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Irreversible Investments under Uncertainty and Inside-ownership

Real Option Approach in a Reduced Form Hazard Model

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Abstract

This thesis investigates the probability of making a marginal investment in 33 Swedish Large Cap firms from 2005 to 2015. We use marginal rate of return as a trigger event in an option to delay. This is then examined in a reduced form hazard model using the Black & Scholes option parameters. We observe how uncertainty affects level of investment with different settings of irreversibility, systematic and idiosyncratic risk, industry segments and inside-ownership. Our primary result shows that a 1-percentage unit increase in quarterly volatility would make the probability to make a marginal investment in a high irreversible firm roughly 20 percentage units lower than a firm with lower irreversibility. However, idiosyncratic risk and inside-ownership comes with ambiguous results as well as the results from different industry segments. Consequently, we address the implications of real option theory and incomplete markets.

Keywords: Real options, irreversibility, hazard model, inside-ownership, systematic risk, idiosyncratic risk.

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1. Introduction

Investment and uncertainty is often associated with a negative relationship, whereas when uncertainty arises, managers are more prone to delay an investment in order to gather more information, which may be revealed in the future (Bernanke, 1983). The flexibility can be measured as an option to delay, i.e. postponing the investment decision further into the future and therefore eliminate some of the risk (Bulan, Mayer, Somerville, 2009).

In accordance to modern theory of well-functioning capital markets, only systematic risk is rewarded with higher expected return if the shareholders are diversified. Therefore, the decision-maker should only consider systematic risk when deciding whether to undertake an investment. Consequently, principal agent theory problem arises when decision-makers are holding a large proportion of shares and are not diversified. In other words, when the decision-makers have a large inside-ownership in the firm without being diversified. Panousi and Papanikolaou (2012), find that managers with large exposure to idiosyncratic risk have a tendency to make suboptimal (more defensive) investment decision due to their risk aversion, and even more so when they hold a large fraction of the firm.

The decision to make a reversible investment is less costly than an irreversible, i.e. taking into consideration the sunk cost of the investment. It is a matter of managerial flexibility. Dixit and Pindyck (1994) find that the trigger price in the option to delay is three times more for an irreversible investment than for a reversible investment. A common approach to valuate flexibility is through real options where different places in time gives you multiple choices of proceeding; you can simply wait, expand, or abandon the project altogether, depending on the situation at that specific time. The time-value could be measured as a call option through Black & Scholes (1973) option pricing model. Recall an American option, where the value of waiting increases when uncertainty increases. Moreover, the price of the option increases with higher required return (discount rate), and decreases with dividend yield. Bulan et al. (2009), examine how uncertainty affects irreversible investments using a real option model in the

Vancouver real estate market. The level of irreversibility directly affects the option to delay and is therefore an important component in investment decision-making.

To further explain the intuition behind real option theory, one has to define investment. Hereafter when referring to an "investment" it is the "marginal investment" that is acknowledged. Consequently, when an investment is undertaken, the option is exercised. Similar to financial options, the value of the underlying asset is greater than the value of the option. In real option theory, the strike price is when the net present value (NPV) is above zero. Gugler et al. (2004) present a measure of marginal return on investment, which is equivalent with the measurements in classical discounted cash flow approach and the NPV. The optimal timing to make an investment is thus when the marginal return on investment is greater than 1. The point where the decision-maker identifies the optimal time to make an investment is called trigger event. When the trigger event occurs, a trigger price has been reached and the option is exercised.

In this thesis, we investigate how decision-maker's risk aversion affect the real option exercise; simply argue that firms with decision-makers exposed to a high degree of irreversibility and/or owns a large fraction of the firm will have a tendency of making less marginal investments than those not. Furthermore, in the light of decision-makers holding a large fraction of the firm, we will try to identify whether decision-makers are actually affected differently to systematic and idiosyncratic risk.

Our contribution to the existing literature in the area of investment and uncertainty is to examine whether inside ownership combined with degree of irreversibility affect level of investment. Moreover, it does not exist any similar studies within the Swedish stock market and its different industries. In addition our contribution lies in our real option approach with the combination of stock market data and accounting data to identify marginal investments and use it as a trigger signal in exercising the option to delay. Last, it is an attempt to measure the value of an option to delay and to quantify a variable (irreversibility), which seldom is given a numeric measure.

Our main results show the firms with a higher degree of irreversibility are more probable to postpone their investments when uncertainty increases, i.e. the value of option to delay is higher when the investments have less flexibility. Furthermore, when separating the components of volatility into systematic and idiosyncratic risk we obtain ambiguous and presumably economically insignificant results, which state that the decision-makers are more probable to undertake an investment when the specific risk increases. When we examine the impact of inside-ownership our results are inconclusive. This could be an effect of outside positions in terms of human capital and pensions or that in fact decision-makers are hedging their holdings.

The thesis will be distributed as follows. Section 2 summarises the relevant literature and our most inspirational papers and how they can motivate this thesis. Section 3 presents our theoretical models and how they work and the economic intuition behind them. Section 4 describes the data and from where it is taken. Additionally we will in depth present our econometric techniques and specification. Section 5 provides a detailed analysis of the results. Last, in Section 6 we conclude major findings, discuss the implications and what could be further analysed.

2. Related Research and Hypothesis

In this section we present related research, our most inspirational papers and how they can motivate the hypothesis of this thesis.

2.1. Related Research

Firms often face the problem of whether to make an investment at a given time or wait until later when they possibly could have more information. Adding the fact the investment has different degrees of irreversibility makes the investment decision even more complex. Bernanke (1983), introduces a model where investments are seen as completely irreversible and after an investment has been undertaken, the firm gives up the possibility to utilise new information that could arrive in the future. However, an investment could in reality be partial irreversible. Dixit and Pindyck (1994) find that an irreversible investment has a trigger price three times greater than a reversible.

The closest study to ours is by Bulan et al. (2009), where the Vancouver real estate market of newly built condominiums from year 1979-1998 is studied. They examine to which extent uncertainty delays investment, through a real option model, and how competition affects this relationship. They come to the conclusion; an increase in both idiosyncratic and systematic risk leads the real estate developers to delay new condominium investments. Panousi et al. (2012), examine the relationship of how decision-maker's idiosyncratic risk and inside-ownership in publicly traded firms in the United States affect the level of investment made in these firms. Panousi et al. (2012), state that if managers are risk averse, they might underinvest when firm-specific uncertainty increases which leads to suboptimal investment decisions from the perspective of well-diversified shareholders. Their empirical findings are in line with Bulan et al. (2009); when idiosyncratic risk rises, firm investment falls, and more so when decision-makers own a large fraction of the firm. Further, they conclude that the negative effect of managerial risk aversion on investment is mitigated if executives are compensated with options rather than with shares or if institutional investors form a large part of the shareholder base. These conclusions are consistent with the notion that institutional investors are better at monitoring the managers compared to individual investors and that options based compensation provides executives with downside protection, which creates incentives at the same time as it mitigates risk-averse behaviour.

