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Q-theory of Investment and Earnings Retentions - Evidence from Scandinavia

Johan E. Eklund

(Ratio Institute, CESIS and JIBS)

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Q-theory of Investment and Earnings Retentions - Evidence from Scandinavia

Johan E. Eklund
Ratio Institute and Jönköping International Business School, Jönköping University
103 64 Stockholm
Box 2303
E-mail: johan.eklund@ratio.se
Phone: +46-(0)8-4415900
Fax: +46-(0)-4415929

Abstract: In a frictionless milieu retentions should have no impact on investment behavior. However, empirical studies typically find that retentions are an important determinant of investment. Managerial discretion and financial constraints are two alternative explanations that have been suggested. This paper uses a panel of listed Scandinavian firms to examine the importance of retentions as a determinant of investment. Measures of Tobin's Q, marginal q and sales accelerator are used to control for investment opportunities. Scandinavian firms are found to depend on retentions to a high degree, more so than in other developed economies. This high dependence on retentions suggests that the Scandinavian capital markets are suffering from allocational inefficiencies. Moreover, these market frictions appear too large to *per se* be caused by information asymmetries or managerial discretion phenomena. Possible institutional explanations are suggested.

JEL classifications: G0, G30

Keywords: investment, liquidity, retained earnings, free cash flow, Tobin's *Q*, marginal *q*.

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1 Introduction

Conventional investment theory holds that investment expanded up to the point where expected marginal return on capital equates with the opportunity cost of capital. In line with this the Modigliani and Miller (1958, 1961) theorems hold that the value of a firm and investment decisions should be autonomous from its financial structure. This in turn implies that the cost of capital and the return on investment should be the same independently if the investment is funded by equity, debt or retained earnings. Thus, in the absence of market frictions, internally generated funds are perfectly substitutable with external capital.

However, starting with Kuh and Meyer (1957), a large number of empirical studies show that the source of financial funding is not irrelevant for the investment decision. These studies typically find that liquidity and retentions are important determinant of investment, thus frictions matter. A positive relationship between investment and liquidity is inconsistent with neoclassical predictions, such as the Modigliani and Miller theorems.[1] There are, in principle, two possible explanations for a positive relationship between investment and liquidity: financial constraints/hierarchy caused by *asymmetric information* or managerial discretion caused by *agency problems*. Asymmetric information between management and investors may make firms financially constrained by making external funds costlier than internally generated funds. This creates a so-called hierarchy of finance, which may lead to under-investment (Myers and Majluf, 1984, and Stiglitz and Weiss, 1981). From a managerial perspective, on the other hand, internally generated "free cash flow" has the advantage that monitoring by the providers of capital can be avoided and external capital may not be as available (Jensen, 1986). Agency conflicts between management and investors may lead to over-investment if managers prefer empire building to shareholder value maximization (Grabowski and Mueller, 1972).

A problem with empirical studies of investment behavior is how to differentiate between managerial discretion (principal-agent problems) and

[1] Modigliani and Miller (1958, 1961) show that under certain assumptions firm value is independent from capital structure and by the same token investments should be independent from dividend policy or access to external capital. However, introducing market frictions these propositions do not hold. Costs associated with bankruptcies and tax policies are example of factors that violate these assumptions.

asymmetric information explanations. To be able to do so it is necessary to control for investment opportunities, i.e. differentiate between firms that are investing at returns above or below their cost of capital. Mueller and Reardon (1993) have developed a method to measure marginal *q*, q_m, which precisely measure the return on investment, i, relative to the cost of capital, r, ($q_m = i/r$). This method to estimate marginal q is used in this paper to discriminate between firms that over- and under-invest, respectively. If marginal $q > 1$ firms are under-investing and conversely if marginal $q < 1$ firms are over-investing. Kathuria and Mueller (1995) and Gugler et al. (2004) use this approach to differentiate between managerial discretion and asymmetric information explanations.

This paper adds to the literature primarily by applying the Gugler et al. (2004) methodology to a panel of 292 Scandinavian firms for the period 1998-2005. The main finding is that the investments of Scandinavian firms, as compared to other countries, are much more sensitive to liquidity. Investments are found to be nearly strictly proportional to retentions. The results imply that Scandinavian countries have institutionally induced market frictions that are more severe than elsewhere. These frictions seem too large, compared to other countries, to *per se* be attributed to asymmetric information and managerial discretion. Instead, further research is necessary in order to detect the institutional determinants of these frictions, i.e. institutionally induced transaction costs.

Apart from *marginal q*, conventional measures of *Tobin's Q* and *sales accelerators* are also used in the investment equations in order to control for investment opportunities. When it comes to liquidity the literature contains a number of different measures and definitions.

In principle, liquidity can be defined in two ways; a *pre-dividend definition* and a *post-dividend definition*. The first alternative is to define liquidity as *after tax profits plus depreciation*. In the second alternative, definition dividends are also subtracted. There are also a number of terms used to denote liquidity. Both definitions are sometimes referred to as cash flow, which is misleading (considering that both changes in debt and equity affect the cash flow). *Free cash flow* is a more appropriate term for the pre-dividend definition of liquidity, and *retained earnings* (*RE*) is a more appropriate term for the post-dividend definition of liquidity. From an empirical point of view, the choice between the two definitions of liquidity is of minor importance due to very high correlation. In this paper *retained earnings* is used.

This paper is organized in five sections. In the following section relevant theories and empirical research on the relationship between investments, agency problems and asymmetric information are reviewed. The marginal q methodology and data are presented in section three. Section four contains empirical findings and analysis. Policy implications and conclusions are discussed in section five.

2 Investments, agency problems and asymmetric information

Neoclassical investment theory predicts that investments are made up to a point where the expected marginal rate of return on capital equates with the cost of capital (Jorgenson, 1963). Investments that fulfill this criterion are said to be efficient. In empirical studies of investment behavior the crucial problem is how to control for unobserved expectations of future investment opportunities. Brainard and Tobin (1968) and Tobin (1969) developed a solution to this problem: *Q*-theory of investment. The *Q*-theory of investment has the advantage of providing information about future market conditions of importance for investments, without detailed knowledge or assumptions of future demand and supply conditions.

In the neoclassical *Q*-theory of investment[2] the investment expenditure of a firm is determined by its Tobin's Q. Tobin's Q is defined as the market value of the firm divided by the replacement cost of capital ($Q_{a,t} = M_t / K_t$). This quotient gives the average return on capital relative its opportunity cost of capital. Assuming that Tobin's Q controls for investment opportunities of a firm, Hubbard (1998) derives the following empirical relationship between investment and Tobin's Q:

$$\frac{I_t}{K_{t-1}} = a + bQ_{a,t} + \varepsilon_t \tag{1}$$

[2] The *Q*-theory is sometimes referred to as the modified neoclassical theory. This refers to the fact that neoclassical theory is, as compared to the Q-theory, not forward looking.

where I_t and K_{t-1} are investment and capital in period t and $t-1$, respectively, and a is the replacement investment coefficient. This basic specification is found in a large number of empirical studies.

However, if we are concerned about the adjustment of the capital stock, K_t, the marginal return on capital is more relevant. The marginal return on capital gives the increase in market value given one additional unit of capital (note that $\Delta K_t \equiv I_t$) relative the opportunity cost. This is the so-called marginal q. Marginal q measures the return on investment, i, relative to the cost of capital, r, ($q_m = i/r$). For investment to be efficient, I^*, q_m should be equal to one. If $q_m < 1$ firms are over-investing, and conversely if $q_m > 1$ firms are under-investing.

