Joakim Blix Prestmo

Three perspectives on real investments in the manufacturing industry

An empirical approach

Doctoral thesis
for the degree of philosophiae doctor

Trondheim, October 2019

Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Economics

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Abstract

This Ph.D. thesis discusses the real investment in the manufacturing industry in Norway and the firms' decision-making-process from three different perspectives. I show, using a novel approach, that firms, and particularly small firms, in the manufacturing industry do, to a lesser degree, use standard methods to shed light on their investment decision. Analyzing a business survey with panel data methods, I find that it is access to credit and demand expectations that are the most critical factors in explaining changes in investment plans. Lastly, the last chapter of this thesis suggests a model for aggregate investments in the manufacturing industry can. Based on the findings of the first chapters of this thesis, I suggest a way to expand the classic investment Euler equation such that it includes financial conditions and the cost of external financing. The investment Euler equation is estimated empirically using standard time series methods, and the estimated equation can forecast the decline in investments during the financial crisis.

Preface

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) for partial fulfillment of the requirements for the degree of Philosophiae Doctor.

The doctoral work has been performed at the Department of Economics, NTNU, Trondheim. Professor Gunnar Bårdsen and John Dagsvik have supervised the work. Gunnar, my main supervisor, has been supporting me throughout the writing of this thesis, and I owe him a great thank for his patience. I would also thank John for his excellent suggestion and lively discussions. I want to thank both of them for their guidance and many comments on my writing.

I would also take the opportunity to thank my former colleagues at Statistics Norway, and particularly Roger Bjørnstad, for encouraging me to start the work on my Ph.D. I will also thank Ådne Cappelen and Torbjørn Eika, for the many discussion we had; they played an essential role in the papers of this thesis. I am grateful to my current employer, BN Bank, which gave me time to focus on finishing the Ph.D. – thanks to Trond Søraas.

Last, but not least, I would like to thank my wife Sina, as well as my parents and the rest of my family for all the support they have given me.

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Trondheim, October 2019
Joakim Blix Prestmo

Chapter 1

Preamble

1.1 Introduction

Real business investments; investments in machines, research and development, and buildings and transportation vehicles; fluctuates significantly. During the last two decades, the growth and decline of aggregated business investments have several times shown two-digit figures for the yearly change in investments. The high fluctuations must be seen in contrast to the development in private and public consumption, which shows far less fluctuation, both in absolute and relative terms. This is supporting the view that investment behavior is crucial for predicting economic trends.

Explanations for the fluctuations in real investments are many, but there is still no consensus in the fields of economics about the driving factors behind the variations in investments from one year to another. My research project makes use of three different methodological strategies to shed light on factors explaining investment behavior. The strategy attacks the problem from three different angles, and the hypothesis is that this will help us to gain new insight for understanding the fluctuations in real investments.

1.2 Research question

This Ph.D. dissertation addresses the question: What causes the large fluctuations in real investments in the manufacturing industry, and how can we forecast aggregate investment?

My approach to answering this question is to apply three very different methodological strategies. I combine insight from a survey I sent out to the industry, with an empirical analysis of a quarterly investment survey and an empirical analysis of macroeconomic data. The first essay discusses a business survey I sent out in 2012. In this essay, I show that there are substantial differences in how large and small firms plan their investments. Valuable insight from this study is that the cost of capital is less important, but access to financial capital is so. The second essay builds on this insight from the first essay and finds supporting evidence for the results of the first essay. Studying a couple of years of data from a business tendency survey, I show that demand expectations and access to credit are by far the most important factors affecting revisions in investment plans. In the first essay I present figures showing that a motive for firms' investments is to reduce labor costs. This result contrasts the conclusion in second essay, where I show in the very short run that it is a positive relationship between capital and labor. These are all hints that tell us that we should model long-term and short-term investments different. The third and last essay of this thesis uses the insight from the two first essays to propose a twist to the classic Q-theory model of Tobin (1969). I suggest that instead of the traditional investment cost function, where there is a cost of installation of the new capital, we should take into effect the cost of funding that is caused by the tightening of the credit market. This way of extending the Q-model is inspired by Kaplan and Zingales (1997). However, in contrast to Kaplan and Zingales (1997), I suggest a way to specify this cost function. In an empirical analysis using time series data, I show how long and short-run investment can be modeled in a way that utilizes the theory model and fully describes the decline in real investments during the financial crisis in 2008 and the lack of growth in investment the years that follow.

1.3 Theoreticalbackground

There are four leading investment theories, all of which are built on the idea that the motivation of the firm is profit-maximizing:

1. The Q-theory, (Tobin 1969)
2. The neo-classical investment theory (Jorgenson 1963) and (Jorgenson and Hall 1967)
3. The Euler-equation (Smith 1960), (Whited 1998) and (Chirinko 1993)
4. Putty-clay (Johansen 1959), (Atkeson and Kehoe 1999) and (Gilchrist and Williams 2005)

The goal of the firm is per definition (in economics) to maximize the profit of the owner. The firms' motivation for running the firm then has some obvious implications.

1. The firm wants to keep costs at a minimum,
   (a) Which imply that the firms should keep employ as low as possible
   (b) Buy the cheapest factor input, given the quality
2. The firm would put/invest its money where the return is the highest

Following those two theorems, we may find the level of the firms' consumption of goods, their level of employment, and their choice of capital investment by minimizing costs at given revenues or by maximizing sales given the costs.

All four investment models generate the result that an investment project starts – if and only if – the return of the investments, measured by the net present value of the future profit stream relative to the investment cost, is larger than the estimated hurdle rate or the market return. Moreover, if the firm receives a higher profit of investing in the firms' money elsewhere, the manager would not invest in her company.

The results in the first essay show that firms only, to some degree, calculate the profitability of their investment projects. They also put their calculations into question. I further show that a fundamental motive for the firm is to both keep the firm alive and create jobs, as well as making a profit, which means that the manager is likely to conduct investments when the profitability is unknown. These results put the researcher in a situation where he wants to question the assumptions above – that one of the goals of this thesis.

1.4 Data

The data used in this dissertation comes from three very different sources. The first essay studies the result of a one-off business survey conducted by myself. The second essay studies the results from the quarterly business tendency survey by Statistics Norway. While the third essay studies aggregated time series investment data from the National account.

These are three widely different data sources, which need profoundly different modeling techniques. The first study is an empirical study on individual firm level (managers are questioned). The second study also has a quantitative approach and is still at an individual firm level, but because the survey is repeated every quarter, the data is organized as a panel dataset. The third and last study is purely quantitative, and the data is macroeconomic data aggregated up to industry level.

1.5 Empiricalstrategy

The empirical methods applied in this thesis are, because of the variance of the data type, highly different. The first essay makes use of a combination of ordered logit models and multinomial logit models to find the firms' most preferred method for making investment decisions. I combine this with two-way diagrams and non-parametric statistics in order to verify the results of the survey.

The second essay studies a binary dependent variable. To study the change in the probability of a change in the firms' response, a probabilistic model, like the probit or logit model, is most appropriate. Due to the dynamics in the panel data, the choice of methodology is not apparent; this is why several model specifications are tested.

The third essay studies whether the knowledge gained from the two first articles may apply to macroeconomics. Using time-series data, the methodology changes dramatically. I apply standard time-series methods, like the Error correction models (ECM) and bounds testing. I have also tested a vector autoregression (VARX), without changing the results of the analysis. Hence the simple ECM framework is kept.

1.6 Summary of the essays

This section gives a brief overview of the papers in this thesis.

1.6.1 Paper 1

The first paper discusses the which methods, if any, are the most preferred ones when the firms make their investment decision. To answer this question, I send out a business survey to firms in the manufacturing industry in Norway. The business survey poses several questions to business managers in the manufacturing industry regarding capital budgeting and how they plan their investment projects. Questions, such as which methods they use to calculate the profitability of their investment decisions and how the firms fund their investments. The firms are further asked a range of questions that might shed light on the driving factors behind which methods they use. The motivation behind this survey is, therefore, to uncover some qualitative characteristics of the investment decisions; this is done by applying both descriptive methods and empirical analysis.

To answer which method is the preferred one, I apply a two-step process. The first step is to estimate the frequency of choosing a given method, using an ordered logit model. The second step utilizes the results from the ordered logit model by inserting the estimated parameters in a multinomial logit model. This gives us an estimated probability that the given method is most preferred by the firm.

The analysis in the first essay shows that the managers' practice differs between small and large firms. I find that smaller firms embrace simple methods for these calculations, and the results show that small firms have less sophisticated decision rules than large firms. A surprisingly large share of the firms prefers to use the Payback model for calculating the profitability of an investment. Moreover, nearly no firms prefer the net present value methods, which is the method textbooks recommend.

1.6.2 Paper 2

Firms continuously analyze whether to stand by their planned investment projects or whether they need to adjust their investment plans. This essay applies panel data to assess the relative contribution of factors explaining changes in firms' investment plans. The analysis builds on data from a quarterly business tendency survey as well as national accounts statistics and register data. Conventional register data on investment decisions contain systematic measurement error due to time lag from when an investment decision is taken to it is effectuated. In contrast, survey data do not suffer from this problem and therefore are particularly well suited for studying investment behavior. I find that changes in the firms' expected demand and access to credit are the most important variables for explaining changes in investment plans. Firms; independent of size; are most likely to adjust their investment downwards when demand expectations are weak, and credit conditions are tight. Neither changes in capital costs nor the financing costs seem to play a significant role in the short-run investment dynamics.

1.6.3 Paper 3

The thrid paper shows how the Investment Euler equation may be extended to capture the cost of external funding and the tightness in the credit market. The theoretical model is tested empirically on aggregated time series data for the manufacturing industry in Norway. I find empirical support for the theoretical model, and present a model where real aggregated investments are explained by the cost of external finance, production, profitability, and the credit spreads. Aggregated manufacturing investments are modeled using the bounds testing approach, together with the error correction framework using national accounts figures and financial statistics. I find that an increase in the cost of external funding relative to the cost of internal funding reduces the return on investments. The analysis shows that a one percentage point increase in the credit spread decreases investments with 7 percent. The profit ratio is known to be essential for investments. I find that the effect of a one percent increase in the profit to production ratio raises investments with a rate of 0.13 percent.

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Investments and Capital Budgeting Practice: Is there a difference between small and large firms?*†

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Abstract

To increase our understanding of how business executives plan their investment budget, this paper analyses the results from the business survey that was sent out to a representative sample of firms in the manufacturing industry in Norway. The business survey was conducted in cooperation with The Business Tendency Survey of Statistics Norway. This linking to the Business tendency survey leads to a far higher response rate compared with similar studies, and it covers a representative share of the firms in the Norwegian manufacturing sector. I find, as many papers have shown before, that there are mismatches between theory and practice, but in contrast to earlier work, there seems to be a considerable mismatch. There is substantial firm size heterogeneity in capital budgeting: Smaller firms embrace simple methods for these calculations, and the results show that small firms have less sophisticated decision rules. Finally, a surprisingly large share of small and middle-sized firms do not put significant weight on their calculated investment criteria. If firms do not put weight on their calculations, this helps us in explaining why firms use gut feeling rather than thorough calculations to decide which investment project they start. Interestingly, being a subsidiary cancels the firm size effect. Indicating that there exists a sharing of best practices across larger corporations.

Keywords: Business Survey, Discount Rates, Capital Budgeting, Firm Size Heterogeneity

1 Introduction

Aggregate investments have been low in most OECD countries in the years following the financial crises, Banerjee et al. (2015). There is no agreement on what caused the investment level not to pick up to the pre-crisis levels. Some analysts have pointed to low expected demand as a possible cause, while others look to the over-capacity caused by larger than sustainable investment levels before the Financial crisis. Difficulties in getting credit is another cause for low investments. In recent years there has been an increased amount of studies analyzing the effect of credit and economic activity on, see e.g. Gertler and Gilchrist (2018) or Borio (2017). In the build-up to the Financial crisis, there was an accumulation of cash holdings in many firms, Bates et al. (2009). The increased cash holdings should have eased the need for credit, thus reducing financial constraints.

The goal of my paper is to study the manager's practice in capital budgeting and investment planning. To bring new insight to the table, I have conducted a one-off business survey of the manufacturing industry in Norway. My hope is that the survey may shed light on the discussion about the lack of investment growth from a different perspective than traditional empirical analysis have given us.

Specifically, the paper discusses which methods are preferred by the managers to support the investment decision. I am particularly interested in studying to what extent their practices are consistent with, or goes against the textbook approach. Textbooks in corporate finance recommend firms to use the net present value method to calculate the expected profitability of an investment[1]. The hurdle rate used to discount the expected cash flow is supposed to take into account the riskiness of the project, but also the share of debt funding. With several projects, the internal rate of return could assist the management with the ranking of its projects, according to this theory. Lastly, the theory recommends that firms should analyze the sensitivity of the assumptions it made to calculate its expected cash flow. If firms follow those recommendations, they will behave as predicted by the Neoclassical investment models. If not, how should we think about modeling real investments?

I have tried to design the survey such that the answers can be used to rank the different methods used by the managers for its investment planning. An additional motive has been to obtain insight about the underlying assumptions behind the Neoclassical investment models. To address these issues, the survey questionnaire contains questions about the firms' qualitative questions concerning its assumptions, such as how significant emphasis it puts to its calculated hurdle rate. I do not believe that

[1] An example of a corporate finance textbook is Brealy et al. (2017)

I can validate or falsify the different theoretical models using the results from this survey. However, it will increase our insight into which perspective a practitioner is taking on in capital budgeting and investment planning, and by this increase our understanding of investment fluctuations. The findings from this survey have been essential to the results of paper 2 and 3 in this Ph.D. dissertation. The results from this paper helps us to put the empirical models of in the second paper in context, while the theoretical model in the last paper is motivated with on the insight from the survey.

The business survey was conducted during the winter 2012/2013 and is unique in the sense that the response rate is as high as 42 percent. Furthermore, being able to use the same respondents as in Business Tendency Survey (BTS) of Statistics Norway, the sample would be stratified. The sample is linked to administrative data and the Statistics Norways's quarterly Investment Survey which enables us to address more detailed research questions. The high response rate and the fact that the survey is representative of the whole population of manufacturing firms make it possible to study firm size effects using ordered logit model and two-way tables in a way few other studies have done.

My research shows that decision-making processes varies substantially between small and large firms. Small firms use different methods than large firms and pay less attention to the formal capital budgeting process. This implies that aggregate investments in countries with a relatively high share of large firms respond differently to shocks affecting firms' expectations than how a similar shock would affect investments in countries with a relatively high share of small firms. Hence, I argue that one has to take into account heterogeneity in the firm size distribution for different countries when modeling aggregate investments. Thus, this paper contributes to the literature on firm size heterogeneity and management practice. I have studied management practice in its use of investment and corporate finance theory and present empirical evidence showing that there is a different management practice between small, middle-sized, and large firms.

The paper starts with a brief literature review in the next section. Section 3 discuss the data and the business survey. The empirical and descriptive methods are explained in section 4, while the analysis is described in section 5. The analysis starts by going through the survey results briefly. This gives detailed coverage of the firms' practice and strategy. Then an econometric model is applied to analyze the business survey data together with administrative data to uncover what methods the firms choose for their capital budgeting process and which factors are best at describing their choices. Section 6 summarizes the paper. Detailed figures, a description of the survey, tables with statistical tests of the survey results, and further survey results not discussed in the paper are found in the appendix.

2 Literature

The study of management practice, and particularly the firms' choices related to its investment decision have been conducted in decades. A comprehensive study of the Chief Financial Officers' (CFO) practice of capital budgeting and investment planning is found in Graham and Harvey (2001). The survey is covering three distinct topics: Capital budgeting, cost of capital, and capital structure. The focus of Graham and Harvey (2001) is to identify whether the standard theory is backed up by empirical findings. One of the strengths of the paper is that the survey covers a large part of the theories discussed by the corporate finance literature. However, many countries are, in contrast to the US, less dominated by large firms and corporations and have a relatively large share of small firms. Graham and Harvey (2001) mainly focus their attention on large corporations, for good reasons. Brounen et al. (2006) extend the work of Graham and Harvey (2001) through their particular focus on capital structure policies. An important message from Brounen et al. (2006) is that capital structure policies differ substantially across countries. There is consequently a need to fold out different management practices since they also seem to differ widely between countries. A potential weakness with both Graham and Harvey (2001) and Brounen et al. (2006) is that both papers have a relatively low response rate. They report a response rate of nine percent and five percent, respectively. A low response rate may make it somewhat difficult to generalize the results. If the respondents are unfamiliar with the terms used in the questionnaire, they are more likely to drop out of the survey. If there are selection effects present in the survey, this can bias the responses towards the use of more complicated methods, and away from more straightforward decision rules.

In a study of venture capitals (VC) Gompers et al. (2019) surprisingly find that few VC funds use the methods recommended by academic textbooks. Their finding goes against Graham and Harvey (2001) showing that only a small share of the funds use the NPV method to calculate the valuation of their investment and supports the view that gut feeling plays a large role in the investment decision. They do not find any firm size effect on the methods chosen by the VC fund to value the investment, but they find that small funds are more likely to rely on gut feeling when taking their decisions.

Bloom and Reenen (2010) surveys the management practice of plant managers at medium-sized firms around the world. Based on their survey, they find substantial differences in practice between countries, with the US rating highest. Their study highlights the importance of studying management practice and they also find that it is not sufficient to study management practice in a few counties. Kengatharan (2016) discusses the empirical research of corporate finance during the last 20 years and represent valuable insights into management practice.

Except for Gompers et al. (2019), none of the papers above focus mainly on how practice varies between small and large firms. However, firm size heterogeneity and management practice are discussed in several other studies. Gertler and Gilchrist (1994) study how firm size affects the firm's response to a monetary policy shock. They find empirical support for a more significant contraction in inventories, sales, and short-term debt in small firms relative to larger firms when the credit supply tightens. Calomiris and Hubbard (1990) have also highlighted the role of firm size heterogeneity. They discuss how firm heterogeneity caused by information asymmetry affects the capital structure and their access to credit. Runyon (1983) also studies investment practices in small US businesses. Runyon (1983) finds that small firms embrace more straightforward methods than Graham and Harvey (2001), but the paper does not compare the practice of small firms with middle-sized and large businesses. This makes it challenging to study relative differences of practice.

3 Data

3.1 The Norwegian Manufacturing Industry

The Norwegian manufacturing industry is characterized by having a relatively large share of small and middle-sized firms. The Norwegian offshore petroleum industry is sizeable, and because of this, the manufacturing industry has a relatively large share of the firms in the ship and rig building industry compared to other OECD countries. Furthermore, the manufacturing industry is prominent in the production of inputs and investment goods and characterized by few producers of consumer goods.

In OECD countries, the average number of employees per enterprise in the manufacturing industry were 17.4 in 2012.[2] The trio – US, Germany, and Switzerland had nearly twice as many employees per enterprise than the average OECD country. The South European countries: Greece, Italy, Portugal, and Spain are at the bottom of the scale with far fewer employees per enterprise than the average country. Norwegian enterprises are also below the average OECD with 13.2 employees per enterprise. If one does not take into account the firm size composition, then studies of corporate finance practice in the US, UK or the Germanic-speaking countries, will not be directly comparable to result from the studies of countries like France, Poland, Netherlands or Norway. All are countries with an average employee per enterprise of about 13. Hence, studying Norwegian data as a representative for countries with a larger share of smaller firms, might further increase our insight into firm behavior.

[2]Unweighted average; data source: OECD Productivity statistics; stats.oecd.org

Table 1: The distribution of firms and employment in the total population and the sample within each firm size category, all figures measured in 2013

	Firms			**Employees**		
Category	*N*	In pop.	In sample	*N*	In pop	In sample
Total manufacturing	13 518	100 %	745	188 954	100 %	92 845
Small manufacturing firms	12 640	93.5 %	34.0 %	49 281	26.1 %	7.2 %
Middle manufacturing firms	540	4.0 %	56.6 %	74 088	39.2 %	29.4 %
Large manufacturing firms	338	2.5 %	9.4 %	65 584	34.7 %	63.3 %

Notes: The table shows figures for number of firms and total employment in the population. The "In pop" and "In sample" figures shows the relative distribution of small, middle and large sized firms in the total population and in the sample respectively. Firms without employment are excluded from this summary table.

Recall that the purpose of the survey is to obtain data that can be applied to study which methods the firms prefer when evaluating investment projects. The survey questionnaire contains further questions that are useful for understanding their choice of methods. The business survey builds on the quarterly Business Tendency Survey (BTS) by the Division for Manufacturing Statistics at Statistics Norway. The BTS is a survey that is based on questioning the firms about the business' prospects and their investment budget, which I analyze in the second paper of this thesis. I sent the questionnaire to the same respondents as those that participate in the BTS. Hence, the respondents have experience in filling out business surveys. The respondents are, in most cases, the general manager or the chief accountant. In the largest firms, the respondents are typically the Chief Financial Officers (CFO). The advantage of using the respondents of the BTS is three-folded.

Regarding data quality, the respondents in this survey are accustomed to answering questionnaires related to expectations and investment practices. Statistics Norway has strong confidence among businesses, which both enhance truthful answers and a high response rate. Second, the sampling procedure used by Statistics Norway secures that the sample is representative and unbiased both across firm size and across industries. Third, the respondents are linked to their firms' organization number, which makes it possible to link the survey data to administrative data from the Business and Enterprise Statistics and data from the quarterly Investment Survey, both from Statistics Norway. Linking survey data with administrative data enables us to cross-validate some of the responses given

Table 2: The education level of the respondents. In percent

	Lower 2nd	Upper 2nd. Pract.	Upper 2nd. General	Technological Ba or M.Sc	Economics Master	Economics Bachelor	Other University	Other studies
Small	1.8	5.4	8.1	15.3	20.7	19.8	27.0	1.8
Middle	0.0	6.7	5.2	7.4	31.9	28.2	18.5	2.2
Large	0.0	0.0	5.5	7.3	34.6	21.8	29.1	1.8
All firms	0.7	5.0	6.3	10.3	28.2	23.9	23.6	2.0

Table 3: Summary statistics for each employment category (no. of employees) of firms in the total population of Norwegian manufacturing industry. Average for the years **2011-2014**

	0 - 9	10-19	20-49	50-99	100-199	200+	All firms
Number of firms	15 663	1 759	1 381	514	271	159	19 747
Employees**	30 391	23 728	42 596	35 463	37 037	63 808	233 023
Value added*	15 787	14 902	28 943	26 273	34 930	71 812	192 646
Gross investments*	2 164	1 239	2 360	2 753	4 354	6 931	19 800

*Notes: *In million NOK, **Total employed within this category. Value added in market prices*

to the questionnaire with the administrative data. After I added the administrative data to the survey data, it was possible to study if there are any biases in average debt to asset ratio, investment level or the number of employees between the firms that responded to the survey and firms that did not respond.

Managers of manufacturing firms typically have a varied educational background. Table 2 shows the education of the respondents. The survey shows that a large share of the respondents has high education and that CFOs and CEOs of large firms are much more likely to have a decree within economics. It is also interesting to note that among smaller firms there is a large share of firms where the managers have a technical background, typically a bachelor's degree from a university college or a master of science from a university. Table 3 summarizes the administrative data of the firms participating in this survey.

Data is organized as a cross-section set. Because data is sampled once, one would expect that the business trends are affecting some of the answers in an unknown direction. If the perception of the firms' prospects varies with the business cycle, the level of uncertainty will also vary. Hence, one would expect that practice related to the investment decisions also varies with the business cycle. Even though the questions are formulated in a general way, an important concern was to conduct the survey when the Norwegian business climate was close to neutral, i.e., when investments increase with a rate close to the long-run growth rate. In such a climate the business managers are more likely to have a balanced view of the prospect of their firms'.[3]

The survey design is based on stratified sampling. The BTS divides the firms into four different strata, and the respondents are drawn randomly from each stratum. The probability of being drawn from the population increases with firm size. Also, all firms within the stratum of the largest firms are included in the sample. The population includes firms in the Norwegian mining and manufacturing sector with more than ten employees. The total number of respondents, drawn from the full population, is 745 firms. The mining and manufacturing industry in Norway consists of almost 20 000 firms, and slightly above 9 000 firms have no employees, and a further 6 500 have less than ten employees. Firms with none or few employees amount to a small fraction of the total employment and total investments in the manufacturing industry. Those firms were excluded from the population before the sampling. Details about the composition of the firms are shown in Table 20 in the appendix. The firms included in the sample add up to approximately 40 percent of the total employment in the manufacturing industry, while it covers 3.5 percent of the total number of firms in the industry.

After correcting for non-responses, 36.5 percent are small firms, 55.2 percent are middle firms, and 8.1 percent are large firms. I want to test whether there are any biases in firm size composition between the response and non-response groups. Using a t-test to test for differences in mean employment of the group with a response and the group with a non-response, I find that the difference in firm size distribution is insignificant between the two samples. Hence, it is possible to argue that there are no selection issues related to firm size between the respondents and the non-respondents in the sample.[4]

To achieve a high response rate, I reduced the number of questions in this survey compared to

[3]For a detailed description of real-time the business climate see Chart 1.10 in the Monetary Policy Report 1/2013, published by the Central Bank of Norway

[4]A two-sided Welch t-test for the difference in mean employment between the group of response and non-response $\Pr(T > |t|) = 0.63$, i.e. I do not reject the H_0 : difference in means is zero. A test for difference in mean employment with the Wilcoxon rank-sum test gives a p-value of 0.37, i.e., one does not reject H_0: difference in means is zero. I do a similar test for difference in the debt to asset ratio, revenue, and total investments, and all indicate that there are small biases between firm responding and not to the survey.

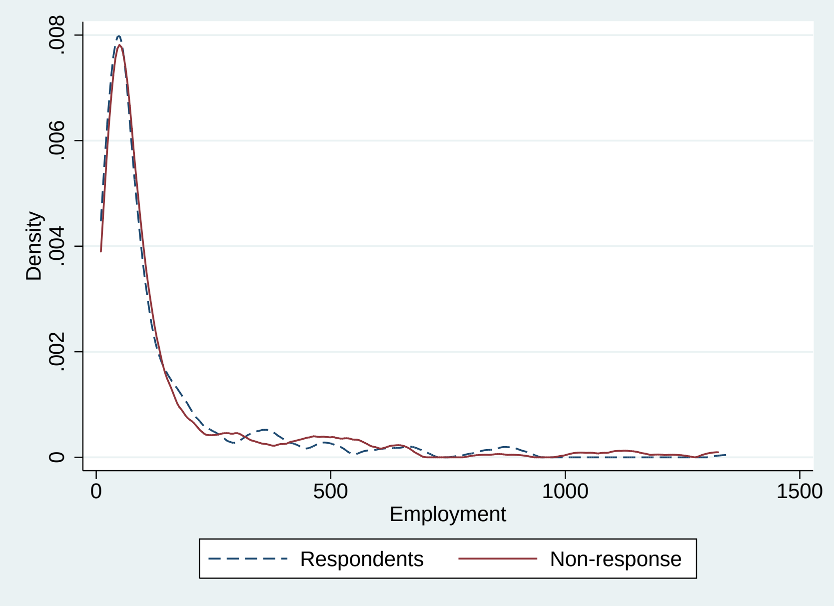


Figure 1: Kernel density distribution of firm employment. Non-response and respondents.

those occurring in Graham and Harvey (2001) and Brounen et al. (2006). Furthermore, for every question, the respondents could choose to answer that the question was "Not relevant for our firm". The motivation for including this response category was to encourage the respondents unfamiliar with the concepts questioned to respond. Finally, the information letter contained detailed information about the survey and it requested the respondents not to hesitate to answer even if they were unfamiliar with the topic addressed in the question. This resulted in a high response rate from both from large as well as small firms, with a response rate of 42 percent.

The survey uses an Internet-based survey program called Enalyser. Respondents were contacted by e-mail, and they replied using an Internet questionnaire. All respondents are linked to their firms with an organization number. The organization's number makes it possible to link the survey results with firm data from administrative registers for Statistics Norway. The survey was initiated Medio November 2012, and a dunning letter was sent Medio December and ultimo January 2013, with a deadline 31st of January. The last questionnaire was received in February 2013.

In order to reduce the possibility that the first response category dominates the survey results, the ordering of the response categories in the questionnaire was rotated whenever it was possible and logical. To make the analysis relevant, I needed to ensure that the firms that responded to the questionnaire conducted investments regularly. Hence, I asked when they conducted their last investment. Two-thirds of the firms had made investments within a half year before they were surveyed, and only

Table 4: Correlation matrix, estimated using the polychoric transformation. Method for calculating profitability of investment project

	EAC	IRR	NPV	Payback	Several methods	No methods
EAC	1					
IRR	0.04	1				
NPV	-0.05	0.50	1			
Payback	-0.21	0.16	0.13	1		
Several models	-0.38	-0.33	-0.30	-0.50	1	
No model	.	.	-0.99	-0.78	-0.51	1

Table 5: Correlation matrix, estimated using the polychoric transformation. Funding source of investment project

	Equity	Bank loan	Bonds	Currency loan	New shares	Parent loan
Equity	1					
Bank loan	-0.50	1				
Bonds	-0.07	0.33	1			
Currency loan	-0.02	0.40	0.76	1		
New shares	-0.13	0.35	0.74	0.70	1	
Parent loan	-0.09	-0.12	0.32	0.31	0.38	1

5 percent had conducted their last investments more than two years before the survey. In addition, 2 percent of the firms said investing in real capital was not relevant for their firms. These firms was taken out of the sample before the empirical analysis. There is a trade-off between asking all relevant questions and keeping the survey short. The longer the survey is, the lower is the response rate likely to be. It has been important for the quality of this survey to ensure a high response rate and to capture the heterogeneity among firms. Therefore, the information letter was carefully designed in order to achieve a high response rate. I put a great deal of attention in convincing the respondents not to be afraid of failing to know the concepts that are taken up by the questionnaire.

Table 4-6 shows the correlation matrix of the responses to the question about methods used by the firms. In this paper, all responses are ordered or binary. When the data series of interest is designed as categorical data, a standard correlation analysis, known as the Pearson correlation coefficient, will introduce bias. A polychoric correlation analysis is more suitable for ordinal and binary data. This method lets you find the correlation of a normally distributed latent variable that is represented with an ordinal variable, Kolenikov et al. (2004). The correlation analysis of the latent variables is estimated

Table 6: Correlation matrix, estimated using the tetrachoric transformation. Hurdle rate for calculating the profitability of investment projects

	Bank loan rate	Bond rate	FRA	WACC	CAPM	Several	Other
Bank loan rate	1						
Bond rate	-0.10	1					
FRA	-0.05	0.72	1				
WACC	-0.22	0.71	0.65	1			
CAPM	-0.10	0.79	0.65	0.81	1		
Several	-0.14	0.73	0.63	0.78	0.84	1	
Other	-0.29	0.69	0.56	0.65	0.67	0.72	1

using maximum likelihood. I have implemented the stata procedure - poloychoric - by Kolenikov et al. (2004). Note that the method is called tetrachoric if it is used on binary data. Obviously, the correlation is high between methods that are used by few and therefore have several zeros. The important result from the correlation analysis is that the correlation between popular methods is low.