Moel and Tufano (2002) study the mining industry and apply the real option of closing and opening gold mines in North America between 1988-1997. They find that the real options model is useful in the decision-making of closing and opening mines. Further they find that these decisions are related to firm-specific managerial factors, which are normally not considered within strict real options models. Real option models have been used among a various range of industries and they all state a negative relationship between investment and uncertainty; Mining (Moel et al., 2002), real estate (Bulan et al., 2006), chemicals (Bell and Campa, 1997).

To determine when the investment is undertaken, equivalent to option to delay exercise, one needs a proxy when the decision-maker observes an optimal time to invest. Gugler, Mueller and Yurtoglu (2004) discuss how the Tobin's q is used as a determinant in investment decisions. Tobin's q is measured as the average return on a firm's capital anticipated by the market. However, Gugler et al. (2004) state the marginal return on investment (qm) is more relevant for investment decisions. The qm has the property of assuming the present value of the future cash flow to be unbiased priced in the market value of the firm. Thus, it can work as a proxy for the NPV of the investment. From their empirical findings, they conclude that some firm's suffer from the existence of cash constraints and other from managerial discretion.

Many papers discuss how managerial risk-aversion affect investment decisions in a firm, for instance; Hartman (1972), Abel (1983), Caballero (1991), Chen, Miao, and Wang (2010), and De Marzo (2012). We motivate our thesis by contributing to the investment and uncertainty research by combining real option theory with irreversibility and managerial risk-aversion at the Swedish Large Cap market.

2.2. Hypothesis

When an investment is undertaken and the option to delay is exercised, the flexibility to wait and process new information is lost. However, if the investment decision is reversible, naturally the flexibility withstands to a larger extent than to a completely irreversible investment. Thus, the trigger price in an industry of irreversible investments should have a higher trigger price than an industry with reversible investments. Following this intuition, we use a similar real option model as Bulan et al. (2009) to investigate the probability of making a marginal investment within a firm. We contribute by introducing the marginal q by Gugler et al. (2004) as a trigger signal in the real option model. This leads to the first hypothesis of the thesis;

Hypothesis 1: The probability of making a marginal investment is lower in an irreversible industry than in a less irreversible industry.

Furthermore, by separating the volatility into systematic- and idiosyncratic volatility in line with the work by Panousi et al. (2012), we will examine how the idiosyncratic volatility affect the decision-maker in firms at the Swedish Large Cap market. Hence, our second hypothesis is;

Hypothesis 2: The idiosyncratic risk will have impact on the probability of making a marginal investment.

Finally, with same measure for inside-ownership as Panousi et al. (2012), we examine the probability of making a marginal investment in firms with different levels of insider-ownership and irreversibility. In a concluding matrix we investigate our third hypothesis;

Hypothesis 3: The uncertainty coefficient is lower in firms with high irreversibility investments and high inside-ownership compared to firms with low irreversibility investments and low inside-ownership.

3. Theory

In this section, we outline the underlying theory for real options and the econometrical model used.

3.1 Models

3.1.1 Option to delay

Suppose that a manager at $t = 0$ has decided to make a marginal investment at some point in the future. Thus, it is uncertain *when* this marginal investment will be undertaken. In every decision to make an investment there is an option to delay present. The decision-maker could in an attempt to remove some uncertainty simply wait and gather more information that might be revealed in the future. The decision to make an investment has a trigger price of $P > P^*$, where P is today's market price of the firm, and P^* is the latent trigger price estimated by the manager, which contains all the future cash flow of the investment. Thus, the payoff for the option is $Max\ (P - P^*, 0)$. This implies that when an investment is made the decision-maker estimates that the project will have a NPV greater than 0, a classical measure of project valuation. In Equation (1) one can observe the investment estimation (Gugler et al., 2004);

$$\frac{\omega[PV_t] + \epsilon}{(1 + r)I} > 1 \tag{1}$$

Where ω is the risk-aversion in relation to the decision-maker's inside-ownership, PV_t is the present value of all future cash flows, ϵ is the value of corporate governance and $(1 + r)I$ is the marginal investment at $t = 1$. The present value of the future cash flows and the full extent of compensation are not observable, but in a well-functioning market all future cash flows are incorporated into the stock price immediately;

$$M_t = M_{t-1} + \sum CF_t \tag{2}$$

Where M_t is the market value of the firm today. Assuming the market value of the firm is an unbiased measure of the future cash flow, one can say that a decision-maker's future cash flow estimation is the same as the marginal return on the capital invested in that period (qm), expressed as;

$$qm_t = \frac{M_t - (1 - \delta_t)M_{t-1}}{I_t} \quad (3)$$

Where δ_t is the depreciation rate of total assets and I_t is the investments undertaken. I_t is strictly an accounting measure originally defined as in Equation (4);

$$I_t = after\ tax\ profit_t + depreciation_t - dividends_t + \Delta debt_t + \Delta equity_t + R\&D_t + Advertising_t \quad (4)$$

Where we use a modified version to fit with our available data;

$$I_t = after\ tax\ profit_t + depreciation_t - dividends_t + \Delta total\ assets_t + R\&D_t \quad (5)$$

Where the change in debt and equity is swapped with the change in total asset and disregard the cost of advertising. Now a decision-maker estimation of future cash flow, relative to the investment is equivalent to qm;

$$\frac{\omega[PV_t] + \epsilon}{(1 + r)I_t} = \frac{M_t - (1 - \delta_t)M_{t-1}}{I_t} \quad (6)$$

To obtain a positive NPV in the investment, qm needs to be greater than 1. Where one can observe the optimal time to undertake an investment as;

$$\frac{M_t - (1 - \delta_t)M_{t-1}}{I_t} > 1 \quad (7)$$

Now recall we want to investigate the trigger price of an investment, or when option to delay is exercised which is now considered the optimal time of investment. To conclude; when $P > P^*$ there is now an established way of observing the event of optimal time to invest (Mavruk, 2015);

$$\frac{\omega[PV_t] + \epsilon}{(1 + r)I_t} = \frac{M_t - (1 - \delta_t)M_{t-1}}{I_t} > 1 \quad (8)$$

Using Black and Scholes (1973) option pricing formula, the trigger price is examined with the formula;

$$P^* = f(\mu^+, \delta^-, \sigma^+) \tag{9}$$

where f is a non-linear function, μ is the discount rate or equivalent the expected rate of return on the asset, δ is the dividend yield and σ is the standard deviation of the asset. The superscript sign represents how the trigger price P^* changes with an increase in each of these parameters.