In the neoclassical Q-theory of investment marginal q and Tobin's average Q will equate. In equilibrium $q_m = Q_a = 1$. Hayashi (1982) show that this is the case only if firms are price takers (perfect competition), and their production and installation functions are homogeneous. These are clearly strong assumptions. Since this is typically not the case, marginal q should be used instead of Tobin's Q. However, due to the difficulties in measuring marginal q, most studies use market-to-book measures of Tobin's Q as a proxy for investment opportunities. In addition to the conventional market-to-book measure of Tobin's Q, this paper also uses a measure of marginal q developed by Mueller and Reardon (1993), (see next section).

As mentioned, in a frictionless milieu investment should only depend on Tobin's Q. However, in the presence of capital market imperfections we no longer expect investments to be independent from liquidity (retentions). To test this, Fazzari et al. (1988), and many subsequent studies, use following specification:

$$\frac{I_t}{K_{t-1}} = a + bQ_t + c\frac{RE_t}{K_{t-1}} + \varepsilon_t \tag{2}$$

where RE_t is retentions in period t. A positive c in equation (2) rejects the frictionless model and implies either financial constraints or managerial discretion in the form of over-investment. Deviations from marginally efficient investments are caused by two principle factors: *agency problems* (managerial discretion) and *asymmetric* *information* (financial hierarchy). Agency problems may cause over-investment, whereas asymmetric information may result in under-investment.

2.1 Asymmetric information

From Akerlof (1970) we know that if outsiders are unable to distinguish between "good" products and "lemons" the average price will drop. In the context of financial markets information asymmetries will affect investment by raising the cost of external capital[3]. As firms are investing, retained earnings are gradually depleted, and at some point it becomes necessary to resort to external funding of some sort in order to invest further. Asymmetric information, however, gives rise to a "financial hierarchy" where the cost of external funds is higher than internal funds. Myers and Majluf (1984) and Stiglitz and Weiss (1981) argue that information asymmetries between managers and investors make external capital more expensive than internal finance. Informational asymmetries may, through increasing the cost of debt and equity, lead to suboptimal investment ($I < I^*$). At this point $q_m > 1$ (see Figure 2 in Appendix 1). Baumol et al. (1970) and Mueller and Reardon (1993) have, for example, found that investments are sensitive to the source of finance, and that there is a financial hierarchy, where internally generated cash flow is invested at a lower return than other external sources of finance. For this reason under-investing firms are expected to have a positive relationship between investments and retentions.

In addition to this, firms with relatively good investment opportunities should also find it simpler to signal this to investors and therefore also find it easier to raise money. All else equal, one should therefore expect firms that have a high Tobin's Q to find it less difficult to access external capital and thus depend less on retentions. To test this hypothesis an interaction term between Tobin's Q and retentions is added. The expected sign of this term is negative, (Gugler et al., 2004).

Since q_m is a measure of investment efficiency we should expect q_m to vary positively with under-investment.

[3] In the absence of information asymmetries, transaction costs may still make external funds more costly than internally generated funds. See Duesenberry (1958).

2.2 Managerial discretion

The separation of ownership from control in corporations creates a principal-agent problem between the owners/investors on the one hand, and managers on the other. In modern corporations the owners and managers are often different and it can therefore also be assumed that they frequently have conflicting interests. Berle and Means (1932) argued that ownership was becoming increasingly dispersed and that this would lead to more and more control being handed over to managers. Jensen and Meckling (1976) analyze how the interests of managers and owners diverge as ownership is separated from control and ownership becomes dispersed. With dispersion of ownership and divergence of interest there is a risk that managers cater to other objectives than shareholder value maximization[4].

Gugler et al. (2004) argue that, even though the managerial discretion hypothesis suggests that over-investing firms rely on retentions to a high extent, this does not rule out the possibility that external funds also are used. By this logic, Gugler et al. argue that the probability of managers resorting to external sources should positively vary with Tobin's Q. To test this hypothesis an interaction term between retentions and Tobin's Q is included. The predicted sign is positive.

Among over-investing firms some will be less resource wasting. All else equal, this will be reflected by a relatively higher marginal q. Marginal q is included to test this hypothesis. The predicted sign is negative.

[4] A number of hypotheses have been suggested as to what managers are maximizing if not profits. Marris (1963) argue that managers are deriving utility from managing large firms and therefore tend to maximize growth rather than shareholder value. Baumol (1959) suggest that managers are instead maximizing sales. Assuming that managers (owner-managers) are pursuing growth instead of profit or shareholder maximization we can expect over-investment. Grabowski and Mueller (1972) suggest that the sensitivity of investments to retentions/free cash flow may be due to this type of managerial discretion.

2.3 Previous research and alternative explanation

The bulk of studies on investment behavior, going back to Kuh and Meyer (1957), find that investments are correlated with internal funds (both free cash flow and retentions). For reviews of the investment literature, see Chirinko (1993), Hubbard (1998), Jorgenson (1971).

Fazzari, et al. (1988) show in their seminal study that investments in firms with high dividend ratios, and therefore less likely to suffer from financial constraints, are less sensitive to cash flow. These results have been corroborated by a number of studies. See for example Schaller (1993) on Canada and Hoshi et al. (1991) on Japan.

Moreover, institutional differences appear to be important in determining cross-country differences in the sensitivity of investments to liquidity. In particular, there may be differences in tax policies that explain, at least partially, cross-country variations in investment sensitivities. Previous studies of the investment-liquidity relationship have found that the institutional context is of importance. Hoshi et al. (1991), for example, find that the corporate structure matters for how sensitive investments in Japanese firms are to cash flow. Independent Japanese firms are more sensitive to liquidity than firms that are part of a group. In Scandinavia, one can also expect the tax system to influence investment behavior. Dividend taxes may, for example, alter investment behavior so that internal funds are less costly than external capital (Sinn, 1991). Some authors claim that the Swedish tax system has systematically disfavored dividends over investment, which has caused managers to use large sums of internal funds for investment without the scrutiny of external investors or capital markets, (see Henrekson and Jakobsson (2001), Henrekson and Sanandaji (2004), Högfeldt (2004), and Magnusson and Jakobsson (2006) for more details on the institutional and political factors that have influenced the Swedish corporate governance system). Presumably, this is also the case in the other Scandinavian countries[5].

[5] The industry and tax policies in Sweden were strongly influenced by the "socialistic" visions in the first half of the 20th century that predicted that firms would become bigger and bigger (large scale) and eventually capitalism would be replaced by socialism. Schumpeter (1942) predicted in Capitalism, Socialism and Democracy, that socialism, due to the superior performance of capitalism, would replace capitalism in western democracies. Similar ideas are found in Galbraith's (1967) The New Industrial

A problem in these types of studies is the possibility that Tobin's *Q* fails to perfectly control for investment opportunities, e.g. due to measurement errors. For example, if there is a positive serial correlation of profits, profits will reflect reinvestment opportunities and retentions in period *t* will be correlated with profits in period *t-1* (Tirole, 2006). If this is the case, profit retentions may be a proxy of investment opportunities, which then can explain why investments are sensitive to retentions. One way of controlling for this possibility is to include growth in sales. From accelerator theories of investments we know that growth in sales (proxies for changes in the desired output) is strongly correlated with changes in the desired level of capital (ΔK_t^*) (see Jorgenson, 1971).

In neoclassical *Q*-theory of investment growth in sales is expected to have an impact since under neoclassical assumptions Tobin's *Q* incorporates the accelerator model (see Ciccolo and Fromm, 1979, Jorgenson and Sibert, 1968, and Mueller, 2003).