4 Structural analysis of firms' preferences over different investment methods

The purpose of this section is to develop an econometric approach for analyzing the most preferred method the respective firms apply when evaluating potential investment projects. There is a reason to believe that firms apply different methods on different prospects and in addition, the preferred method may vary over time even for the same type of investment prospect. This may be due to the complexity of the projects, changes of stakeholders for the respective projects or changes in the manager's view about which is the preferred method. Also, other factors than purely economic ones may influence investment decisions. Thus, even under identical "external" choice conditions, a manager may use different methods at different points in time due to his inability to assess precise and definite values of the methods once and for all. This matter is discussed in the literature on decision making in organizations, see Simon (1979) and March (1991), and in the context of a normative decision-making model, see e.g. Schwartz and Howard (1981). Schwartz and Howard (1981) highlights the effects of personal and social norms on decision making.

To obtain information about preferences, one possibility would be to ask each firm to rank order the different methods, or to ask which method is the most preferred one. However, a complication with this approach is that it might be difficult for the manager to decide which is the most preferred method unless one specifies details of the actual investment project. To make a precise description review of my approach, let V_{tij} be a latent index that represents the utility of method j at time t, as viewed by firm i. That is, the more often the firm uses method j, the higher is V_{tij}. Let $j = 0$ represent the response "No method" and assume that the latent popularity index has the structure

(1) $V_{tij} = \alpha_i + \beta_{j0} + X_i\beta_j + Z_{tij}\theta + \eta_{tij}$ with $V_{ti0} = \alpha_i + \varepsilon_{ti0}$

where α_i is a fixed firm specific effect, β_{j0} is an alternative specific constant, X_i is a vector of observed explanatory variables that might depend on both the firm and the method, with the associated parameter vector β, Z_{tij} a variable that characterizes the potential investment project t considered by firm i for method j. Typical attributes that varies with the different investment projects are the size of the investment, what kind of real capital the firm currently invests in, the life span of the investment project, the level of uncertainty of future cash flow, etc. With no loss of generality, I assume that the mean value of Z_{tij} across time is zero. For later use, define $Z_{ti} = (Z_{ti1}, Z_{ti2}, ...)$. The terms η_{tij} and ε_{ti0} are IID random variables.

Under suitable distributional assumption about the stochastic error terms $\{\eta_{tij}\}$ one can derive the probability that firm i shall choose method j at time t, conditional on X_i and Z_{tij}, expressed formally as:

(2) $P_j(X_i, Z_{ti}) = P(V_{ij} = \max_r V_{tri} | X_i, Z_{ti})$

For example, if the stochastic error terms are independent and standard Gumbel distributed the model in (2) becomes a multinomial logit model. To estimate the unknown parameter, one can obtain data from a traditional stated preference survey (SP). To design the questionnaire of SP, one needs to specify hypothetical values of $\{Z_{tij}\}$ in order to formulate precise survey questions, Kroes and Sheldon (1988). In the context of this paper, this may be difficult because there may be a variety of investment projects, and some of their attributes may be hard to quantify. However, since there is a variety of investment projects, I am in this paper more interested in revealing the average choice behavior of the firms regarding the preferred method. More precisely, our ambition is not to obtain an estimate of $P_j(X_i, Z_{ti})$, but instead.

(3) $P_j(X_i) = P(V_{ij} = \max_r V_{ir} | X_i) = E_Z P_j(X_i, Z_{ti})$

where E_Z denotes the expectation operator with respect to the temporal (investment project) variation in Z_{ti}. Thus, in the choice probability given in (3) the unobservable vector (unobservable in our case) is integrated. If panel data on realized choices among methods, including Z_{ti}, were available so that estimates of $P_j(X_i, Z_{ti})$ could then be obtained, and one could then calculate $P_j(X_i)$ as:

$$(4) \qquad \frac{1}{T}\sum_{t=1}^{T} P_j(X_i, Z_{ti})$$

However, such data are not available in our case, and therefore, another alternative approach is called for. The alternative approach used in this paper consists of a two-stage procedure as follows. In the first stage, I analyze the intensity with which the respective methods are used by the firms. In other words, at this stage the purpose is to estimate a model of how often the respective methods are used by the firm. To this end, the ordered logit (or probit) modeling framework can be applied. In the second stage, the estimation results from the first stage are used to calculate choice probabilities of the most preferred method, as given in (3).

To obtain suitable data the survey questionnaire contains questions on how often firms use the respective evaluation methods, and which can be used for estimating the first stage model, namely the ordered logit model. The questions in the survey questionnaire that are appropriate to this end are questions like; is a given method always used, or often used, or rarely used, etc... Thus, these answers correspond to response categories, $k = 1, 2, ..., m$, those firms that are in category 1 are those who state that they always use a given method, those who are in category 2 are those who often use the method, etc. Let $\varepsilon_{1ij} = Z_{1ij} + \eta_{1ij}$ for $j > 0$. Recall that the distribution of Z_{1ij} is assumed to be independent of t. Since Z_{1ij} is unobservable, I model ε_{1ij}, similarly to η_{1ij} as a random variable (from the viewpoint of the researcher). Consequently, under specific distributional assumptions about $\{\varepsilon_{1ij}\}$ it is possible to calculate the choice probability given in (4). Let $P(Y(k)) = 1$ if firm i is observed to be in response category k given method j and zero otherwise. Assume that $\varepsilon_{1ij},\ j = 0, 1, 2, \dots$ are IID and let $F(\cdot)$ be the c.d.f. of $\varepsilon_{1ij} - \varepsilon_{1i0}$. Hence, it follows that:

$$(5) \qquad P(Y_{ij}(k) = 1|X_i) = P(\gamma(k) < V_{1ij} - V_{1i0} < \gamma(k-1)|X_i)$$

$$(6) \qquad = F(\gamma(k) - X_i\beta_j - \beta_{j0}) - F(\gamma(k-1) - X_i\beta_j - \beta_{j0})$$

where $\gamma(k)$ are unknown threshold values which are estimated jointly with the parameter vector β_j and β_{j0}. The reason why I consider $V_{1ij} - V_{1i0}$ instead of V_{1ij} is because I wish to get rid of the fixed effect while retaining a reasonable interpretation, Ferrer-i Carbonell and Frijters (2004). Thus, V_{1i0} represents an "anchoring" effect that makes the evaluation scales comparable across firms.

The threshold parameters $\{\gamma(k)\}$ are implicitly representing the average of the firm's interpretation of the response categories, such as "often" or "rarely", for example. Note that here it is assumed that $\{\gamma(k)\}$ do not depend on the method j. It seems reasonable that the threshold levels do not depend on the evaluation methods. It follows from the above expression that I can rewrite (6):

(7) $\quad P(Y_{ij}(k) = 1|X_i) = F(\tilde{\gamma}_j(k) - X_i\beta_j) - F(\tilde{\gamma}_j(k-1) - X_i\beta_j)$

where $\tilde{\gamma}_j(k) = \gamma(k) - \beta_{j0}$. Hence, I obtain $\tilde{\gamma}_j(k)$ by taking the respective mean across the threshold levels $\gamma(k)$, $k = 1, 2, .., m$ such that $\bar{\tilde{\gamma}}_j(k) = \bar{\gamma}(k) - \beta_{j0}$. Note that although I cannot identify the unknown parameter β_{j0}, but because it is a constant it cancels in utility comparisons and therefore is irrelevant in this context. Figure 2 illustrates the relationship between the threshold parameters, $\gamma(k)$ and the k ordered response categories

V_{1ij}	$\gamma(k=1)$	$\gamma(k=2)$	$\gamma(k=3)$	$\gamma(k=4)$	∞
$Y_{ij}(k)$	1	2	3	4	

Figure 2: Relationship between threshold values, $\gamma(k)$ with the corresponding preference level, V_{ij} and the response categories of the endogenous variable, $Y_{ji}(k)$. Firms that prefer a given method as high as it can, will have a value of $V_{ij} > \gamma(k=4)$

In the following, I shall assume that $\varepsilon_{1ji},\ j = 1, 2, 3, ...$ are independent Gumbel distributed. Which, implies that that the c.d.f. of the error is given by $\exp(-e^{(-x)})$. Then it is well known that $F(\cdot)$ becomes a logistic distribution function so that the model in (6) and (8) becomes an ordered logistic model which can readily be estimated by the method of maximum likelihood. The model parameters are estimated separately for each method:

(8) $\quad P(Y_i(k) = 1|X_i) = F(\tilde{\gamma}_j(k) - X_i\beta) - F(\tilde{\gamma}_j(k-1) - X_i\beta)$

Consider next how the results above can be used to obtain the probability of the most preferred evaluation method, given that the parameters of the utility function have been estimated. Under the assumption of IID Gumbel distributed error terms, independent across methods, it follows that the probability that evaluation method j is the most preferred method, as view by firm i, is equal to

(9) $$P(V_{ij} = max_r V_{ir}|X_i) = \frac{\exp(X_i\hat{\beta}_j - \bar{\tilde{\gamma}}_j)}{\sum_{r=1}^{m} \exp(X_i\hat{\beta}_r - \bar{\tilde{\gamma}}_r)}$$

The empirical counterpart of the choice probability in (9) is the fraction of time firm i would choose method j, given the explanatory variables. Note that the multinomial model given in (9) depends crucially on $Corr(\varepsilon_{1ji}, \varepsilon_{1ki})$ being independent of j and k for $j \neq k$. This assumption could in principle be tested by estimating a multivariate ordered logit model in the first stage, but that is not done in this paper. The average probability of choosing method j is calculated as

$$\frac{1}{N}\sum_{i=1}^{N} P(V_{ij} = max_r V_{ir}|X_i) = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{\exp(X_i\hat{\beta}_j - \bar{\tilde{\gamma}}_j)}{\sum_{r=1}^{m}\exp(X_i\hat{\beta}_r - \bar{\tilde{\gamma}}_r)}\right) \tag{10}$$

The empirical model is estimated by using the maximum likelihood using STATA with the *oglm* and *glm* packages. The calculation of the predictions and the calculated probabilities of the preferred method is done in Python with the *numpy* and *pandas* libraries.

4.1 Descriptive methods

To verify the business survey using administrative data and study if there are any differences in how the choice of the method the firm uses or how often the firm apply different measures varies between small and large firms. I test for differences in means between the respective groups and between response categories. To do this, I apply two types of tests. I use the t-test and the Wilcoxon Rank Sum test for comparing the results in two sub-samples, and I use the Kruskal-Wallis and ANOVA to compare both between groups and blocks.

The above-mentioned tests may all be used to test whether I can reject or not the hypothesis of differences in the mean between groups and/or between blocks. However, neither the ANOVA nor the Kruskal-Wallis test can pinpoint exactly which response category that is significantly different from the other. For this, I employ Dunn's test, which can account for multiple pairwise comparisons of the Kruskal-Wallis rank test or the Tuckey-Kramer pairwise comparison for the two-way ANOVA. Applying the full apparatus of tests, I find that there are significant differences in firms' decision rules. Detailed results and explanations of the methods are reported in the appendix.

5 Empirical Analysis

Neoclassical investment models have been, and still are, the standard framework for analyzing investment decisions both in corporate finance and in economics in general. The net present value (NPV) model and the Q-model both highlight the importance of the net discounted profit for the investment decision. This section analyses the results from the business survey and sheds light on how business managers choose methods to support their investment decision process. I start each subsection with a description of the methods and a brief overview of earlier findings. Then I continue with a descriptive analysis of the survey results and round off each subsection with a description of the results from the empirical study.

5.1 How do firms calculate their hurdle rate?

In capital budgeting, it is important to have a view of the firm-specific risk. This is because it is a crucial part of the cost of capital. The traditional view is that the risk-free interest rate normally equals the interest rate on long term government bonds, like Treasury bonds, see e.g. Huang and Huang (2012). Hence, the firm-specific interest rate, r_j, can then be expressed as the risk-free rate, r_F, plus the firm-specific risk premium, θ_j:

(11) $r_j = r_F + \theta_j$

What kind of method the firm uses to specify the company or project risk varies between companies. A textbook approach for finding the θ_j is based on the use of the capital asset price model (CAPM), see Lintner (1965). By estimating the stock return, σ_j, relative to the market return, σ_M, called the β, one finds the firm's risk premium: $\theta_j = \frac{\sigma_j}{\sigma_M}(r_m - r_F) = \beta(r_m - r_F)$, where r_m is the market return.

Following this approach, when calculating the minimum acceptable rate of return (hurdle rate), one assumes that the project risk premium equals the average firm risk premium. For investment projects, it is not always the average company cost of capital, but the risk and cost of the specific project that is relevant. To obtain identification of the project risk might be demanding. An approach suggested by Brealy et al. (2017) when it is difficult to calculate the internal project risk is to identify firms with homogeneous project portfolios that match your investments project and estimate their θ_j based on the CAPM.

The CAPM excludes the cost of debt when estimating the firm-specific hurdle rate. By calculating the weighted-average cost of capital (WACC), the cost of debt is taken into account. An alternative to the CAPM is to use the difference between the cost of debt and riskless debt instruments as the market valuation of the firms' risk, unless there are provisions or restrictions reducing the value of debt, Merton (1974). This will be a less demanding approach and reduce the time spent on investment analysis.

A particular focus of this paper is the effect of firm size heterogeneity on firms' investment decision making. When analyzing the firm size heterogeneity I divide the firms into small, middle, and large firms based on their number of employees. Compared to the volatility of the firms' employment figures, the volatility of the sales figures varies significantly. Therefor, employment is the preferred

Table 7: Questions about firms' choice of hurdle rate

Methods used by firms to calculate the hurdle rate, percentage answered: Methods that always are used by the firm. In percent[a)]				
	All firms	Small firms	Middle-sized firms	Large firms
Bank rate*	51.7	68.3	45.1	15.0
Bond rate*	0.6	0.0	1.0	0.0
FRA	11.5	7.5	13.1	16.7
WACC*	15.9	3.1	21.2	30.0
CAPM	4.5	1.5	6.2	6.7
Several*[1]	5.4	0.0	8.7	6.3
Other*[2]	20.5	13.3	21.7	42.1
The firms' appraisal of its calculated hurdle rate, by firm size. In percent[b)]				
Great	28.0	30.8	27.2	25.2
Moderate	41.9	57.7	42.9	41.2
Small	17.2	11.5	16.9	17.7
No	5.4	.	4.2	3.4
Not relevant	7.5	.	8.8	12.6

*Firm size differences are significant using the Kruskal-Wallis equality-of-population rank test.

1, 2) Several = Several different models and Other = Other models.

a) The rows do not sum to 100 percent since the firms might use more than one calculation method.

b) In order to motivate the respondents to answer, the firms could answer either *"No"* or *"This question is not relevant to our firm"* measure for splitting the sample into firm size categories. Small firms include firms with less than 50 employees, middle firms include firms with 50 or more, but less than 500 employees, and large firms include firms with 500 or more employees. Out of the total sample: 34 percent of the firms are small firms, 57 percent are middle firms, and 9 percent are large firms.

The survey questionnaire contains questions about which hurdle rate the firm normally uses when doing its profitability analysis. Table 7 shows the result for the share of the firms that answers that it always uses the different hurdle rate calculations. It turns out that more than half of the firms (51.7 percent) use their bank loan rate as their hurdle rate. This is especially true for small firms, while large firms to a lesser degree use bank loan rates as a substitute for calculating their own hurdle rate. Looking into the figures, it turns out that 73 percent of the firms that are financing their investments with bank loans answer that they use bank loan rate for calculating profitability. Still, 53 percent of the firms not funding their investment with bank loans use bank lending rates as their hurdle rate. Since profitability depends on the expected prices and volumes, it is the expected interest rate that should be used in calculations. Interest rates from the forward rate agreements (FRA) market reflect market expectations. Hence, it should be more suited for profitability calculations than bank loan rates. A decent share of the firms is using interest rates from the FRA market, and on average, it is chosen by 11.5 percent of the firms. It is also relevant to note that 12 percent of the firms respond “No” or “Not relevant” for all models.

As explained in section 4, the way I will study firms’ preferred methods is by the two-step procedure. To find which method the firms prefer to use to calculate its hurdle rate, I will be using a combination of the ordered logit model and the multinomial logit model. The results from the empirical model, shown in table 8, show that firm size is also important for explaining how the firms calculate their hurdle rate. Large firms are less likely to use the bank loan rate as their hurdle rate, but large firms have a higher probability of choosing advanced methods to calculate its hurdle rate than middle-sized and small firms do. The effect of being a subsidiary does also affect the calculation of the hurdle rate. Hence, strengthening the evidence that there is a spill-over-effect regarding how capital budgeting is done within corporations.

Interestingly, firms with debt funding have a higher probability of calculating their hurdle rates than firms with predominantly other funding sources. I question the firms about their use of sensitivity analysis to shed light on the uncertainty of investments, and if the firm respond that they use sensitivity analysis often, then it is a higher probability that they are using sophisticated methods for calculating the hurdle rate, while it reduces the probability of using bank loan rates as their hurdle rate. To see if

Table 8: Factors affecting firms' choice of hurdle rate

	Bank loan rate	Bond rate	FRA	WACC	CAPM	Other models
Small firms	0.558*	-0.175	-0.199	-0.351	-0.162	-0.005
	(1.73)	(-0.51)	(-0.66)	(-1.11)	(-0.49)	(-0.02)
Large firms	-0.651*	0.266	0.199	0.111	0.869**	0.878**
	(-1.83)	(0.58)	(0.49)	(0.26)	(2.00)	(2.08)
Subsidiary	-0.237	1.013***	1.138***	0.987***	1.034***	0.862***
	(-0.86)	(3.12)	(3.92)	(3.28)	(3.31)	(3.01)
Funding investments w/equity	0.156	-0.222	0.687	-0.363	-0.058	0.257
	(0.43)	(-0.44)	(1.45)	(-0.81)	(-0.12)	(0.57)
Funding investments w/debt	0.634**	0.281	0.603**	0.416	0.690**	-0.008
	(2.17)	(0.83)	(1.98)	(1.33)	(2.12)	(-0.03)
Sensitivity analysis	-0.704***	0.787**	0.614*	1.511***	0.868**	0.549*
	(-2.62)	(2.18)	(1.94)	(4.41)	(2.54)	(1.68)
Threshold 1	-1.248	2.570***	2.448***	2.206***	2.754***	2.542***
	(-1.58)	(2.83)	(3.03)	(2.68)	(3.14)	(3.04)
Threshold 2	-0.290	6.486***	3.890***	4.052***	5.196***	3.548***
	(-0.38)	(5.93)	(4.67)	(4.73)	(5.57)	(4.15)
Threshold 3	0.522		5.416***	4.797***	6.646***	4.748***
	(0.68)		(6.18)	(5.46)	(6.52)	(5.39)
Controls	✓	✓	✓	✓	✓	✓
No. of observations	228	228	228	228	228	228
Log-likelihood	-261.75	-139.67	-232.90	-206.65	-181.08	-238.47
χ^2- test, p-value	0.000	0.000	0.000	0.000	0.000	0.000
Pseudu R^2	0.065	0.115	0.075	0.124	0.125	0.078

Notes: The empirical model for the probability that the firm chose a given method to calculate its hurdle rate is estimated using a ordered logit model: $Y_i = F(\tilde{\gamma}(k) - X_i\beta) - F(\tilde{\gamma}(k-1) - X_i\beta)$, where $\tilde{\gamma}$ is the thresholds parameters, X_i is the firm specific variables, and $F()$ is the logit function. Control variables include administrative data on firm level such as debt to asset ratio, profit ratio, last year investments. Standard errors are bootstrapped, with the significance levels of the z-test represented with stars: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The category "Several different models" represent the **baseline method**, noted as V_{ti0} in the section above.

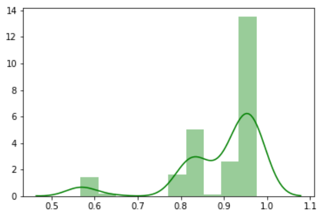
Table 9: Multinomial probabilities for the different investment profitability calculation methods

	Bank loan rate	Bond rate	FRA	WACC	CAPM	Other models
mean	0.8974	0.0076	0.0385	0.0150	0.0098	0.0316
std	0.0979	0.0071	0.0324	0.0134	0.0110	0.0396
min	0.5836	0.0017	0.0063	0.0034	0.0021	0.0056
P25	0.8440	0.0025	0.0109	0.0057	0.0028	0.0106
P50	0.9383	0.0050	0.0226	0.0100	0.0045	0.0176
P75	0.9686	0.0109	0.0473	0.0246	0.0141	0.0327
max	0.9771	0.0399	0.1402	0.0774	0.0626	0.1720

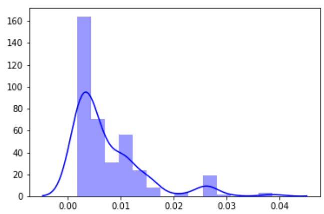
the emphasis the firms put on the estimated hurdle rate affects which method they chose, I ran models where this variable was included. How strong emphasis the firms put on its hurdle rate did not affect which method is preferred, with one exception and that was the method “Other models”. I control for the financial situation of the firm by adding debt to asset ratio and the profit margin, defined as earnings before interest and tax (EBIT) relative to total revenues. Neither variables have an effect on the choice of what method the firm prefers.

Note that the threshold values or cut points, as they also are called, are estimated constants that help us categorize the predicted values. I use γ to label the threshold values in the discussion of the econometric methods in section 4. See figure 2 in the same section for a visual explanation of the cut points.

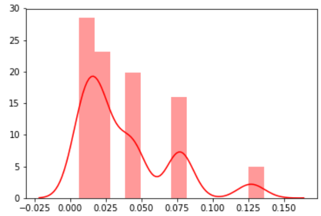
Step two of the calculation of the most preferred method includes the use of the multinomial probability model. I insert for the estimated parameters from the ordered logit model, as shown in section 4. The response category “Several models” is used as the reference category. Table 16 summarize the results, with the predicted mean, which is our estimate of the share of firms that prefer this method in front of the other methods to calculate its hurdle rate. The results show that the majority of firms prefer to use the bank loan rate. A small share of firms prefer the FRA or to use “Other models”, while the other methods are estimated to be the preferred one by nearly none of the firms. To visualize the distribution of the different firms’ most preferred method, I show the distribution of the predicted probabilities for preferring the given method in Figure 3.



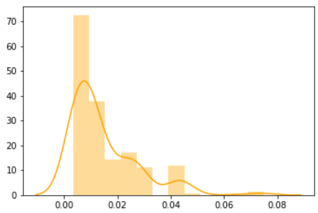
(a) Bank loan rate



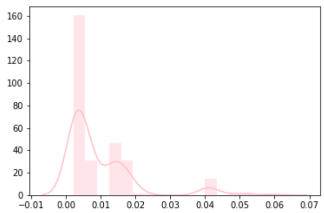
(b) Bond rate



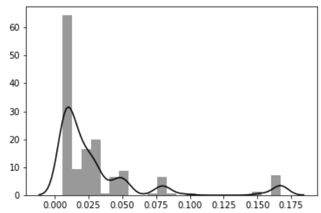
(c) FRA



(d) WACC



(e) CAPM



(f) Other models

Figure 3: Distribution of estimated multinomial probabilities for the most preferred method. Histogram and kernel density estimator

5.2 Investment criteria

The firms' choice of investment criteria to its capital budgeting process is an intensively studied topic in applied corporate finance. The textbook methods presented in Brealy et al. (2017) for calculating investment projects are the Net present value (NPV), Internal rate of return (IRR), Payback method, Book of return, and profitability analysis. Boye and Koekebakker (2006), a popular book among Norwegian business schools, also includes the Equivalent annual cost (EAC) as a recommended method. Brealy et al. (2017) present the NPV method as the benchmark model for calculating investment projects. Equivalent annual cost (EAC) is an extension of the NPV method. In contrast to the NPV, it adjusts the estimated NPV for differences within the lifespan of projects, making projects with a longer lifespan less worth.

Even though the NPV is assumed to give the most accurate assessment of a project's profitability, Graham and Harvey (2001) find that the internal rate of return is slightly more common among CFOs. Brealy et al. (2017) argue that one reason for the popularity of the IRR might be due to the fact that financial officers need to convince their executives or its owners to get the project approval. The reason is that the IRR might be chosen because it is easier to grasp than the NPV. The Payback

Table 10: Investment criteria used to calculated profitability of investment projects. Percentage of firms responding that the method is used by the firm

	All Firms	Small	Medium	Large
EAC	9.52	7.5	10.1	14.8
IRR*	28.6	14.2	33.9	55.6
NPV*	35.4	19.2	40.7	70.4
Payback period	37.2	31.7	40.7	37.0
Other methods	15.5	20.8	12.2	14.8
No method*	19.0	25.8	17.5	0

*) Firm size differences are significant using the Kruskal-Wallis equality-of-population rank test.

a) The rows do not sum to unity since the firms might use more than one calculation method.

b) In order to motivate the respondents to answer, the firms could answer either *"No"* or *"This question is not relevant to our firm"*.

method, Book of return and Profitability analysis are all less common than the NPV and IRR, but 57 percent of CFOs use the payback method occasionally, see Graham and Harvey (2001). Kengatharan (2016) conclude as in Graham and Harvey (2001) that discounted cash flow (DCF) methods are most common.

My findings differ from those found in Graham and Harvey (2001). When questioned which method executives use when calculating the profitability of projects, my analysis shows that the most common method is the payback method. The figures in Table 10 shows the proportion of firms using the different methods *often* or *now and then*. The survey results show that a total of 37 percent of the respondents said they normally use the payback method, while 35 percent use the NPV method and slightly fewer firms, 29 percent, use the IRR method.[5] This is surprising given the results in Graham and Harvey (2001). Furthermore, I find that the Equivalent annual cost method is less common, with only 10 percent of the respondents using this method. More interestingly, 20 percent of the respondents said that they do not use any formal method at all, and 15 percent have a model, but not one of the methods listed in Table 10.

To explain how firm size and other factors explain the firms' choice of method for calculation of profitability, I use a simpler version of the ordered logit model that contains only two response categories, namely "often" or "never". In contrast to the ordered logit model presented in section

[5]The difference in the response rate between NPV and payback is not significantly different at a 5 % significance level.

Table 11: How often the firm cannot give a good estimate of the expected cash flow. In percent

	All firms	Small firms	Middle-sized firms	Large firms
Always	2.4	5.0	1.1	.
Often	28.2	24.0	31.2	26.9
Now and then	47.2	50.4	45.7	42.3
Rarely	19.2	18.2	18.3	30.8
Never	3.0	2.5	3.8	.

4 there is now only one threshold. Otherwise, the interpretation is unchanged, and I use the same two-step model to predict the preferred method. After I have modeled the ordered logit model, I do as earlier and calculate the most popular method given the explanatory factors using the multinomial logit choice probability. Table 12 summarize the estimation results from the simple ordered logit model while table 16 shows the multinomial choice probabilities. The empirical analysis from the simple ordered logit model shows that the importance of firm size varies heavily between the different methods. There is a strong positive firm size effect for the probability of the firm using IRR or NPV. Both methods, and particularly the NPV, is used predominantly by large firms, and less by small firms. This result holds even if I control for the education level of the manager. It is the most educated managers that use NPV and IRR, while education counts negative for firms that respond that they are not using a model for calculating the profitability. This is a result backed up by Brounen et al. (2004). For the other methods, I find that the probability is slightly higher for larger and smaller firms than middle-sized. The empirical results show that whether the firm is a subsidiary or not is important for explaining if the firm uses a known calculation method. I find that firms that are subsidiaries are more likely to use formal calculation methods, such as IRR and Payback indicating that there is some transfer of knowledge and practice within the corporations, which smaller firms benefit from. Funding sources also affect which method is preferred. If the firm funds it selves with equity, the probability of using one of the methods described above increases compared to firms funding their investments with a bank loan.

To avoid that any random composition affects the results, I create several new variables. Those variables are: Firm investments in machines relative to buildings; this variable is 1 if the ratio is greater than 1, maintenance and repair, a variable that is 1 if the respondent that the motive of their last investment was in the category maintenance and repair, real investments relative to employment, debt to asset ratio and profitability. Since this is not the variables of interest, I have not added them to

Table 12: Factors affecting firms' choice of investment criteria

	EAC	IRR	NPV	Payback	No model
Small cap	0.047	-0.142	-1.152***	-0.183	0.544
	(0.08)	(-0.34)	(-2.62)	(-0.51)	(1.03)
Large cap	0.426	1.265***	0.956**	0.292	.
	(0.72)	(2.96)	(2.26)	(0.77)	.
Higher education	0.282	0.626*	0.857**	0.259	-1.046**
	(0.54)	(1.68)	(2.26)	(0.82)	(-1.99)
Subsidiary	0.588	0.583*	-0.217	0.465	-1.009
	(1.21)	(1.70)	(-0.62)	(1.52)	(-1.63)
Freq. of EquityFunding	0.459	0.244	-0.565**	0.287	-0.538
	(1.09)	(0.96)	(-2.15)	(1.29)	(-1.36)
Freq. of DebtFunding	-0.288	0.064	-0.522***	0.201	-0.013
	(-1.20)	(0.38)	(-3.06)	(1.36)	(-0.05)
Sensitivity analysis	-0.251	1.348***	1.167***	0.274	.
	(-0.45)	(3.80)	(3.14)	(0.81)	.
Imp. of HurdleRate	1.637	2.404***	2.054***	0.943**	-3.212***
	(1.54)	(2.95)	(3.24)	(2.02)	(-5.31)
Threshold	-4.752***	-5.333***	-1.166	-3.637***	3.143**
	(-2.72)	(-4.30)	(-1.15)	(-3.96)	(2.24)
Controls	✓	✓	✓	✓	✓
No. of observations	236	236	236	236	146
Log-likelihood	-66.57	-113.61	-113.10	-139.86	-56.67
χ^2-test, p-value	0.448	0.000	0.000	0.004	0.000
Pseudu R^2	0.086	0.249	0.281	0.103	0.324

Notes: The empirical model for the probability that the firm is using the current method for calculating its profitability is estimated using a logit model: $logit(Y_i) = X_i\beta + \varepsilon_i$, where X_i is the firm specific variables. Control variables include administrative data on firm level such as debt to asset ratio, profit ratio, last year investments. Standard errors are bootstrapped, with the significance levels based on the z-values represented with stars: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The category "Other models" represent the **baseline method**, noted as V_{ti0} in the section above.