Depending on the assumptions regarding risk preferences and complete markets, the specification for the discount rate will be different. In a world where investors are risk neutral, the discount rate is simply equivalent to the risk-free rate of return. Alternatively, if assumed that investors are risk-averse but markets are complete, the discount rate, or required rate of return on an asset can be derived using the capital asset pricing model (CAPM) in Equation (10);

$$\mu = r_f + \beta(E(r_m) - r_f) \tag{10}$$

Furthermore, one may utilise CAPM to separate the idiosyncratic risk. This is done by taking the regression residuals from CAPM;

$$\log(\sigma^{idio}) = log\sqrt{e^2} \tag{11}$$

For a for a risk neutral decision-maker, only systematic risk is interesting when evaluating an investment and thus not be affected by the idiosyncratic risk. A decision-maker with a considerable stake in the firm may be risk averse and responsive to idiosyncratic risk. Therefore, one can control for the different sources of volatility.

Systematic risk is obtained by taking the difference between total and idiosyncratic volatility;

$$\log(\sigma^{syst}) = \log\sqrt{(\sigma^{total})^2 - (\sigma^{idio})^2} \tag{12}$$

Another approach for estimating volatility is through a GARCH(1,1) one step ahead forecast of the price returns to estimate the variance of residuals from the first lag, i.e. the next period's forecast consist of both last period forecast and last period's squared return (Bollerslev, 1986);

$$\sigma^2 = \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{13}$$

3.1.2 Reduced form hazard model

The probability to make a marginal investment is investigated through a reduced form hazard model. When an optimal time to invest is identified ($qm > 1$), the latent trigger price is observed through the Black and Scholes option setting $P^* = f(\mu^+, \delta^-, \sigma^+)$. The hazard rate of investment $h(t)$ is thus the probability of a marginal investment occurring, conditional on that the decision-maker has not made one until t, defined as;

$$h(t) = \Pr(\, P_t > \; P_t^* | \; P_x^* \forall x < t) \tag{14}$$

The equation above is our specified dependent variable, which will be defined by a dummy variable of making a marginal investment and the stock price (P). In other words, 1 if the marginal return is above 1, and 0 otherwise. The relationship between this latent trigger price and the Black and Scholes parameters is then examined in the fully specified hazard model, outlined as;

$$h(t) = \exp(X'\beta) h_0(t) \tag{15}$$

Where X' is the vector containing the independent variables $(\mu^+, \delta^-, \sigma^+)$ and β is the vector of coefficients. The hazard coefficients are expressed as probabilities, hence a coefficient of 2 implies; probability of making an investment is twice as likely if the variable for the coefficient increases by 1-percentage unit. Accordingly if the hazard coefficient is 0.5 it implies; probability of making an investment is half the chance. $h_0(t)$ is the baseline of the hazard rate and describes how the price evolves over time (t). In the hazard model, several distributions could be used for $h_0(t)$, however only two are fitting in a real option approach; Exponential and Weibull distribution. The Weibull distribution has the property of being increasing (decreasing) over time as the exponential coefficients are over (below) unity. Exponential distribution is static regardless of time. Using Akaike information criterion one could determine which distribution fits the data best.

4. Data and Methodology

In this section, we describe our data, the source of our data, and what econometric techniques we have used. Moreover, we state how and why the firms have been divided into different groups and the delimitations that have been made.

4.1. Data

The data is mainly gathered from Bloomberg. It contains data of 33 Nasdaq OMX Stockholm Large Cap firms from year 2005 to 2015. The chosen time interval for which the data is observed is a result of the new International Financial Reporting Standards (IFRS) introduced in the European Union in 2005. The introduction of IFRS significantly increased the transparency of how publicly traded firms report financial information to the market (Hamberg, Mavruk and Sjögren, 2013). The data needed for this thesis was simply not sufficient before year 2005. Even though the IFRS increased the transparency of financial reporting, the data for some of the Large Cap firms were still not sufficient. After a careful analysis of all the 73 Nasdaq OMX Stockholm Large Cap firms, 33 of them qualified with data sufficient for making the analysis (see appendix Table 1). The reason for a firm to be excluded could be; too many missing observations in a variable needed or that the firm went public after 2005. The data set is delimited to only Large Cap firms, as the Mid- and Small Cap firms are illiquid and lack data of many of the variables needed. The foremost reason for exclusion is lacking the data from accounting measures, included in the marginal q model.

As some firms have dual class shares, the share with higher average trading volume over the sample period is chosen to observe. The raw financial data of all the 33 firms is collected from Bloomberg at a quarterly frequency. In addition, weekly data of stock prices, market returns and betas of all firms are used in the volatility and CAPM calculations in order to increase the accuracy.

The data of insider-ownership in each firm is gathered at a quarterly basis from the Swedish Finansinspektionen's webpage (Finansinspektionen, 2015). The risk free rate is taken directly from the Swedish Riksbank's webpage (Riksbanken, 2015). The risk free rate used, is the 3-month Treasury bill. It is collected at a quarterly and weekly basis and is measured as the average 3-month Treasury bill rate over each quarter/week.