Growth in sales is also predicted to have a positive effect in both the under- and the over-investing group. Financially constrained firms are likely to find it less difficult to raise external funds if their sales are increasing. Firms that are over-investing should by the same logic find it easier to raise external capital if they have rapid sales growth.

Table 1 summarizes the hypotheses that are tested. Since both the agency hypothesis and the financial friction hypothesis predict a positive relationship between investments and liquidity it is difficult to differentiate between them. As mentioned, the solution is to identify firms that are under- or over-investing. Managerial discretion (which implies excessive spending) is inconsistent with under-investments. Similarly, financial constraint explanation is inconsistent with over-investment. The hypotheses in Table 1 follow Gugler et al. (2004), with the exception that growth in sales has been added and the prediction of q_m differs. Gugler et al. do not include q_m in the first column, and they make no predictions for the over-investing firms.

To test the robustness of the results, Tobin's average *Q* and dividend ratios are used, *mutatis mutandis,* to differentiate between the two categories of firms.

State. For an analysis of how the Swedish industrial and tax polices were influenced by these ideas, see Henrekson and Jakobsson (2001) and Högfeldt (2004).

Table 1 Summary of hypotheses and predicted signs

Investment theory	Neoclassical Q-theory of investment	Marginal q theory of investment: Under-investment (asymmetric information)	Over-investment (Managerial discretion)
	All firms	Firms with $\overline{q}_m > 1$	Firms with $\overline{q}_m < 1$
Dependent variable	I_t/K_{t-1}	I_t/K_{t-1}	I_t/K_{t-1}
Explanatory variables:			
Intercept	+	+	+
Retained Earnings, RE_t	0	+	+
Tobin's average Q, $Q_{a,t-1}$	+	+	+
Marginal q, $q_{m,t-1}$	0	+	-
Growth in Sales_t	0	+	+
$Q_{a,t-1}$ *RE_t	0	-	+

3 Methodology and data

Mueller and Reardon's (1993) method to estimate q_m links investment, I_t, to changes in market value, M_t. The intuition behind their method is that \$1 worth of investment should be reflected by at least \$1 increase in market value. This is the case if q_m is equal to one, implying that the return on investment, i, is equal to the cost of capital, r, ($q_m = i/r$). If $q_m > 1$ this means that the return is above the cost of capital. This in turn means that further investment is profitable. Conversely, if $q_m < 1$ firms are over-investing at returns below their cost of capital (see Appendix 2).

Mueller and Reardon's method can be used to calculate three different, but closely related, measures of marginal q. The first alternative is to calculate a firm and time specific q_m:

$$q_{m,t} = \frac{M_t - (1-\delta)M_{t-1}}{I_t} \tag{3}$$

where δ is the depreciation rate. The second alternative is to calculate a firm specific multi-period weighted average of q_m:

$$\overline{q}_m = \frac{M_{t+n} - M_{t-1}}{\sum_{j=0}^{n} I_{t+j}} + \frac{\sum_{j=0}^{n} \delta_{it+j} M_{t+j-1}}{\sum_{j=0}^{n} I_{t+j}} - \frac{\sum_{j=0}^{n} \mu_{t+j}}{\sum_{j=0}^{n} I_{t+j}} \tag{4}$$

Equation (3) is used to calculate the $q_{m,t}$ that enters the investment equation as explanatory variable. μ_t is the error in market valuation of the firm in period t. The last term in (4) approaches zero as n grows. $\overline{q}_m$ is used to split the sample into over- and under-investing firms. To estimate q_m, according to both equation (3) and (4), it is necessary to assume a depreciation rate (δ). For this purpose, the third alternative can be used as no assumptions regarding the depreciation rate are necessary. This method yields simultaneous estimates of the average q_m and δ for all firms:

$$\frac{M_t - M_{t-1}}{M_{t-1}} = -\delta_i + q_m \frac{I_t}{M_{t-1}} + \frac{\mu_t}{M_{t-1}} \tag{5}$$

This is an equation that can be empirically estimated. It should be noted that it is not necessary to calculate the cost of capital with this method. From the efficient market hypothesis we expect $\mu_{t+j} = 0$ for all j. This means that when the number of observations grows, the last term in (5) will become smaller and approach 0. If the market fails to assign a correct market value in period t, equation (3) will give an incorrect estimate of q_m. However, assuming that the errors in market valuation are not persistent and that possible errors are corrected by the market in subsequent periods equations (4) and (5) will still be accurate measures of q_m, (see Gugler et al., 2004, and also Mueller and Reardon, 1993, for further details on q_m). Since depreciation rates can be assumed to differ across industries, industry specific depreciation rates, δ_i are estimated. Industries are also subjected to random shocks that affect the value. For this reason equation (5) is also estimated with time effects. First, equation (5) is estimated. Then the estimated δ_i's, including time effects, are plugged into equations (3) and (4). Equation (3) is used to calculate explanatory variable for the regression analysis and Equation (4) is used to split the sample into over- and under-investing firms. See Appendix 2 for a derivation of these three measures, and how they are linked to Tobin's *Q*.

Tobin's *Q* is measured as the quotient between market value and capital ($Q_{a,t} = M_t/K_t$).

Variables and data

The accounting and market price data have been obtained from Standard and Poor's database Compustat Global (mnemonic items in brackets). Market value, M_t, is defined as the number of common shares times the market price per share (*Mkval*), plus total debt (*Dt*). Since the M_t is comprehensive, it is necessary to use an equally comprehensive definition of investment. Investment, I_t, is therefore measured as:

$$I = \textit{After tax profits} - \textit{Dividends} + \textit{Depreciation} + \Delta E + \Delta D + \textit{Advertising costs} + \textit{R\&D}$$

where after tax profit is income before extraordinary items (*Ib*), dividends (*DVT*), depreciation (*DVC*), ΔE is new equity (*SSTK – PRSTKC*), ΔD is change in debt (*DT*), R&D is research and development expenditures (*XRD*) and Adv. is marketing and advertising expenditures (approximated with *XSGA*)[6]. Retained Earnings, RE_t, is defined as the sum of the first three variables in the investment function (after tax profit, dividends and depreciation). Capital, K_t, is defined as total assets (*AT*). As sales variable (*SALE*) is used.

Marginal *q*, $q_{m,t}$, and weighted average of marginal $q, \overline{q}_m$, are calculated from equation (6) and (7), respectively. Tobin's *Q*, $Q_{a,t}$, is calculated as the quotient

[6] This definition allows for investments to be negative if losses of a firm are large enough. The reason that investment can be negative is that the accounting depreciation data fails to capture actual economic depreciation of capital. Negative investments make no sense in equations 3 and 4 and have therefore been excluded. The results in the remainder of the paper are robust if negative "investments" are excluded or not. Only few investment observations are negative.

between M_t and K_t. All variables are adjusted to 2005 constant prices (Eurostat HCPI, 2005 = 100). In total, data for 292 listed Scandinavian firms have been collected (2004 observations). The data rages from 1998 or 1999 to 2005 and is unbalanced.

Results and analysis

The basic investment equation that is estimated is an extended version of equation (2) and is of the following form:

$$\frac{I_t}{K_{t-1}} = \alpha + \beta_1 Q_{a,t-1} + \beta_2 \frac{RE_t}{K_{t-1}} + \beta_3 q_{m,t-1} + \beta_4 \frac{RE_t \times Q_{a,t-1}}{K_{t-1}} + \beta_5 \frac{\Delta Sales_t}{Sales_{t-1}} + \mu_t \qquad (6)$$

In addition to retained earnings, RE_t, and Tobin's average Q, Q_a, marginal q, q_m, Tobin's Q interacted with retentions, $RE_t \times Q_{a,t-1}$, and growth in sales are added. Both marginal q and Tobin's Q are lagged one period to avoid endogeneity problems. An alternative to RE_t is to use a pre-dividend definition of liquidity, free cash flow. Using free cash flow instead of retained earnings is, however, inconsequential from an empirical point of view, considering that the correlation is close to one (see correlation matrix in Appendix 3). The results in this paper hold also for this definition of liquidity.