Table 13: Multinomial probabilities for the different investment profitability calculation methods

	EAC	IRR	NPV	Payback
mean	0.1605	0.7996	0.0004	0.0394
std	0.1146	0.1349	0.0005	0.0349
min	0.0105	0.4022	0.0000	0.0033
P25	0.0687	0.7219	0.0001	0.0153
P50	0.1389	0.8266	0.0003	0.0314
P75	0.2363	0.9148	0.0006	0.0451
max	0.5170	0.9830	0.0046	0.1752

the results shown in table 12.

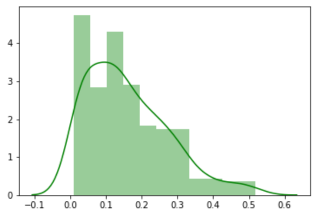
To find the most commonly used model, I calculate the multinomial logit probabilities, as shown above. The results show that the Internal rate of return is the most preferred method to calculate the profitability of an investment. The firms are divided into two. While most firms are estimated to prefer the IRR, about a quarter of the firms prefer the EAC. The multinomial probability model predicts practically zero probabilities of choosing the NPV and the Payback-model. Based on the responses, the model estimate that the firms that are using the NPV or the payback together with the IRR, prefer the IRR before one of these two models.

5.3 Investment funding

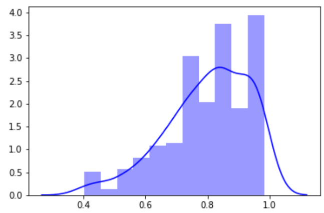
To get an understanding of how funding source affects investment behavior, the survey questionnaire contains questions on how the firms finance their investments. The theory of corporate finance is not clear on what is the best strategy. Bessler et al. (2011) summarize capital structure theory by highlighting three theories:

1. Trade-off theories discuss how firms adjust their debt. There is a trade-off between higher tax-deductibility (in the case of tax non-neutrality), and financial distress, such as the increased risk of bankruptcy as the debt rises

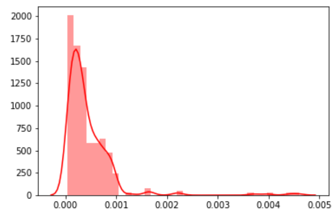
2. Pecking order theories describe how asymmetric information affects the financing structure.



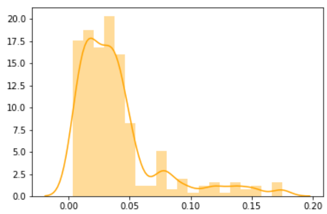
(a) EAC



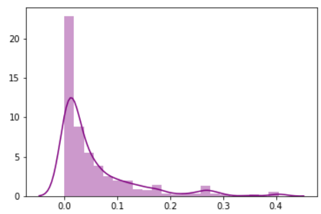
(b) IRR



(c) NPV



(d) Payback



(e) Several models

Figure 4: Distribution of estimated multinomial probabilities for firms' preferred method for calculating the profitability. Histogram and kernel density estimator

Because of the information advantage the manager has above the market, the firms will strive to increase its debt ratio rather than issuing equity when the firms' market value is below the managers' estimation of the firm value

3. Market timing theories tell a story where the firm raises equity capital preferably when the stock market conditions are good. One measure for market conditions could be the market to book values, and a policy could be to issue equity when this ratio is relatively high

These three groups of theories may give insight into how companies finance their investments.

The importance of funding is addressed in several papers. Two recent studies of the importance of funding show that access to liquid funds and funding is important for investment decisions. The debt-equity ratio is studied by Lewis and Tan (2016), by exploiting the variation in R&D investment, they are able to show how the funding affects profits. Using a natural experiment Rauh (2006), finds that there are strong cash flow effects on investments. I have a somewhat different approach to the funding decision. I want to find the most common source of funding, and with a hypothesis that this will make it easier to understand what limits new investment projects. Note that this paper does not intend to test the capital structure theories explicitly, but rather identify some qualitative

Table 14: Investment funding source, by firm size. Average response, response categories 1 to 3

Firm size	Equity*	Bank Loan*	Bonds	Currency loan	New shares	Parent loan*
Small	2.30	2.17	1.03	1.09	1.01	1.38
Middle†	2.53	1.92	1.00	1.07	1.03	1.74
Large†	2.37	1.58	1.08	1.13	1.00	1.68
All firms	2.43	1.98	1.02	1.08	1.02	1.61

Note: Response categories: 3: Yes, almost always; 2: Now and then; 1: No, almost never. The reported results are average responses, the higher the figure, the larger is the share of the firms responding that they use the specific financing source. *Firm size is significant at the 5 percent level using a Kruskall-Wallis rank test. †Difference in mean between the different response categories are significant for large and middle-sized firms using two-way ANOVA with the Tuckey-Kramer multiple pairwise comparison test.

characteristics about factors affecting firms' funding decisions. Hence, sufficient liquid funds are a necessity for investments and having knowledge about where the company gets its funding from is necessary for understanding what might restrict the access to liquidity. Without equity capital, the firm needs external funding, either from banks, in the form of bank loans, or from the credit market, in the form of issued bonds or shares.

Titman (2002) summarizes his paper with a hypothesis about the bond market in the EU before and after the introduction of the Euro. He suggests that firms with their main activity in small countries might find it more profitable to raise funding in the bond market after the Euro was implemented. This is because the single currency decreases the risk premiums on bonds in small countries with illiquid markets because the common currency reduces the exchange rate risk. Hence, the gap between the observed cost of issuing bonds and shares are reduced. If this is correct, I should find that Norwegian firms are to a little degree exposed to the bond market. An interesting finding in Harford and Uysal (2014) shows that unrated firms are less likely to get bond financing. Knowing that small and middle-sized firms to a less degree take the cost of being rated, one would expect that fewer of them finance investments with bonds.

The results from the survey responses regarding firms' funding sources are summarized in Table 14. I find that more than half of the firms use equity and retained earnings to finance all its new projects. Furthermore, the results show that there are significant differences between small, middle, and large-sized firms in how they finance their investments. Nearly a third of the firms answered that they finance their investments with a loan from banks, and 15 percent get financing through its parent

Table 15: Factors affecting the choice of funding source

	Equity	Bank Loan	Parent Loan
Middle sized firms	0.221	-0.315	0.464*
	(0.26)	(0.25)	(0.26)
Large firms	0.722*	-1.112***	1.010***
	(0.38)	(0.33)	(0.34)
Debt to asset ratio	-1.983***	1.600***	0.385
	(0.65)	(0.60)	(0.60)
Net profit to book value	0.025**	-0.014	0.003
	(0.01)	(0.01)	(0.01)
Paid dividends	-0.112	0.703***	-0.767***
	(0.30)	(0.27)	(0.29)
Importance of cash for investments	-0.384	1.005***	0.084
	(0.27)	(0.26)	(0.26)
Threshold 1	-5.164***	0.100	0.616
Threshold 2	-3.200***	0.710	1.283**
Threshold 3	-0.904*	2.488***	2.977***
Controls	✓	✓	✓
No. of observations	281	281	281
Log-likelihood	-252.067	-345.799	-325.104
χ^2-test, p-value	0.000	0.000	0.001
Pseudu R^2	0.056	0.067	0.041

Notes: The empirical model for the probability that the firm fund its investments with Equity, Bank loan or Parent loan is estimated using a ordered logit model: $Y_i = F(\tilde{\gamma}(k) - X_i\beta) - F(\tilde{\gamma}(k-1) - X_i\beta)$, where $\tilde{\gamma}$ is the thresholds parameters, X_i is the firm specific variables, and $F()$ is the logit function. Control variables include administrative data on firm level such as debt to asset ratio, profit ratio, last year investments. Standard errors are bootstrapped, with the significance levels of the z-test represented with stars: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

company. None of the firms uses currency loans; bonds or issues new shares to finance its project on a regular basis, but a few firms use one those three funding sources now and then.

To extend the study of what affects the firms' choice of funding source, I estimate an ordered logit model to explain factors affecting which funding source they prefer. The ordered logit model exploits the ranking of the responses in the questionnaire and uses both administrative data and the survey responses to explain the funding choice. I present estimation results for three models in Table 15, one for the probability that the firm is funding its investment with equity, one for funding investment with a bank loan and one model for funding investments with parent loan. The other funding sources are used by too few firms that I can make a valid model for them. The explanatory variables are the response to the question of whether access to cash is limiting firm investments, firm size dummies,

Table 16: Multinomial probabilities for the funding choice

	Equity funding	Bank loan funding	Parent loan
mean	0.80044	0.16169	0.03785
std	0.16678	0.16026	0.0221
min	0.12658	0.00329	0.00707
P25	0.72857	0.05009	0.02159
P50	0.85789	0.09926	0.03487
P75	0.92320	0.21396	0.04914
max	0.98169	0.83331	0.17705

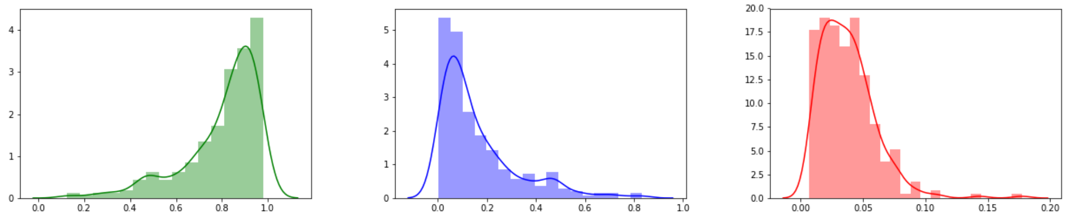
and firm-level administrative data.

The analysis shows that firms with high profitability are more likely to fund themselves with equity, while profitability has no effect on firms choosing debt funding. Firms that respond that their investments are limited by its availability to liquid funds do have a higher likelihood of funding themselves with bank loans, than firms which report not to be limited by access to cash. Large firms have a reduced likelihood to fund their investments with bank loans relative to small and middle-sized firms, showing that small firms are most likely to fund their investments with bank loans. Studying firms that are funding their investments with equity, I find that things are turned around. The results show that large firms are more likely to fund their investments with equity than small firms are. Controlling for the financial situation of the firm, I find that firms with a high debt to asset ratio are more likely to fund their investments with bank loans relative to firms with low debt ratios, which are more likely to fund their investments with equity.

Not surprising, as shown in Table 16, more than 3/4 of the firms prefer funding its investments with equity, while 16 percent prefer a bank loan. A few firms are found to prefer funding from its parent company. Based on the survey results, I know that most of the subsidiaries finance investments with retained earning, explaining the low figure of firms preferring parent loans as funding. Figure 5 shows the distribution of the estimated probabilities for the three funding sources.

5.4 Leaning towards model results or gut feeling?

A capital budgeting process might start with an analytical approach, where the firm calculates its cost of capital and then the profitability of the investment project. However, figures showing the



(a) Equity funding **(b)** Bank loan funding **(c)** Parent loan

Figure 5: Distribution of estimated multinomial probabilities for the preferred funding source. Histogram and kernel density estimator

profitability are of no use if the investment decision does not hinge on the calculated profitability. I was curious about how the firms anticipated the results from their calculations, so I included a few questions in the questionnaire regarding how they considered the results and how the firms in the business survey handled the uncertainty of their projects.

The questionnaire contains questions on whether the calculated hurdle rate is important for the decision of implementing the investment project. Table 7 showed that 27 percent of the respondents put great emphasis on the calculated hurdle rate, and close to half of the firms put moderate emphasis on the calculations. Looking at the firms putting no or only some emphasis on the hurdle rate, one could wonder why they bother calculating it. 16 percent of the firms put only some emphasis on the calculation and 4 percent no emphasis. 9 percent answered that calculating the hurdle rate is not relevant for their firms. Keeping in mind that 20 percent of the firms said they did no profitability analysis; this figure is not surprising.

There are several uncertain elements the firm has to take an decision on when they are calculating the hurdle rate or the expected profitability. The inputs used by the methods depend on market prospects, entry or exit of firms, etc. It is not obvious how to estimate the inputs for the calculations. The firm has to ask themselves whether there are any reasons to believe that the forecasted future income stream or cost is biased, or their inputs are reasonable. If firms find it difficult to forecast the input variables to the profitability analysis, one would expect that the firm would put less emphasis on the analysis. The survey questionnaire continues to question how often firms cannot give a good estimate of the expected project cash flow. Table 7 shows that one out of three respondents answered that high uncertainty often or always made it close to impossible to calculate the cash-flow of the project. Almost half of the firms said that they *now and then* experienced such uncertainty. Only a fifth of the respondents said that they *rarely* or *never* experienced such uncertainty. Given the response, it is obvious that formal capital budgeting methods play a smaller role in the investment decision than the impression one gets from textbooks on corporate finance.

To study which factors that explain which firms put higher than the average emphasis on the calculation of the hurdle rate, I employ the ordered logit model. The empirical results are shown in Table 17. In the case where the firm put high weight on the profitability analysis when taking its investment decision, one expects that the firm put effort to calculate the hurdle rate. I find that it is a higher likelihood that the firm puts a high emphasis on the hurdle rate if it is a subsidiary. Interestingly there is no effect on the manager's education nor firm size. However, firms that use the methods preferred by theory such as the WACC or FRA to calculate the hurdle rate or the IRR and NPV to calculate profitability puts a higher weight on the hurdle rate than firms that employ simpler methods.

5.5 Project analysis

A sensitivity analysis is a good way of illustrating the risk of a project. Classic sensitivity analysis identifies which part of the project where the possible losses or gains can come from. One might also use such an analysis to estimate the success-rate for an investment project. A break-even analysis is another type of sensitivity analysis that can illustrate the uncertainty of a project. This method has the advantage that it calculates the number of sold products, the product price or the average costs needed to get a positive NPV, and by this illustrates key target values for the investment project. More advanced methods might include analyzing the sensitivity of a project with a Monte Carlo simulation of the investment calculations. By building an economic model and then test it by running a Monte Carlo simulation, one might get a better and more accurate description of the risk involved in a specific project. In order to get an overview of this topic, the firms were questioned whether they used sensitivity analysis to shed light on the project uncertainty. If so, I question the firm if they had any knowledge about real options modeling or Monte-Carlo simulations.

Table 18 shows that approximately 26 percent of the firms answered that they always or often conduct a sensitivity analysis before an investment project is initiated, while 43 percent of the firms say they do it now and then. Even though they consider the uncertainty related to future costs and income to be large, nearly 31 percent of the firms do not conduct any sort of sensitivity analysis. Table 18 shows how the response differs when I sort the firms by size. While the small firms to a lesser

Table 17: Factors explaining the level of emphasis the firms' put in its calculated hurdle rate

Uncertain cash flow estimates	-0.769**
	(0.35)
Using theory-close methods	0.504**
	(0.26)
Subsidiary	0.622**
	(0.28)
Using sensitivity analysis	1.315***
	(0.35)
Threshold 1	-2.444***
Threshold 2	-1.888***
Threshold 3	-0.509
Threshold 4	1.836***
Controls	✓
No. of observations	189
Log-likelihood	-231.38
χ^2-test, p-value	0.000
Pseudu R^2	0.084

Notes: The model is estimated using a ordered logit model: $Y_i = F(\tilde{\gamma}(k) - X_i\beta) - F(\tilde{\gamma}(k-1) - X_i\beta)$, where $\tilde{\gamma}$ is the thresholds, X_i is the firm specific variables, and $F()$ is the logit function. Control variables include administrative data on firm level such as debt to asset ratio, profit ratio, last year investments. Standard errors are bootstrapped, with the significance levels of the z-test represented with stars: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 18: Survey responses, by firm size. In percent

Percentage of firms conducting sensitivity analysis as a part of its investment planning				
	Small	Middle	Large	All firms
Always	5.8	9.7	15.4	8.7
Often	8.3	22.0	30.8	17.7
Now and then	19.8	20.4	23.1	20.4
Rare	19.0	23.7	26.9	22.2
Never	47.1	24.2	3.9	30.9
Percentage of firms considering the opportunity cost of capital, by firm size				
	Small	Middle	Large	All firms
Always	24.8	19.6	34.6	22.7
Often	12.4	9.2	11.5	10.6
Now and then	20.7	27.7	26.9	25.1
Rare	14.9	19.0	15.4	17.2
Never	27.3	24.5	11.5	24.5

a Because of the way the data is organized, in this case the Kruskal-Wallis equality-of-populations rank test show whether the average response differ.

b The differences in firm size are significant at the 5 percent level using the Kruskal-Wallis test.

degree do sensitivity analysis, this is rather common among large firms.

Results from an ordered logit model, see Table 19, shows that there are several factors that explain which firms that are using sensitivity analysis actively to understand the risk of a project. Here I define that a firm conducts sensitivity analysis if it answers if it is conducted “Now and then” or more often. The empirical results show that firms that use theory preferred methods to calculate the hurdle rate or profitability are more like to conduct a sensitivity analysis than firms that use different methods.

Large firms have a higher probability of conducting a sensitivity analysis than small and middle-sized firms. Subsidiaries are more likely to conduct a sensitivity analysis, backing up the findings I earlier have shown that subsidiaries are more likely to chose the textbook methods in investment planning. The effect is so strong that it cancels the effect of being a small firm.

The survey question on how strong emphasis the firm put on the calculated hurdle rate. Including this response to the empirical model, I find that firms that put a moderate or high emphasis on its hurdle rate have a higher probability of making a sensitivity analysis before the firm puts its investments decision into action.

6 Final remarks

This paper highlights some of the differences and similarities between corporate finance theory and practice. By analyzing data from a survey among firms in the Norwegian manufacturing industry, I have obtained evidence on the practitioner’s decision-making strategy. I have shown that a significant share of firms struggles with handling uncertainty and risk. The executives’ lack of information makes small and middle-sized firms reluctant to analyze the profitability of their projects in-depth using textbook methods. When the executives’ express high uncertainty about their profitability analysis one should expect that this increases the use of sensitivity analyses to shed light on the uncertainty, but the survey results show that only a small fraction of the executives do this. Even such basic recommended methods in investment decision making; namely calculation of the NPV or the IRR is not common among executives in small firms. Surprisingly, I also find that executives in middle-sized firms calculate NPV or IRR more rarely than earlier research on international corporations has indicated. The effect of uncertainty is extensively discussed in the literature, but more important than measuring the effect of uncertainty is that the reluctance of using recommended capital budgeting models implies that standard investment models will struggle to explain the actual behavior.

I have shown that while a large share of the investment theory is supported by respondents’ an-

Table 19: Factors explaining the use of sensitivity analysis

Middle sized firms	0.516*
	(0.29)
Large firms	1.658***
	(0.40)
Higher education	-0.044
	(0.27)
Using theory-close methods	1.259***
	(0.29)
Subsidiary	0.498*
	(0.27)
Importance of hurdle rate	0.804*
	(0.45)
Threshold 1	0.493
Threshold 2	1.888***
Threshold 3	3.215***
Threshold 4	4.838***
Controls	✓
No. of observations	224
Log-likelihood	-295.09
χ^2-test, p-value	0.000
Pseudu R^2	0.134

Notes: The model is estimated using a ordered logit model: $Y_i = F(\tilde{\gamma}(k) - X_i\beta) - F(\tilde{\gamma}(k-1) - X_i\beta)$, where $\tilde{\gamma}$ is the thresholds, X_i is the firm specific variables, and $F()$ is the logit function. Control variables include administrative data on firm level such as debt to asset ratio, profit ratio, last year investments. Standard errors are bootstrapped, with the significance levels of the z-test represented with stars: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

swers to the survey questionnaire, a significant share is the theoretical models are not supported by data from this survey.

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A Summary statistics

Table 20: Descriptive statistics of administrative data for firms in the sample. All figures are in million NOK

	Revenues	**Profits**	**Dividends**	**Equity**	**Long debt**	**Short debt**	**Cash**	**Debt to asset**	**Value added**	**Investment***
Small sized firms										
mean	946.0239	57.68629	.0801511	196550.9	120006.5	262626.1	93.68286	.6454495	25705.36	342.6786
st error	2257.621	370.8038	.3901303	394293.5	267561.4	732945	369.0036	.2349724	75092.37	2503.635
p25	321.9002	-3.33868	0	45880.04	4582.49	65766.58	0	.50165	10106.91	0
median	582.978	14.91542	0	103450.3	36399.43	122674	17.285	.6218786	16181.53	0
p75	953.7294	48.87902	.015	211245.9	107266.7	230476.2	72.28	.7954009	24714.15	0
	234	234	234	234	234	234	234	234	234	233
Medium sized firms										
mean	3674.756	219.4388	.3301665	937967.8	430247.9	1052057	900.6001	.6559518	90997.99	6996.396
st error	4938.763	697.5276	1.357506	1681071	869186.4	1565797	10674.12	.208873	134330.7	42393.8
p25	1274.717	8.74777	0	189241.3	40230.62	301505.8	0	.5204746	37840.98	0
median	2142.848	84.16469	0	431125.9	150560.3	544563.6	28.97	.6640224	56954.62	0
p75	4004.095	210.1488	0	956254.2	376832.3	1203269	132.99	.7883168	93894.12	0
N	322	322	322	322	322	322	322	322	322	322
Large firms										
mean	34064.18	1964.4	3.469569	2.12e+07	9750476	1.63e+07	4673.236	.6574264	759290	54971.17
st error	56530.68	5137.007	13.2933	7.96e+07	3.67e+07	2.81e+07	47479.2	.1982087	1016182	252297.6
p25	8951.95	117.5679	0	1528764	338007.3	2143964	0	.5568067	218895.6	0
median	12546.57	771.3342	0	3292612	1210447	4260649	77.545	.6916347	379892	0
p75	30470.79	2332.82	0	1.21e+07	4351111	1.31e+07	275.89	.7720472	791763.8	0
N	130	130	130	130	130	130	130	130	130	130
Total										
mean	8502.894	494.9415	.8398148	4519734	2090646	3663724	1340.285	.6526488	195370.4	13837.86
st error	27738.96	2398.986	5.985451	3.55e+07	1.63e+07	1.37e+07	21924.78	.2159871	529287.1	115135.3
p25	753.1193	4.64944	0	110537.1	27360.95	170727.9	0	.5186248	19776.36	0
median	1766.895	58.07133	0	324513.1	121058.6	444085.4	27.015	.6549432	44535.94	0
p75	5456.109	234.0651	0	1228627	491875.1	1614622	133.43	.7883168	117956.3	0
N	686	686	686	686	686	686	686	686	686	685

Notes: The means are unweighted, ie. small firms have the same weight as large firms, when calculating sample means.

*Because matching between the survey data and the administrative data were not perfect, there are one observation less in this variable

B Test results

To identify differences in the mean of the variable of interest between two sub-samples there are several test one could apply. The standard approach to apply for testing a hypothesis of no difference in the mean between two groups is the t-test. The t-test hinges on the normality assumption, ie. that the variables that is to be tested have a normal distribution, but the population variance may be unknown. Relax the normality assumption, I could apply the non-parametric Wilcoxon Rank Sum test instead of the t-test.

The second kind of test aims to identify whether the respondents answers the questionnaire in a random way or that there are significant differences between the different response categories. There are several ways to do this. The standard approach is to apply a one-way analysis of variance (ANOVA). An alternative is the Fisher's exact test for contingency tables, but in contrast to the Fisher's exact test the ANOVA also takes into consideration the differences in the variance within the groups, not only the differences in means as the Fisher test. An argument against the ANOVA test is that it assumes normality. Even though our sample is fairly large one might argue that a non-parametric test, such as the Kruskal-Wallis rank test, is more suitable.

In contrast to the one-way ANOVA, the two-way ANOVA tests difference in means between not only groups, but simultaneously also tests for differences between different blocks of questions. This allows us to test responses in two dimensions in one test. In our case, this means that I can test a) whether or not firms answer randomly on a given question and b) whether firm size matter for the responses. Still I have to care about the normality assumption. The Friedman test is a non-parametric variant of the two-way ANOVA for the case where I have one observation per cell. In our case I have multiple observations per cell and the Friedman test cannot be used. Since the data set is sufficiently large, I assume that the two-way ANOVA can be used, but I employ the Kruskal-Wallis test when the question that is analyzed only have one dimension.

This section shows the results from the Tuckey-Kramer and ANOVA test applied to the questionnaire. First part of the procedure is to run a standard ANOVA test with interaction terms. The second step is to apply the Tuckey-Kramer test. If the test reject H_0, then the difference in mean is significantly different from zero at the 5 percent level. After showing the ANOVA tables do the Tuckey-Kramer test results for pairwise comparison for groups (firm size) and blocks (questions) follows.

Table 21: ANOVA results, for funding source

Source	Partial SS	df	MS	F	Prob > F
Model	1144.66177	17	67.3330452	109.63	0.0000
Financing	602.360771	5	120.472154	196.14	0.0000
cap	4.67547226	2	2.33773613	3.81	0.0224
Financing#cap	35.8678817	10	3.58678817	5.84	0.0000
Residual	926.226828	1508	.614208772		
Total	2070.8886	1525	1.35795974		

N = 1526, R-squared =0.5527, Root MSE = 0.783715

Table 22: Tuckey-Kramer pairwise comparison, firm size effect for choice of funding source

Firms size	group means		difference	TK-test
1 vs 2	1.1538	1.2506	0.0968	3.1686
1 vs 3	1.1538	0.9867	0.1672	3.2725
2 vs 3	1.2506	0.9867	0.2639	5.3682*

* Indicate rejecting of the H_0, ie. difference in mean significantly different from 0

Table 23: Tuckey-Kramer pairwise comparison, for choice of funding source

Funding source	group means		difference	TK-test
1 vs 2	2.4068	1.8172	0.5896	13.0085*
1 vs 3	2.4068	0.2422	2.1647	44.8366*
1 vs 4	2.4068	0.4469	1.9599	40.7558*
1 vs 5	2.4068	0.2679	2.1390	44.3627*
1 vs 6	2.4068	1.2659	1.1410	24.4793*
2 vs 3	1.8172	0.2422	1.5751	31.6413*
2 vs 4	1.8172	0.4469	1.3703	27.6302*
2 vs 5	1.8172	0.2679	1.5493	31.1636*
2 vs 6	1.8172	1.2659	0.5513	11.4479*
3 vs 4	0.2422	0.4469	0.2048	3.9144
3 vs 5	0.2422	0.2679	0.0257	0.4903
3 vs 6	0.2422	1.2659	1.0237	20.0930*
4 vs 5	0.4469	0.2679	0.1790	3.4268
4 vs 6	0.4469	1.2659	0.8190	16.1312*
5 vs 6	0.2679	1.2659	0.9980	19.6117*

* Indicate rejecting of the H_0, ie. difference in mean significantly different from 0

Table 24: ANOVA results for chose of hurdle rate

Source	**Partial SS**	**df**	**MS**	**F**	**Prob > F**
Model	379.669454	20	18.9834727	20.86	0.0000
hurdle rate	125.999034	6	20.999839	23.08	0.0000
cap	20.1111473	2	10.0555737	11.05	0.0000
hurdle rate#cap	49.2487595	12	4.10406329	4.51	0.0000
Residual	1240.37029	1363	.910029557		
Total	1620.03974	1383	1.17139533		

N = 1384, R-squared =0.2344, Root MSE = 0.9539

Table 25: Tuckey-Kramer pairwise comparison, for choice of hurdle rate

Hurdle rate	group means		difference	TK-test
1 vs 2	2.0456	0.5506	1.4951	22.8358*
1 vs 3	2.0456	1.0729	0.9727	15.1913*
1 vs 4	2.0456	1.0529	0.9927	15.4331*
1 vs 5	2.0456	0.8090	1.2366	18.8886*
1 vs 6	2.0456	0.8587	1.1869	18.3082*
1 vs 7	2.0456	1.2400	0.8056	12.7299*
2 vs 3	0.5506	1.0729	0.5224	7.4424*
2 vs 4	0.5506	1.0529	0.5023	7.1302*
2 vs 5	0.5506	0.8090	0.2584	3.6143
2 vs 6	0.5506	0.8587	0.3081	4.3450*
2 vs 7	0.5506	1.2400	0.6894	9.9189*
3 vs 4	1.0729	1.0529	0.0200	0.2895
3 vs 5	1.0729	0.8090	0.2639	3.7604
3 vs 6	1.0729	0.8587	0.2142	3.0783
3 vs 7	1.0729	1.2400	0.1671	2.4516
4 vs 5	1.0529	0.8090	0.2439	3.4621
4 vs 6	1.0529	0.8587	0.1942	2.7801
4 vs 7	1.0529	1.2400	0.1871	2.7341
5 vs 6	0.8090	0.8587	0.0497	0.7009
5 vs 7	0.8090	1.2400	0.4310	6.2009*
6 vs 7	0.8587	1.2400	0.3813	5.5337*

* Indicate rejecting of the H_0, ie. difference in mean significantly different from 0

Table 26: Tuckey-Kramer pairwise comparison, for firm size effect of choice of hurdle rate

Firm size	group means		difference	TK-test
1 vs 2	1.0238	1.2238	0.2001	5.1597*
1 vs 3	1.0238	1.2097	0.1859	2.7500
2 vs 3	1.2238	1.2097	0.0142	0.2167

* Indicate rejecting of the H_0, ie. difference in mean significantly different from 0

Table 27: ANOVA results for chose of investment criteria

Source	Partial SS	df	MS	F	Prob > F
Model	36.090	17	2.1229	12.71	0.0000
criteria	16.9238	5	3.3847	20.26	0.0000
cap	2.670348	2	1.3351	7.99	0.0003
criteria#cap	12.18441	10	1.2184	7.29	0.0000
Residual	333.7821	1998	.16705		
Total	369.8730	2015	.1835		

N = 2016, R-squared =0.0976, Root MSE = 0.4087

Table 28: Tuckey-Kramer pairwise comparison, for firm size effect of choice of investment criteria

Firm size	group means		difference	TK-test
1 vs 2	0.1986	0.2584	0.0598	4.3397*
1 vs 3	0.1986	0.3210	0.1224	4.8693*
2 vs 3	0.2584	0.3210	0.0626	2.5792

* Indicate rejecting of the H_0, ie. difference in mean significantly different from 0

Table 29: Tuckey-Kramer pairwise comparison, for choice of investment criteria

Investment criteria	group means		difference	TK-test
1 vs 2	0.0952	0.2857	0.1905	8.5423*
1 vs 3	0.0952	0.3542	0.2589	11.612*
1 vs 4	0.0952	0.3720	0.2768	12.413*
1 vs 5	0.0952	0.1548	0.0595	2.6695
1 vs 6	0.0952	0.1905	0.0952	4.2712*
2 vs 3	0.2857	0.3542	0.0685	3.0699
2 vs 4	0.2857	0.3720	0.0863	3.8707
2 vs 5	0.2857	0.1548	0.1310	5.8729*
2 vs 6	0.2857	0.1905	0.0952	4.2712*
3 vs 4	0.3542	0.3720	0.0179	0.8008
3 vs 5	0.3542	0.1548	0.1994	8.9428*
3 vs 6	0.3542	0.1905	0.1637	7.3411*
4 vs 5	0.3720	0.1548	0.2173	9.7436*
4 vs 6	0.3720	0.1905	0.1815	8.1419*
5 vs 6	0.1548	0.1905	0.0357	1.6017

* Indicate rejecting of the H_0, ie. difference in mean significantly different from 0

C Survey methodology and the survey plan

C.1 The Survey

The respondent will answer an Internet questionnaire. The program used is Enalyser. By choosing an Internet survey, one ensures that dunning letters can easily be sent. A dunning letter was sent two times, with approximately one month interval. All respondents received an information letter together with the survey. To strengthen the response rate, the information letter was carefully written. There were put emphasis on two matters. First, the importance of the results the survey might induce. And secondly, that it was not expected that the respondents where familiar with all the concepts that the survey questioned.