4.2. Methodology

The volatility is calculated with three different approaches. The first way is simply the historical volatility of the weekly stock returns. The second is, following the previous literature of Panousi et al. (2012), by running an OLS regression on CAPM using weekly input data and extract the sum of residuals for each firm, which is the idiosyncratic volatility (see Equation 11). To get the systematic volatility, one simply subtracts the idiosyncratic volatility from the corresponding total volatility (see Equation 12). The third approach is by performing a GARCH(1,1) forecast (see Equation 13) of the weekly stock returns from 2005-2015. The weekly calculations of volatility and CAPM are then scaled to quarterly volatilities and returns in order to get the same time measure for all variables. The logic of using weekly observations is because higher frequency data yields more precise estimates of the volatility. For the scope of this thesis, we believe weekly observations suits our model better than daily observations as microstructure effects could affect them. For each firm, the data set contains data of the following variables presented in Table 1 below:

Table 1: Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
price	1314	120.8	97.89	6.750	837.5
qm	1314	0.303	0.460	0	1
rf	1314	0.253	0.144	0.0207	0.525
div yield	1314	0.863	0.778	0	3.819
required rate of return	1314	1.904	6.490	-14.37	13.04
vol idio	1314	2.018	1.695	0.121	10.64
vol tot	1314	11.41	3.631	3.477	22.89
vol sys	1314	11.16	3.474	2.826	21.92
vol garch	1314	13.73	2.616	8.755	22.75

Notes. Price is the stock price. Qm the binary for marginal q, rf the risk free rate, div yield the dividend yield, required rate of return based on capm, vol idio the idiosyncratic volatility, vol tot the total volatility, vol sys the systematic volatility, vol garch the GARCH(1.1) volatility forecast. Price is express in real SEK and all other variables in %. All variables are presented as quarterly observations for each firm from 2005-2015.

Before any regressions and calculations are made, the raw data is examined in detail to identify if it contains any missing values and/or large outliers. As presented in Table 1, the number of observations is 1314 for all variables because firm id 22 has 6 missing values as it went public in June 2006. In Stata, the command "grubbs" is used to identify outliers, which are observations with 1.96 standard deviations or more from the mean, i.e. each variable are tested at the 5% significance level. If outliers are identified, the command "winsorize" is used to replace outliers in the percentiles where they are observed with the first corresponding value towards the mean. The variables corrected for outliers in our data set are; price returns (in the top and bottom 2.5%), dividend yield (in the top 1.5%), and required rate of return based on CAPM (in the top and bottom 0.5%).

The level of insider-ownership is measured as the total number of shares held by the CEO over the total number of shares outstanding in the firm. The 33 firms are divided into two groups – One group with "High inside-ownership" and one with "Low inside-ownership". To create these groups, the average quarterly fraction of inside-ownership and total shares outstanding is calculated for each firm. The firms with an average inside-ownership higher than the median of all the firms are then divided into the "High insider-ownership" group and the firms with an average inside-ownership lower than the median to the "Low insider-ownership" group (see Appendix Table 1). As firm id 8 has the same fraction of inside ownership as the median of the sample, this firm is excluded.

The classification of firms with "High irreversibility" and "Low irreversibility" is calculated in the same procedure as for inside-ownership. First, the average quarterly depreciation rate of total assets is calculated (see Panousi et al., 2012) for all firms except for the firms with id 9, 21, 23, 24 and 25, which did not have the data of quarterly depreciation over total assets. The median depreciation rate of the firms is then used to split them into High- and Low irreversibility groups (see Appendix Table 1). To examine whether different industry sectors are exposed to different level of irreversibility, all firms have also been divided into industry classifications (see Appendix Table 1).

Moreover, the marginal q is calculated for each quarter in all firms. If the marginal q is > 1, a dummy variable is created and later used as a sign of trigger event in the model. The model used for our analysis of the data is a reduced form hazard model, estimated with a maximum likelihood regression. The base line hazard model is tested with both Exponential and Weibull distribution to identify which distribution that fits the model best. To get as efficient results as possible, the "Huber-White standard errors" are used in all regressions to cluster the subjects. The different regressions are also always performed with two different fixed effect specifications - Isolation over time and/or id.

Finally, a comparison where all firms are divided into four groups is made; High irreversibility & High inside-ownership, High irreversibility & Low inside-ownership, High inside-ownership & Low irreversibility and Low irreversibility & Low inside-ownership (see Appendix Table 2). To make the comparison, the hazard coefficient of volatility for each group is compared in a matrix with inside owner-ship in rows and irreversibility in columns.

5. Results and Analysis

In this section the results from our regressions are presented and discussed.

Our results are estimated by maximum likelihood and presented as hazard ratios. The Akaike information criterion suggests a Weibull-distribution (over exponential) for the baseline hazard function. The volatility measures used is explicitly the volatility from our GARCH(1,1), except when isolating the idiosyncratic and systematic volatility. The GARCH(1,1) outperforms historical volatility in all settings in the sense of statistical significance. Also, there is a strong evidence of using a volatility that is forward-looking instead of historical volatility, since the nature of valuation of an investment is forward-looking as well.

In Table 2, results are presented as follows; column (1) and (2) are results from the whole sample, proceeding with column (3) and (4) where financial institutions and real estate firms have been dropped. Financial institutions and real estate firms have a different financial and accounting structure and are therefore excluded to obtain a more homogenous sample. In the regressions we control for two different kinds of required return (discount rates), the risk free rate (risk neutral) and the one based on CAPM (risk averse).

Table 2: Regression output of all firms and all firms with financial institutions and real estate excluded.

VARIABLES	(1) All – rf	(2) All - CAPM	(3) Excl Fin. - rf	(4) Excl Fin. - CAPM
vol_garch	**0.919**	**0.919**	**0.758*** **	**0.787** **
	(0.0694)	(0.0772)	(0.0693)	(0.0864)
rf	**0.645**		**0.0400**	
	(0.956)		(0.0874)	
div_yield	**1.479** **	**1.453* **	**1.753** **	**1.403**
	(0.291)	(0.304)	(0.402)	(0.437)
capm		**0.998**		**0.998**
		(0.0329)		(0.0599)
Observations	**301**	**301**	**145**	**145**
Prob > chi2	**0.156**	**0.235**	**0.00548**	**0.0474**

*** p<0.01, ** p<0.05, * p<0.1

Notes. In column (1) and (2), regression output for the all firms with required rate of return based on rf in column (1) and capm in column (2). In column (3) and (4) same regression specifications but for the group where financial institutions and real estate firms have been excluded. All coefficients are expressed as hazard rates, i.e. exponentiated form, $exp\ (B)$. The Huber-white standard errors are displayed below each corresponding hazard rate.

Starting with column (1) and (2) the coefficients have the correct sign (vol_garch and rf less than unity and div_yield over unity) according to real option theory. The only coefficient, which is significant, is dividend yield. However the "prob > chi2" of 0.156 in column (1) suggests it does not exist a coefficient with sufficient explanatory power within the model as a whole. The results in column (3) and (4) are significant for the volatility variable and in the dividend yield for the risk neutral setting. Moreover, with the new settings, the model has explanatory power in at least one variable according to the "prob > chi2". As we examine the relationship between investment and uncertainty, it is most convenient that our volatility coefficient becomes significant.