Ideally, dividing I_t and RE_t with K_{t-1} should normalize equation (6) and make it empirically testable. However, none of the variables are normally distributed; both skewness and kurtosis are high for all the variables in equation (6). Jarque-Bera and Shapiro-Wilk tests indicate significant non-normality at one percent level for all the variables.

There are several ways of dealing with non-normality; transformation of variables, trimming of the sample, or some sort of robust estimation technique. Which method is more appropriate depends on the cause of non-normality. From histograms of the variables it is clear that extreme values are the problem. Therefore, as a first step to reduce the weight of outliers, all the variables have been caped at the 1st and

99^{th} percentiles. This makes the variables more normally distributed and makes it possible to use standard OLS estimations.

To trim the sample in this way is, however, unsatisfactory. A more appropriate way of dealing with non-normality is to employ some sort of a robust estimation technique. The standard technique is to use quintile median regressions. Median regressions can, however, be more sensitive to outliers than Iteratively Reweighed Least Squares. The Iteratively Reweighed Least Squares use a maximum likelihood estimator where case weights are calculated from scaled residuals. Median absolute deviation is used as scale, see Huber (1981).

As a robustness check all three types of estimation are used and reported (trimmed OLS, Iteratively Reweighed Least Squares and Median Regression). Iteratively Reweighed Least Squares, which is the theoretically most appropriate way of dealing with non-normality, also yield the best results in terms of explanatory power. Otherwise the results are robust with respect to the choice of estimation method.

Other statistical problems, such as multicollinarity for example, do not seem to plague the data (see correlation matrix). The correlation between $Q_{a,t}$ and growth in sales for example is only 0.17, which must be considered low given that both are indicators of investment opportunities. $Q_{a,t}$ and $q_{m,t}$ is only weakly correlated (0.14). Surprisingly, there is no correlation between $q_{m,t}$ and I_t. The strongest correlation is found between RE_t and I_t (0.38). As $Q_{a,t}$, $q_{m,t}$ and growth in sales all are measures of investment opportunities one might still be concerned about multicollinarity. Therefore, the Variance Inflation Factor (VIF) has also been calculated. No VIF is above two, which indicates that there is no significant problem with multicollinarity.

Since it is a panel data set, all regressions are estimated with industry and time effects (fixed effect). The time effects control for possible cyclicity of investments and the industry effects control for differences in investment behavior across industries. All results are robust with regard to the inclusion or omission of time, industry and country effects. Regressions reported here have been estimated with industry (2-digit SIC) and time effects (not reported). In addition, possible country effects have been tested for. Sweden is found to have a significantly higher investment rate than the other Scandinavian countries, but country effects do not alter the results and consequently they have been excluded.

Retained earnings are clearly the most important variable and the estimated coefficient is not significantly different from one. These coefficients are also in the upper end of the distribution of coefficients found in this type of studies.

Independent of investment opportunities, Scandinavian firms rely to a very large extent on retentions to fund their investments. Both firms that are in the financially constrained category and firms that are in the category of over-investing display almost a strict proportionality between retentions and investments. The frictionless hypothesis is clearly rejected.

Using the same methodology and variables definitions, Gugler et al. (2004) find the coefficient for US to be 0.20. For financially constrained firms their estimates are a bit higher, 0.30, and for over-investing ones the coefficient is 0.15. Fazzari et al.'s (1988) study of US firms also finds most coefficients on cash flow to lie in the rage 0.20 to 0.40.

Still, there are significant differences across firms. Looking at the aggregate investments, retentions account for not more than about 50 percent of all investments. The reason is that the majority of firms rely on retentions whereas only few firms raise most of the new equity (ΔE). Only 9 percent of the firms raised new equity during the period, and even among these firms the equity additions were skewed. Ten firms accounted for more than 50 percent of all new equity additions. The majority of firms rely to a high extent, or solely, on retentions to fund their investments.

Assuming that profits are serially correlated, profit retentions may simply be a proxy for investment opportunities. To control for this possibility growth in sales is also included.[7]

Results for all firms are reported in Table 2. Growth in sales is found to vary positively with investment. Tobin's Q is also positively related to investments, while marginal q has no robust significant impact on investment. One explanation could be that $Q_{a,t}$ controls for investment opportunities and thereby renders $q_{m,t}$ insignificant. However $q_{m,t}$ remains insignificant even after omitting $Q_{a,t}$. An alternative

[7] In empirical applications of the accelerator model of investment, accelerator sales models yield superior predictions as compared to value added and profit accelerators, see Jorgenson (1971).

interpretation can therefore be that q_m fails as a forward looking measure of investment opportunities. Both Tobin's Q and growth in sales have a relatively low economic significance.

The constant (replacement investment coefficient) is roughly in the neighborhood of 15 percent, meaning that replacement investment amount to approximately 15 percent of K_{t-1}, which seems plausible.

Table 2 All firms

Dependent variable: I_t/K_{t-1}

	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Median Regression
Constant	0.123***	0.166***	0.181***
	(3.08)	(5.40)	(4.73)
RE/K_{t-1}	1.080***	1.008***	1.010***
	(14.41)	(145.95)	(490.81)
Tobin's Q, $Q_{a,t-1}$	0.053***	0.004***	0.005***
	(9.32)	(3.69)	(4.13)
Marginal q, $q_{m,t-1}$	0.000	-0.000	-0.000***
	(0.01)	(- 1.26)	(-2.82)
$\Delta Sales_t/sales_{t-1}$	0.136***	0.038***	0.004***
	(7.15)	(7.55)	(9.43)
$Q_{a,t-1} * RE_t$	-0.101***	-0.001	-0.002***
	(- 3.90)	(- 0.69)	(-19.47)
No. observations	1836	2002	2003
No. firms	292	292	292
R^2	0.38	0.96	-
Pseudo R^2	-	-	0.32
F-value	19.9	861.3	-

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.

The next step is to split the data into two groups; firms with $\bar{q}_m > 1$ (under-investing) and firms with $\bar{q}_m < 1$ (over-investing). $\bar{q}_m$ are calculated using equation (4). The $\bar{q}_m$'s are estimates of the weighted average return on investments relative to the cost of capital for each firm. Equations (3) ($q_{m,t}$) and (4) ($\bar{q}_m$) are both sensitive to the choice of depreciation rates. To obtain accurate depreciation rates equation (5) was first estimated including both time and industry specific effects, from which time and industry specific depreciation rates were obtained. For more details on the estimation of marginal q, see Mueller and Reardon (1993), Gugler et al. (2004) and Eklund

(2008). The results for these under-investing firms are reported in Table 3. Over-investing firms are reported in Table 4.

Table 3 Under-investing firms with marginal $q > 1$

Dependent variable: I_t/K_{t-1}	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Median Regression
Constant	-0.009	0.028	0.013
	(-0.15)	(0.79)	(0.25)
RE_t/K_{t-1}	1.085***	1.003***	0.925***
	(10.19)	(35.74)	(32.50)
Tobin's Q, $Q_{a,t-1}$	0.036***	0.010***	0.004***
	(5.08)	(3.90)	(10.78)
Marginal q, $q_{m,t-1}$	0.000	-0.000	-0.000
	(1.14)	(-0.38)	(-0.86)
$\Delta Sales_t/sales_{t-1}$	0.141***	0.004***	0.004***
	(4.75)	(10.32)	(9.31)
$Q_{a,t-1}$ * RE_t	-0.049*	-0.017***	-0.001***
	(-1.74)	(-7.38)	(-4.23)
No. observations	637	727	729
No. firms	106	106	106
R^2	0.48	0.77	-
Pseudo R^2	-	-	0.24
F-value	12.95	54.2	-

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.