The survey was dispatched, by e-mail, to all respondents of SSB's Business Tendency Survey. The latter survey includes firms in the manufacturing sector only and is a voluntary survey, normally with a response rate of 95 per cent. The business tendency survey has approximate 800 respondents, and it accounts to about 3.5 per cent of the population of firms. In the strata with the largest firms (>300 employees), all firms are included in the sample. While in the strata with the smallest firms, a large share is excluded. To be included in the sample, the firm needs to have at least 10 employees. Because of this stratification, the sample covers approximately 40 per cent of the total employment in the manufacturing sector.

Information letter

The letter is included in the survey. The letter explains short about the survey. Further, it informs about the importance of answering also the topics unknown for the executive and that lack of knowledge about corporate finance is expected. It is also informed how their effort might benefit their business and the entire economy by giving the decision-makers better understanding of investment behaviour. They are also informed that the data would be stored in such a way that it will be impossible to identify the different firms. Tracking firms, via identification numbers, is done for sending dunning letter and linking the firms with firm specific variables from account statistics.

C.2 Survey questions

The questionnaire where in Norwegian, so the questions have been translated.

1. How does the firm finance its investments in machines, buildings and means of transportation,

ergo investments in real capital?

- Equity (Yes, almost always/Now and then/No, nearly never/Not relevant for the firm)
- Bank loan
- Bonds
- Currency loan
- Emission of stocks
- Loan from parent company

2. Is your firm using one or more of the following calculation methods when doing profitability analysis? (Multiple draws)

   - Equivalent annual cost (Yes/No)
   - Internal rate of return
   - Net present value method
   - Payback method
   - Other method
   - No method

3. If one or more of the mentioned methods are in use, what kind of hurdle rate is normally used?

   - Bank interest rate (Yes, almost always/Now and then/No, nearly never/Not relevant for the firm)
   - Expected bond rate
   - Calculated interest rate, with help of future rate agreements
   - Calculated interest rate, with help of the weighted average cost of capital method (WACC)
   - Calculated interest rate, with help of the capital asset pricing model (CAPM)
   - Calculated interest rate, with several models
   - Interest rate calculated in other ways

4. How significant is the calculation of the hurdle rate for the investment project?

   - Great

- Moderate
- Small
- No
- Not relevant for the firm

5. What was the cause for conducting the last considerably investment project?

    - Wear and tear (Yes/No)
    - Environmental or public issues
    - Increase capacity
    - Change in product composition
    - Old or unfashionable
    - Relocation
    - New and better technology available
    - Desire to reduce personnel cost
    - No specific reason or other reasons

6. In a thought scenario: Would a considerably rise in wage cost induce an increase in investments in real capital? (Yes, to a large degree/Yes, to some degree/No, dubiously)

7. How often is investment projects implemented even though it was not possible to give a good estimate of the cash surplus, e.g., because there is great uncertainty about how much the sale will increase? (Always/Often/ Now and then/Rare/Never)

8. Is sensitivity analysis employed to make the uncertainty in the investment cost visible? (Always/Often/ Now and then/Rare/Never)

9. Real option pricing is a way to express the value of future investment possibilities. Is this a concept you are acquainted with, and if so is the method used?

    - Yes, the method is used often
    - The method is rarely used
    - The method is known, but not used

- No, is not familiar with the concept

10. Is Monte-Carlo simulations used to reveal uncertainty?

    - Yes, nearly always
    - Often
    - Now and then
    - Rarely
    - No
    - Not familiar with the concept

11. Do you consider an alternative way to use the capital assets, other than paying dividend, before carrying through investment projects? (Always/Often/ Now and then/Rare/Never)

12. If not alternative use is considered, why is that?

    - Financing investments requires collateral, so the capital is not free assets
    - The survival of the firm is more important than a possible extra profit
    - Other reasons

13. What is/or do you think is the most important reason for the firm ownership?

    - Maximising profit
    - Create jobs
    - Realise business ideas
    - Other reasons

14. How would a reduction in the market position of the firm alter its investment plans?

    - The firm would most likely increase investments
    - The firm would neither increase nor decrease investments
    - The firm would probably decrease its investments
    - Not relevant for the firm

15. Liquidity is necessary for investments. How often is this a limiting factor for investment projects?

- Always
- Often
- Now and then
- Rarely
- Not relevant for the firm

16. How important is good cash holdings/liquid funds for financing investment projects?

    - Important
    - Less important
    - Not important
    - Not relevant for the firm

17. How important is the firm's profit for financing investment projects?

    - Important
    - Less important
    - Not important
    - Not relevant for the firm

18. When did the firm complete its last considerable[6] investment?

    - Second half of 2012
    - First half of 2012
    - In 2011
    - In 2010 or earlier
    - Not relevant for the firm

19. What is your highest achieved educational degree?

    - Secondary school

[6] I have chosen not to define the size of a considerable investment, because the size of the firms differs substantially and it is no obvious link between firm size and capital stock across different industries. The respondent was given the responsibility to define herself what a considerable investment is.

- Upper secondary school, vocational subject
- Upper secondary school, general
- Polytechnic education
- Graduate, business or economics
- Undergraduate, business or economics
- Higher education, other
- Other educations

D Further survey results

Table 30: Percentage of firms considering the opportunity cost of capital, by firm size. Percent

	Small	Middle	Large	All firms
Always	24.8	19.6	34.6	22.7
Often	12.4	9.2	11.5	10.6
Now and then	20.7	27.7	26.9	25.1
Rare	14.9	19.0	15.4	17.2
Never	27.3	24.5	11.5	24.5
Reason for not considering the opportunity cost				
	Small	Middle	Large	All firms
Collateral	8.1	15.7	33.3	14.0
Survival	59.8	45.7	20.0	49.2
Other	33.3	42.9	46.7	39.7
Motive for ownership, by firm size. Percent				
	Small	**Middle**	**Large**	**All firms**
Maximising profit	77.7	77.2	73.1	77.0
Create jobs	31.4	23.9	11.5	25.7
Realise business ideas	37.2	34.2	23.1	34.4
Other motives	8.3	10.3	26.9	10.9

Notes: The respondents could answer more than one category

Table 31: Investment responses of changes in business environment. Percent

In a thought scenario: Would a considerably rise in wage cost induce an increase in investments in real capital? Response by firm size and in percent				
	Small	Middle	Large	All firms
No, doubtfully (unchanged or lowered)	34.7	34.1	42.3	34.9
Yes, might increase	51.2	47.0	46.2	48.5
Yes, would increase	14.1	18.9	11.5	16.6
How would a reduction in the market position of the firm alter your investment plans. Response by firm size and in percent				
	Small	Middle	Large	All firms
Not relevant for us	5.0	3.3	3.9	4.0
Reduce investments	62.2	59.0	69.2	61.0
No change in investments	24.4	24.6	15.4	23.8
Increase in investments	8.4	13.1	11.5	11.3

Table 32: What were the reasons for the firm's last investments. Percent

	Avg. response	Standard error
Lack of capacity	51.2	(0.50)
New technology available	37.3	(0.48)
Existing capital old/unfashionable	33.1	(0.47)
Wear and tear	32.2	(0.47)
Desire to reduce wage costs	25.9	(0.44)
Change in product composition	13.6	(0.34)
Environmental requirements	10.5	(0.31)
Relocation of its facilities	8.1	(0.27)
Other reasons	3.0	(0.17)

Notes: Since the firms could answer more than one reason for investing, the column does not sum to one.

Table 33: How firms decisions are affected by liquidity constraints and cash flow effects.

How often liquidity constraints limit investments, by firm size. Percent

Frequency	Small	Middle	Large	All firms
Always or often	39.7	26.2	25.9	31.1
Now and then	27.3	30.1	25.9	28.7
Rare or never	29.8	39.9	48.1	36.9

Importance of cash flow for the financing of investment projects, by firms size. Percent

Importance	Small	Middle	Large	All firms
Not important/relevant	5.8	13.2	11.6	10.4
Some importance	13.3	17.6	15.4	15.9
Important	80.0	69.2	73.1	73.9

Importance of profit for new investments, by firm size. Percent

Relevance	Small	Middle	Large	All firms
Not important/relevant	2.5	6.0	7.4	4.8
Some importance	16.7	15.9	11.1	15.8
Important	80.8	78.1	81.5	79.4

Table 34: Proportion familiar with real option models, by firm size

Relevance	Small	Middle	Large	Total
No, is not familiar with the concept	46.88	44.68	36.00	44.35
The method is known, but not used	48.44	47.52	60.00	49.13
The method is rarely used	3.13	7.80	4.00	6.09
Yes, method used often	1.56	0.00	0.00	0.43

Table 35: Proportion answering that Monte Carlo analysis is done to reveal uncertainty, by firm size

Relevance	Small	Middle	Large	Total
Not familiar with the concept	55.38	52.14	44.00	52.17
No	38.46	33.57	52.00	36.96
Rarely	6.15	8.57	0.00	6.96
Now and then	0.00	4.29	4.00	3.04
Often	0.00	0.71	0.00	0.43
Yes, nearly always	0.00	0.71	0.00	0.43
Number of respondents	65	140	25	230

Table 36: Response to the question: What were the reasons for the firm last investments. Percentage of respondents answering yes. By firm size

	Mean	**Standard deviation**
Small firms		
Wear and tear	0.31	0.47
Environmental	0.066	0.25
Capacity	0.53	0.5
Product composition	0.13	0.34
Old/Unfashionable	0.37	0.49
Relocation	0.066	0.25
New technology	0.4	0.49
Reduce wage costs	0.24	0.43
Other reasons	0.025	0.16
Middle firms		
Wear and tear	0.31	0.47
Environmental	0.11	0.31
Capacity	0.52	0.5
Product composition	0.12	0.32
Old/Unfashionable	0.3	0.46
Relocation	0.092	0.29
New technology	0.35	0.48
Reduce wage costs	0.27	0.45
Other reasons	0.038	0.19
Large firms		
Wear and tear	0.42	0.5
Environmental	0.27	0.45
Capacity	0.38	0.5
Product composition	0.27	0.45
Old/Unfashionable	0.35	0.49
Relocation	0.077	0.27
New technology	0.38	0.5
Reduce wage costs	0.27	0.45
Other reasons	0	0

Constraining Factors for Manufacturing Investments: An Empirical Study of the Norwegian Manufacturing Industry

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Abstract

Firms continuously analyze whether to stand by their planned investment projects or whether they need to adjust their investment plans. This paper applies panel data to assess the relative contribution of factors explaining changes in firms' investment plans. The analysis builds on data from a quarterly business tendency survey as well as national accounts statistics and register data. Conventional register data on investment decisions contain systematic measurement error due to time lag from when an investment decision is taken to it is effectuated. In contrast, survey data do not suffer from this problem and therefore are particularly well suited for studying investment behavior. I find that changes in the firms' expected demand and access to credit are the most important variables for explaining changes in investment plans. Firms; independent of size; are most likely to adjust their investment downwards when demand expectations are weak, and credit conditions are tight. Neither changes in capital costs nor the financing costs seem to play a significant role in the short-run investment dynamics.

Keywords: Real investments, Business survey, Panel data model

JEL Classification: E22, L20, D22

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1 Introduction

Growth has been nearly absent in Europe and fairly weak in the Nordic countries through all the years after the Financial crisis in 2007/2008. Finally, most of the major economies are showing signs of recovery, and investments started rising in the mid 2010s, after nearly a decade without substantial growth. Banerjee et al. (2015) point to the fact that there is a ‘Secular Stagnation’ in Europe characterized by high income per capita and solid profit growth within firms, but still, real investments are not picking up after it plummeted the years after the financial crisis. Banerjee et al. (2015) highlight two possible explanations for this phenomenon: i) The first one is overcapacity due to the solid investment growth during the pre-Financial Crisis boom, and ii) The second one is low demand and hence low return on investments. Uncertainty and financial frictions are also factors viewed as important for explaining investment behavior. Uncertainty, both in price evolvement and expected demand, may reduce investment in a setting with imperfect markets, Bertola (1998) and 1996. Financial frictions dampen investment by causing external costs to rise due to agency problems, or it may induce liquidity constraints due to moral hazard, lack of competition, or high transaction costs. The purpose of this paper is to analyze the relative strength of the factors affecting real investments. For this purpose, I apply a panel data study on data from the Business tendency survey (BTS). There are several reasons for using data from the BTS. Firstly, these data do not suffer from bias due to the lag in delivery time of real capital. Remember that conventionally measured investment figures are notoriously difficult to interpret because of substantial delays from the time when the investment decision is taken until the changes in the capital stock is measured, either in official statistics or in the financial statements of the firms. The delivery times of real capital are also affected by the business cycles and depend on several factors such as the capacity utilization of the construction industry. In contrast, in the BTS, the answers provide direct information about changes in investment plans barely without any delay. Secondly, the BTS contains much more information about factors affecting real investments than regular register data do.

The BTS of Statistics Norway is a quarterly survey going back to 1990. The BTS is intended to provide information about the management of a representative share of the manufacturing industry in Norway, and it includes all large firms. Forecasters and government institutions use the survey regularly in its analysis. The BTS was revised in 2011. The old questionnaire contained questions about whether the firm had revised its investment plan – up, unchanged, or down. Upon request, I introduced an additional question into the survey. The added question intends to capture information about which factors that contribute to the firms' decision to revise down their investment.

The data set I use in this study is a panel data set that contains information from the questionnaire on whether or not changes in the investment plans had taken place for firms in the manufacturing industry as well as variables from the national account together with administrative data. Thus, this study uses both stated and revealed preference data. The revised version of the BTS Questionnaire questions the respondents about the motive behind their recent actions, and not only about their intentions.

The standard approach when studying real investments is to focus on a partial analysis of factors affecting investment decisions. In empirical studies of firm data, the identification strategy would, in many cases, not allow the researcher to study the effect of more than one or at most a couple of factors at a time. The contribution of this paper consists in establishing and estimating an empirical model for the probability of revising down investment plans, as a function of a set of several key explanatory variables.

In the empirical analysis, I find that the variable denoted "weak demand expectations" has the strongest effect on changes in the probability of a downward revision in firm investment. Limitations in firms' access to credit are also significant in explaining declining investment, but not as much as changes in demand expectations. In contrast to standard economic theory, changes neither in the price of capital nor in the cost of financing affect investments in the short run. This finding is in line with the results discussed in the first paper of this thesis, and one would expect that neither cost of capital, nor the price or cost expectations affect the level of real investments if firms to a lesser degree use formal methods for analyzing investment projects. The result of this analysis, which partly goes against the Investment Euler equation model (the benchmark model for analyzing aggregate investments, see, e.g. Smets and Wouters, 2007) is backed up by evidence obtained by the results in Paper 1.

2 Related literature

This section gives an overview of theoretical models and related empirical literature. I give a brief overview of theoretical investment models. Understanding those models are important for explaining how the questionnaire is designed. The last part of the section discusses relevant empirical studies.

2.1 Popular theoretical models

This subsection discusses some of the most popular models applied in the field of investment theory. The discussion serves as the basis for the selection of the possible response categories in the business tendency questionnaire discussed in section 3. I chose to highlight four popular investment theories; the Q-model, the Investment Euler equation model, The Jorgenson accelerator model, Real Options Theory, and the Financial accelerator theory. Investment models do often start with the Q-theory, Tobin (1969). The beauty of the Q-model lies in its microeconomic foundations and its logic result. The Q-theory expands the standard neoclassical production function with a representation of installation costs, such as in Abel (1981). The model states that the firm's value is given by today's dividend and the sum of all future dividends. Future dividends are the discounted sum of all future profits. If I maximize the value of the firm with respect to capital, subject to the law of motion of capital, I find the solution for the optimal investment level

$$(1) \qquad I_s = \frac{q_s - pk_s}{\chi} K_s,$$

The relation in (1) is the Q-model, where I_t is investment at time t, q_t is the shadow price of capital, pk_t is the price of capital goods, χ is the installation cost parameter and K_t is the capital level. The Q-model implies that the firm invests if the shadow price (the ratio between the marginal return on capital and the cost of capital) is larger than the price of one unit of capital goods. The investment level depends on the cost parameter χ and the capital stock, K_s.

The Q-model has the same implication as the Net present value (NPV) model known from corporate finance. The conclusion from both models is that investments will increase as long as a rise in the real capital stock increases the net present value of the firm's dividend more than if the money was invested in an asset paying interests equal to $E[r]$. When forecasting investments, using the Tobin's Q-model, the interest rate plays an essential role as the nominal anchor.

The Investment Euler equation model differs from the Tobin's Q-model by being a period-to-period arbitrage condition for the firm's investment behavior Chirinko and Schaller (1996). Following Whited (1998) one may write the Investment Euler equation as:

$$(2) \qquad E_{t-1}\beta_t[F_K(K_t,N_t) - \psi_K(I_t,K_t) + (1-\delta)(\psi_I(I_t,K_t) + pk_t)] = \psi_I(I_{t-1},K_{t-1}) + pk_{t-1},$$

where β_t is the discount factor, ψ_K is the cost function related to the capital level and ψ_I is the adjustment cost function related to the investment.

The Investment Euler equation model serves as a framework for understanding firms' timing of the investment project by highlighting the trade-off between investing today versus tomorrow.

As a response to the failure of neoclassical models to fit data and the ad hoc nature of the empirical analysis of its time, Jorgenson (1963) developed what is known as the accelerator model.

In the accelerator model, the firm sets its capital levels in order to maximize profit. I assume that for optimal production, Y_t^*, there exists an optimal capital stock, K_t^*. Investment is set so that the firms' capital stock adjusts towards the firm's optimal capital stock. Because adjustment to the optimal capital level has a certain lag (L) represented by the lag function $w(L)$, investments may be written as: $I_t = w(L)(K_(t+1)^* - K_t^*)$, where depreciation is assumed away. If I assume that at the optimal level of production the capital to output ratio is constant and equal to γ, then I can replace the capital level with the production times γ at time t, and time $t+1$. In addition, if I take into account that the optimal production level in the next period is unknown, I may replace the capital level with the expected production level. The resulting accelerator model therefore becomes

(3) $$I_t = \alpha\gamma(E[Y_{t+1}] - Y_t)$$

Given the current production, investment is determined by the expected production, the adjustment parameter, α, and the optimal capital to output ratio, γ. This model gives a reasonable explanation of investment behavior if firms use expectations about future production as a proxy for determining its optimal capital stock at the beginning of the period $t+1$. The problem with the accelerator model is the strong assumption of a constant capital to output ratio. In the short run, this is a less strong assumption, and the model might be useful for explaining short-run movements in investments. However, if I relax this condition and only assume that it holds in the short run, the model might still be unrealistic in the sense that it might not be able to explain which economic and structural factors that cause a change in the capital to output ratio. A permanent change in the relative productivity of capital and labor or the relative costs of capital to labor will make it profitable to change the labor intensity in production, and hence the optimal capital to production ratio changes. Further, for this model to hold; inventories and the length of the order book must be fixed.

The Modigliani-Miller proposition says that the firm's value is independent of its capital structure (Modigliani-Miller, 1958) . In real life, cash-flow and firm leverage have proved to be crucial for investment decisions and hence, for firms' prospects. Bernanke et al. (1999) proposed a medium scale macro model with financial frictions, known as the Financial accelerator model. In their macroeconomic model, the financial structure of entrepreneurs and consumers plays a crucial role in creating business cycle fluctuations – the reason why the financial structure matters are the presence of the external finance premium. Because of agency costs, lenders require a higher premium from the borrower when the debt-to-equity ratio is high. With a procyclical pattern in the price setting of net wealth, the risk premium would rise during downswings and fall in upswings. The procyclical behavior causes investments and consumption to expand further in good times and contract more in bad times.

Abel et al. (1996) propose an alternative to the controversial assumption of convexity of the installation cost function by using elements of real option value theory in the Q-model. By including the real option value theory Abel et al. (1996) introduce a model where firms take into account the future resale and purchasing price when optimizing their capital stock. The model treats the possibility of a future sale of the firms' acquired capital as a put option and the possibility of future investment in capital as a call option. The real options model shows how a change in the output price or an exogenous demand shock affects the value of the investments given different investment decision timing. A great benefit of this model is that it introduces a way to include uncertainty in the model.

2.2 Empirical studies of business surveys

There are several studies of business tendency surveys and investment planning. In this subsection I will here review a few of them.

Bachmann and Zorn (2013) discuss the effect of technology shocks on aggregate investments by using the results from the IFO investment survey. They find that aggregate demand shocks, such as substantial declines in private or public demand, explain most of the changes in aggregate investments, while financial conditions or technology shocks, are relatively unimportant. The strength of the study of Bachmann and Zorn (2013) is the linkage between the National account and the IFO survey. Together with two decades of historical data, firm-level investment behavior is studied over several business cycles. The IFO survey is designed such that it questions the firms on which factors that affected the investment activity in general. The consequence of this is that the precision of the estimates may be reduced because this introduces a possibility for misunderstanding the questionnaire when it is filled out. Bachmann et al. (2013) have also studied the German manufacturing industry. They study the result from the IFO business climate survey and discuss how to produce an uncertainty index using results from the survey. They show that the IFO survey correlates well with other measures, and show that the index for uncertainty explains changes in manufacturing production. Baker et al. (2013) establish a new measure for policy uncertainty and provide support to the finding in Bachmann et al. (2013), showing that firm investments are harmed by increases in uncertainty and that it increases the stock price volatility.

Vermeulen and Fuss (2008) also study how results from a business survey may be used to improve the investment model. Vermeulen and Fuss (2008) use forecast errors from the business survey to measure price and sales uncertainty and find significant effects of changes in the uncertainty of demand on both planned and realized investments. Österholm (2013) estimate a forecasting model for aggregate business investments using survey data from the Swedish Economic Tendency Survey. Österholm (2013) finds evidence that data on firms' responses to a business survey will improve investment forecasts significantly. It has a simple set-up and discusses forecast errors of several types of forecasting models against a standard autoregressive time-series model. My paper takes this strategy a step further. Instead of analyzing aggregate data, I use firm-level data. Firm data gives higher variation in the data and hence improves the identification strategy, and using firm data makes it possible to link the survey results with other survey data.

3 The business survey and data

The BTS of Statistics Norway is a quarterly survey going back to 1990. The purpose of the survey is to obtain information about business conditions and firms' investment behavior from managers in the manufacturing and mining industry in Norway. Statistics Norway conducts the survey electronically by sending a questionnaire to a sample of firms by email. Specifically, the survey questionnaire is addressed to the liaison at the firm, which is CFOs at large firms, financial managers in middle-sized firms and usually the manager at the smallest firms, because those firms are often without a designated financial manager. To classify the industries, the standard industry classification convention in Europe is used. The survey is voluntary, but still, the response rate is about 95 percent. The number of employees stratifies the population into four strata. From each stratum, a random sample of firms is selected and asked to participate in the survey. Each firm in the selected sample participates in the survey for six quarters before a new firm, which again is drawn randomly from the same stratum, replaces it. Thus, the survey has a rotating sample design. In the stratum containing the largest firms, all of the firms in the population are included in the sample, while firms with less than ten employees or a gross revenue less than 10 million Norwegian kroner (NOK) are excluded from the sample.

There was a substantial revision of the BTS in 2011. I were in a position to influence the revision of the questionnaire. The new version of the survey asks a specific question about why the firms' investment plans where cut. The questionnaire starts by asks whether the firm has revised its investment plan relative to last quarter. If the firm has revised it down, they are questioned about their reason for doing this revision. To avoid any misunderstanding from the respondents on what they actually was answer in to, it was decided only to include a question about which factors affect firms that are downsizing investments. This gives a more robust identification strategy at the cost of missing what causes firms upscale their investments. The BTS also question the firms about their expectations in general. To cross-validate that it is the factors that the firms' states to affect investments are the relevant ones, I also study how expectations, in general, affect their investment planning.

The questions from the questionnaire I study are:

Q1: "*Does your business consider undertaking a change in your approved plans for investment in real capital*: [down], [unchanged] or [up]?"[1]

Q2: "*Which of these factors – if any particular – contributes to limiting planned investments in real capital*: [Access to credit], [expected demand], [cost of capital], [financing costs], [public regulations], [public subsidies], [excess capacity], [other factors], [no specific factors]?"

Q3: "*What are your expectations for the development the next quarter relative to today for the following variables*: [production], [capacity], [employment], [home orders], [foreign orders], [total orders], [home prices], [input prices], [foreign prices]?"

The introduction of the second question in the BTS makes it possible to analyze which factors affect changes in manufacturing investments. The firms may answer why they revised down their investment plan. Of particular interest is whether there were any known factors, or no specific factors, which is a response category for the firms that are not able to pinpoint which

[1] Translation from Norwegian to English done by the author.

factor that caused them to change their plan. The BTS also covers firms' expectations. In this question, the respondents answer if they expect the variables to decline, to be unchanged or increase. The third question gives us the possibility to study how the firms' expectation about the development of key variables affects the probability of revising down investments. Also, I may check if the firms answer consistently – meaning that I can find a relationship between the empirical models analyzing questions two and question three.

Table 1: Descriptive data for the different response category to the question **Q2**: *Which factors contributes to limiting your firm's investments in real capital*. Conditional means, from the pooled sample

	Access to credit	Expected demand	Price of Capital	Cost of Finance	Official regulations	Public Subsidies	Excess capacity	Other reasons	No special reason	Unconditional mean
Small firms	.1972	.6944	.05	.0806	.0861	.0583	.1917	.0889	.0805	.481
Middle sized firms	.1959	.7331	.0709	.1115	.0676	.0709	.1858	.1385	.0743	.457
Large firms	.12	.88	.2	.12	.04	.04	.04	.04	.04	.062
All firms	.1938	.7180	.0646	.0954	.0764	.0631	.1836	.1087	.0764	.473
Employment, t	86.9	116	113	107	93.7	90.2	124	150	142	128
Investment, t	3066	3963	5611	3795	7212	3957	3210	4566	4929	4290
Decline in production, $t-1$	.194	.718	.0647	.0956	.0765	.0632	.184	.109	.0765	.303
Decline in production, $t+1$	.194	.72	.0648	.0957	.0766	.0633	.184	.115	.0705	.304

Note: The table shows the share firms relative to the full sample which responded yes for the respective categories. *Employment*: Mean employment figure conditional on the response category, at the current quarter t. *Investment*: Mean aggregate firm investment, conditional on response category, in thousand NOK, quarterly figures at time t. *Decline in production*: Share of firms reporting that production declined last quarter, $t-1$ and firms reporting that production is expected to decline a year ahead, $t+1$.
The last column is figure for unconditional means

The results from the BTS are linked with Statistics Norway's Investment Survey, a survey of the firms' investments in the manufacturing industry. Matching those two surveys allows me to control for both the size and type of investment the firms' have done.

In Table 1, I present figures showing how firms that responded to Question 2. For each response category, the results show the proportion of firms that answer this was one of the reasons for my revise. To go deeper into the figures, I split the response frequencies by firm size and studying whether the investment level or the number of employees differ for the different categories. The survey shows that while 20 percent of small and middle-sized firms report that they revised down investment due to difficulties of accessing credit, only 12 percent of

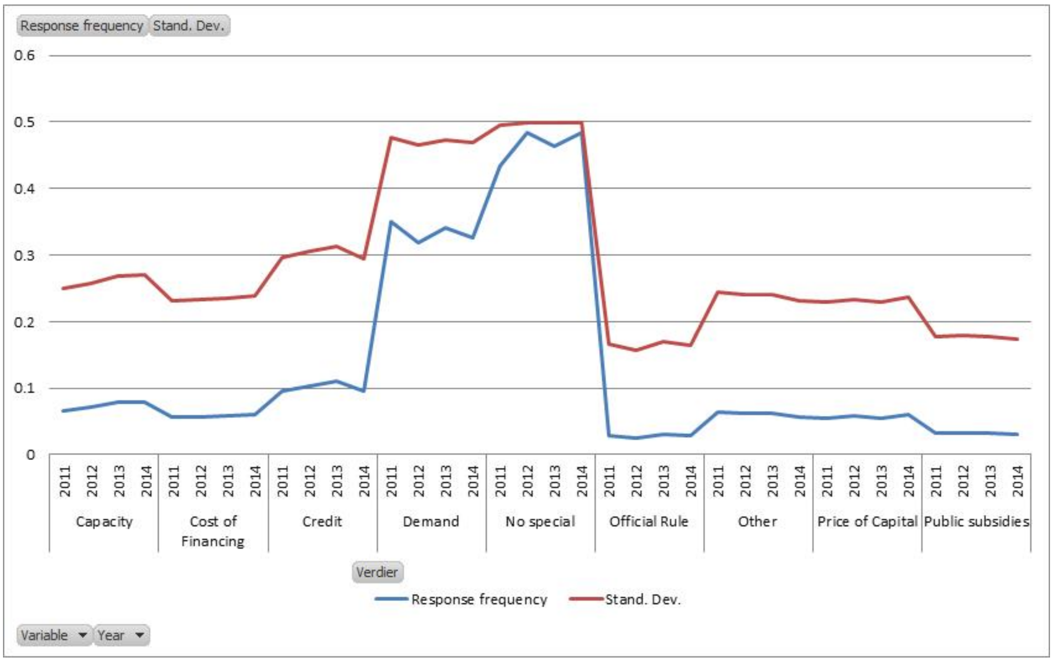

Figure 1: Factors explaining why the firms have revised down investments, average response and standard deviations. Quarterly responses are averaged over a year. In percent

large firms did so. Changes in expected demand are reported by 72 percent of the firms to be one of the reasons for revising down investment. There is a slightly overweight of large firms reporting that this was the cause. It is also interesting to note that firms that report that official regulations are constraining investments have, on average 20 percent higher investments than firms report that other factors are causing them to reduce investment plans.