In terms of interpretation, these results imply; a one percentage unit increase in quarterly volatility in column (3) is equivalent to a 0.242 reduction in the quarterly hazard rate, i.e. the probability of making an investment is 24,2 percentage lower. Following the same logic in column (3) the dividend yield has an even greater impact on investment with a hazard ratio of 1.753. In line with real option theory of a negative relationship between uncertainty and investment, these results provide a good economic significance in our volatility coefficients. However, one should discuss the magnitude of these hazard coefficients and whether it is reasonable to assume that it is 1.753 more probable to invest if the quarterly dividend yield increases with one percentage unit. The mean of quarterly dividend yield in our sample is 0.778 percent, which would imply a 1-percentage unit increase would more than double the quarterly dividend yield. Additionally, dividend yield is one of the most crucial variable for the markets valuation of stock prices, which in terms will have a major impact on our trigger price. Therefore, one can assume the model is sensitive to fluctuations in the dividend yield and indeed possess a large impact on probability to invest.

In Table 3, a comparison between High and Low irreversibility firms with different required rate of return is displayed. This is the first attempt to identify a relationship between the uncertainty, irreversibility and investment.

Table 3: Regression output of High and Low irreversibility firms.

VARIABLES	(1) Irreverse H – rf	(2) Irreverse H - CAPM	(3) Irreverse L – rf	(4) Irreverse L – CAPM
vol_garch	**0.603***** (0.0937)	**0.783**** (0.0908)	**0.801**** (0.0877)	**0.703** (0.169)
rf	**0.000491**** (0.00188)		**0.0663** (0.239)	
div_yield	**1.814** (1.067)	**1.759** (0.862)	**1.910*** (0.675)	**1.674** (0.752)
capm		**1.177***** (0.0509)		**0.921** (0.111)
Observations	**54**	**54**	**53**	**53**
Prob > chi2	**0.0136**	**0.00145**	**0.0951**	**0.206**

*** p<0.01, ** p<0.05, * p<0.1

Notes. In column (1) and (2), regression output for the High irreversible group with required rate of return based on rf in column (1) and capm in column (2).. In column (3) and (4) same regression specifications but for Low irreversibility group. All coefficients are expressed as hazard rates, i.e. exponentiated form, $exp\ (B)$. The Huber white standard errors are displayed below each corresponding hazard rate.

All volatility measures are now significant at the 5-percentage level or less, except in column (4) where both the model and all the explanatory variables are insignificant. In column (1) and (3), one can observe the difference in the coefficients for uncertainty between our two irreversibility groups. Making the same comparison with column (2) and (4) one observe the opposite relationship, however column (4) is not significant at any level and with "prob > chi2" of 0,206 one cannot conclude any coefficient is significantly different from zero. By comparing column (1) and (3), the volatility coefficient is clearly statistically significant at the 1 percent and 5 percent level correspondingly, and "prob > chi2" confirms the model's validity. The hazard coefficient of high irreversibility in column (1) is 0,603 compared to the low irreversibility coefficient in column (3) of 0,801. Moreover, performing a z-test on the volatility coefficients in column (1) and (3) is statistically significant at the 1 percent level.

Consequently, we determine the measurement of irreversibility (see Panousi et al., 2012), depreciation over total assets, in fact is a good measurement and the degree of irreversibility indeed has an impact on the probability of making a marginal investment; thus rejecting the null hypothesis of no relationship in *hypothesis 1*. Additionally with the reduction in total observations between the regressions in Table 2 and Table 3, the regressions maintain or even increase the significance. This strengthens the evidence for irreversibility to be a major factor in investment decisions. In column (1), for the first time the coefficient of required rate of return is statistically significant. With the same logic as with the dividend yield, a 1-percentage unit increase in the quarterly risk free rate decreases the probability of making an investment by 99,9 percent. This is most certainly not economically significant, even though the risk free rate is a good proxy for cost of debt (finance an investment) and naturally a strong underlying determinant of making an investment decision. One cannot simply justify a coefficient with such immense magnitude. Moreover, the required rate of return in column (2) is highly significant and more troublesome because the coefficient is above unity, which implies that the probability of making an investment increases with a higher discount rate. This is not in line with the real option theory, hence the economic significance is contradictive and one could therefore suspect spurious results in this regression. Finally, the dividend yield in column (3) has a hazard rate of 1.910 and is significant at a 10 percent level. This may confirm our previous statement of dividend having a major impact on the probability of investment.

Table 4 below has the same setup of regressions as for the previous tables except for the volatility that is now divided into a systematic and idiosyncratic component.

Table 4: Regression output of High and Low irreversibility firms.

VARIABLES	(1) Irreverse H – rf	(2) Irreverse H - CAPM	(3) Irreverse L – rf	(4) Irreverse L - CAPM
vol_sys	**0.663***	**0.811***	**0.863***	**0.892**
	(0.159)	(0.101)	(0.0668)	(0.0685)
vol_idio	**1.593****	**1.292**	**1.328***	**1.271**
	(0.345)	(0.367)	(0.203)	(0.289)
rf	**7.26e-05**		**0.0151**	
	(0.000437)		(0.0488)	
div_yield	**0.797**	**1.277**	**1.673**	**1.268**
	(0.516)	(0.778)	(1.426)	(1.161)
capm		**1.105*****		**1.005**
		(0.0411)		(0.0457)
Observations	**54**	**54**	**53**	**53**
Prob > Chi2	**0.0166**	**0.00541**	**0.117**	**0.352**

*** p<0.01, ** p<0.05, * p<0.1

Notes. In column (1) and (2), regression output for the High irreversible group with required rate of return based on rf in column (1) and capm in column (2). In column (3) and (4) same regression specifications but for Low irreversibility group. The volatility is divided into one idiosyncratic and one systematic variable. All coefficients are expressed as hazard rates, i.e. exponentiated form, $exp\ (B)$. The Huber white standard errors are displayed below each corresponding hazard rate.

The systematic volatility is always below unity as expected and significant in all columns except for column 4. However, the idiosyncratic volatility is always above unity, which is against the real option theory where it is expected to be unity or less. Even though the coefficients are greater than 1, they appear to be significant in the regressions with risk free required rate of return. Additionally, the required rate of return based on CAPM is also greater than 1 and only significant in column (2). We suspect idiosyncratic volatility and CAPM suffer from the same drawbacks as in the case with CAPM stated in the previous paragraph. Moreover, the risk free rate is below unity but is always insignificant. Only the regressions in the group of high irreversibility have a satisfying "Prob > Chi2".