The effect of RE_t on investments remains close to one in both groups of firms. In most of the regressions marginal q turns out to be insignificant. In economic terms, retentions are clearly the most important variable that explains most of the variation. As predicted, information asymmetries and financial constraints appear to become less problematic for firms with high $Q_{a,t}$'s. This can be seen from the negative coefficient on $Q_{a,t-1}$* RE_t. The same term is negative, but not robustly so, among over-investing firms. The hypothesis that over-investing firms are resorting to more external finance when $Q_{a,t}$ is high is therefore rejected.

An interesting observation is that over-investing firms appear to be more sensitive to changes in Tobin's Q and growth in sales than financially constrained firms. One straightforward interpretation is that financially constrained firms simply cannot increase their investments in response to hikes in investment opportunities.

The results in Table 3 and 4 have been subjected to a number of robustness tests. First, firms having $\bar{q}_m$'s close to one were excluded (0.8 < $\bar{q}_m$ < 1.2). By excluding these firms a clearer separation between over- and under-investing forms is achieved. Secondly, the results in Table 3 and 4 were replicated using a different calculation of $q_{m,t}$ and $\bar{q}_m$ assuming a 10 percent depreciation rate across all firms and industries. The results remain robust in both these cases (Not reported).

Table 4 Over-investing firms with marginal $q < 1$

Dependent variable: I_t/K_{t-1}

	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Median Regression
Constant	0.161***	0.094	0.227***
	(3.19)	(1.24)	(5.83)
RE_t/K_{t-1}	1.341***	1.014***	1.020***
	(12.63)	(110.31)	(115.83)
Tobin's Q, $Q_{a,t-1}$	0.092***	0.060***	0.028***
	(9.76)	(22.31)	(11.00)
Marginal q, $q_{m,t-1}$	- 0.000	- 0.000	- 0.000***
	(- 0.60)	(-0.97)	(- 4.48)
$\Delta Sales_t/sales_{t-1}$	0.137***	0.117***	0.138***
	(5.86)	(9.68)	(12.12)
$Q_{a,t-1} * RE_t$	- 0.325***	- 0.002	- 0.004*
	(- 6.22)	(-0.83)	(- 1.65)
No. observations	1199	1274	1274
No. firms	186	186	186
R^2	0.41	0.97	-
Pseudo R^2	-	-	0.39
F-value	15.3	783.8	-

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.

As a further robustness check, Tobin's Q, $\overline{Q}_a$ (period average), was used in the same way as marginal q, $\bar{q}_m$, to distinguish between over- and under-investing firms. The results are robust as compared to the grouping based on marginal q. The results are reported in Appendix 4. Finally, the sample was also split into high and low dividend firms. Fazzari et al. (1988), for example, find that low dividend firms tend to be more sensitive to retentions. Dividend ratios were calculated as the dividends over free cash flow. These results are also reported in Appendix 4. Again, the results are robust and the retention coefficients are close to one.

In contrast to Gugler et al. (2004), few of the coefficients on $q_{m,t}$ are significant. Gugler et al. find coefficients in the range of 0.002 and 0.005. Thus, from an economic point of view marginal *q,* as measured here, has a negligible impact. A possible explanation for this is the fact that the methodology of measuring marginal *q* does not yield a forward looking measure of future investment opportunities. It is forward looking in the sense that an investment made in period *t* is reflected in the market value, which is based on market expectations. But marginal *q* does not necessarily yield a good prediction of future investment opportunities. Mueller and Reardon's (1993) measure of marginal *q* may, in other words, be an appropriate *ex post* measure of performance but less adequate as an *ex ante* indicator of investment opportunities.

These investment-retention coefficients are very large when compared internationally. There are several alternative explanations that possibly can explain the strong effect retentions have on investments. First, in this sample only listed Scandinavian firms are included, which may cause a selection bias. Assuming that the majority of the firms are mature and have depleted their investment opportunities in the sense that they no longer require large external funding for their investments, this could probably shed some light on the results (see lifecycle theories of the firm, Mueller, 1972).

Second, the age of firms is possibly also a factor that matters for how sensitive investments are to retentions. One hypothesis is that information asymmetries that constrain firms financially are gradually reduced as firms matures and build a reputation. If this is the case internal funds should become less important over the life-cycle of the firm. Examining Canadian firms, Schaller (1993) finds that young firms are more cash flow sensitive. However, this seems unlikely, considering that all firms independent of investments opportunities are sensitive to retentions.

A counter hypothesis is that as a firm matures investment opportunities are depleted. When this happens managers may find it more difficult to access external capital thereby resorting extensively to internally generated funds, see the life-cycle theory of the firm in Grabowski and Mueller (1975).

Finally, there may be strong institutional factors such as tax policy (Sinn, 1991) favoring retentions over other sources of finance. All in all, institutional factors are likely to be the cause of the high dependence on retentions. Transaction costs of various sorts, as pointed out by Duesenberry (1958), can make investments sensitive to retentions. To what extent tax policies and various market regulations (i.e. labor market rigidities) contribute to these frictions is an area where more research is needed.

Apart from financial frictions, in terms of information asymmetries and agency problems, the results also have macro economic implications. Financial market imperfections can, for example, lead to *"financial accelerators",* which may magnify initial economic shocks, see Bernanke et al. (1996) and also Fisher (1933). This implies that a large coefficient on retentions/cash flow can augment business cycles. Firms relying solely on internal funds will reduce their investments when their revenues/profits falls which then acts magnifying. Vice versa, when profits are high investments will also be high. Empirical studies by Greenwald et al. (1984), Bernanke and Gertler (1989) and Hoshi et al. (1991) find evidence that these types of capital market frictions contribute to fluctuations in output.

Conclusions

Using comprehensive definitions of investment and retained earnings, this paper shows that Scandinavian firms are highly dependent on retained earnings to fund their investments. Independent of investment opportunities Scandinavian firms rely heavily on retained earnings. Both firms that are financially constrained and firms that are over-investing rely largely on retentions to fund their investments. Investments are almost strictly proportional to retentions.

A positive relationship between investment and internally generated funds can in principle be explained by either information asymmetries (Myers and Majluf, 1984) or managerial discretion (Grabowski and Mueller, 1972). In order to separate between these two alternative explanations it is necessary to distinguish between firms that are under- and over-investing, respectively. In this paper a method to measure marginal q

developed by Mueller and Reardon (1993) is used to differentiate between these two categories of firms. The results are also robust when controlling for high and low dividend firms, and firms with high or low Tobin's *Q*.

It is hard to accept that the two alternative hypotheses, asymmetric information and managerial discretion, can explain the results, given the exceptionally strong effect of retentions on investments. Instead, further studies are called upon to explore the institutional specificities of Scandinavian corporate governance systems. The question that arises is related to the cause of the frictions that make firms so dependent on retentions. The tax system may be one factor obstructing an efficient capital allocation. Another possible explanation for this high dependence on retentions may be found in the roots of the corporate governance systems, which, for a long time, have favored large growing enterprises at the expense of smaller new firms. This tendency has arguably been particularly strong in Sweden (Högfeldt, 2004), which is also found to have the highest investment rate in Scandinavia.