The descriptive statistics of the sample population used in this analysis are summarized in Table 1 and 2. The correlation matrix reported in Table 3 shows that the firms' choices are somewhat correlated over time. A reason for this is that many firms chose not revise down their investments for long periods. That is as expected. I see that on average; nearly 8 percent of the firms are revising down their investments in any given quarter. Hence, it might be worth to take into account serial correlation when modeling the investment decisions. Figure 1 shows the mean response during the sample period. The average response for revising down investment plans, do not change much in this period.

The correlation matrix, shown in Tables 4 and 5, shows that the correlations between the independent variables are relatively small when it comes to factors explaining the investment plan revision. As one would expect, I find that firms' expectations about the key economic indicators are correlated with each other. Another way to interpret the correlation between the

Table 2: **Summary statistics for the responses to question 3 – given that the firms are revising down their investments. In percent**

Variable	Better	Unchanged	Worse
Q3a: Expected production	13.1	41.0	46.0
Q3b: Expected capacity	13.5	45.3	41.2
Q3c: Expected employ	4.7	41.9	53.5
Q3d: Expected home orders	13.2	46.5	43.4
Q3e: Expected foreign orders	14.2	46.5	38.5
Q3f: Expected total orders	15.3	36.7	47.8
Q3g: Expected home prices	11.0	62.9	26.0
Q3h: Expected input prices	28.8	59.4	11.7
Q3i: Expected foreign prices	10.5	57.5	31.1
Q3j: Expected profitability	14.6	34.3	51.1

Note: Question 3(Q3i) have discrete response: 1, 2, 53 where. 1: conditions expected to worsen, 2 is no expected change and 3 is expected to improve

responses is sthat the expectations are consistent. Meaning that firms that expect production to rise also expect capacity to decline.

Table 3: **Correlation matrix for the decision variable measured at different lags. Quarterly figures**

	$s=t$	$s=t-1$	$s=t-2$	$s=t-3$
$s=t$	1			
$s=t-1$	0.368	1		
$s=t-2$	0.261	0.363	1	
$s=t-3$	0.253	0.267	0.382	1

3.1 Benefits and disadvantages of studying a business survey

Investment equals the desired change in real capital, divided by delivery time. Thus, in order to analyze investment behavior empirically, one needs information about delivery times. It is not sufficient to know the desired change in real capital. Conventional data sources on investment figures, either aggregate or firm-level data, are by nature biased due to the delay from the time that the investment decision is taken to the investment is observed. The implementation delay

Table 4: **Correlation matrix for the factors that is causing the firms to revise down its investments**

	Access to credit	Expected demand	Price of capital	Cost of financing	Official regulations	Public subsidies	Expected capacity	Other reasons	No special reasons
Access to credit	1								
Expected demand	-0.114	1							
Price of capital	0.113	0.045	1						
Cost of financing	0.271	-0.074	0.199	1					
Official regulations	0.013	0.008	0.172	0.132	1				
Public subsidies	0.193	0.069	0.3	0.265	0.198	1			
Expected capacity	-0.079	0.07	-0.017	0.04	0.064	0.002	1		
Other reasons	-0.04	-0.285	-0.034	-0.033	-0.047	0.006	-0.068	1	
No special reasons	-0.141	-0.459	-0.076	-0.093	-0.083	-0.075	-0.136	-0.1	1

Table 5: **Correlation matrix for the firms' expectation about factors affecting their business trends**

	Expected production	Expected capacity	Expected employ	Expected home orders	Expected foreign prices	Expected total orders	Expected home prices	Expected input prices	Expected input prices
Expected production	1								
Expected capacity	0.793	1							
Expected employ	0.499	0.526	1						
Expected home orders	0.606	0.57	0.444	1					
Expected foreign orders	0.509	0.441	0.362	0.534	1				
Expected total orders	0.619	0.555	0.485	0.759	0.698	1			
Expected home prices	0.29	0.281	0.202	0.247	0.255	0.268	1		
Expected input prices	0.133	0.154	0.176	0.151	0.296	0.24	0.663	1	
Expected foreign prices	0.064	0.074	0.039	0.06	0.078	0.071	0.219	0.218	1

makes survey data particularly interesting when studying investment behavior. Specifically, let K^* denote the optimal capital level and K the actual capital level, then the firm's desired change in real capital is given by $I^* = K^* - K$, and the corresponding investment is given by $I = I^*/D$, where D is the delivery time (Haavelmo, 1960). If I^* is used instead of I this yields a measurement error. Thus, if D is large, then the discrepancy between I and I^* increases. The delivery time is probably affected by the business tendency in a procyclical manner. This introduces a procyclical wedge, making it more difficult to assess which factors are affecting real investments during the different facets of the business cycle. The BTS measures both changes in investment plans and its causes at the same time, and consequently, this type of measurement error associated with delivery time vanishes. In other words, using survey data makes it possible to link decisions about real investments and the factors driving the decisions without the bias that results when data from registers or national account are used to analyze investment patterns.

Apart from the issue of delivery time bias, there are both strengths and weaknesses associated with using survey data to answer behavioral questions. The advantage with surveys is that they make it possible to obtain information about intentions to act. They enable us to measure expectations and not only past events. Most importantly, surveys allow the researcher to collect information about variables not always available in conventional data sources. On the downside, survey answers may not always correspond to what choices would be in real choice settings. To reduce the measurement error in the BTS, Statistics Norway carefully motivates the respondents to answer truthfully, and help is offered to fill out the survey questionnaire when needed. It is, of course, important that the questionnaire is actually filled out by those close to the decision-making process. That is why the questionnaire is sent electronically to the managing director or the financial manager for each firm.

4 Empirical method

In this section, I develop the empirical model. I assume that firms make their investment decisions based on maximizing some objective function (utility). For many firms, this utility function is the net present value of future profit, but not always. For example, in Paper 1 it is shown using business survey data, that for firms in the manufacturing industry 3/4 report that maximizing profit is only one of the motives for the owners. This evidence indicates that the assumption of firms being profit maximizers may be too restrictive. In my case, I do not observe

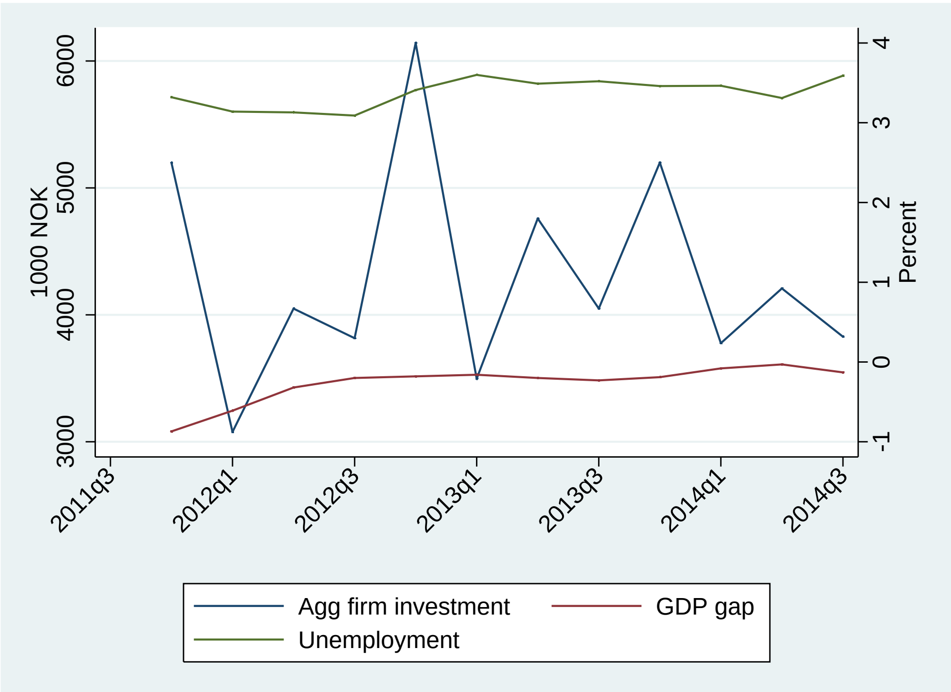

Figure 2: Macro economic data. Investments are aggregated firm investments from the Statistics Norway Investment statistics, in 1000 NOK. The unemployment rate is from the Labour force survey, in percent (right axis). The GDP gap estimated using National account figures in 2012-prices, with HP-filter of 20 000 on data including Statistics Norway's official forecasts for the 5 years following last observation (right axis).

profits and the empirical model will hold true whether or not a given firm maximizes the net present value of future profits or, alternatively, maximizes a more general utility function that allows the firm to account for other factors when making investment decisions. However, in the following, I shall discuss the model by referring to the net present value of future profits (NPV) as the firms' utility function, but it is understood that the arguments and model will hold for more general utility functions.

When investment decisions taken by the firm are carried out in order to increase the net present value of future profits (NPV), the firm's decision whether to revise the investment plan or not depends fully on whether a change in the investment schedule increases the NPV of future profits. This implies that when firms revise down their investments, this is done in order to increase the NPV of future profits.

Let π_{it0} denote the NPV of firm i in year t given that investment is realized according to plans and similarly let π_{it1} be the NPV of firm i in year t given that investment is cut. Let $Y_{it} = 1$ if $\pi_{it1} - \pi_{it0} > 0$ and $Y_{it} = 0$ if $\pi_{it1} - \pi_{it0} < 0$. The values $\pi_{itj},\ j = 0,1$, are latent variables to the researcher, who only observes Y_{it}. Assume that

$$\text{(4)} \qquad \pi_{it1} - \pi_{it0} = V(\xi_{it} + \varepsilon_{it})$$

where $V(\cdot)$ is known apart from a set of unknown parameters (specified by the researcher), ξ_{it} is a vector of observed explanatory variables, and ε_{it} is an error term that represents the effect of unobserved variables. The term ε_{it} is supposed to capture the effect on $\pi_{it1} - \pi_{it0}$ from variables that are perfectly known to the firm as well as factors that are uncertain to the firm and vary over time in a manner that is unpredictable to the firm. Specifically, in the first paper it is shown that a large portion of firms in the manufacturing industry does not apply traditional investment decision methods. Instead, they rely heavily on intuition when making investment decisions. The factors affecting intuition are typically changing over time, such that a decision taken a quarter ago may be considered not optimal when the investment decision is up for revision. The model in (4) is not a full structural model because it does not include the possible effect of past realizations of investments on the current investment decision. The reason for this is that it is very hard to identify the effect of previous values of the dependent variable on the current realization (state dependence). In general, one cannot separate the effect of state dependence from unobserved heterogeneity without additional theoretical arguments which often may be ad hoc and therefore controversial. See Heckman (1981, 1991) for a discussion of this issue in particular cases. The model in (4) is, in this sense, a reduced form model.

The error term ε_{it} will also capture errors in the specification of the functional form of $V(\cdot)$. The variables that enter the vector ξ_{it} consists of choice variables such as access to credit and expected demand (x_{it}), firm-specific variables (z_{it}), such as number of employees, investment level and sales, and aggregated figures (y_t) such as employment conditions and aggregated demand. In order to obtain a model that one may estimate empirically, further assumptions are needed. The error term ε_{it} is perceived as a random variable that is assumed to be independent of the systematic term $V(\xi_{it})$. The error terms may be serially correlated. I formulate and estimate three model versions. The first two versions differ only with respect to the assumptions about the error term process (as a stochastic process in time), ε_{it}. In the first model (LogitFE) I assume a particular permanent-transitory error structure, namely

$$(5) \qquad \varepsilon_{it} = \eta_i + u_{it}$$

where η_i is a fixed effect that captures the effect on investment of unobserved variables that are firm specific and do not change over time whereas u_{it} are serially uncorrelated random variables, with standard logistic c.d.f. that is independent of η_i. It represents the effect on investment of unobserved variables that vary over time. When the distribution of the fixed effects across the population is accounted for it follows that the unconditional autocorrelation function of the error term in the LogitFE model equals

$$(6) \qquad Corr(\varepsilon_{it}, \varepsilon_{it-k}) = \frac{3Var(\eta_i)}{\pi^2 + 3Var(\eta_i)}$$

In the second model (LogitNRE) it is assumed that:

$$(7) \qquad \varepsilon_{it} = \eta_i i + u_{it}$$

where η_i is a random effect that is assumed to be normally distributed across firms, whereas u_{it} have the same properties as above. The autocorrelation function in the LogitNRE is thus the same as for the LogitFE given in (6). The third model is also a random effect Logit model but in contrast to the second model the random effects are distributed according to the following p.d.f.:

$$(8) \qquad f_\alpha(z) = \frac{1}{\alpha\pi} \frac{\sin(\alpha\pi)}{e^{\alpha z} + e^{-\alpha z} + 2\cos(\alpha z)}$$

where α is a parameter, and $0 < \alpha \leq 1$, that has an interpretation as:

$$(9) \qquad \alpha = \frac{1}{\sqrt{3Var(\eta_i)/\pi}}$$

The p.d.f. given in (8) is symmetric around zero but differs somewhat from the normal density in that it has heavier tails than the normal one. A great advantage with the distribution given in (8) is that it implies that:

$$(10) \quad E_{\eta_i}\left(\frac{1}{1+\exp(-V(\xi_{it}-\eta_i)}\right) = E_{\eta_i}\left(\frac{1}{1+\exp(-\alpha V(\xi_{it}}\right)$$

where the expectation is taken with respect to the random effect. The property in (10) is proved by Dagsvik et al. (2016). I shall call the first model the Fixed Effect Logit model (LogitFE), the second model the Normal Random Effect Logit model (LogitNRE) and the third model the Invariant Random Effect Logit model (LogitIRE). The relation in (10) implies that the unconditional Invariant LogitRE model also has the logit functional form at any given point in time. The LogitRE model is more restrictive than the LogitFE model because random effects are assumed to be distributed across firms according to specific distributions whereas there are no restrictions on the distribution of the fixed effects across firms in the LogitFE model. Another advantage with the logitFE is that the fixed effects are allowed to be correlated with the observed vector of covariates in contrast to the second model version where the random effects are assumed independent of ξ_{it}.

Let $F(\cdot)$ denote the logistic c.d.f. of $-u_{it}$. From the above assumptions it follows that in the LogitFE model

$$(11) \quad \Pr(\xi_{it},\varepsilon it) = \Pr(Y_{it}=1|\xi_{it},\varepsilon_{it}) = \Pr(V(\xi_{it})+\eta_i+u_{it}>0|\xi_{it},\eta_i) = F(V(\xi_{it}+\varepsilon_{it})$$

where the interpretation of $\Pr(\xi_{it},\varepsilon it)$ is as the probability that firm i shall revise down the investment in year t, given $(\xi_{it},\varepsilon it)$.

Unfortunately, the usual maximum likelihood method for the LogitFE yields inconsistent estimates. This is known as the incidental parameter problem, Neyman and Scott (1948). However, the conditional likelihood method can be applied to obtain consistent estimates of the parameters of (Chamberlain, 1980), but it is not straightforward finding the fixed effects using this method. An alternative method to obtain bias-corrected estimates of the fixed effects is using a maximum likelihood method proposed by Hahn and Newey (2004) that is known as the analytical bias correction. In order to estimate the fixed effect model, I use Stata with the logitfe package, Cruz-Gonzales et al. (2016) which utilize the analytical bias correction method for a two-way error component model.

Since the length of the panel is somewhat short, about eight quarters on average, it is common to compute standard errors of $\hat{\eta}_i$ by the bootstrap method. However, these bootstrap estimates might be biased since they rely on possible biased estimated standard errors of the fixed effect due to the short panel. Stamman et al. (2017) show that using the analytical bias correction the distortions of the estimated standard deviation for the estimated parameters is reduced and negligible when the number of time periods is eight or larger.

The corresponding conditional probability for LogitNRE and LogitIRE are similar to the model in (11), namely

$$(12) \quad \Pr(\xi_{it}, v_i) = F(V(\xi_{it}) + v_i)$$

The LogitNRE and the LogitIRE can be estimated by the maximum likelihood method. STATA contains a maximum likelihood package for the estimation of LogitNRE. The LogitIRE can be estimated by a version of simulated maximum likelihood procedure, as done by Dagsvik et al. (2016). But one can also apply the generalized estimating equations (GEE) estimation approach. In this paper, I have used the maximum likelihood method to estimate the LogitNRE model and the GEE approach to estimate the LogitIRE model. In order to use the GEE approach one needs to make convenient assumptions about the autocovariances

$$(13) \quad Cov(Y_{it}, Y_{is}) = \Pr(Y_{it} = 1, Y_{is} = 1 | \xi_{it}, v_i) - \Pr(Y_{it} = 1 | \xi_{it}) \Pr(Y_{is} = 1 | \xi_{it})$$

In the logitIRE it is assumed that

$$(14) \quad Cov(Y_{it}, Y_{is}) = \rho^{t-s} \sqrt{Var(Y_{it}, Y_{is})} = \rho^{t-s} \sqrt{P_{it}(1 - P_{it}) P_{is}(1 - P_{is})}$$

where $P_{is} = \Pr(Y_{is} = 1)$. Which mean that

$$(15) \quad Corr(Y_{it}, Y_{is}) = \rho^{t-s},$$

where ρ is an unknown positive parameter that is less than one. The assumption in (15) is, however, not equal to the true autocorrelation function. Still, the GEE method still yields consistent estimates.

4.1 Average partial effects

In linear models the partial effects are simply the coefficients associated with the respective explanatory variables. In nonlinear models this is not so. Assume that $V(\xi_{it}) = x_{it}\beta + z_{it}\gamma + y_{it}\psi$ where x_{it}, z_{it} and y_{it} are the explanatory variables. It follows from (11) that the average partial effect for the LogitFE model with respect to x_{it} in year t is given by

$$(16) \quad \frac{1}{N}\sum_{i=0}^{N} \frac{\partial \Pr(\xi_{it})}{\partial x_{it}} = \frac{1}{N}\sum_{i=1}^{N} \beta F\left(x_{it}\beta + z_{it}\gamma + y_{it}\psi + \eta_i\right)\left(1 - F\left(x_{it}\beta + z_{it}\gamma + y_{it}\psi + \eta_i\right)\right)$$

Similarly for the average partial effect with respect to the other explanatory variables. Similarly, the corresponding aggregate partial effect (in year t) for the logit random effect models is given by

$$\frac{1}{N}\sum_{i=1}^{N}\frac{\partial \Pr(\xi_{it})}{\partial x_{it}} = \frac{1}{N}\sum_{i=1}^{N}\beta E\left[F\left(x_{it}\beta+z_{it}\gamma+y_{it}\psi+v_i\right)\left(1-F\left(x_{it}\beta+z_{it}\gamma+y_{it}\psi+v_i\right)\right)\right] \tag{17}$$

where E is the expectation with respect to v_i.

5 Empirical findings

The approach taken by this paper has similarities to the approach of Österholm (2013), but I apply firm-level data instead of aggregate data. Firm data contain considerably more information than aggregate ones, and using firm data makes it possible to link the survey results with other survey data as well as register data. However, in contrast to Vermeulen and Fuss (2008) who also uses firm-level data, I analyze the impact of factors supposed to explain the firms' revision of investment plans.

Recall that the vector of firm-specific choice variables, x_{it}, consists of Access to credit, Expected demand, Price of capital, Cost of financing, Official regulations, Public subsidies, Expected capacity, Other reasons, No special reasons. The vector z_{it} contains firm-specific variables such as registered investments, firm size, industry and y_{it} is a vector of aggregate macro variables, such as the production gap and unemployment rate. To study whether there are any differences in factor composition and export intensities I divide the manufacturing industry into 5 sub-industries. The differences between industries were found to be small and did not affect the parameter estimates of the explanatory variables and because of that they are left out from the empirical model.

The benchmark models estimate the probability of revising down investment without taking into account any firm-specific information or macro variables. The estimated coefficients are shown in Table 6, with average partial effects found i Table 7. Note that Table 6 reports estimates of the coefficients of $V(\xi_{it})$ for the LogitFE and the LogitNRE, whereas for the logitIRE model the table reports estimates for $\alpha V(\xi_{it})$, where one recall that α might be less than one. Since I have not used a full information maximum likelihood procedure, I cannot obtain estimates of α. However, the estimates of the variance of the random effects in LogitNRE and of the variance in the distribution of the fixed effects in LogitFE indicate that these variances are small compared to 1. Therefore the order of magnitude of the variance of random effects

Table 6: Factors causing a downward revise of investment plans

	(1) LogitFE	(2) LogitNRE	(3) LogitIRE
Access to credit	0.546	0.531	0.635
	(0.217)	(0.179)	(0.172)
Expected demand	1.040	0.972	1.243
	(0.177)	(0.164)	(0.159)
Price of capital goods	0.103	-0.065	-0.068
	(0.266)	(0.229)	(0.219)
Financing costs	0.272	0.397	0.214
	(0.234)	(0.208)	(0.237)
Official regulations	0.260	0.330	0.550
	(0.312)	(0.249)	(0.264)
Public subsidies	-0.146	0.040	-0.134
	(0.299)	(0.296)	(0.276)
Expected capacity	0.522	0.533	0.643
	(0.188)	(0.191)	(0.177)
Other reasons	0.504	0.872	0.887
	(0.242)	(0.220)	(0.232)
No special reasons	-1.217	-1.294	-1.640
	(0.256)	(0.252)	(0.253)
Constant		-2.306	-3.123
		(0.231)	(0.301)
Time dummies	✓	✓	
Fixed effects	✓		
Firm size dummies	✓	✓	
Industry dummies	✓	✓	✓
AR(1) coefficient		0.33	
Log likelihood	-1072.4	.	-1697.0
No. firms	277	517	900
N	2609	4812	7960
Wald test ($\chi 2$)	755.6	159.3	437.1

a Dependent variable: *Did your firm revise down your investment plan this quarter?* .

b) Standard errors of the random effects model calculated using 200 bootstrap estimations.

c) The Hausman-test rejects the null [p-value = 0.00] that the coefficients of the fixed effect and the random effect are similar, hence I use FE in the rest of the paper.

d) The sample size varies because the LogitFE and the LogitIRE are no able to fully utilize the full sample because lack of variation in data within each firm. The appendix table 12 show results from a model using the same sample on all models. Significance levels: * $p < 0.1$, ** $p < 0.5$, *** $p < 0.01$

Table 7: Factors causing a downward revise of investment plans. Average partial effects

	(1) LogitFE	(2) LogitNRE	(3) LogitIRE
Access to credit	0.039	0.039	0.034
Expected demand	0.069	0.072	0.066
Price of capital	0.007	-0.005	-0.004
Cost of financing	0.019	0.029	0.011
Official regulations	0.018	0.024	0.029
Public subsidies	-0.009	0.003	-0.007
Expected capacity	0.037	0.039	0.034
Other reasons	0.036	0.064	0.047
No special reasons	-0.070	-0.095	-0.087

Note: Average marginal effects, evaluated using logitfe package for the FE model, and STATA's margins, dydx(*) for the LogitIRE model.

in LogitIRE is small compared to 1. The mean of the estimated fixed effects is -1.228, and the variance is 1.104, while the random effects model has a variance of 1.762. Hence, by using formula (9) I conclude that α is close to 1. In the Appendix, I also report results from the estimation of the linear probability model (LPM), see Appendix table 13. Regardless of which model that is chosen, the firms' demand expectation is found to be the most important factor in explaining why the investment plans are revised down. Specifically, the results using the LPM demonstrate the effect of ignoring the non-linear properties of the data, since the estimated parameters are nearly twice as large as for the non-linear model. It is further worth to note that the average partial effect is nearly identical for the three models, thus proving the robustness of the empirical results. To study how the fixed effect depends on the structural part of the model, I estimate a model for the fixed effects with the average response for each variable. The results, shown in Table 11 of the appendix, indicate that the fixed effects are nearly independent of the structural part of the model.

The firm's access to credit is found to be less important than changes in firms' demand expectations. Still, firms' access to credit is crucial for understanding why investment plans are revised down. The average partial effects reported in Table 7, show that a change in the demand expectations changes the probability for firms revising down investments with 7 percentage points, while the marginal effects of a change in the credit conditions are about 4 percentage points. Less surprising is the positive effect of excess capacity, where the effect of changes in

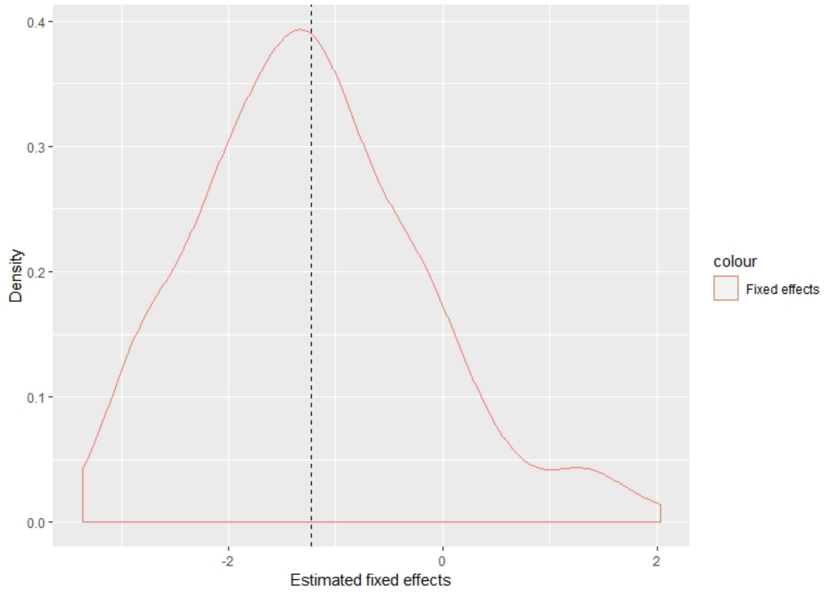

Figure 3: Density plot for the fixed effects of the LogitFE model

the firms' expectations about its capacity is of the same order as for credit conditions. Because capacity utilization and demand expectations might capture the same elements, I test for the presence of any interaction terms in the empirical specification. The interaction term is close to zero and insignificant and is not reported in the table. A reasonable explanation is that excess capacity is lagging demand expectations. Hence it is not necessary the same firm that reports that excess capacity and demand expectations are one of their reasons for revising down investments. This view is also supported by the results from the correlation matrix, Table 4. As shown, the expected capacity is barely correlated with demand expectations. It is indicating that weaker demand does not necessarily imply excess capacity.

Other reasons, unclear which, are also important for explaining the revision. As is "No special" reasons, which probably include increased general uncertainty or just a change in the manager's "gut feeling". I find it extremely interesting that firms are changing investment plans for no particular reason.

As discussed above the Q-model of Tobin (1969) argues that investments will increase when the value of an additional unit of capital is larger than the cost of installing the same unit of capital. The estimations result in Table 6 show that in contrast to the implications of the Q-model – there is no short-run effect of a decrease in the cost of capital on the investment plan. The investment Euler equation highlights that firms emphasize the relative gain of investing in period t relative to period $t+1$. To compare the gain between the two periods, the discount rate, which equals the financing costs plus the project-specific risk premium, plays a crucial role in the theoretical model. The empirical analysis shows that changes in the financing costs do not affect their decision of changing investment plans in the short run in the LogitFE and LogitNRE model, while the LogitIRE estimates a moderately positive effect on the probability of reducing investments. It might not be surprising that the effect of changes in the funding cost is uncertain, given that there are relatively rarely any unexpected changes in financing costs from one quarter to the other. However, this result is also consistent with the findings in Paper 1. Here, I find that an overwhelming share of firms that neither calculate the project risk nor consider it when doing investment budgeting. This also shows that it is access to external financing that is important, not the cost. If the funding cost is set accurately by the market, it should reflect the return and risk of the investment project. Hence it is already taken into account when calculating the return on investment. Changes in the price of capital are found not to affect the probability of revising down investments. This means that a change in the price of capital has zero effect on the firm's decision to revise down its investments. This might seem like a puzzling result, but is in line with what has been found in the empirical analysis based on time series data, Chirinko et al. (1999). An apparent reason for the lack of empirical evidence is that there are few episodes of sudden changes in the price of investment goods, hence making identification of any price effects difficult. Another reason is that the price of intermediate goods is priced according to the firms' willingness to pay for those goods.

The invariant random effect and the fixed effect model do not fully utilize the data compared to the normal random effect model. The fixed effect model uses only within variation and hence leaves out all individuals without such variation. One of the strengths of the NRE is that this model utilizes more data than the FE model. The invariant random effect model uses the between variation to calculate the parameters as the NRE, but in order to estimate the autoregressive correlation structure, the model needs at least three observations. This implies that the sample size differs between the three models unless the sample is reduced in size to match both the criteria from the FE and the IRE model. To test how the different models utilize the data, I estimate the NRE and the IRE on the same sample as for the FE model. Not surprising this reduces the difference of the estimated effects of access to credit and expected demand, for the NRE and the FE, while there is not much change in the estimates for the IRE model. To sum up: Some of the differences in the model results are driven by the fact that the NRE model exploits more data than the other models. Particularly, this includes data from firms whose observations are only present at the start or the end of the sample. Table A6 in the appendix summarizes the results.

Taking into consideration that macroeconomic conditions might affect the investment decision, I add macroeconomic controls such as the unemployment rate and the estimated GDP-gap. The estimated coefficients do not change significantly, when macro variables are added as explanatory variables. Table 8 shows the results of models with extended controls. Extending the model further with the inclusion of firm-specific data, matched by the help of accounting statistics, I find only a small effect of the size of the firms' investments. This is not surprising given that most firms have zero investments in a given quarter.

To see if the businesses with a different investment level are affected differently, I estimate the benchmark model including firm investment, both a model with aggregated firm investment, model (3), and a model with only machine investments, model (4), both models reported in Table 8. I find that both models give an estimated effect of production expectations are somewhat stronger while the estimated effect of liquidity constraints are moderated relative to models without controlling for firms' investment level.

To study whether firms with high investment rates report differently, I estimate the model, including only firms with above-average high investment levels, model (5) in Table 7. I calculate the average investment level for any given quarter and keep only observations with investments above average – this analysis results in two observations. First, the effect of expected capacity on firms' probability of revising down investments is nearly halved and insignificant, and I find that credit conditions have a stronger effect on investments relative to the effect of demand expectations. This indicates that firms with large investment projects are more vulnerable to changes in credit conditions than firms with smaller projects. If smaller projects are more often financed with internal funds, then this result is, as I would expect.