Again, the null hypothesis of *Hypothesis 1* of investment and uncertainty is rejected while examine between high and low irreversibility, and the z-test of the difference between the coefficients is significant at the 5 percent level. The result of idiosyncratic risk implies if one where to say managers act in line with the corresponding findings, it would suggest mangers to be risk loving in regards to specific risk. Hence, we suggest the results from idiosyncratic volatility have no economic significance. We cannot conclude any relationship between idiosyncratic volatility and probability of investment. Therefore, the null hypothesis of *Hypothesis 2* cannot be rejected.

A different approach is to divide the firms into different industry sectors. Table 5 below displays regression results from two different industry sectors; "Durable goods and services" and "Industrial goods and services".

Table 5: Regression output of firms divided into industry sectors.

VARIABLES	(1) Durable G&S – rf	(2) Durable G&S CAPM	(3) Industrial G&S – rf	(4) Industrial G&S - CAPM
vol_garch	**0.598**	**0.588****	**0.475*****	**0.589****
	(0.230)	(0.149)	(0.126)	(0.147)
rf	**1.502**		**0.00168**	
	(10.03)		(0.00700)	
div_yield	**3.132**	**1.470**	**0.472**	**0.396**
	(7.660)	(2.745)	(0.345)	(0.258)
capm		**0.924**		**1.049**
		(0.115)		(0.0940)
Observations	**11**	**11**	**64**	**64**
Prob > chi2	**0.150**	**0.127**	**0.00360**	**0.00856**

*** p<0.01, ** p<0.05, * p<0.1

Notes. Column (1) is regression output for Durable goods and services with the risk free rate (rf) used as required rate of return. Column (2) is output for the same regression but instead of rf as required rate of return, capm is used. In column (3) and (4) the same setup of regression output is displayed, but for the Industrial goods and services sector. All coefficients are expressed as hazard rates, i.e. exponentiated form, $exp\ (B)$. The Huber white standard errors are displayed below each corresponding hazard rate.

First thing to point out is that none of the “Durable” regressions have a sufficient “prob > chi2” and the only significant coefficient is the volatility in column (2). The lack of observations within the “Durable” sector is most certain a major reason for the poor statistical significance. On the other hand, the “Industrial” regressions in column (3) and (4) with almost 6 times the observation count, performs rather well and both has significant volatility estimators. However in column (3) and (4) dividend yield has a hazard rate below unity and in column (1) the risk free discount rate has a hazard rate above unity. All these coefficient has no economic significance and furthermore, the CAPM measure for required return continues to perform poorly. The one thing we may conclude is that “Durable” sector is less sensitive to uncertainty than the “Industry” sector, which could be assumed to be more irreversible. However, the lack of both economic and statistical significance makes even this conclusion most dubious. Lastly, our regressions for pharmaceutical, resource, financial & real estate, consumption, energy and tele-communication firms did not have enough observations or made non-sense regressions and are therefore omitted.

Finally we examine the impact of CEO insider share holdings together with irreversibility. In Table 6 and Table 7, regression output from the four different groups are presented. In Table 6, the risk free rate is used as required rate of return and in Table 7 required rate of return based on CAPM is used.

Table 6: Firms divided into groups with different levels of inside-ownership and irreversibility.

	(1)	(2)	(3)	(4)
VARIABLES	Inside H - Irr H	Inside H - Irr L	Inside L - Irr H	Inside L - Irr L
vol_garch	**0.577*** **	**0.236***	**0.202*** **	**0.601**
	(0.0619)	(0.196)	(0.0861)	(0.197)
rf	**1.44e-09*** **	**1.978e+14***	**9.04e-07***	**0.0234**
	(1.13e-08)	(3.515e+15)	(6.54e-06)	(0.167)
div_yield	**3.104**	**535.5***	**1.752**	**0.0897**
	(3.838)	(1,742)	(2.182)	(0.210)
Observations	**37**	**14**	**15**	**39**
Prob > chi2	**.**	**0.000771**	**0.000771**	**0.00266**

*** p<0.01, ** p<0.05, * p<0.1

Notes. In all regressions, the rf is used as required rate of return. Column (1) is regression output for the group of High inside-ownership and High irreversibility. Column (2) is regression output for the group of High inside-ownership and Low irreversibility. Column (3) is regression output for the group of Low inside-ownership and High irreversibility. Column (4) is regression output for the group of Low inside-ownership and Low irreversibility. All coefficients are expressed as hazard rates, i.e. exponentiated form, $exp\ (B)$. The Huber white standard errors are displayed below each corresponding hazard rate.

In these regressions the risk free rate is used as required rate of return, all hazard coefficients have the right sign according to real option theory, except for rf in column (2) and dividend yield in column (4). The volatility coefficients are statistically significant in all groups, except for the group in column (4). Moreover, the risk free rate coefficients are statistically significant in the same groups as the volatility is. The coefficients for dividend yield are only statistically significant in column (2). By looking at the "Prob > chi2" for the four regressions, we can see that the regressions in column (2), (3) and (4) are statistically significant at the 1% level. Regarding column (1); the dot in prob > chi2 is a sign of misleading results because the clustered standard errors are computed within a sample of too few observations (trigger events). However, the economical significance in these regressions is ambiguous. We discuss this in a concluding paragraph at the end of this section.

Table 7: Firms divided into groups with different levels of inside-ownership and irreversibility.

	(1)	(2)	(3)	(4)
VARIABLES	Inside H - Irr H	Inside H - Irr L	Inside L - Irr H	Inside L - Irr L
vol_garch	**0.826**	**0.718**	**0.290*** **	**0.496**
	(0.162)	(0.208)	(0.0878)	(0.279)
	1.138* **	**0.939**	**1.635*** **	**0.923**
	(0.0394)	(0.0780)	(0.310)	(0.104)
div_yield	**1.447**	**5.458** **	**2.461**	**0.0421**
	(1.334)	(4.170)	(2.781)	(0.0925)
Observations	**37**	**14**	**15**	**39**
Prob > chi2	**.**	**0.0175**	**0.000156**	**1.69e-06**

*** p<0.01, ** p<0.05, * p<0.1

Notes. In all regressions, the required rate of return based on capm is used. Column (1) is regression output for the group of High inside-ownership and High irreversibility. Column (2) is regression output for the group of High inside-ownership and Low irreversibility. Column (3) is regression output for the group of Low inside-ownership and High irreversibility. Column (4) is regression output for the group of Low inside-ownership and Low irreversibility. All coefficients are expressed as hazard rates, i.e. exponentiated form, $exp\ (B)$. The Huber white standard errors are displayed below each corresponding hazard rate.