How investment behavior is affected by control structures, such as pyramids and dual-class shares, and how these interact with ownership may, for example, be important, particularly the question of the extent that control structures mitigate problems with asymmetric information and agency problems or makes them more severe. Further research on how relations to banks and ownership spheres affect investment behavior is also necessary.

Finally, this paper raises two important policy concerns that call for more research. First, the extent tax policies/industry policies can explain these results. If tax policies, for instance, favor retentions over dividends, one needs to understand the implications for business renewal and structural change. Assuming that some Scandinavian firms are suffering from financial constraints, while at the same time, other firms are over-investing, this implies that capital is allocated inefficiently. A policy change that reduces dependence on retentions to fund investments would then improve resource allocation, bringing about a swifter reallocation of resources between different sectors of the economy. Secondly, if the investment-liquidity relationship is robust over time, one needs to investigate the extent to which it contributes to excessive business and output fluctuations. All else equal, high dependence on retentions means that investments will co-move with business cycles to a higher extent. These aspects call for further research.

References

Akerlof G A (1970) The Market for Lemons: Quantity, Uncertainty and the Market Mechanism. Quarterly Journal of Economics 84:488-500

Baumol W J, Heim P, Malkiel B G and Quandt R E (1970) Earnings Retentions, New Capital and the Growth of the Firm. Review of Economics and Statistics 52:345-355

Baumol W J (1959) Business Behavior, Value and Growth. MacMillan, New York

Berle A A and Means G (1932) The Modern Corporation and Private Property. Macmillan, New York

Bernanke B, Gertler M and Gilchrist S (1996) The Financial Accelerator and the Flight to Quality. Review of Economics and Statistics 1:1-15

Bernanke B and Gertler M (1989) Agency Costs, Net Worth, and Business Fluctuations. American Economic Review 79:14-31

Brainard W C and Tobin J (1968) Pitfalls in Financial Model Building. American Economic Review 58:99-122

Chirinko S R (1993) Business Fixed Investments Spending: Modeling Strategies, Empirical Results and Policy Implications. Journal of Economic Literature 31:1875-1911

Ciccolo J and Fromm G (1979) “q” and the Theory of Investment. Journal of Finance, vol 34:535-547.

Duesenberry S J (1958) Business Cycles and Economic Growth. MacGraw Hill, New York

Eklund J (2008) Corporate Governance in Scandinavia: Ownership Concentration and Dual-Class Equity Structure. In Bjuggren P-O and Mueller D C (ed) (2008) The Modern Firm, Corporate Governance and Investment. Edward Elgar, Cheltenham, UK. Forthcoming

Fazzari S M Hubbard G R and Petersen B (1988) Financing constraints and corporate investment. Brookings papers on Economic Activity 19:141-195

Fisher I (1933) The Debt-Deflation Theory of the Great Depression. Econometrica 5:337-357

Galbraith J K (1967) The New Industrial State, Hamish Hamilton, London

Grabowski H and Mueller D C (1975) Life-Cycle Effects on Corporate Returns on Retentions. Review of Economics and Statistics 57:400-409

Grabowski H and Mueller D C (1972) Managerial and Shareholder Welfare Models of Firm Expenditures. Review of Economics and Statistics 54:9-24

Greenwald B Stiglitz J and Weiss A (1984) Financial Market Imperfections in the Capital Market and Macroeconomic Fluctuations. American Economic Review 74:194-199

Gugler K Mueller D C and Yurtoglu B B (2004) Marginal q, Tobin’s q, Cash Flow and Investment. Southern Economic Journal 70:512-531

Hayashi F (1982) Tobin’s Marginal q and Average q: A Neoclassical Interpretation Econometrica 50:213-224

Henrekson M and Jakobsson U (2001) Where Schumpeter was nearly right – the Swedsih model and Capitalism, Socialism and Democracy. Journal of Evolutionary Economics 11:331-358

Henrekson M and Sanandaji T (2004) Ägarbeskattningen och företagandet, Om skatteteorin och den svenska policydiskussionen. SNS Förlag, Stockholm

Hoshi T Kashyap A and Scharfstein D (1991) Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups.- The Quarterly Journal of Economics 106:33-60

Hubbard R G (1998) Capital-Market imperfections and Investments. Journal of Economic Literature 36:193-225

Huber P (1981) Robust Statistics. John Wiley & Sons, New York

Högfeldt P (2004) The History and Politics of Corporate Ownership in Sweden. NBER working paper 10641

Jensen M C (1986) Agency Costs of Free Cash Flow, Corporate Finance and Takeovers. American Economic Review 76:323-329

Jensen M C and Meckling W (1976) Theory of the firm; managerial behavior, agency costs and ownership structure. Journal of Financial Economics 3:305-360

Jorgenson D W (1971) Econometric Studies of Investment Behavior: A Survey. Journal of Economic Literature 9:1111-1147

Jorgenson D W and Sibert C (1968) A Comparison of Alternative Theories of Investment Behaviour. American Economic Review 58:681-712

Jorgenson D W (1963) Capital Theory and Investments Behavior, American Economic Review 56:47-56

Kathuria R and Mueller D C (1995) Investments and Cash Flow: Asymmetric information or managerial discretion. Empirica 22:211-234

Kuh E and Meyer R J (1957) The Investment Decision: An Empirical Study. Harvard University Press, Cambridge, MA

Magnusson L and Jakobsson U (2006) Den Svenska Modellen för Företagsägande och Företagskontroll vid Skiljevägen. The Swedish Research Institute of Industrial Economics, Policy Paper no. 1

Marris J (1963) A Model of the "Managerial" Enterprise. The Quarterly Journal of Economics 77:185-209

Modigliani F and Miller M (1958) The Cost of Capital, Corporation Finance and the Theory of Investment. American Economic Review 48:261-297

Modigliani F and Miller M (1961) Dividend Policy, Growth, and the Valuation of Shares. Journal of Business 34:411-433

Mueller D C and Reardon E (1993) Rates of Return on Corporate Investments. Southern Economic Journal 60:430-453

Mueller D C (2003) The Corporation – Investments, Mergers, and Growth. Routledge, London

Mueller D C (1972) A life Cycle theory of the Firm. Journal of Industrial Economics 20:199-219

Myers S C and Majluf N S (1984) Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have. Journal of Financial Economics 13:187-221

Schaller H (1993) Asymmetric Information, Liquidity Constraints and Canadian Investment. Canadian Journal of Economics 26:552-574

Schumpeter J A (1942) Capitalism, Socialism and Democracy. George Allen & Urwin, New York

Sinn H W (1991) Taxation and the Cost of Capital: The ‘Old’ View, the ‘New’ View and Another View. NBER Working paper 3501

Stiglitz J E and Weiss A (1981) Credit rationing in markets with imperfect information. American Economic Review 71:393-318

Tirole J (2006) The Theory of Corporate Finance. Princeton University Press

Tobin J (1969) A General Equilibrium Approach to Monetary Theory. Journal of Money, Credit and Banking 1:15-29