Macroeconomic events such as changes in exchange rates or aggregate demand affect firms differently, depending on several factors, such which industry the firm operates in. Export driven industries respond positively to reduce inland pressure and a depreciation of the exchange rate, while industries with their product-market at home benefit from higher consumer demand and increased public spending. For instance, do the capital intensive part of the food industry in Norway has a relatively smaller export share in comparison to the raw material industry, which exports most of its production. To tackle that the various industries respond differently to macroeconomic shock, I include interactions of the GDP gap with industry dum-

Table 8: Factors causing a downward revise of investment plans

VARIABLES	(1) LogitFE	(2) LogitFE	(3) LogitFE	(4) LogitFE	(5) LogitFE
Access to credit	0.544	0.544	0.426	0.424	0.875
	-0.216	-0.216	-0.247	-0.247	-0.396
Expected demand	1.039	1.039	1.133	1.132	0.759
	-0.177	-0.177	-0.202	-0.202	-0.326
Price of capital	0.104	0.104	0.207	0.206	-0.249
	-0.266	-0.266	-0.303	-0.303	-0.475
Cost of financing	0.272	0.272	0.529	0.529	-0.063
	-0.234	-0.234	-0.268	-0.268	-0.455
Official regulations	0.26	0.26	0.143	0.141	0.591
	-0.312	-0.312	-0.37	-0.37	-0.548
Public subsidies	-0.147	-0.147	-0.102	-0.1	-0.317
	-0.299	-0.299	-0.328	-0.328	-0.608
Expected capacity	0.522	0.522	0.508	0.508	0.157
	-0.188	-0.188	-0.209	-0.209	-0.376
Other reasons	0.504	0.504	0.458	0.456	0.17
	-0.242	-0.242	-0.272	-0.272	-0.418
No special reasons	-1.217	-1.217	-1.352	-1.351	-1.387
	-0.256	-0.256	-0.307	-0.307	-0.445
GDP gap		-0.515	-0.642	-0.645	
		-0.362	-0.41	-0.409	
Firm agg. Investment			0.0000035		
			-0.0000075		
Firm machine investment				0.0000028	
				-0.0000084	
Time dummies	✓	✓	✓	✓	✓
Firms with investments > mean	.	.	.	.	Yes
Observations	2609	2609	2050	2050	833
No. firms	277	277	211	211	110
Log likelihood	-1072.4	-1072.4	-828.3	-828.3	-348.5

a Dependent variable: *Did your firm revise down your investment plan this quarter?* .

b) Standard errors of the random effects model calculated using 200 bootstrap estimations.

c) Modeled using a logit model with fixed effects (1)-(5).

d) In the model (5) only firms with reported investment above average is included. Significance levels: * $p < 0.1$, ** $p < 0.5$, *** $p < 0.01$

mies for the random effect specification. Including this interaction, the term is found to affect the results and hence is not reported barely. This shows that macroeconomic shocks are not important for explaining differences between industries.

5.1 Using firms' expectations to forecast investments

The Business tendency survey includes a large set of complementary questions in addition to the questions about the dynamics of the investment analyzed above. The Business tendency survey asks firms how the firm expects important economic conditions to develop. The firms are asked about their expectations on how nine key variables are expected to evolve during the coming quarter relative to the situation today. They may answer: Better, Unchanged, Worse. To analyze whether firms answer consistently and if using different data will give new insight relative to studying what the firms' express are their reasons for revising the investment plan. I will, therefore, model the probability of revising down investments using the firms' expectations as explanatory variables. In contrast to the empirical models in the first part of the paper, I now have an ordinal response. There is no reason to assume that the effect of a change in expectations is linear in the explanatory variables. Because of this, I estimate a model where I have translated the variables to binary variables: One variable for expectations about better conditions and one for worse conditions, with no changes in expectations as a base. Of course, this increases the number of explanatory variables, but it also has the benefit of simplifying the interpretation. I employ the same empirical methods as above, namely a Fixed Effect Logit model, an Invariant Random Effect Logit model and the Normal Random Effect Logit model. The empirical results are shown in Table 9 and Table 10.

The empirical findings support the results from the benchmark model studied above. I find that an expectation of higher production still is one of the most important factors for explaining a decline in the investment plan. The average partial effect of an expected rise in production is estimated to be -0.022, while the effect of an expected worsening in the production is 0.036.

While excess capacity is reported to be important for firms revising down investments in the first analysis, I do not find an effect of the capacity variable on its probability of reducing its investment plan when studying firms' expectations. This may be due to the higher correlation between expected production and excess capacity, see Table 5. To investigate this further, I estimate a model where I include interaction effects. This changes the results slightly. There is still a positive effect of an expected decline in production, but there are no effects of an

Table 9: How expectations affects firms' probability of revising down it investments

VARIABLES	Logit FE	Logit IRE	Logit NRE
Increase in production	-0.344	-0.254	-0.496
	-0.274	-0.236	-0.261
Decrease in production	0.489	0.539	0.534
	-0.237	-0.212	-0.224
Increase in capacity utilization	0.121	0.215	0.323
	-0.266	-0.211	-0.253
Decrease in expected utilization	-0.18	-0.439	-0.109
	-0.241	-0.199	-0.247
Increase in employment	-0.617	-0.599	-0.566
	-0.266	-0.242	-0.274
Decrease in employment	1.03	0.957	1.302
	-0.154	-0.154	-0.147
Increase in home orders	-0.005	0.045	-0.148
	-0.251	-0.241	-0.207
Decrease in home orders	-0.031	-0.107	0.006
	-0.211	-0.216	-0.227
Increase in foreign orders	-0.145	0.079	0.096
	-0.243	-0.225	-0.218
Decrease in foreign orders	-0.094	0.392	0.137
	-0.203	-0.192	-0.201
Increase in total orders	0.201	0.089	0.144
	-0.268	-0.261	-0.255
Decrease in total orders	0.049	0.022	0.062
	-0.221	-0.204	-0.205
Increase in home prices	-0.195	-0.324	-0.539
	-0.222	-0.213	-0.202
Decrease in home prices	0.412	0.434	0.511
	-0.205	-0.212	-0.227
Increase in input prices	-0.127	0.07	0.082
	-0.256	-0.3	-0.26
Decrease in input prices	0.027	0.243	0.298
	-0.206	-0.183	-0.192
Increase in foreign prices	0.089	0.243	0.268
	(0.153	-0.145	-0.139
Decrease in foreign prices	0.408	0.318	0.561
	-0.244	-0.209	-0.242
Observations	2609	4812	7690
Industry dummies	.	.	.
Time dummies	✓	✓	✓
Firm size dummies	.	Yes	Yes
Fixed effect	Yes	.	.
AR(1) coefficient	.	0.33	.
Log likelihood	-1117.7	.	-1759.5
Regressors	29	31	31
Wald test ($\chi 2$)	179	159.3	363.2
Number of firms/groups	277	517	900

a Dependent variable: *Did your firm revise down your investment plan this quarter?*

b) Estimated using a random effect panel data model. Robust standard errors, clustered at firm level.

c) Modeled using a logit model

d) Significance levels: * $p < 0.1$, ** $p < 0.5$, *** $p < 0.01$

expected increase in production alone. However, if firms expect a decline in production and at the same time increasing capacity utilization; this has a strong effect on the probability of a downward revision in their investment plan for the coming quarter. I find an estimated average partial effect of 0.15.

Table 10: How expectations affects firms' probability of revising down it investments, Average partial effects

VARIABLES	Logit FE	LogitIRE	LogitNRE
Increase in expected production	-0.022447	-0.019196	-0.027571
Decrease in expected production	0.0358016	0.0407126	0.0296527
Increase in expected capacity	0.0083328	0.0162256	0.0179137
Decrease in expected capacity	-0.01182	-0.033184	-0.006048
Increase in expected employment	-0.037201	-0.045279	-0.031438
Decrease in expected employment	0.0812915	0.0723123	0.0723169
Increase in expected home orders	-0.00036	0.0033979	-0.008193
Decrease in expected home orders	-0.002096	-0.008051	0.0003482
Increase in expected foreign orders	-0.009611	0.0059534	0.0053265
Decrease in expected foreign orders	-0.00625	0.0296367	0.0076191
Increase in expected total orders	0.0138992	0.0067263	0.0079993
Decrease in expected total orders	0.0033651	0.0016819	0.0034274
Increase in expected home prices	-0.012829	-0.024518	-0.029923
Decrease in expected home prices	0.0303774	0.0328251	0.0283568
Increase in expected input prices	-0.008408	0.0052684	0.0045469
Decrease in expected input prices	0.0018497	0.0183985	0.0165747
Increase in expected foreign prices	0.0060827	0.0183661	0.0149029
Decrease in expected foreign prices	0.0301253	0.0240097	0.0311626

Lower home prices both contribute to reduced profitability and hence not surprisingly, those factors raise the likelihood of the firm revising down investments. The finding that an implicit reduction of firms' expected profitability increases the probability of lowering investments is in line with standard investment models. The estimations also show that the expectations about the firms' changes in employment are essential for predicting short run investments. It is a strong predictor, and if the firm expects employment to decline. I find that the probability of a downward revise is high, with an estimated average partial effect of 0.08. This implies that the effect of reduced labor costs due to a shift towards higher capital spending is more than offset by the employment effect following a reduction in production. In other words, there is a procyclical co-movement of changes in labor and capital goods.

Controlling for the business cycle effects by introducing the unemployment rate or the GDP gap does not affect the size of the estimated coefficients. Hence I do not report those results.

Indicating that the factors affecting investments do not change in my sample when the labor or product market changes. A relevant critique is that small variation in both markets during the sample period weakens the possibility of identifying this effect.

6 Summary

This paper has identified which factors affect investment behavior in the short run and the relative strength of those factors. By applying data from a business tendency survey, I have shown that firms' investment plans are being postponed or lowered due to a reduction of demand or further liquidity constraints. Traditional investment models discussed in this paper highlight the user cost of capital as an important factor, but this paper does not find empirical evidence in favor of this.

The main finding is that a demand shock increases the probability of a reduction in firm-level investment by 7 percentage points, whereas a shock in credit constraints increases the probability of a reduction in the firm investment by 4 percentage points. The effect of changes in the capacity has about the same effect as changes in credit constraints. This result is backed up by analyzing the effect of the firms' expectations and their probability of revising down investments. Furthermore, the study shows that firms' expectation on its employment level is also a strong predictor for reduced investment level.

I do not find significant effects of other explanatory variables on the firms' probability of revising down its investments. Neither a change in the price of capital goods, the level of interest rate nor public subsidies have a significant impact on the probability of firms revising down its investment level in the coming quarter.

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A Appendix

In order to study whereas the fixed effects are dependent of the structural part of the model I estimate the relationship between the mean of the explanatory variables and the fixed effect:

$$\eta_i = \alpha + \beta \overline{X_i} + \varepsilon_i, \tag{18}$$

where $X_i = \frac{1}{T}\sum_{t=1}^{T} X_{i,t}$ and ε_i is an IID error term. The empirical model is estimated with ordinary least squares (OLS) using R. The results are reported in table 11.

The random effect and the fixed effect model utilizes the variation in data to identify the effects of changes in the explanatory variables differently. When there are missing values in the data sample this have consequences for which observations that are included in the estimation of the models. The fixed effect model (logitFE) will leave out all firms which have no variation in the endogenous variable, while the random effect model with autocorrolated errors (LogitIRE), will leave out all firms with less than three observations. To study how the differences in data sample affects the estimated models I create a test sample where I include only observations where there are variation in the endogenous variable and the firm is observed at least in three time periods (without gaps). Table 12 summarizes the results.

To investigate whether the dynamics of a panel data contribute to identification of the investment decision I apply several models. Table 14 show results for both the standard linear specification, a logit model and the GMM approaches as discussed in section 4 . The first column shows the result of the linear probability model (GLS) specified without the lagged dependent variable and serve as the baseline case. The baseline GLS specification shows as

Table 11: Effects of the explanatory variables on the estimated fixed effect

VARIABLES	OLS
Access to credit	0.087
	(0.324)
Expected demand	-0.452
	(0.355)
Price of capital	-1.411
	(0.548)
Cost of financing	-0.556
	(0.523)
Official regulations	-0.026
	(0.545)
Public subsidies	0.729
	(0.574)
Expected capacity	0.633
	(0.379)
Other reasons	-0.084
	(0.460)
No special reasons	0.727
	(0.426)
Constant	-1.211
	(0.344)
Observations	274
Adjusted R^2	0.101
F-test, p-value (df 9)	0.000

Table 12: Factors causing a downward revise of investment plans. Estimated coefficients of the benchmark models, 2011q3-2014q3. Sample sized reduced when modeling the LogitIRE and LogitNRE to compere the regression when differences in the sample is reduced

VARIABLES	LogitFE	LogitIRE	LogitNRE
Access to credit	0.546	0.467	0.511
	(-0.217)	(0.174)	(0.146)
Expected demand	1.04	0.947	0.994
	(-0.177)	(0.174)	(0.146)
Price of capital goods	0.103	0.175	-0.157
	(-0.266)	(0.269)	(0.223)
Financing costs	0.272	0.566	0.148
	(-0.234)	(0.236)	(0.197)
Official regulations	0.26	0.038	0.262
	(-0.312)	(0.312)	(0.248)
Public subsidies	-0.146	-0.192	-0.070
	(-0.299)	(0.283)	(0.243)
Expected capacity	0.522	0.453	0.634
	(-0.188)	(0.174)	(0.154)
Other reasons	0.504	0.711	0.545
	(-0.242)	(0.229)	(0.195)
No special reasons	-1.217	-1.121	-1.205
	(-0.256)	(0.262)	(0.214)
Constant		-1.082	-1.180
	(0.275)	(0.231)	
$\text{Chi}^2(22)$	755.6	162.6	239.1

Table 13: Effects of the explanatory variables on the estimated fixed effect estimated with a linear probability model (LPM)

VARIABLES	LPM, FE
Access to credit	0.0617
	(0.0188)
Expected demand	0.1107
	(0.0144)
Price of capital	0.0042
	(0.0187)
Financing costs	0.0271
	(0.0206)
Official regulations	0.0332
	(0.0321)
Public subsidies	-0.0135
	(0.0299)
Expected capacity	0.0629
	(0.0186)
Other reasons	0.0748
	(0.0250)
No special reasons	-0.0120
	(0.0126)
Observations	7,690
Time dummies	✓
Firm size dummies	.
Fixed effect	✓
Log likelihood	0.0963
Degrees of freedom	22
Chi^2	183.8
Number of firms	900

the logit specification that 'expected demand' and 'excess capacity' together with 'access to credit' and 'other reasons' explain why firms revise down its investments. Adding the lagged dependent variable to the GLS and logit specification does increase the estimated coefficients for 'access to credit' and 'excess capacity' with nearly 50 percent. While the effect of 'expected demand' is unchanged.

Table 14: Dynamic panel data model: Factors causing a downward revise in investment plans.

	GLS		Conditional logit		Difference GMM		System GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L1. dependent var		0.0866***		0.399***	0.167***	0.162***	0.160***	0.153***
		(0.0233)		(0.129)	(0.0319)	(0.0340)	(0.0315)	(0.0321)
Access to credit	0.0513***	0.0555***	0.563***	0.652***	0.0892***	0.103***	0.0871***	0.0998***
	(0.0162)	(0.0173)	(0.197)	(0.186)	(0.0230)	(0.0246)	(0.0229)	(0.0244)
Expected demand	0.0992***	0.0902***	1.108***	1.061***	0.0782***	0.0826***	0.0779***	0.0819***
	(0.0130)	(0.0137	(0.150)	(0.170)	(0.0167)	(0.0176)	(0.0166)	(0.0175)
Price of capital	-0.0142	0.00794	-0.147	0.146	0.0126	0.0140	0.0131	0.0126
	(0.0142)	(0.0159	(0.267)	(0.260)	(0.0230)	(0.0244)	(0.0231)	(0.0243)
Cost of financing	0.0158	0.0150	0.152	0.117	0.00138	-0.00138	0.00211	-0.00222
	(0.0179)	(0.0183)	(0.233)	(0.188)	(0.0213)	(0.0227)	(0.0212)	(0.0224)
Official regulations	0.0240	0.00251	0.241	0.0489	-0.00254	-0.0112	-0.00432	-0.0134
	(0.0249)	(0.026	(0.277)	(0.387)	(0.0292)	(0.0315)	(0.0292)	(0.0312)
Public subsidies	-0.0139	-0.0124	-0.172	-0.169	-0.0136	-0.00439	-0.0141	-0.00405
	(0.0230)	(0.0265	(0.226)	(0.308)	(0.0361)	(0.0368)	(0.0364)	(0.0370)
Expected capacity	0.0567***	0.0586***	0.539***	0.568***	0.0689***	0.0619***	0.0688***	0.0609***
	(0.0178)	(0.0185)	(0.176)	(0.188)	(0.0226)	(0.0230)	(0.0224)	(0.0229)
Other reasons	0.0558***	0.0501**	0.548***	0.503*	0.0611**	0.0641**	0.0612**	0.0646**
	(0.0210)	(0.0212)	(0.209)	(0.268)	(0.0242)	(0.0263)	(0.0243)	(0.0264)
No special reasons	-0.0127	-0.00986	-1.269***	-1.253***	-0.00769	-0.00347	-0.00847	-0.00539
	(0.0111)	(0.0120)	(0.254)	(0.268)	(0.0151)	(0.0161)	(0.0151)	(0.0160)
Production last quarter						0.0194***		0.0196***
						(0.00552)		(0.00551)
Employment last quarter						0.0151**		0.0141*
						(0.00783)		(0.00787)
L1.Unemployment rate						-0.0654***		-0.0688***
						(0.0245)		(0.0235)
L2.Unemployment rate						0.0826***		0.0736***
						(0.0223)		(0.0204)
Observations	8,541	7,633	2,835	2,355	6,489	5,764	7,451	6,732
Number of firms	908	876	278	247	833	818	869	856
Fixed effects	✓	✓	✓	✓				
Model df	8	9	9	10	10	14	10	14
F-test	16.11	14.26	.	.	.	.	.	.
Wald (chi2)	.	.	192.6	153.2	122.5	142.7	121.3	146.2
Sargan test (p-value)	.	.	.	.	0.0006	0.0136	0.0004	0.0617
AR(2) test (p-value)	.	.	.	.	0.5183	0.7691	0.4458	0.6069

a Linear specification in (1) and(2), using xtreg. Non-linear model in (3) and (4), using clogit. Linear specification with instruments in (5) and (6) GMM using the Arellano-Bond estimator. Linear specification with instruments in (7) and (8) GMM using the Blundell-Bond estimator. Production last quarter, employment last quarter together with the unemployment rate are assumed to be predetermined and used as instruments.

c Godness of fit measure: F-test for linear models and Wald test (χ^2) non-linear probability models.

d AR(2) test: Arellano-Bond test for zero autocorrelation in first-differentiated errors. It is the P-value for a test of autocorrelation of order 2 that is reported. All p-values are close to zero for the test of AR(1).

e Sargan test: Test for overidentifying restrictions, H_0: overidentifying restrictions are valid

Robust standard errors in parentheses, using bootstrapping, Significance levels: *** p$<$0.01, ** p$<$0.05, * p$<$0.1

Dynamic models are by nature subject to autocorrelation in the error terms. As suggested in section 4 applying the Arellano-Bond or the Blundell-Bover estimator may help us solve problem with autocorrelation that the GLS does not help us with. Further the GMM estimator allows for using instruments to tackle the endogeneity of the lagged dependent variable.

Table 15: Dynamic panel data model: Factors causing a downward revise in investment plans. Firms expectations as explanatory variables. Linear specification, panel data

	GLS	Con. logit	Difference GMM		System GMM	
	(1)	(2)	(3)	(4)	(5)	
L1.Dependent var	0.0579	0.249	0.124**	0.121**	0.140***	0.136**
	(1.92)	(1.46)	(3.02)	(2.85)	(3.38)	(3.22)
Expected production	0.0277*	0.643**	0.0220	0.0260	0.0228	0.0257
	(2.42)	(2.78)	(1.57)	(1.75)	(1.58)	(1.72)
Expected capacity	0.00570	-0.0912	0.00960	0.00643	0.0109	0.00909
	(0.46)	(-0.41)	(0.61)	(0.42)	(0.68)	(0.58)
Expected employ	0.0567***	0.988***	0.0329**	0.0303**	0.0338**	0.0295*
	(5.92)	(6.06)	(2.84)	(2.59)	(2.89)	(2.49)
Expected home orders	-0.00806	0.0888	-0.0118	-0.0124	-0.0133	-0.0117
	(-1.05)	(0.48)	(-1.08)	(-1.16)	(-1.18)	(-1.07)
Expected foreign prices	0.00131	0.0341	0.00397	0.00686	0.00398	0.00620
	(0.14)	(0.20)	(0.34)	(0.59)	(0.34)	(0.54)
Expected total orders	-0.00485	-0.276	-0.00808	-0.00605	-0.00880	-0.00502
	(-0.52)	(-1.41)	(-0.63)	(-0.49)	(-0.68)	(-0.40)
Expected home prices	0.0350*	0.504	0.0366	0.0404*	0.0347	0.0370
	(2.51)	(1.88)	(1.92)	(1.99)	(1.79)	(1.82)
Expected foreign prices	-0.000465	-0.0233	-0.0136	-0.0166	-0.00954	-0.00840
	(-0.04)	(-0.10)	(-0.85)	(-1.04)	(-0.59)	(-0.52)
Expected input prices	-0.0225*	-0.332*	-0.0297*	-0.0311*	-0.0311*	-0.0338*
	(-2.00)	(-1.97)	(-2.37)	(-2.28)	(-2.44)	(-2.40)
GDP gap	-0.0479	-0.962				-0.123
	(-1.72)	(-1.80)				(-1.68)
Production last quarter				0.0249***		0.0227***
				(3.87)		(3.43)
L2.Unemployment rate				0.0540*		0.0275
				(2.10)		(1.34)
L1.GDP gap						0.0343
						(0.84)
Constant	-0.117***		-0.0181	-0.253**	-0.0228	-0.184*
	(-3.58)		(-0.46)	(-2.73)	(-0.56)	(-2.32)
Observations	4253	1271	3371	3001	4222	3803
Number of orgnr	593	145	505	488	584	567
Fixed effect	✓	✓				
Model df	10	11	10	12	10	14
F	7.789	.	.	.	.	.
Wald test (chi2)	.	122.5	66.00	83.19	103.2	140.1
Sargan-test (p-value)			0.017	0.39	0.000	0.065
AR(2)-test (p-value)	.	.	0.48	0.98	0.57	0.84

a Model (1) linear specification using GLS. Model (2) non-linear specification using conditional logit. Model (3) and (4) GMM using the Blundell-Bond estimator. Model (5) and (6) GMM using the Arellano-Bond estimator. Production last quarter, employment last quarter together with the unemployment rate and the GPD gap are assumed to be predetermined and used as instruments in the system GMM and GDP gap is excluded from the instruments in the difference GMM.

b Estimated standard errors using clustering at firm level. Significance levels:

c AR(2) test: Arellano-Bond test for zero autocorrelation in first-differentiated errors. It is the P-value for a test of autocorrelation of order 2 that is reported. All p-values are close to zero for the test of AR(1).

d Sargan test: Test of overidentifying restrictions, H_0: overidentifying restrictions are valid

Specifying the difference GMM estimator and the system GMM estimator using the similar specification as for the GLS shows that the estimated size of the lagged dependent variable is more than halved. More interesting is it that the effect of ‘access to credit’ and ‘expected demand’ are now equally important for explaining the probability that the firm would revise down its investments. In other words the conventional GLS strategy underestimates the effect of ‘access to credit’ and overestimate the effect of changes in ‘expected demand’. The estimated coefficient of ‘expected demand’ is slightly reduced, but still significant at 1 percent level. Changes in ‘excess capacity’ are still important for explaining the revisions, but the estimated effect is somewhat lower for both the coefficient on ‘access to credit’ and ‘expected demand’. Measures affecting the firms’ investment decisions that are not explicitly covered by this survey are called ‘other reason’. As shown by the estimation results a significant share of the changes in investments are caused by those factors and the effect is barely affected by the choice of model specification.

The Sargan test for overidentifying restrictions fail for the benchmark model using both difference and system GMM. I introduce predetermined variables, such as the firms’ response to the question ‘how strong was the firm’s production’ and ‘how high was the firm’s employment’ last quarter, together with the lagged unemployment rate, from the Labour force survey. Using these variables as additional instruments secures a significantly high p-value for the Sargan test using the system GMM estimator. The AR(2) test rejects autocorrelation in all cases.

Applying the similar dynamic structure as the first strategy, shows that adding dynamics changes the estimated coefficient. The estimate for the lagged dependent variable is nearly zero and insignificant in the standard linear specification, a bias towards zero if the GMM models gives the right estimate. The estimated coefficient for the lagged dependent variable is barely affected by the choice of GMM model specification, a finding that also holds for the other variables. The benchmark model reject the Sargan test for overidentifying restrictions, to solve this predetermined variables are included. As shown in Table 15 adding predetermined variables barely have effect on the estimated coefficients.

Manufacturing Investments in Norway – The Effects of Internal Funds and Credit Spreads* †

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October 8, 2019

Abstract

This paper shows how the investment Euler equation may be extended to capture the cost of external funding and the tightness in the credit market. The theoretical model is tested empirically on aggregated time series data for the manufacturing industry in Norway. I find empirical support for the theoretical model, and present a model where real aggregated investments are explained by the cost of external finance, production, profitability, and the credit spreads. Aggregated manufacturing investments are modeled using the bounds testing approach, together with the error correction framework using national accounts figures and financial statistics. I find that an increase in the cost of external funding relative to the cost of internal funding reduces the return on investments. The analysis shows that a one percentage point increase in the credit spread decreases investments with 7 percent. The profit ratio is known to be essential for investments. I find that the effect of a one percent increase in the profit to production ratio raises investments with a rate of 0.13 percent
Keywords:
JEL Classfication: E22, E27

1 Introduction

In the decades before the Great Recession, there were larger fluctuations in fixed investments than there were in both private and public consumption, see Figure 1 for data from the National Accounts of Norway. The large fluctuations in investments amplify the booms and busts during the business cycle. Hence, being able to predict investment is of utmost importance for central banks and governments.

The discussion in the first paper of this thesis showed that an overweight of the firms in the manufacturing industry, and particularly small firms and middle-sized firms, do not use conventional capital budgeting models when planning their investments. They base their investment decisions partly on gut

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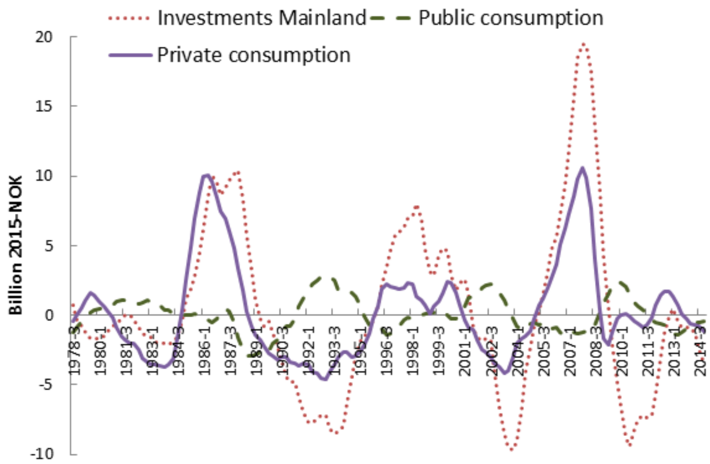


Figure 1: **Key components of Mainland GDP in Norway measured as deviation from its HP-trend in bill. 2012-NOK**. *Source*: Statistics Norway. Due to the high volatility of the national account data, the HP-filter have a smoothing parameter, lambda, of 20.000

feeling. This is not the same as saying that the economic conditions are not affecting aggregate investments, but that it is more to it than what can be explained by the behavior of rational agents. Hence, a broader set of models is needed. This raises an important question – is it possible to incorporate the rule of thumb behavior into the investment theories? Motivated by those findings, the second paper in this thesis discusses a panel data study on manufacturing firms that were designed to address the questions raised in the first paper of this thesis. The panel data study of the behavior of the manufacturing industry showed that expected demand and firms' access to credit explains most of the short-term movements in real investments. Factors that enter typically in the net present value calculations, such as funding costs, product prices, and product costs, fail to explain the short-term change in investments. Following the results of the second paper of this thesis, it is evident that capturing firms' access to credit and demand expectations are crucial for forecasting and understanding the short-run movements in real investments. In this paper, I have chosen to study aggregate data from the national accounts, even though there has been a shift in empirical macroeconomic studies towards using firm-level data instead of aggregate data. Increased availability of firm-level data in the last couple of decades explains this shift, together with the fact that it increases the possibility of identifying the effects one is studying. Firm-level studies are essential and may shed light on aspects that are not in reach with an aggregated approach. Forecasting fixed investments are crucial for central banks when it is setting the policy rate, and for that, one needs an aggregate approach. This paper contributes to the literature by showing an alternative way to extend the Tobin's Q-model, Tobin (1969) and the investment Euler equation to capture the effects of credit constraints and the cost of external finance. To test the model, an empirical investment Euler equation is estimated with aggregate data. In contrast to the standard approach, I assume imperfect capital markets and applying the insights from the first paper, which showed the importance of capturing the effect of credit constraints.

The Q-model is known for its usual assumption about the quadratic installation cost function – the cost of installing an extra unit of capital. My approach is to apply a cost function dependent on internal funds and credit market conditions[1]. I use the slightly more general approach from Kaplan and Zingales (1997) as a motivation for the cost function. The extension of the Q-model to capture credit constraints gives a theoretical investment model based on Neoclassical theory, which captures the effect of financial constraints and funding sources on the firms' investment behavior. The theory model shows how aggregated investments depend positively on production and internal funds, and negatively on financial constraints.

To test the theory model, I apply the bounds testing approach for non-stationary time series data. I refer to Pesaran et al. (2001) for a discussion of this empirical approach. The results from the empirical analysis shows that the theory model outlined cannot be rejected when using data for the manufacturing industry in Norway. Investments, production, profits, and credit market conditions form a stable long-run relationship. A highlighted result is that it is necessary to include the credit market conditions in the empirical model for finding a stable long-term relationship. The credit market conditions are particularly crucial for explaining the periods where investments depart from the production and profit ratio trend. The empirical analysis excludes the user cost of capital from the long-run relationship; however, it plays a role in understanding the short-run movements. The reason that the empirical analysis excludes the user cost of capital from the long-run relationship may be due to several factors. Two relevant factors are that changes in producer prices are usually small and moving slowly, making it difficult to identify any effect of changes in user costs on investments. Second, because the life of an investment project stretches over several years, it is the expected long-term interest rate, and not the short-term interest rate, that matters when firms make their investment decision. Both arguments make it challenging to identify any effects of the user cost of capital because the firms' expected long term interest rate is not known.

This paper continues with a discussion of relevant literature in Section 2, the theorerical model is presented in Section 3, the data is presented in Section 4, a discussion of the empirical methodology is given in Section 5 and Section 6 covers the empirical testing of the theory model. Section 7 summarizes the paper.