Now for the regressions with required rate of return based on CAPM in Table 7 above; all the hazard coefficients have the right sign according to the real option theory, except for the required rate of return based on CAPM in column (1) & (3) and the dividend yield in column (4). The volatility coefficient is now only statistically significant in column (3), while the variable CAPM has statistically significant coefficients in column (1) and (3). Furthermore, the coefficients for dividend yield are only statistically significant in column (2). The "prob > chi2" is statistically significant at the 5% level or less in all regressions, except in column (1) where we again get a dot at the "Prob >chi2". As in Table 6, the economical significance in these regressions is ambiguous as well.

In Table 8 and Table 9, volatility hazard rates from the four different groups in Table 6 and Table 7 are presented in two concluding matrices. In Table 8, the risk free rate is used as required rate of return and in Table 9 required rate of return based on CAPM is used.

Table 8: Concluding matrix.

L, L 0.601 (0.197)	**L,H** 0.236* (0.196)
H, L 0.202*** (0.0861)	**H, H** 0.577*** (0.0619)

Notes. Volatility hazard coefficients in a matrix with irreversibility in columns and inside-ownership in rows. Risk free rate used as the required rate of return.

Table 9: Concluding matrix.

L, L 0.496 (0.279)	**L,H** 0.718 (0.208)
H, L 0.290*** (0.0878)	**H, H** 0.826 (0.162)

Notes. Volatility hazard coefficients in a matrix with irreversibility in columns and inside-ownership in rows. Required rate of return based on capm used.

By comparing the different volatility hazard ratios, one cannot draw any conclusions whether decision-makers or more specifically CEO inside-ownership would affect the managerial decisions of investments. For example, by comparing the left column in Table 8, we observe a hazard ratio of 0.601 in the L, L group and 0.202 in the H, L group. Economically, this is in line with our previous results stating that probability of making an investment is lower (0.202) in firms with High irreversibility compared to firms with Low irreversibility (0.601). However, the volatility hazard coefficient in group L, L is statistically insignificant, thus no conclusion can be drawn. Moreover, we compare the bottom row in Table 8 and observe volatility hazard ratios of 0.202 in group H, L and 0.577 in group H, H. This result of a higher hazard ratio in group H, H compared to H, L would imply that firms with High irreversibility and High inside-ownership have a higher probability of making a marginal investment, when uncertainty increases, compared to firms with High irreversibility and Low inside-ownership. Both coefficients are statistically significant at the 1 percent level, which is troublesome as the results are economically insignificant according to the theory of inside-ownership and irreversibility. Therefore, we suspect these results to be spurious, for reasons discussed in the paragraphs below. When comparing between the other groups in Table 8 and Table 9, the results are ambiguous and similar to the results stated above. To conclude, adding inside-ownership do make the results economically insignificant and we can therefore not reject the null hypothesis of *hypothesis 3* that inside-ownership does affect decision-makers behaviour in investment decisions.

5.1. Discussion and implications

The reason of our poor results in regards to inside-ownership could have multiple explanations. First, we assume the theory of having no hedging possibilities and that the decision-maker is not diversified. When in fact, the inside owner could actually create a hedge in various ways and have a lot of diversification opportunities. Secondly, our proxy for the magnitude of insider-ownership is most trivial. To obtain a more correct proxy for risk aversion correlated to inside-ownership, one could relate inside-ownership to personal wealth and not market cap of the firm. Closely related to personal wealth is also human capital, and especially future income. Assuming an elderly decision-maker one could expect large savings and less future income (salary). This implies he cannot afford to lose a large stake of his life savings and will therefore act more risk averse. Same relationship but the opposite goes for a younger decision-maker with large future income and low savings. Consequently, this could imply an outside position and thus an incomplete market, which could also be the reason for the spurious result in regards to idiosyncratic and systematic estimates.

We would also like to address the monetary policies after the financial crisis where the interest rate has been low, stock market bullish combined with a rather low growth rate. Since we both have accounting and market based input it is important to point out the market does not only reflect discounted future cash flow. Recent years the stock market has had a massive inflow of capital due to the low interest rates, i.e. the stock market has been a substitute for bonds. Correlation between the stock market and interest rates has thus been negative.

Moreover, when in fact using the proxy of shares over total outstanding, one could control for firm size as the size of the firms within sample varies. Moreover, the level of competition in different industry segments has a large impact on the probability of making an investment. The investment could be necessary to maintain a market share or keep up to technical development. While on the other hand, firms with low competition rather push the investment into the future and benefit from higher marginal. One could therefore extend the sample and control for industry groups with approximately same level of competition.

Finally, the assumption of instant pricing of investments in stock prices could also be open for discussion. A solution could be to control for different kind of lags in investments i.e. assuming investments take time to be reflected in the stock price. Closely related to this issue is the level of the data. If one were to use project level data, the results would be far more robust. This would however be hard for some industries but surely doable for others. For example, developers with building permits or other firms with public documents. Also, developers, airlines, pharmaceuticals often make announcements when taking major investment decisions.

6. Conclusion

In this thesis, we have studied the probability of making a marginal investment with a real option approach. We investigate the impact of the degree of irreversibility independently and combined with inside-ownership in the firm. Moreover, we make an attempt to observe idiosyncratic and systematic risk separately.

Our primary results are in line with real option theory which suggests that firms with a higher degree of irreversibility, and thus have less flexibility, are more sensitive to uncertainty than firms with lower irreversibility. In a setting where the decision-maker is considered risk neutral, a 1-percentage unit increase in quarterly volatility would make the probability to make a marginal investment in a high irreversible firm roughly 20 percentage units lower than a firm with lower irreversibility. All our results in this setting are both statistical and economically significant which also implies the irreversibility measure, depreciation rate of total assets, is a good proxy.

In an attempt to observe if uncertainty affects the hazard ratios between different industry sectors. The results prove to be somewhat in accordance to real option theory but are not statistically significant. A reason could be different levels of competition for the firms within the broad segments.

When isolating the components of volatility into systematic and idiosyncratic risk the results are statistically significant but economically questionable. The idiosyncratic risk is always positive and significant when risk free is considered as the required rate of return. Implying decision-makers are risk loving and have a tendency to take on risk which is not associated with higher expected return.