Appendix 1

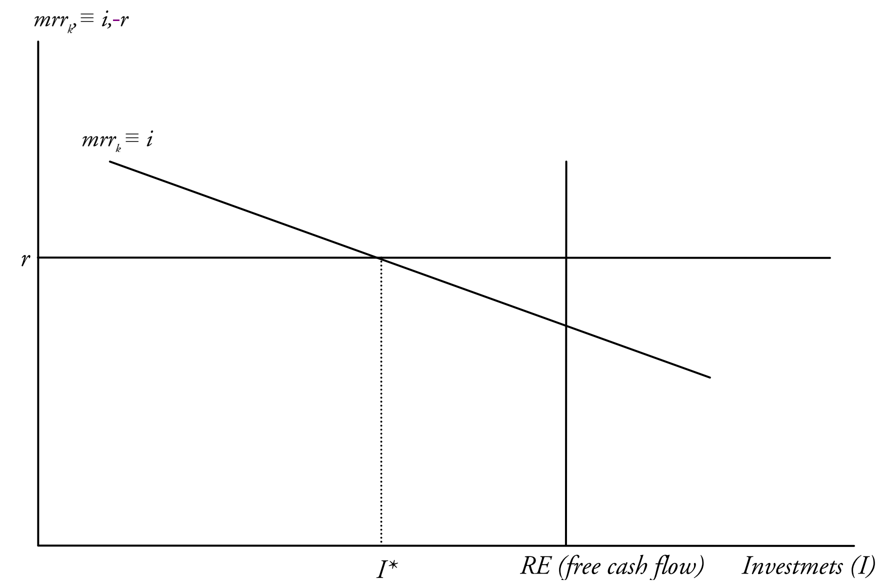

Figure 1 Managerial discretion and over-investment

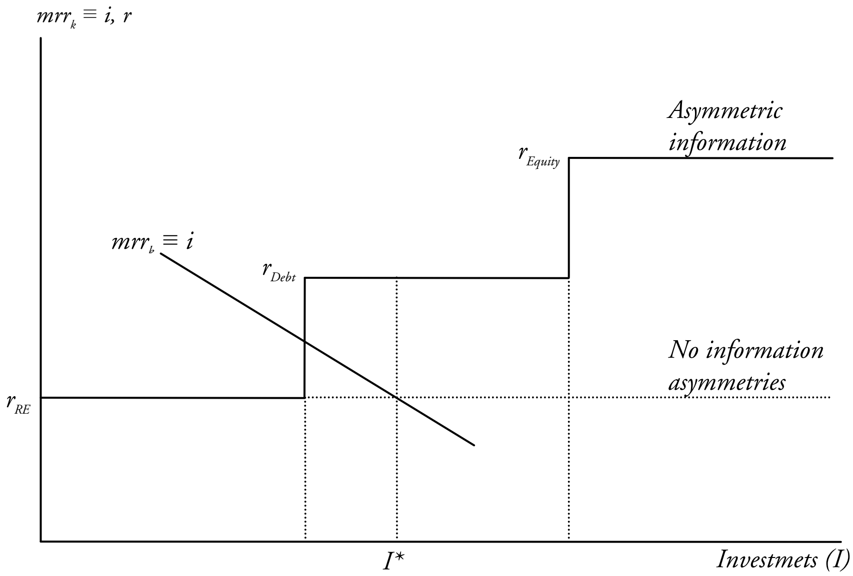

Figure 2 Investments and asymmetric information

Appendix 2 Tobin's average Q and marginal q

Mueller and Reardon's (1993) method of measuring marginal q can be derived from Tobin's Q. Tobin's Q is defined as the ratio between the market value and the replacement cost of capital. Tobin's Q measures the average return on capital, K, (hence average Q) whereas marginal q measures the marginal return r, of new capital (I). Both these measures can be derived from the rule of *marginal efficiency of investment*. Note that in a competitive equilibrium where all firms are price takers Tobin's Q and marginal q will both be equal to one (Hayashi, 1982).

At time t, the market value, M_t, of a firm can be defined as the present value of future cash flows. An investment, I_t, made in period t, will generate future cash flows, CF_t, in t plus j periods. The present value of CF_t that I_t generates is the following:

$$PV_t \equiv \sum_{j=0}^{\infty} CF_{t+j} / (1+r)^j \tag{7}$$

where r is the discount rate. For investment to be rational from a shareholder-value maximization perspective, only investments that have a positive net present value should be considered ($PV_t - I_t > 0$).

The market value of a firm at time t can, in other words, be expressed as the sum of all future cash flows that all investments generate:[8]

$$M_t \equiv \sum_{t=0}^{\infty} \sum_{j=0}^{\infty} \frac{CF_{t+j}}{(1+r)^j} \equiv \sum_{t=0}^{\infty} PV_t \tag{8}$$

The stock of capital at time t can be defined as the sum of investments:

$$K_t \equiv \sum_{t=0}^{-\infty} I_t - \sum_{t=0}^{-\infty} \delta K_{t-1} \tag{9}$$

[8] Investments are typically thought of as generating a finite number of future cash flows. A firm can, on the other hand, be assumed to generate infinitely many future projects.

Tobin's average q is the quotient between equations (8) and (9) ($Q_{a,t} = M_t/K_t$).

The marginal return on new capital or marginal q, q_m, can be derived from the net present value rule. q_m is the quotient between i and r, where i is a quasi-permanent rate of return that I_t generates ($q_{m,t} = i/r$).

$$PV_t = \frac{i_t I_t}{r_t} = q_{m,t} I_t \tag{10}$$

The market value at time t can be expressed as the market value in the previous period, plus the present value of investment made in period t, minus the depreciation, δ, of M_{t-1}:

$$M_t = M_{t-1} + PV_t - \delta M_{t-1} + \mu_t \tag{11}$$

μ is the error that the market may make in evaluating the firm in period t. By substituting PV_t in equation (10) with $q_{m,t}I_t$ and rearranging we obtain:

$$q_{m,t} = \frac{M_t - (1-\delta_i)M_{t-1}}{I_t} \tag{3'}$$

Taking equation (11) and replacing the second term with subsequent periods yields a multi-period version of equation (11):

$$M_{t+j} = M_{t-1} + \sum_{j=0}^{n} PV_{t+j} - \sum_{j=0}^{n} \delta_t M_{t+j-1} + \sum_{j=0}^{n} \mu_{t+j} \tag{12}$$

If this is divided by $\sum_{j=0}^{n} I_{t+j}$ we get the following:

$$\frac{M_{t+j}}{\sum_{j=0}^{n} I_{t+j}} = \frac{M_{t-1}}{\sum_{j=0}^{n} I_{t+j}} + \frac{\sum_{j=0}^{n} PV_{t+j}}{\sum_{j=0}^{n} I_{t+j}} - \frac{\sum_{j=0}^{n} \delta_t M_{t+j-1}}{\sum_{j=0}^{n} I_{t+j}} + \frac{\sum_{j=0}^{n} \mu_{t+j}}{\sum_{j=0}^{n} I_{t+j}} \tag{13}$$

The multi-period version of equation (7) is:

$$\frac{\sum_{j=0}^{n} PV_{t+j}}{\sum_{j=0}^{n} I_{t+j}} = \frac{\sum_{j=0}^{n} q_{m,t+j} I_{t+j}}{\sum_{j=0}^{n} I_{t+j}} = \overline{q}_m , \tag{14}$$

Substituting the second part of equation (10') into equation (9') and rearranging we get:

$$\overline{q}_m = \frac{M_{t+n} - M_{t-1}}{\sum_{j=0}^{n} I_{t+j}} + \frac{\sum_{j=0}^{n} \delta_{t+j} M_{t+j-1}}{\sum_{j=0}^{n} I_{t+j}} - \frac{\sum_{j=0}^{n} \mu_{t+j}}{\sum_{j=0}^{n} I_{t+j}} \tag{4'}$$

Thus, equation (4) is the multi-period weighted average of equation (3).