2 Literature review

There has been a large body of research over the last 10-30 years with a focus on explaining the lumpy behavior of real investments. While the early empirical studies focused on aggregated data, see e.g. Bean (1981) or Bernanke (1983), more recent research has been analyzing firm-level data, see e.g. Bloom et al. (2007) or Eklund (2010). Firm-level studies have increased our understanding of the lumpiness at the aggregated level. Contributions by Doms and Dunne (1998), Thomas (2002) together with Gourio and Kashyap (2007) showed that changes in the extensive margin, the fraction of firms investing, explains the lumpiness in aggregate investment. According to Bachmann et al. (2013), it is not the intensive margin, the size of each firm's investment, that fluctuates over the business cycle. Lumpy investment behavior has been studied using different approaches. Kahn and Thomas (2008) apply a generalized (S,s) model, Sveen and Weinke (2007) apply a New-Keynesian model and Bachmann et al. (2013) apply a DSGE

[1] An alternative could be to include two cost functions; the installation cost function and the external funding cost function. To simplify the analysis, this paper chooses to include only the latter cost function.

model. Although all three approaches contribute with interesting findings, none of them pin-point which factors are driving the lumpiness, and by this explains drivers of the lumpy behavior.

While the early investments models of Jorgenson (1963) and **?** explained the capital adjustment process with the development in expected profitability without uncertainty or imperfections in the capital markets, the focus of recent decades has been at studying the effects of uncertainty, as in Abel et al. (1996), Abel and Eberly (1996), Caballero and Pindyck (1996), Bertola (1998), Bond et al. (2004) and Bloom et al. (2007).

A large body of research on capital structure and uncertainty, pioneered by the work of Merton (1973), and followed up by Jensen and Meckling (1976), have shed light on the importance of imperfections in the capital market. The effect of liquidity constraints on investments is studied in the empirical work by many, and particularly by Schiantarelli (1996). Alfaro et al. (2016) study the interaction between uncertainty and liquidity constraints, and show that a shock in uncertainty amplifies the effect of liquidity constraints on investments and vice versa. Empirical studies by Fazzari et al. (1988), Kaplan and Zingales (1997), and Bond and Van Reenen (2007) have shown the importance of cash flow and profits for explaining firm investment. The argument is that because of liquidity constraints; retained earnings are crucial for financing investments.

Estimating models based on the Q-theory failed for many years, Galeotti and Schiantarelli (1991). Cooper and Ejarque (2001) and Galeotti and Schiantarelli (1991) showed how the introduction of market power improved the empirical properties of the Q-model. Another strategy has been to augment Q-models with capital gearing and production as in Cuthbertson and Gasparro (1995) or with retained earnings as in Fazzari et al. (1988) and more recently in Eklund (2010). In a paper by Andrei et al. (2018) show that Tobin's Q explains a large share of the investment behavior without including other factors. Rauh (2006) expands the cost function of the Q-model, such that the model capture credit constraints and exploit the mandatory pension plan payments to identify the effect on reduced cash flow on investments for financially constrained firms.

Bernanke and Gertler (1995) discusses the effect of the credit channel on the optimal investment level. Relevant for the empirical modeling of investments, they highlight that short term interest rates should not affect investments, because most investment projects stretch over a longer horizon. If so, the Jorgenson and Hall (1967) user cost of capital should be insignificant for explaining investment behavior at the aggregate level. Gertler et al. (2007) build a macroeconomic model with a financial accelerator showing how lending affects real variables, such as investments. Particularly interesting for my paper is the effect of the external finance premium. Gertler et al. (2007) show how the leverage ratio plays an essential role in explaining the fluctuations of real investments. Benedictow and Hammersland (2016) study the credit channel using aggregate data on Norwegian businesses. They find a positive link between credit, stock markets, and investment for a part of the industries in Norway.

Two recent articles that study how credit and banking affect real investments are Balduzzi et al. (2017) and Cingano et al. (2016). Balduzzi et al. (2017) find that business investments, particularly for small firms, depend heavily on the banks' funding costs. While Cingano et al. (2016) show using a two-stage procedure to study how real investments are affected by a credit tightening that was caused by a liquidity shock.

In an empirical analysis, Kothari et al. (2014) present evidence for the importance of profits and stock prices on aggregate corporate investments. However, Kothari et al. (2014) focuses on short-run effects and do not address the issue of non-stationarity of the data. The study that is closest to mine is a paper by Love (2003). She shows how an investment Euler equation can be extended to take into account the effect of financial constraints. In her reduced-form model, it is shown that cash flow and production affect investments. I extend the work of Love (2003) by taking explicitly into account credit market conditions into the theoretical and empirical model.

3 The investment model

This section discusses the theoretical investment model. In this model, aggregate production is represented by a standard Cobb-Douglas production function. The production function includes a supply shock parameter, A, real capital, K, and labor, L, and is given by

(1) $$X_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

where X_t is gross production, α is the capital share in the production function, $1-\alpha$ the labor share. There are constant returns to scale, and labor is fully flexible, such that firms may hire the necessary employment given its capital stock. Production is increasing and concave in capital and labor, ie. $\partial X/\partial K > 0, \partial^2 X/\partial K^2 < 0$, $\partial X/\partial L > 0$, and $\partial^2 X/\partial L^2 < 0$. The choice of using a Cobb-Douglas production function instead of a more general CES-function is not important for the results in this analysis.

I follow the setup of the Q-model with one exception – the cost function. In this model, there is no explicit cost of installing new capital. To leave out the installation cost function is a choice I have done to simplify the analysis. Instead, the cost function is dependent on the change in the credit market conditions and the cost of external funding. The cost function is building on work by Kaplan and Zingales (1997). The cost of external funding is also discussed in Fazzari et al. (1988), but they choose a different strategy and focus on how constraints are affected by firm size. See also Fazzari et al. (2000) for a critique of the approach in Kaplan and Zingales (1997).

The motivation for studying the wedge between the costs of internal and external funding is that the wedge is counter cyclical and consequently is an important factor for explaining the increase in financing costs through the life of a business cycle. Essential for understanding the effect of this wedge, is the fact that cost of internal funds equals the alternative cost of capital, while the cost of external funds is driven up by several factors, such as the information wedge between insiders (equity holders) and outsiders (debt holders), see Jensen and Meckling (1976).

In this paper, the cost of external funds is a function of the investment level, the size of the internal funds available, and the credit spread between average bank loans and the interbank offered rate. The spread typically increases when the competition in the bank loan market is weak or when the banks' funding costs increase, as might happen when the financial supervisor authorities apply stricter bank regulation schemes. An increase in the cost of external funds is assumed to be independent of the firms' investment level and the level of internal funds. Hence, no direct feedback from investments to financial conditions is assumed. This might seem like a strong assumption, but it is worth noting that it is typically financial and not real investments that cause the largest movements in the credit market. External funds is defined as the difference between investments and internal funds: $EX_t = I_t - M_t$. I follow the approach used by Summers (1981) when I design the cost function:

$$(2) \qquad C_{EX}(I_t, M_t, S_t) = \frac{1}{2} b S_t \frac{I_t}{M_t}^{2},$$

where b is the cost parameter deciding the firms' sensitivity to changes in the spread or the investment to internal funds ratio, S_t is the interest rate spread, I_t is investments and internal funds available at time t are M_t. Internal funds is a function of accumulated profits up to time $t-1$ less dividends payed that period. This give us the reasonable interpretation that, if a firm have been profitable in the past, their funding cost will be lower today. For a positive b, the costs of investing will be positive even in the situation where $I_t = M_t$, and there is no need for external funding. As in Kaplan and Zingales (1997) the cost function is increasing and convex in investments, i.e., $C'_{EX}(I_t) > 0$ and $C''_{EX}(I_t) > 0$, meaning that the higher an investment is, the higher are the cost of external funds. Further, it is assumed that the costs accelerate when the investments increases. The cost function is decreasing and convex in internal funds, ie. $C'_{EX}(M_t) < 0$ and $C''_{EX}(M_t) > 0$. Thus the cost of external funds decreases with the amount of internal funds, but the cost reduction is declining in internal funds. Another way of telling this story, the firms cost of external funds is lower the more profitable a firm has been in the past.

This way of modeling credit constraints may be seen as a reduced form model for the banking sector. The interest rate spread capture changes in the market for bank funding. Gertler and Kiyotaki (2010) present a baseline model for evaluating frictions in the banking sector. Their model implies that the interest rate spread rises when asset prices decline. This is because of the reduction of the net worth of the banking sector that a broad decline in asset prices generates.

The profit at the current time period, t, is given by the revenue less variable costs and investment costs:

$$P_X X_t(A_t, K_t, L_t) - wL_t - C_{EX}(S_t, I_t, M_t) - P_K I_t,$$

where P_X is the product price, P_K is the price of one unit of capital and w_t is the cost of one unit of labor.

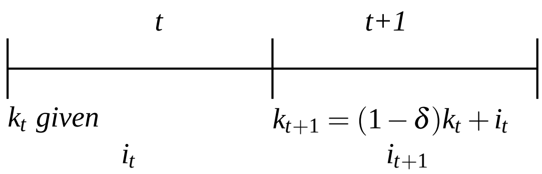


Figure 2: Timing of the events

The capital stock grows according to the capital law of motion, $K_{t+1} = I_t + (1-\delta)K_t$, where δ is the depreciation rate. If we take the profit function as given, including future periods and use the discount factor, β, to find the discounted net profit over an infinite time horizon. I can then set up the Bellmann equation:

$$(3) \qquad V(K_t) = \max_{I_t} \left\{ P_X X_t(A_t, K_t, L_t) - P_K I_t - \frac{1}{2} b S_t \frac{I_t^2}{M_t} - wL_t + \beta E_{t+1} V(K_{t+1}) \right\},$$

subject to

$$K_{t+1} = I_t + (1-\delta)K_t$$

where E_{t+1} is the expectation at time $t+1$, given the information the agent has on time, t. Solving this problem gives us our first order condition (FOC):

$$(4) \qquad \frac{\partial V(K_t)}{\partial I_t} = -P_K - bS_t \frac{I_t}{M_t} + \beta E_{t+1} \frac{\partial V(K_{t+1})}{\partial K_{t+1}} \frac{dK_{t+1}}{dI_t} = 0$$

From the capital law of motion, we have $dK_{t+1}/dI_t = 1$, such that (4) is simplified to

$$(5) \qquad \frac{\partial V(K_t)}{\partial I_t} = -P_K - bS_t \frac{I_t}{M_t} + \beta E_{t+1} \frac{\partial V(K_{t+1})}{\partial K_{t+1}} = 0$$

The last term in the FOC (5), $\frac{\partial V(K_{t+1})}{\partial K_{t+1}}$, is the shadow price of capital, normally labeled λ_{t+1}. If we set $q_{t+1} = E_{t+1}\lambda_{t+1}\beta$ and solve for investment in the FOC, we get the equation for the optimal investment at time t:

$$(6) \qquad I_t = \frac{M_t}{S_t b} (q_{t+1} - P_K)$$

This is the well-known result from the Tobins Q-model, Tobin (1969) – one should invest when the shadow price of capital is larger than the price of investing in one extra unit of capital. Contrary to traditional Q-model, the effect of a high q on the investment is positively affected by the amount of internal funds, and moderated by the cost parameter and by the interest rate spread. If the interest rate spread increases, then the optimal investment level goes down. Likewise, if the amount of internal funding decreases the weighted average cost of the funding goes up, and this decreases the net discounted value of the investment project. Hence investments go down. This is typical for economic downturns. Low competition in the banking sector during downturns, due to reduced lending willingness, will lead to an increase in the interest rate spread. If at the same time, firms are struggling to finance new investments with retained earnings due to lower profits, then the decline in the aggregate investment demand is amplified because of the increased funding cost. One will be in the same situation if the investment demand comes from young firms and start-ups without sufficient amounts of equity and hence need to fund itself with external capital.

To solve for the investment Euler equation I apply the envelope theorem

$$(7) \qquad \frac{\partial V(K_t)}{\partial K_t} = \alpha P_X A_t L_t^{1-\alpha} K_t^{\alpha-1} + \beta E_{t+1} \frac{V'(K_{t+1})}{\partial K_{t+1}} \frac{dK_{t+1}}{dK_t}$$

I use the product function to replace $\alpha P_X A_t L_t^{1-\alpha} K_t^{\alpha-1}$ with $\alpha P_X \frac{X_t}{K_t}$. After inserting for the derivative of the capital law of motions with respect to K_t, I get the following:

$$(8) \qquad \frac{\partial V(K_t)}{\partial K_t} = \alpha P_X \frac{X_t}{K_t} + \beta E_{t+1} \frac{V'(K_{t+1})}{\partial K_{t+1}} (1-\delta)$$

I continue by inserting for $\frac{\partial V(K_{t+1})}{\partial K_{t+1}}$ and $\frac{\partial V(K_t)}{\partial K_t}$ from the first order condition with respect to investments, (5) into equation (8), and replace $\beta = \frac{1}{1+r}$, which after some rearrangement gives us the investment Euler equation:

$$(9) \qquad P_K + bS_t \frac{I_t}{M_t} = \frac{1}{1+r}\alpha P_X \frac{X_t}{K_t} + \frac{(1-\delta)}{1+r}\left[P_K + E_{t+1} bS_{t+1} \frac{I_{t+1}}{M_{t+1}}\right]$$

To get an expression for investment level I rearrange the investment Euler equation:

$$(10) \quad I_t = \frac{M_t}{bS_t}\left[\frac{\alpha}{1+r} P_X \frac{X_t}{K_t} - (r+\delta)P_K\right] + E_{t+1}\left[\frac{\tilde{S}_{t+1}}{\tilde{M}_{t+1}} I_{t+1} \frac{1-\delta}{1+r}\right],$$

where I_t is the firms' investment in period t, X_t is production, K_t is the capital level, M_t is internal funds, S_t is the interest rate spread, b the cost parameter, P_K is the price of capital goods, P_X is the product price, r_t is the interest rate, δ is depreciation rate and α is the capital share. Finally, I let $\tilde{S}_{t+1} = \frac{S_{t+1}}{S_t}$ and $\tilde{M}_{t+1} = \frac{M_{t+1}}{M_t}$. The investment model have a long run part, represented by the first elements on the right-hand-side, and a dynamic short run part, represented by the last element of the right-hand-side.

The interpretation of the Euler equation is that any expected increase in the interest rate spread in the first time period, rise current investment costs and hence increases the relative profitability of investing in the second time period. Any decrease in the expected internal funds shifts investments in the same direction.

The long-run element of the investment model is characterized by a higher investment level when the internal funds rise. This happens either if because profits are above its normal level, or because there is less investment spending. A well functioning credit market is essential for investments. A high interest rate spread makes it costly to fund investments. It may also signal to firms that there are substantial frictions in the financial markets and harming investments by making external funding relatively costly. The higher the real capital level is, all else given, the less are the return to capital of a marginal increase in investments. Hence, the incentives to invest further are damped. Increased production rises the aggregate utilization rate and enhances the need for investing in new capital to meet the increased demand. How the price of capital goods affects investments depends on the size of the depreciation rate and the return on capital. A high depreciation rate reduces the value of investments, and a high return on capital increases the alternative cost of the capital, both negatively affect investments.

From our investment function (10) we expect investment to depend positively on production and internal funds and negatively on the interest rate spread and the user cost of capital. Capital is a function of investments and the depreciation rate; hence, it is left out in the reduced form. Compactly the investment function can be written:

$$(11) \quad I = F(\underset{+}{X}, \underset{+}{M}, \underset{-}{S}, \underset{-}{UC}, \underset{+}{P_X}),$$

where UC is the user cost of capital, capturing the price of capital goods, interest rates, taxes, and depreciation rate.[2]

[2] Taxes are left out of the model for keeping the specification simple, but may easily be included in the model

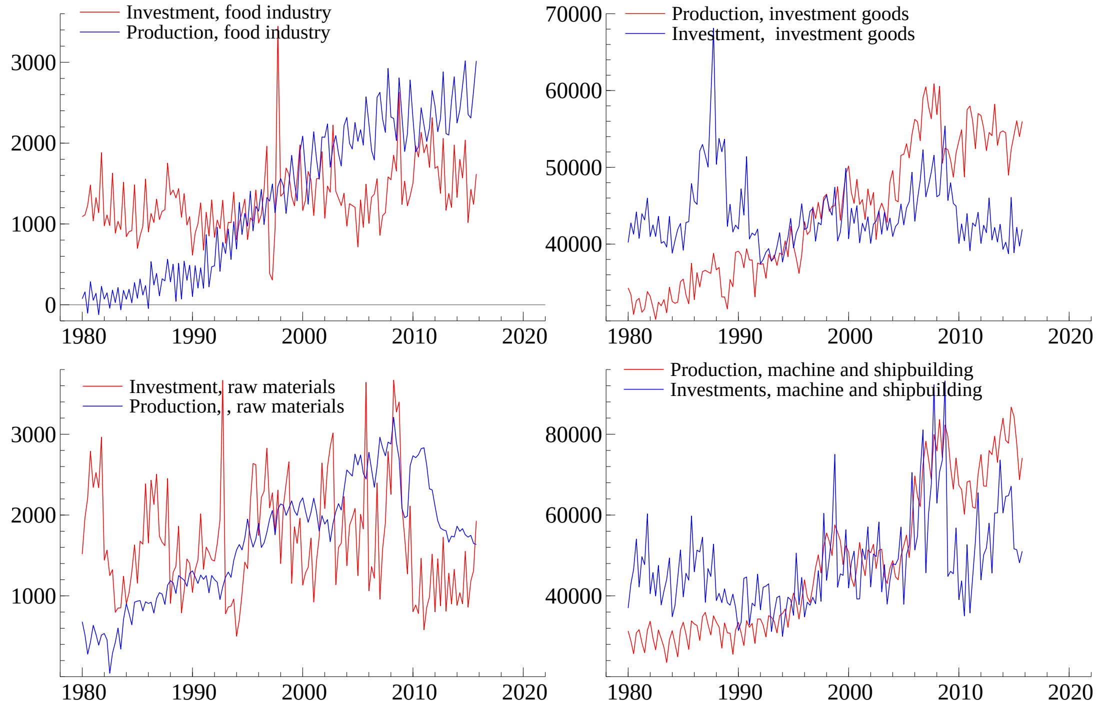


Figure 3: **Real gross investments and real gross production in four different manufacturing industries**. Scaled by means and range, see footnote 4 for labeling details.

4 Data and the Norwegian manufacturing industry

Large deliveries of goods and services to the Norwegian offshore oil industry characterizes the Norwegian manufacturing industry. Between a third and a half of the industry have been linked to the oil extracting industry. This makes the industry particularly vulnerable to oil-price shocks and less dependent on world markets. For an overview of the characteristics of the Norwegian manufacturing industry, see the discussion in Paper 2.

4.1 Data

To study aggregate investments, I use data from the Norwegian national accounts; this includes data for investment (real prices), gross production (real prices), net profit (nominal prices), and net production (nominal prices). The figures are seasonally adjusted, and the sample period stretches from 1984Q1 till 2013Q4. Data for 2014 and 2015 are preliminary and particularly uncertain. Because of this, data for those years are left out when estimating the model. However, the out-of-sample forecasting includes data for 2014 and 2015. Based on the type of end-product the industry produces the manufacturing industries, the National Account aggregates the industry into four different sub-groups.[3] Figure 3 shows the development to real investment and gross production for the four sub-groups during the observation period.

[3]The industries are, with coding in parenthesis: Food and consumption goods (15), Investment goods and raw materials (25), Energy intensive goods (30), Shipbuilding and machine industry (45).

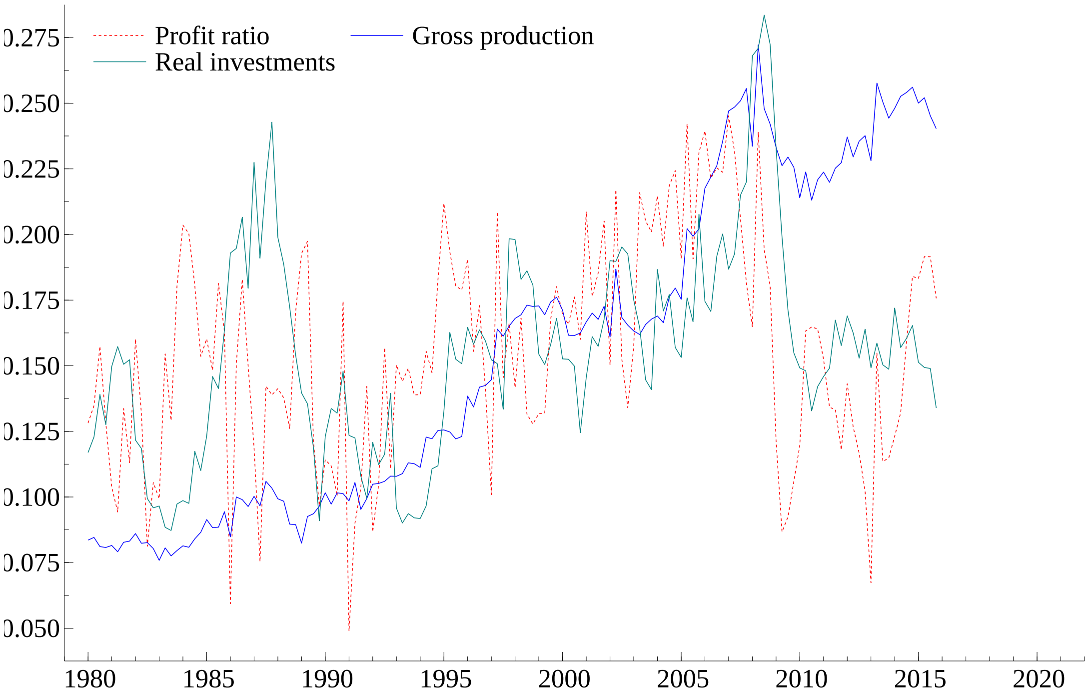


Figure 4: **Real investments, gross production and profit ratio for the manufacturing industry.** Fixed 2013-prices, in logarithmic scale, and real investments and gross production rebased to match profit ratio.

Without access to data for the internal funds at an aggregated level, I need to proxy internal funds in the empirical model. I use the aggregated profit for the different sectors in the manufacturing industry. To get real profits, I deflate the net profit with net production at a nominal price, which give us the profit to production ratio. The use of the profit ratio as a proxy for accumulated internal funds hinges on the assumption that a high-profit share increases retained profits and hence internal funds.

Bank loan rates for businesses are collected from Statistics Norway's financial statistics, the 3-month Norwegian interbank rate (NIBOR) is from Norges Bank, and the sentiment figures are data from the Statistics Norway's business tendency survey.[4] The interest rate margin is calculated as the difference between the bank loan rate for Norwegian businesses and the NIBOR. The user cost of capital is the traditional Jorgenson and Hall (1967) specification. This specification of the user cost is tested against a version where the interest rate is replaced by its moving average to reduce the effect of short term fluctuations in NIBOR when estimating the user cost and by this, capturing the long-run movements in the interest rate.[5] Figure 5 shows the relationship between the usercost of capital and the interest rate spread during the sample period.

An interesting feature one finds when studying the national account figures for the manufacturing industry is the increased return on capital in the ship, platform, and machine industry during the second half of the 2000s. This industry is mainly producing goods and services to the petroleum industry in

[4]All data, except the sentiment data, are merged into one database, used by the Statistics Norway's KVARTS macro model, available on request for researchers.

[5]A moving average with four quarters of lags and leads.

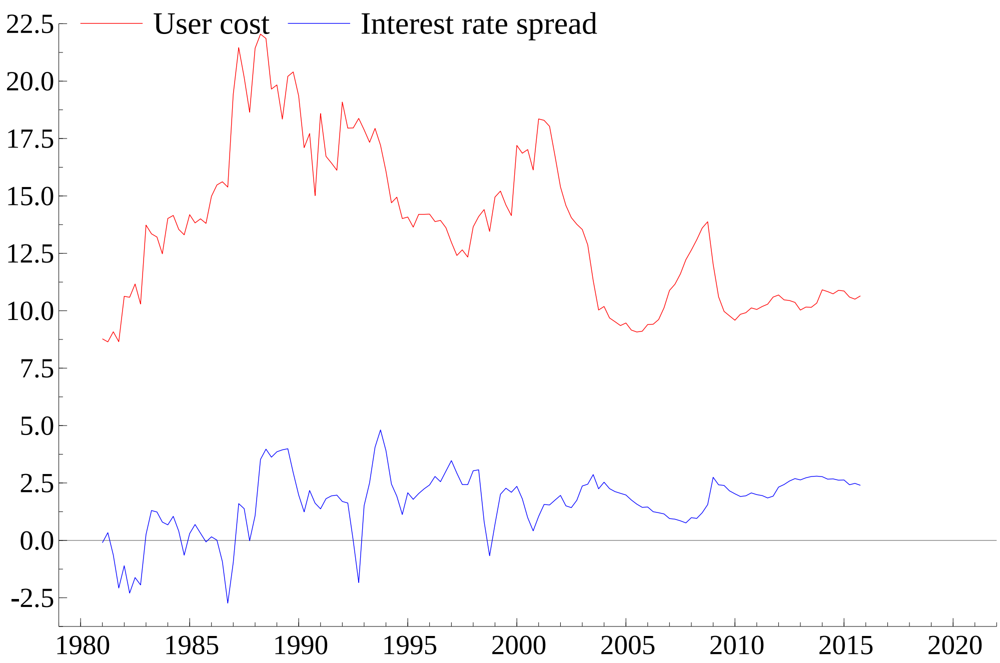


Figure 5: **Interest rate spread and user cost of capital. In percent**
Source: Norges Bank and Statistics Norway

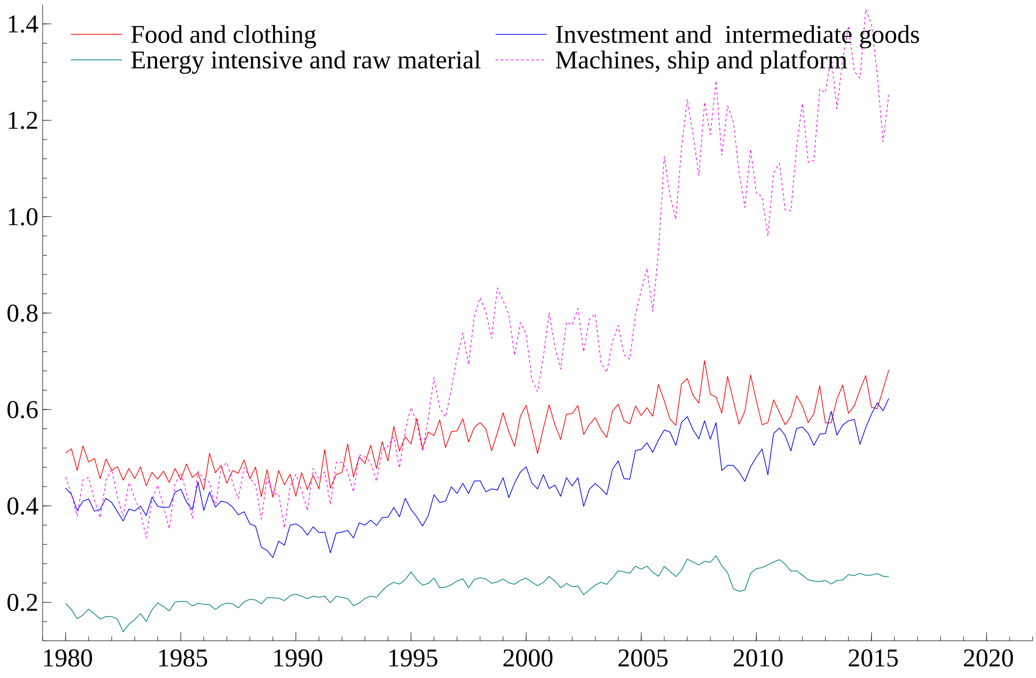


Figure 6: **Gross production to real capital ratio in four different manufacturing industries.** Fixed 2013-prices, in a logarithmic scale

Norway and abroad. As shown in Figure 7 the profits in this industry are far above average returns mainly due to the high returns on producing investment goods and intermediate inputs to the petroleum extracting industry during the years of record-high oil and gas prices. A similar picture is drawn in Figure

6, which shows the increase in the production to capital ratio in the same period. For a discussion of the cause of the effects by the deliveries from the manufacturing to the petroleum industry see Cappelen et al. (2013) or Bjørnland and Thorsrud (2016).

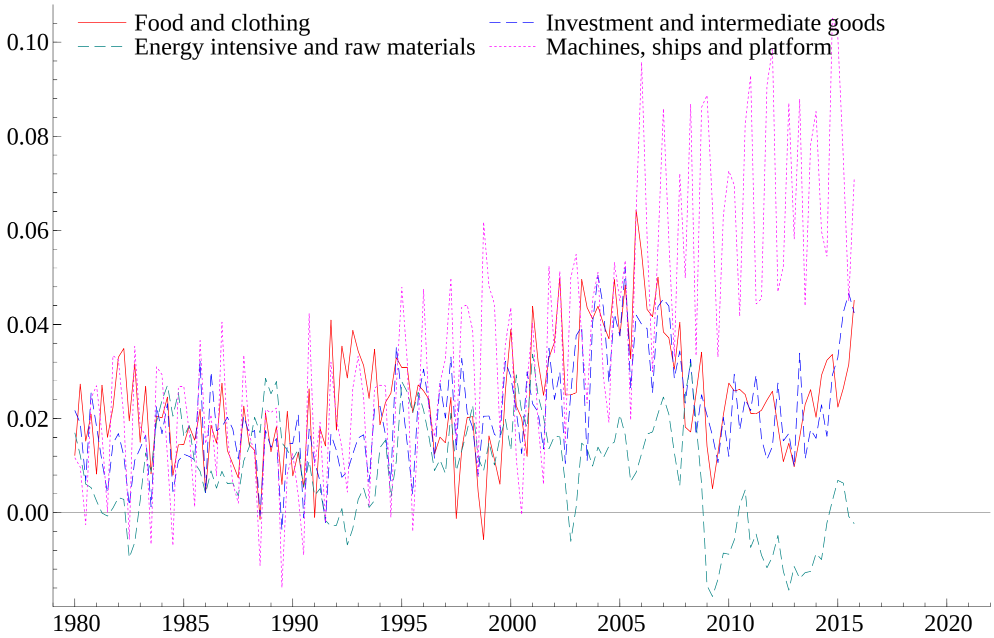


Figure 7: **Real profit to real capital ratio, for the four aggregated manufacturing industries in Norway.**

5 Empirical testing of the theory model

The last part of this paper will focus on testing empirically the theory model above. The traditional approach when modeling investments is to estimate a model for the investment to capital ratio, or if one abstracts from the depreciation rate – the growth rate of capital. However, the order of integration complicates this way of modeling investments. Aggregate investment is often integrated of order 1, while real capital in many cases is integrated of order 2[6]. Thus, it is not obvious that the growth rate of capital is a stationary time-series. Making the use of traditional estimation methods and specification tests invalid. To come around this, I will first apply the autoregressive distributed lag model (ARDL) with bounds testing as shown by Pesaran et al. (2001). This methodology can deal with the non-stationary we find in most aggregated time series and at the same time study the long-run relationship between the different data series.

