)
Observations	2’733	2’505	2’505
R^2, within	0,0028	0,0098	0,0672
R^2, between	0,0167	0,0001	0,9805
R^2, overall	0,0075	0,0023	0,3200
Prob. > χ^2	8,61 (0,0033)	22,18 (0,0011)	1175,30 (0,0000)
Estimation method	GLS	GLS	GLS

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level. The sample is comprised of 76 Swedish firms from Q1 2009 to Q4 2017. The regression coefficients are reported as absolute values while the R^2 values are given in decimal form.

Appendix C: Regression on R&D

Table 15. Summary statistics

Variable	Observations[1]	Mean	SD	25^{th} percentile	Median	75^{th} percentile
R&D/A	1'387	0,025	0,041	0,005	0,010	0,029
R&D/A $_{t-1}$	1'344	0,025	0,041	0,005	0,010	0,029
q $_{t-1}$	1'387	2,640	2,572	1,266	1,765	2,932
ROA $_{t-1}$	1'387	0,018	0,171	-0,004	0,051	0,096
SGRO	1'258	0,299	2,572	-0,060	0,050	0,182
WACC $_{t-1}$	1'387	0,076	0,028	0,059	0,075	0,092
TR	1'430	0,045	0,248	-0,095	0,015	0,155
Beta	1'430	1,231	0,760	0,860	1,230	1,600

For variable definitions, see Table 1. The statistics are all observed after interpolation, filling in missing data, and winsorization of extreme outliers. ROA's, WACC's and TR's values are given as decimals. 1. The differences between the variables concerning the number of observations reported are due to the data points excluded when lagging variables or calculating growth over multiple periods.

Table 16. Correlation matrix

Variable	R&D/A	R&D/A $_{t-1}$	q $_{t-1}$	ROA $_{t-1}$	SGRO	WACC $_{t-1}$	TR	Beta
R&D/A	1							
R&D/A $_{t-1}$	0,8158 ***	1						
q $_{t-1}$	0,3459 ***	0,3413 ***	1					
ROA $_{t-1}$	-0,5444 ***	-0,5405 ***	0,0771 ***	1				
SGRO	0,2653 ***	0,2640 ***	0,2814 ***	-0,1330 ***	1			
WACC $_{t-1}$	-0,0084	-0,0025	0,1231 ***	0,0720 ***	0,0686 **	1		
TR	0,0414	0,0533 *	-0,0004	0,0156	-0,0007	-0,0219	1	
Beta	-0,0933 ***	-0,0805 ***	-0,1272 ***	-0,0322	-0,0045	0,3074 ***	0,0632 **	1

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 17. Regression output

R&D/A	No control	With control	Full model
R&D/A $_{t-1}$			0,6835 *** (0,000)
q $_{t-1}$	0,0024 *** (0,000)	0,0028 *** (0,000)	0,0021 *** (0,000)
ROA $_{t-1}$		-0,0006 *** (0,000)	-0,0004 *** (0,000)
SGRO		0,0011 *** (0,000)	0,0003 (0,169)
WACC $_{t-1}$		0,0007 *** (0,013)	-0,0001 (0,810)
TR		0,0001 *** (0,002)	0,0000 (0,410)
Beta		-0,0033 *** (0,009)	-0,0045 (0,215)
Observations	1'387	1'258	1'258
R^2, within	0,0287	0,1487	0,2238
R^2, between	0,1542	0,7500	0,9885
R^2, overall	0,1196	0,4877	0,7471
Prob. > χ^2	43,95 (0,0000)	272,01 (0,0000)	3692,96 (0,0000)
Estimation method	GLS	GLS	GLS

For variable definitions, see Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level. The sample is comprised of 43 Swedish firms from Q1 2009 to Q4 2017. The regression coefficients are reported as absolute values while the R^2 values are given in decimal form.