By rearranging equation (3) and dividing with M_{t-1} to remove heteroscedasticity we obtain:

$$\frac{M_t - M_{t-1}}{M_{t-1}} = -\delta_i + q_{m,t} \frac{I_t}{M_{t-1}} + \frac{\mu_t}{M_{t-1}} \tag{5'}$$

Equation (5) can be empirically estimated. Since depreciation rates differ across industries, industry specific depreciation rates, δ_i are estimated. Industries are also subjected to random shocks that affect the value. For this reason equation (9) is also estimated with specific time shocks. First, equation (5) is estimated and then the estimates of δ_i, including time effects, are plugged into equations (3) and (4). From the efficient market hypothesis we expect $\mu_{t+j} = 0$, for all *j*. This means that when the number of observations grows, the last term in (5) will become smaller and approaches 0.

Appendix 3

Table 5 Correlation matrix [a]

Variables	$\Delta Sales/sales_{t-1}$	Tobin's Q_{t-1}, $Q_{a,t-1}$	Marginal q, $q_{m,t-1}$	Average marginal q, $\bar{q}_m$	I_t/K_{t-1}	RE_t/K_{t-1}	$Q_{a,t-1}$ * RE_t/K_{t-1}	Dividend ratio
$\Delta Sales/sales_{t-1}$	1							
Tobin's Q, $Q_{a,t-1}$	0.167*	1						
Marginal q, $q_{m,t-1}$	0.020	0.141*	1					
Average marginal q, $\bar{q}_{m,t-1}$	- 0.001	0.002	- 0.016	1				
I_t/K_{t-1}	0.250*	0.283*	0.010	- 0.084*	1			
RE_t/K_{t-1}	0.175*	0.073*	0.007	- 0.036	0.379*	1		
$Q_{a,t-1}$ * RE_t/K_{t-1}	- 0.084*	0.016	0.021	- 0.023	0.102*	0.283*	1	
Dividend ratio	0.015	0.003	- 0.036	- 0.005	0.016	0.025	- 0.000	1
$\frac{(RE_t + Dividends_t)^b}{K_{t-1}}$	0.015	0.111*	0.052*	- 0.046*	0.390*	0.957*	0.872*	- 0.004

* indicates significance at 5 percent. [a] based on the trimmed sample. [b] Equivalent to Free Cash Flow

Table 6 Descriptive statistics [a]

Variables	Mean	Median	Std. dev.	Skewness	Kurtosis
$\Delta Sales/sales_{t-1}$	0.079	0.039	0.32	3.55	26.76
Tobin's Q, $Q_{a,\ t-1}$	1.277	0.891	1.19	3.34	16.67
Marginal q, $q_{m,t-1}$	5.971	4.209	28.08	- 0.72	26.71
Average marginal q, $\bar{q}_{m,t-1}$	1.378	0.744	6.16	11.65	166.26
I_t/K_{t-1}	0.225	0.164	0.28	1.14	5.13
RE_t/K_{t-1}	0.061	0.073	0.12	- 1.60	10.08
$Q_{a,t-1}* RE_t/K_{t-1}$	- 0.957	0.059	41.98	- 44.31	1975.92
Dividend ratio	0.282	0.198	0.40	2.14	12.14

[a] based on the trimmed sample

Appendix 4 Robustness checks

In Tables 7 and 8 the sample has been divided into firms with Tobin's *Q* above and below one. Tobin's *Q* is the period average for each firm.

Table 7 Under-investing firms with Tobin's average $Q > 1$

Dependent variable: I_t/K_{t-1}	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Median Regression
Constant	0.115***	0.078***	0.052
	(2.56)	(2.75)	(1.35)
RE_t/K_{t-1}	0.984***	1.014***	1.010***
	(9.13)	(136.76)	(253.15)
Tobin's Q, $Q_{a,t-1}$	0.040***	0.003***	0.004***
	(5.55)	(2.76)	(5.77)
Marginal q, $q_{m,t-1}$	0.000	-0.000	-0.000***
	(0.66)	(-1.24)	(-3.20)
$\Delta Sales_t/sales_{t-1}$	0.124***	0.003***	0.004***
	(4.61)	(6.59)	(8.60)
$Q_{a,t-1} * RE_t$	-0.077***	-0.003*	-0.002***
	(-2.42)	(-1.64)	(-30.03)
No. observations	854	958	959
No. firms	140	140	140
R^2	0.41	0.98	-
Pseudo R^2	-	-	0.41
F-value	12.22	951.54	-

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.

Table 8 Over-investing firms with Tobin's average $Q < 1$

Dependent variable: I_t/K_{t-1}	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Median Regression
Constant	0.103**	0.095***	0.151***
	(2.44)	(2.85)	(4.21)
RE_t/K_{t-1}	1.146***	1.450***	1.106***
	(5.43)	(12.13)	(22.98)
Tobin's Q, $Q_{a,t-1}$	0.061**	0.083***	0.077***
	(2.09)	(4.50)	(3.80)
Marginal q, $q_{m,t-1}$	-0.000	-0.000	0.000
	(-0.40)	(-0.70)	(0.16)
$\Delta Sales_t/sales_{t-1}$	0.142***	0.136***	0.003***
	(5.41)	(9.57)	(4.25)
$q_{a,t-1} * RE_t$	-0.118	-0.537***	-0.240***
	(-0.48)	(-4.58)	(-2.46)
No. observations	982	1042	1044
No. firms	152	152	152
R^2	0.39	0.50	-
Pseudo R^2	-	-	0.25
F-value	14.24	22.82	-

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.

In Tables 9 and 10 the sample has been divided into low and high dividend payout ratio firms.

Table 9 Low dividend firms

Dependent variable: I_t/K_{t-1}

	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Regression	Median
Constant	0.116**	0.165***	0.200***	
	(2.12)	(3.77)	(5.09)	
RE_t/K_{t-1}	1.027***	1.039***	0.970***	
	(10.86)	(31.67)	(38.56)	
Tobin's q, $q_{a,t-1}$	0.057***	0.011***	0.003***	
	(6.97)	(3.05)	(9.84)	
Marginal q, $q_{m,t-1}$	0.000	-0.000	-0.000***	
	(1.38)	(-1.11)	(-4.70)	
$\Delta Sales_t/sales_{t-1}$	0.120***	0.004***	0.004***	
	(4.84)	(6.64)	(12.28)	
$q_{a,t-1} * RE_t$	-0.090***	-0.018***	-0.001***	
	(- 2.93)	(-5.36)	(-6.36)	
No. observations	885	998	1000	
No. firms	147	147	147	
R^2	0.42	0.68	-	
Pseudo R^2	-	-	0.29	
F-value	12.6	42.4	-	

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.

Table 10 High dividend firms

Dependent variable: I_t/K_{t-1}	Fixed Effects [a]	Iteratively Reweighed Least Squares	Quintile Regression	Median
Constant	0.136**	0.179***	0.190***	
	(2.34)	(4.35)	(4.21)	
RE_t/K_{t-1}	1.121***	1.007***	1.007***	
	(7.54)	(136.47)	(200.24)	
Tobin's q, $q_{a,t-1}$	0.040***	0.006***	0.007***	
	(3.97)	(2.58)	(2.89)	
Marginal q, $q_{m,t-1}$	-0.000	-0.000	-0.000	
	(-0.63)	(-0.82)	(-1.62)	
$\Delta Sales_t/sales_{t-1}$	0.158***	0.069***	0.132***	
	(4.83)	(4.78)	(9.21)	
$q_{a,t-1} * RE_t$	-0.034	-0.002	-0.002	
	(-0.51)	(-0.67)	(-0.88)	
No. observations	951	1001	1003	
No. firms	145	145	145	
R^2	0.42	0.99	-	
Pseudo R^2	-	-	0.44	
F-value	13.6	1339.3	-	

[a] Trimmed sample, *** indicates significance at 1 percent, ** at 5 percent and * at 10 percent level. t-values in brackets.