The theory model does not impose any a priori parameter values, so it is the role of the researcher to estimate the partial effects of changes in the explanatory variables on the investment growth. I apply an empirical strategy where the long-run structure of the empirical model is linked to the theory model,

[6]Depending on how I structure the ADF-test, I find that capital in the Norwegian manufacturing industry is of order 1 or order 2

while the short-run dynamics are freely estimated to enhance its forecasting properties. Eisner and Nadiri (1970) highlight the importance of estimating the coefficients of the Jorgenson investment model freely and letting data decide, instead of using the a priori restrictions given by the theoretical model. Following Eisner and Nadiri (1970), I do not estimate the exact theoretical specification, but a linearized version without any further restrictions. I will then let data and the relevant tests decide which restrictions that hold.

A conventual method of specifying an empirical Euler equation is to use the hybrid modeling approach, see Fuhrer and Rudebusch (2004). Using a similar approach on the theoretical investment equation (11) where $E[I_{t+1}]$ is approximated with $\alpha_1 i_{t-1} + \alpha_2 i_{t-2} + \mu E_{t-\tau} i_{t+1}$, where $E_{t-\tau}$ is the expectation operator at time $t-\tau$ with $\tau \in [0,1]$ and τ is the timing of the expectation formation. When τ is equal to 1, then the model is estimated on expectations formed on information until the quarter a head of the quarter where the investment is implemented.

We now have the following empirical specification:

$$
\begin{aligned}
(12)\quad i_t =& \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 i_{t-2} + \mu E_{t-\tau} i_{t+1} + \beta_1 E_{t-\tau} (m_{t-n} - \theta_1 S_{t-n}) + \\
& \beta_2 (x_{t-n} - \theta_2 k_{t-n}) + E_{t-\tau} \frac{1}{\kappa} \sum_{j=0}^{\kappa-1} \theta_2 uc_{t+j-n} + \eta_t,
\end{aligned}
$$

where i_{t+s} the log investment level at time $t+s$ with $s \in [-2,1]$. The explanatory variables are; m_t the log profit to production ratio as a proxy for internal funds, S_t the interest rate spread, x_t the log gross production, k_t the log real manufacturing investments, uc_t the user cost of capital. The lag of the explanatory variable is given by the parameter n, with $n \in [1,4]$. Long term interest rates may play an important role in the firms' expectation about the user cost of capital. Where, $j = \kappa > 0$ include lead interest rates. Using forward rate agreements (FRA) as a proxy for the lead interest rates is meaningful from an empirical and theoretical stand point, but as shown in Paper 1, the FRA rate is not commonly used by practitioners.

A challenge when studying investments is the fact that there is potentially a substantial lag from when the firm takes its investment decision and until the actual change in investments happens. Hence, firms' investment decision is taken up to several quarters before the investment is effectuated, meaning that it is lagged variables that explain investments, unless the firms have expectations that are not backward looking. See Haavelmo (1960) for a good discussion on the lag from decision to action. Hence, the hybrid model is particularly suited for studying the empirical validity of an investment model with lagged explanatory variables $(n > 0)$. It is not obvious which lag that affects firms investment decision, so I let the empirical analysis decide on which lag to include in the model. The time lag from decision to investment, make it relevant to let the expectations be formed a quarter before the investment is measured in data $(E_{t-\tau} = E_{t-1})$.

I will start the empirical analyses with the long-run investment model. In addition to the explanatory variables, a constant is added to capture the constant maintenance investments and depreciation of capital, and I also test if a trend is needed to capture any unexplained effects growing over time. If we allow for a longer adjustment process and assume that expectations are formed with adaptive expectations during the months before the data is observed we may rewrite model (12) to become a general error correction model (ECM):

$$(13)\quad \Delta i_t = \alpha_0 + \sum_{i=0}^{q-1} \alpha_i^* \Delta \mathbf{z}_{t-i} + \sum_{i=1}^{p-1} \beta_i^* \Delta i_{t-1} - \beta(i_{t-1} - \theta' \mathbf{z_{t-n}}) + \kappa \mathbf{c} + u_t,$$

where α_0 is the first element of the constant, Δ is the difference operator, $\mathbf{z_t}$ is a vector of explanatory variables, where the $\alpha's$ are the short-run adjustment parameters, $\mathbf{c}$ is a vector of deterministic variables, such as time dummies and the possibility of a trend. Moreover, u_t is the error with zero mean and constant variance, σ^2. We recognize $\beta(i_{t-1} - \theta' \mathbf{z_{t-n}})$ as the long-run empirical specification. Where β is the adjustment coefficient, and θ is the cointegrating vector. If there is a short time-lag from when the firms' make their decisions to their investment is effectuated, and there is available capacity, then the speed of adjustment will be high – hence the response of changes to the driving factors of investment is fast. Likewise, if the effect on the investments of any changes in the covariates is short-lived, then few lags of the change in z are included in the model, and hence q, is small, and there are few lags of the exogenous variables included in the econometric model.

Unit root and Bounds testing

The ECM builds on a fundamental assumption. That is the stationarity of the left and right-hand side of equation (13). With non-stationary data, this is the case if the variables in the long run solution are cointegrated. Cointegration describes the situation where the variables are typically individually integrated of order one, I(1), while at the same time, there exists a linear combination of the variables that are stationary. It is important to note that if the level variables are I(1), then the Δ-terms are stationary, I(0). Because cointegration as known from Engle and Granger (1987) requires that the variables in the long term relationship all are non-stationary and integrated of order 1, it is crucial for using this methodology that the properties of the variables are as assumed by the researcher.

The standard test for stationarity is the Augmented Dickey-Fuller (ADF) test. Using this test, I find that the Δ-terms are stationary. However, the ADF-tests for investment and the level variables in the $\mathbf{z}$ vector are inconclusive. Some of the variables are stationary, and other variables are non-stationary. Also, the results depend on whether a stochastic trend is included or not. See Appendix Tables 3 to 11 for results from the ADF-tests. Other relevant unit-root tests could have been applied, such as the ADF-GLS (Elliott et al. (1996)), Phillips-Perron test (Phillips and Perron (1988)) or the KPSS-test (Kwiatkowski et al. (1992). However, Pesaran et al. (2001) suggests an alternative approach that is less vulnerable to the assumptions behind those tests. Their approach is known as bounds testing. Instead of estimating an ECM like (13), the approach assumes that the level terms in the ECM are estimated freely. The next step is then to calculate the F-statistics for the null hypothesis that all long-run parameters are zero. The F-statistics is then compared with the critical values estimated by Pesaran et al. (2001). There are upper and lower critical bounds, and a long-run relationship is conclusive only if the F-statistics is greater than the upper bound critical F-statistic.

Table 1: Test values of the Bounds test, $H_0: \ \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$

Case		F_L	F_U	F-statistic
Case 5	Unrestricted trend, unrestricted constant	3.120	4.250	11.10
Case 3	No trend, unrestricted constant	2.620	3.790	9.25
Case 1	No trend, no constant	2.140	3.340	4.35

Testing the theory model

The theoretical model is tested empirically by studying the estimated coefficients in the θ vector. If the elements θ are significantly different from zero and the signs are in line with the theory model. I will conclude that the empirical test do not reject the theory model. If any of the variables in $\mathbf{z}$ are insignificant, they are excluded from the empirical model.

6 The empirical investment equation

I will start the empirical analysis by estimating an ECM and test the hypothesis that the level variables should be included in the model and a long run relationship exists. This is a test for the presence of cointegration using the Pesaran et al. (2001) approach. The procedure starts with an estimation of the baseline model with an error correction specification, where no restrictions are put on the explanatory variables:

$$
\begin{aligned}
(14) \quad \Delta i_t = & \alpha_0 + \theta_1 i_{t-1} + \theta_2 x_{t-1} + \theta_3 m_{t-1} + \theta_4 S_{t-1} + \theta_5 UC_{t-1} + \phi t + \\
& \delta_1 \sum_{i=1}^{2} \Delta i_{t-i} + \delta_2 \sum_{i=1}^{2} \Delta x_{t-i} + \delta_3 \sum_{i=1}^{2} \Delta m_{t-i} + \delta_4 \sum_{i=1}^{2} \Delta S_{t-i} + \delta_5 \sum_{i=1}^{2} \Delta UC_{t-i},
\end{aligned}
$$

where i is real investments, x is real gross production, m is profit to production ratio, S is the interest rate margin, UC is the user cost of capital and t is a time trend. Small caps indicate that the variables are in logarithms. The number of lags of the delta-terms in the baseline model is set based on a F-test of jointly excluding one lag from every variable starting from a model with 4 lags. The test finds that two lags should be included in the model, because the test fails to exclude the second lag.

Estimating equation (14), I find strong support for a cointegrating relationship between investment and variables suggested by theory. The F-test statistics and the critical values for the bounds test are reported in Table 1. The calculated F-statistics are well above the upper threshold (F_U) for all of the estimated cases.

With evidence of a long-run empirical relationship from the bounds test, I can now proceed to the next step: Modeling investments using an ARDL(p,q) model in levels to find the long-run relationship between investments and the explanatory variables from the theory model (10). The empirical study gives us the long-run relationship shown below in equation (15) and as the standard errors for the coefficients show; the coefficients are all highly significant, except for the coefficient for the user cost of capital which is insignificantly different from zero and excluded from the long-run relationship. The bounds still holds in the case when θ_5 is left out from the empirical model. The ARDL model is estimated with the differenced terms included in the empirical model, but they are excluded when the long-run solution is presented.

$$(15) \quad i = \underset{(0.0491)}{0.3940}x + \underset{(0.0407)}{0.1369}m - \underset{(0.0113)}{0.07297}S + \underset{(0.593)}{4.735}$$

The results of the ARDL(p,q) give strong empirical support for the generalized theoretical model. Production, profit to production ratio, and the interest rate spread are all important and necessary for explaining aggregate investments in the long run, and the signs are as expected. The long-run effect of a one percent change in gross production is an increase in aggregate investments of about 0.4 percent. Higher production reduces available production capacity and hence pushes the manufacturing industry to increase its capacity by increasing investments and by this being able to meet any further increases in demand. Improved profitability increases the return on capital, and it is likely to possibly affect the firms' profit expectations. The other channel that an increase in profitability has on investment is its effect on reducing funding costs. The way that the firm chose to fund its investment heavily impact the cost of funding. The theory model emphasizes that the higher share of the investment that is funded with retained earning the lower is the funding costs expected to be.

I find that the effect of a one percent change in the profit to production ratio is a 0.14 percent increase in investments. As known from the first paper, a large share of the firms prefer to fund investments with retained earnings, and this holds particularly for smaller firms. As shown in the Appendix to Paper 1, the lack of cash flows reduces investments in small as well as large firms. This may be an argument that funding cost is not only increasing in retained earning but that the firms' funding is bounded when the share of internal funding is sufficiently low.

A necessity for using external funding in an investment project is that banks have sufficient the lending willingness of banks to business' investment projects. I find an estimated effect of 0.07 percentage on aggregate investments of a one basis point decrease in the interest rate spread. Compared to the years ahead of the financial crisis, the interest rate spread, in Norway, was 50 basis points higher than in the years 2012 to 2015. The estimated effect on the investments of a rise in the interest rate spread with 50 basis points is about a 3.5 percent decline in the long-run level. If the increased interest rate spread is motivated by less competition among banks, then it is likely that a part of the investment decline in the years after the Financial Crisis was due to a reduced supply of credit. Paper 2 found that access to credit is together with expected demand by far the most important reasons for changes in firms' investment plans. The competition among banks is essential for understanding the lending willingness, and hence, the changes in the interest rate spread. The many bankruptcies before in 2007 and 2008 made it necessary to tighten the financial regulations. This gave us the Basel III capital requirement. To accumulate a higher equity capital level, many banks increased their interest rates even when the cost of borrowing was unchanged. See Naceur and Omran (2011) for a discussion of the recent developments in the credit markets for bank loans, or Hungnes (2011) for a study of the Norwegian bank loan market.

As in most empirical studies of aggregate investments, also this study finds that there is an insignificant effect of the *level* of the user cost of capital on investments. To see how vital interest rate expecta-

Table 2: **Empirical investment model, using a ARDL-model.** The model is specified as an equilibrium correction model and estimated with ordinary least squares using quarterly data that is seasonally adjusted.

Δi_t	Coefficients	Standard errors
Δi_{t-3}	0.269683	0.07485
z_{t-1}	-0.206047	0.04539
Δx_{t-3}	0.608692	0.2141
ΔUC_{t-1}	-0.004541	0.00228
ΔS_{t-1}	-0.018696	0.00856
$\Delta_3\ obx_{t-1}$	0.0707756	0.02946
Constant	-0.003810	0.00719
I:1993(1)	-0.286963	0.07271
I:1997(4)	0.282994	0.07103
I:2006(1)	-0.221740	0.07373
Test summary	**p-values**	
AR 1-5 test:	[0.1826]	
ARCH 1-4 test:	[0.9582]	
Normality test:	[0.0534]	
Hetero test:	[0.0537]	
Hetero-X test:	[0.0851]	
RESET23	[0.6691]	
Forecast, χ^2-test	[0.9592]	
Chow, F-test	[0.9599]	

Note: Estimated using ordinary least squares. Sample period: 1984Q1-2013Q4. The long-run model:
$z_t = i_t - 0.3940 x_{t-1} + 0.1369 m_{t-3} - 0.07297 S_{t-1} + 4.735$

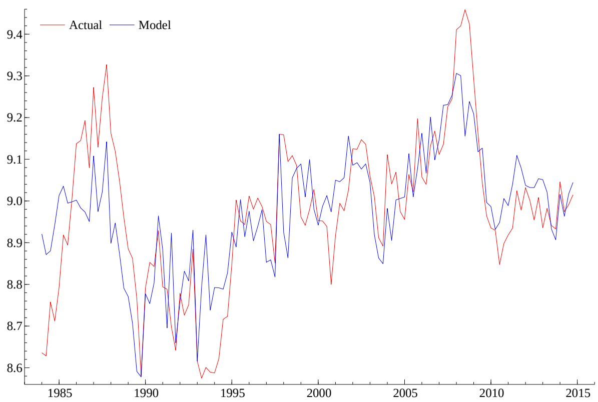
tions are for the user cost of capital, I tested for several different specifications of the user cost of capital. The robustness check compared the baseline with a model where the user cost of capital included both lags and leads of the actual interest rate together with the lead of the price of capital goods, but also a version with only leads was tested. None of the specifications gave a significant parameter estimate of the user cost. As discussed in Chirinko et al. (1999), this is a known result from studies on aggregate data. The lack of any effects of the user cost of capital on investments is also backed up by the findings in Paper 2, which showed that there is neither an effect of the price of capital goods nor the funding cost on the probability of a change in the firms' investment plans. Essential to understanding how interest rates affect investment, is to remember the result from the Neoclassical growth model: With a standard Cobb-Douglas production function, the derivative of production with respect to capital equals the interest rate. Hence, the interest rate rises when the return to capital rises and vice versa. In other words, it is when the profitability of investments rises, that the interest rate increases. This mechanism makes it near impossible to identify any effect of interest rates on aggregate investments.

Utilizing the long-run model (15) I estimate the short-run investment model, using the error correction specification of equation (14). Table 2 shows the empirical results from the empirical model. The short-run model is estimated freely, but I constrain the model to utilize the long-run relationship from equation (15). To find the exact model specification, I use the automated general-to-specific variable selection procedure in Autometrics, Hendry and Krolzig (2005).

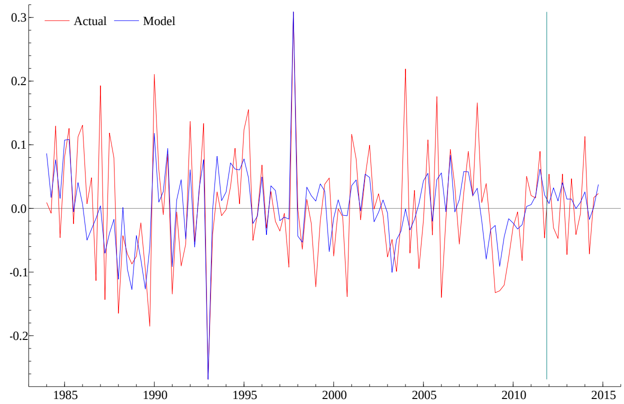
The short-run dynamics continue to support the theoretical model. As expected both an increase in the quarterly change in investments and production increases the investment growth temporarily. Similarly, I find a moderate negative effect of an increase in the change in the interest rate margin. I did not find any long-run effects of changes in the user cost of capital, but as in Chirinko et al. (1999), I find that there are short-run effects of changes in the user cost of capital. The estimated effect is small and as expected; negative. How easy it is to finance the firms' investment, do not only depend on the interest rate margin and the retained earnings. The value of the firm is also a crucial factor. In line with the financial accelerator literature, Bernanke et al. (1996), I test how changes in firm valuation affect the short-run dynamics of the investment level. By using the quarterly change in the Oslo Bors Benchmark Index (OSEBX) as a proxy for change in firm valuation, I find that an increase in the average valuation at the stock exchange increases investment, but the effect is only temporary and last for three quarters.

There are three time-dummies in the model. In November 1992, the Norwegian Central Bank, which at the time were following a fixed exchange rate regime, had to defend the Norwegian krone (NOK) by buying a large amount of NOK. This caused the money market rate to increase much more than bank loan rates, such that the interest rate margin became negative in 1993Q1. The second time-dummy captures the increased uncertainty caused by the Asian crisis in 1997. One of the consequences was an unexpected decline in oil prices, which is an essential predictor for investment goods in the petroleum industry. The third time-dummy captures a policy event. Due to the announcement of a substantial rise in dividend tax in 2006, there was an extraordinary payout of dividends during 2005.

The cointegrating vector, together with the estimated and actual figures from the OLS-regression, is shown in Figure 8. Figure 9 shows the recursive estimates and Chow-tests. As seen in the figure, all parameter coefficients are stable and barely affected by the turmoil of the Financial Crisis. The 1-up



(a)



(b)

Figure 8: (a) The long run model and actual data (b) The full investment model and actual data, quarterly change in investments, Δi_t

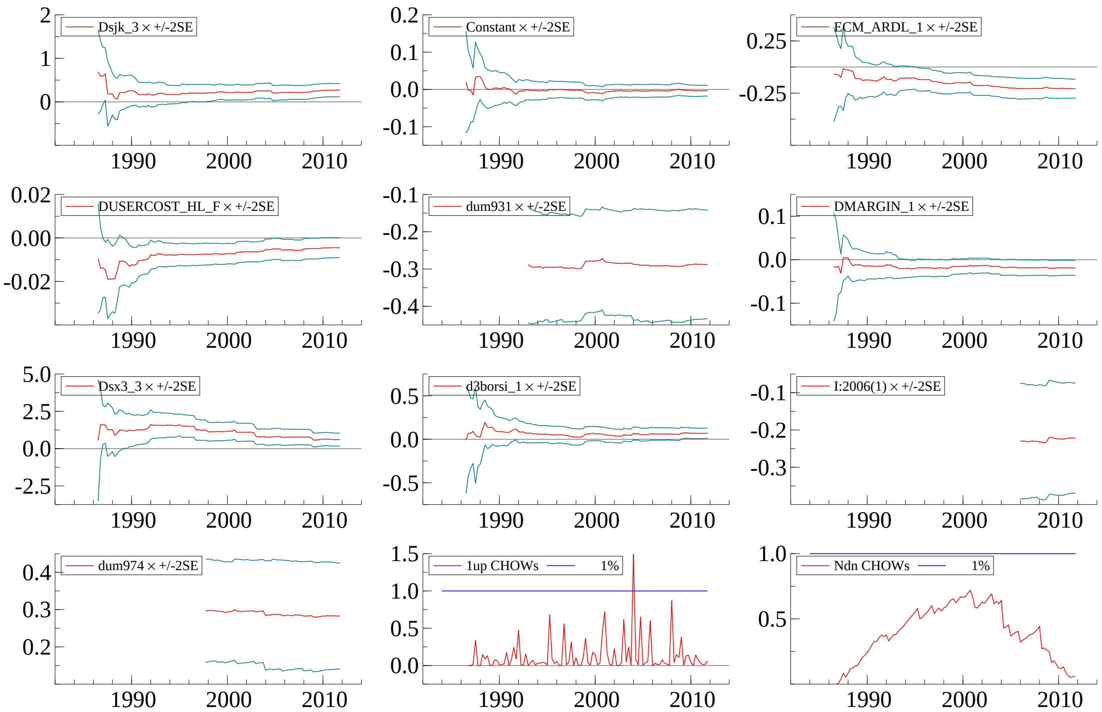


Figure 9: Recursive estimates, Investment model

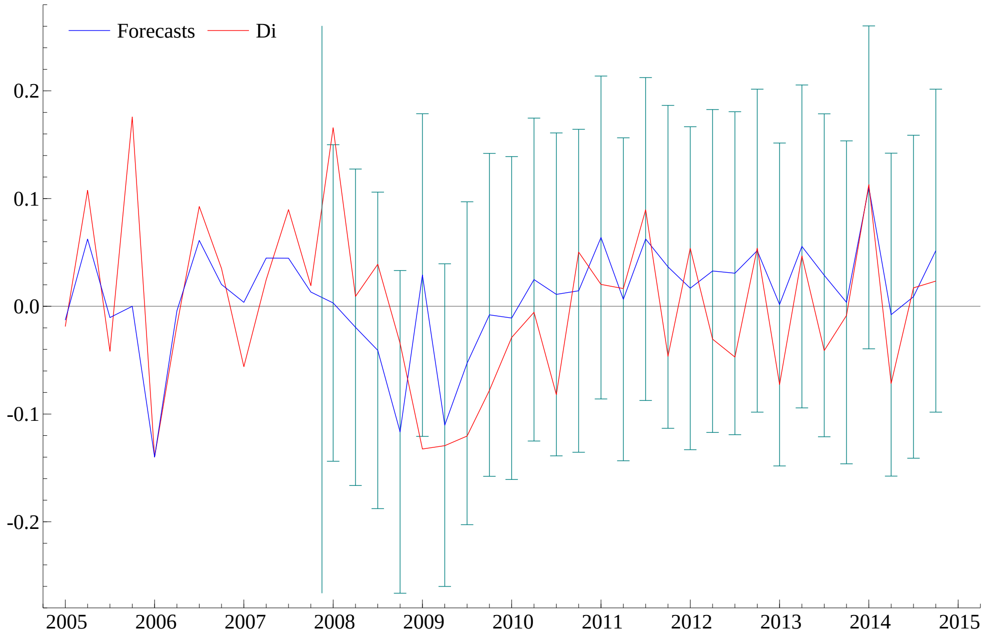


Figure 10: Dynamic four-step ahead out-of-sample forecast

Chow-test indicates that there is one outlier, and that is during the financial crisis. The Break-point chow tests do not find any F-statistic that indicates any structural break in the data generating process.

Forecasting properties

The estimated investment model shows stable forecasting properties. To test whether this model would have forecasted the decline in investments during the Great Recession, I estimate the both the long-run and the short-run model with data until the 4th quarter of 2007. Shortening the sample period reduces the estimated coefficient for the profit to production level in the long run model with a third. The other coefficients are barely affected by the change in estimation period. The results of the dynamic four-step out-of-sample forecasts for the quarterly growth in aggregate investments are shown in Figure 10. The model is forecasted with true realizations of the explanatory variables, which of course helps the model in forecasting the investment behavior. It is interesting to note that the model forecasts the decline in investment in Q1 2008, which is one quarter before the actual decline started, and this with a model where the agents have backward-looking expectations. The forecasts are well within the 95 % error bars. The forecast accuracy measured with the N up-step Chow test and a 1-step Chow F-test is are highly significant with a p-value of 0.95.

The strong forecasting properties strengthen the empirical support of the theoretical model and underline the importance of including the interest rate margin and profit to production ratio when modeling real investments.

7 Summary

Investments are not unpredictable, and this paper suggests a model that forecast real investments and able to predict the decline during the Financial Crisis. I present a neat theoretical framework to model investments in such a way that essential features explaining investment behavior such as profitability, credit market conditions, and the production level is included in the model. The theory model extends the well known Q-theory and does not represent a new way of modeling investment, but is instead an alternative way to capture Neoclassical elements into a theoretical model describing how credit market conditions amplify shocks in the economy. The results are fully backed by earlier work by the author using a different approach. This essay strengthen the results from the two first papers of this thesis, which identified retained earnings, demand expectations and credit conditions as the critical factors explaining short-run investment behavior.

Future work might be to include the investment Euler equation studied in this paper into a macroeconomic model. There is extensive literature studying financial frictions and banking in DSGE models, and extending a DSGE model with the proposed investment Euler equation would give a model where changes in credit markets would amplify aggregate investments.

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A Appendix tables

Table 3: ADF tests **log(I)** (T=120, Constant+Seasonals; 5%=-2.89 1%=-3.49)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
4	-3.166*	0.83229	0.09523	0.4344	0.6648	-4.631	
3	-3.166*	0.83784	0.09488	2.060	0.0417	-4.646	0.6648
2	-2.765	0.85938	0.09623	0.08618	0.9315	-4.625	0.1156
1	-2.819	0.86028	0.09582	-0.8883	0.3762	-4.642	0.2268
0	-3.151*	0.84910	0.09573			-4.652	0.2738

Date: 1985(1) - 2014(4)

Table 4: ADF tests **Dlog(K)** (T=135, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-2.569	0.77439	0.004433	-5.425	0.0000	-10.80	
2	-4.068**	0.62562	0.004890	-0.5615	0.5754	-10.61	0.0000
1	-4.543**	0.60799	0.004878	-4.123	0.0001	-10.62	0.0000
0	-7.401**	0.42280	0.005163			-10.52	0.0000

Date: 1982(2) - 2015(4)

Table 5: ADF tests **log(I/K)** (T=120, Constant; 5%=-2.89 1%=-3.49)

D-lag	t-adf	beta Y_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
5	-3.178*	0.80770	0.1233	-0.02365	0.9812	-4.106	
4	-3.340*	0.80729	0.1228	0.8948	0.3728	-4.123	0.9812
3	-3.222*	0.82191	0.1226	2.082	0.0396	-4.133	0.6733
2	-2.762	0.84965	0.1244	0.1820	0.8559	-4.111	0.1726
1	-2.813	0.85205	0.1239	-0.8217	0.4130	-4.128	0.2828
0	-3.173*	0.83997	0.1237			-4.138	0.3339

Date: 1985(1) - 2014(4)

Table 6: ADF tests **Dlog(I)** (T=124, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-5.283**	-0.075177	0.09812	0.2684	0.7888	-4.581	
2	-5.914**	-0.048705	0.09773	-1.315	0.1912	-4.596	0.7888
1	-8.539**	-0.19299	0.09803	0.3666	0.7146	-4.598	0.4121
0	-12.74**	-0.15410	0.09767			-4.613	0.5907

Date: 1985(1) - 2014(4)

Table 7: ADF tests **Dlog(I/K)** (T=124, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-5.220**	-0.067474	0.1270	0.03504	0.9721	-4.065	
2	-5.984**	-0.063980	0.1264	-1.224	0.2234	-4.081	0.9721
1	-8.555**	-0.19845	0.1267	0.3256	0.7453	-4.084	0.4778
0	-12.87**	-0.16371	0.1262			-4.100	0.6621

Date: 1985(1) - 2014(4)

Table 8: ADF tests **Dlog(X)** (T=135, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-6.249**	-0.81424	0.04115	-5.328	0.0000	-6.345	
2	-19.80**	-2.1546	0.04525	10.56	0.0000	-6.162	0.0000
1	-13.29**	-0.88671	0.06133	3.457	0.0007	-5.561	0.0000
0	-19.03**	-0.46835	0.06381			-5.489	0.0000

Date: 1982(2) - 2015(4)

Table 9: ADF tests **GDP GAP** (T=135, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	$\beta GDPGAP_{t-1}$	sigma	t-DY_lag	t-prob	AIC	F-prob
4	-3.416**	0.97190	0.1842	-1.613	0.1092	-3.347	
3	-4.192**	0.96738	0.1854	2.559	0.0116	-3.342	0.1092
2	-3.530**	0.97317	0.1892	-3.088	0.0025	-3.308	0.0116
1	-5.038**	0.96379	0.1952	24.35	0.0000	-3.253	0.0004
0	-1.155	0.98077	0.4544			-1.570	0.0000

Date: 1982(2) - 2015(4)

Table 10: ADF tests **log(YE/Y)** (T=135, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	βYE_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
4	-1.642	0.86957	0.1499	-0.6447	0.5204	-3.727	
3	-1.882	0.85613	0.1495	-2.404	0.0178	-3.739	0.5204
2	-2.683	0.80060	0.1525	-0.6783	0.4989	-3.707	0.0496
1	-2.997*	0.78654	0.1522	-4.131	0.0001	-3.719	0.0902
0	-4.867**	0.66439	0.1619			-3.602	0.0002

Date: 1982(3) - 2013(4)

a Hvis sesongdummier inkluderes får en klarere indikasjon på I(0).

Table 11: ADF tests **Dlog(YE/Y)** (T=135, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
4	-6.685**	-1.3945	0.1515	0.3279	0.7436	-3.705	
3	-8.124**	-1.3243	0.1510	1.107	0.2706	-3.720	0.7436
2	-10.02**	-1.1095	0.1511	3.085	0.0025	-3.725	0.5179
1	-10.67**	-0.65328	0.1564	1.448	0.1502	-3.664	0.0157
0	-18.13**	-0.46123	0.1571			-3.663	0.0143

Date: 1982(3) - 2013(4)

Table 12: ADF tests **Residual of the one-equation model** (T=120, Constant; 5%=-2.89 1%=-3.49)

D-lag	t-adf	beta Y_{t-1}	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-6.082**	-0.16838	0.08448	0.8721	0.3850	-4.902	
2	-6.541**	-0.083841	0.08439	0.1951	0.8456	-4.912	0.3850
1	-7.935**	-0.065035	0.08404	0.04199	0.9666	-4.928	0.6717
0	-11.57**	-0.060937	0.08368			-4.945	0.8492

Date: 1985(1) - 2014(4)