Finally our results of combining irreversibility and inside-ownership provides little to no sense which leads to a fulsome discussion of incomplete markets and the complications of human capital, lagged effects and competition which may affect our model.

We did not get any economically significant results regarding the relationship between inside-ownership and investments, a theoretical wrong sign on idiosyncratic risk and incomplete markets in general, this could be topics for further research.

Furthermore, future research could include further specifications of insider-ownership, for example extend the decision-maker definition from not only the CEO but also other positions. Additionally, large shareholder may or may not have different ways to affect the level of investment. A large shareholder could also have different risk aversions depending on his outside positions.

Appendix

Table 1: List of all firms divided into different groups.

Firms	Id	Industry sector	Irreversibility	Inside-ownership
ABB SS Equity	1	Industry	High	Low
ALFA SS Equity	2	Industry	High	Low
ALIV SS Equity	3	Durable goods	Low	High
ATCOA SS Equity	4	Industry	Low	Low
AXFO SS Equity	5	Consumption goods	Low	High
AZN SS Equity	6	Pharmaceuticals	Low	Low
BOL SS Equity	7	Resources	Low	Low
ELUXB SS Equity	8	Durable goods	Low	-
FABG SS Equity	9	Finance and Real Estate	-	High
GETIB SS Equity	10	Pharmaceuticals	High	High
HMB SS Equity	11	Consumption goods	Low	High
LUMI SS Equity	12	Resources	Low	High
ORI SS Equity	13	Durable goods	High	Low
SAND SS Equity	14	Industry	Low	Low
SWMA SS Equity	15	Durable goods	High	Low
TRELB SS Equity	16	Industry	High	High
VOLVB SS Equity	17	Industry	Low	Low
BALDB SS Equity	18	Finance and Real Estate	High	High
BILL SS Equity	19	Resources	Low	High
HOLMB SS Equity	20	Resources	High	Low
HUFVA SS Equity	21	Finance and Real Estate	-	Low
HUSQB SS Equity	22	Durable goods	High	Low
INVEB SS Equity	23	Finance and Real Estate	-	High
KINVB SS Equity	24	Finance and Real Estate	-	High
LUPE SS Equity	25	Energy	-	High
NDA SS Equity	26	Finance and Real Estate	High	Low
NOBI SS Equity	27	Durable goods	Low	High
PEABB SS Equity	28	Industry	High	High
SAABB SS Equity	29	Industry	High	Low
SKFB SS Equity	30	Industry	High	High
STER SS Equity	31	Resources	Low	Low
TLSN SS Equity	32	Tele-Communication	Low	Low
WALLB SS Equity	33	Finance and Real Estate	High	High

Notes. All firms with corresponding id number. Firms divided into 8 different industry sectors, High- and Low inside-ownership and High and Low irreversibility.

Table 2: Inside-ownership and irreversibility.

Low inside-ownership & Low irreversibility	Low inside-ownership & High irreversibility
ATCOA SS Equity	ABB SS Equity
AZN SS Equity	ALFA SS Equity
BOL SS Equity	ORI SS Equity
SAND SS Equity	SWMA SS Equity
VOLVB SS Equity	HOLMB SS Equity
STER SS Equity	HUSQB SS Equity
TLSN SS Equity	NDA SS Equity
	SAABB SS Equity
High inside-ownership & Low irreversibility	**High inside-ownership & High irreversibility**
ALIV SS Equity	GETIB SS Equity
AXFO SS Equity	TRELB SS Equity
HMB SS Equity	BALDB SS Equity
LUMI SS Equity	PEABB SS Equity
NOBI SS Equity	SKFB SS Equity
	WALLB SS Equity

Notes. Firms divided into a matrix of different groups classified after level of irreversibility and inside-ownership.

References

Abel, A. (1983). *Energy Price Uncertainty and Optimal Factor Intensity. A Mean-Variance Analysis.* Econometrica, vol. 51, No. 6, pages 1839-1945.

Bell, G. K. and J. Campa. (1997). *Irreversible Investments And Volatile Markets: A Study Of The Chemical Processing Industry.* The Review of Economics and Statistics, vol. 79, No. 1, pages 79-87.

Bernanke, B. (1983). *Irreversibility, Uncertainty, and Cyclical Investment***.** The Quarterly Journal of Economics, vol. 97, pages 85-106.

Black, F. and M. Scholes. (1973). *The Pricing of Options and Corporate Liabilities.* The Journal of Political Economy, Vol. 81, No. 3, pages 637-654

Bollerslev, T. (1986). *Generalized Autoregressive Conditional Heteroskedasticity.* Journal of Econometrics, Vol. 31, pages 307-327.

Bulan, L., C.J. Mayer, and C.T. Somerville. (2009), *Irreversible investment, real options, and competition: Evidence from real estate development.*

Caballero, R. (1991). *On the Sign of Investment-Uncertainty Relationship.* The American Economic Review, Vol. 81, No. 1, pages 279-288.

Chen, H., J. Miao, and N. Wang. (2010). *Entrepreneurial Finance and Nondiversifiable Risk.* The Review of Financial Studies.

Dixit, R.K., and R.S. Pindyck. (1994). *Investment under Uncertainty.* Princeton University Press.

Finansinspektionen (2015), available online; http://insynsok.fi.se.

Gugler, K., D.C. Mueller, and B.B. Yurtoglu. (2004), *Marginal q, Tobin's q, Cash flow and investment.*

Hartman, R.W. (1972). *Equity implications and state tuition Policy and Student Loans.* Jouran of Political Economy, Vol. 89, No. 3, Part 2, pages 142-171.

Hamberg, M., T. Mavruk, and S. Sjögren. (2013). *Investment allocation decisions, home bias and mandatory IFRS adoption. Journal of International Money and Finance*, No. 36, pages 107-130.

Marzo, G. (2012). *Investment Project Valuation from the Entity-Firm Perspective.* University of Ferrara.

Mavruk, T. (2015). *Empirical testing of option to delay irreversible investments in the presence of risk-averse managers.* University of Gothenburg.

Moel, A., and P. Tufano. (2002). *When are Real Options Exercised? An Empirical Study of Mine Closings.*

Sveriges Riksbank (2015), available online; http://www.riksbank.se/sv/Rantor-och-valutakurser/Sok-rantor-och-valutakurser.

Panousi, V., and D. Papanikolaou. (2012). *Investment, Idiosyncratic Risk, and Ownership.*