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FIRM LEVERAGE AND INVESTMENT DURING THE CRISIS

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FIRM LEVERAGE AND INVESTMENT DURING THE CRISIS

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RESUME

De private investeringer faldt kraftigt i mange lande under den seneste finansielle krise. Danmark er ingen undtagelse. Den høje gældskvote, som nogle virksomheder opbyggede før krisen, bidrog til faldet i investeringer under krisen, særligt for små og mellemstore virksomheder. Sammenhængen findes både overordnet og inden for grupper af mere homogene virksomheder defineret ved fx branche, likviditet og geografi. Effekten er tydeligst i brancher, hvor virksomhederne reducerede deres investeringer mest under krisen, og er ikke kun udtryk for det forhold, at virksomheder normalt investerer mindre efter en periode med store investeringer. Den signifikante effekt på tværs af undergrupper af virksomheder indikerer, at der findes en selvstændig 'bruttogældskanal', som har betydning ud over de variable, der typisk inkluderes i investeringsrelationer. Virksomhedernes bruttogæld kan således have betydning for den makroøkonomiske volatilitet. Resultaterne tyder endvidere på, at det ikke var begrænsninger i adgangen til kredit som var årsagen til investeringsudviklingen under krisen.

ABSTRACT

Private investment in advanced economies contracted sharply during the most recent financial crisis. Using firm-level data from Denmark, this paper argues that the high leverage, which was build up by some firms before the crisis, contributed to the reduction in investment during the crisis, in particular for small and medium-sized enterprises. The significant effect of high leverage is present also in subsamples defined by industry, liquidity ratio, and geography. The effect is most clear in industries in which firms decreased their aggregate investment most during the downturn, and it cannot solely be attributed to a 'regression to the mean'-effect. The persistent effect across subsamples points to the existence of a separate leverage or 'balance sheet' channel in addition to the effects of other variables conventionally included in investment relations. Consequently, the degree of leverage among non-financial firms may have implications for macroeconomic volatility. Furthermore, results indicate that the development in investment during the crisis was not primarily a result of more difficult access to finance for highly leveraged firms.

KEY WORDS

Leverage; Investment; Macroeconomic Stability.

JEL CLASSIFICATION

D22; D92; E22; G31.

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1. INTRODUCTION

Private investment in advanced economies contracted sharply during the most recent financial crisis. Business investment accounts for the bulk of the investment slump, and the main driving factor has been the overall weakness of the economic activity and uncertainty about the future state of the economy (Banerjee et al., 2015; IMF, 2015). However, in some countries, an additional factor contributing to the reduction in investment may have been the build-up of debt in the private non-financial sector in the period leading up to the crisis. Investment generally contracted more during the financial crisis in countries in which firms build up large leverage before the crisis, although there is substantial variation across countries.

Denmark is a good example of a country in which firms build up a relatively high leverage ratio before the crisis and reduced their investment substantially during the crisis. Using Danish firm-level data, this paper investigates the extent to which leverage contributed to the development in investment at the firm-level during the period 2007-12. To be more specific, our empirical approach aims at assessing the extent to which firms which were highly leveraged before the crisis reduced investment more than firms with lower leverage but otherwise similar characteristics.

We find that the high leverage, which was build up by some firms before the crisis, contributed to the reduction in investment during the crisis. Furthermore, we find that this 'balance sheet channel' is not merely a consequence of a 'regression to the mean' effect (i.e. that it is normal for firms to cut back on investment after a period of large investment) or better access to finance for less leveraged firms. Some firms may also prefer to hold back investment and reduce their leverage in order to increase their resilience to future shocks and retain flexibility in future financing choices. In addition, increased uncertainty in itself makes investment less desirable, and therefore uncertainty plays a large role for investment (Bloom et al., 2007).

Based on the model, an assessment of the economic relevance of the balance sheet channel results in a rough estimate that high leverage explains approximately 15-20 percent of the total reduction in investment in the period 2008-2012. We therefore conclude that high leverage, or in aggregate terms, a high level of gross debt relative to total firm assets, may contribute to higher macroeconomic volatility.

The paper proceeds as follows. Section 2 presents the macroeconomic context of the study and discusses relevant literature. Section 3 presents the data. Section 4 provides some descriptive evidence, while section 5 presents the main econometric results. Section 6 focuses on the mechanism through which the leverage channel works while section 7 concludes.

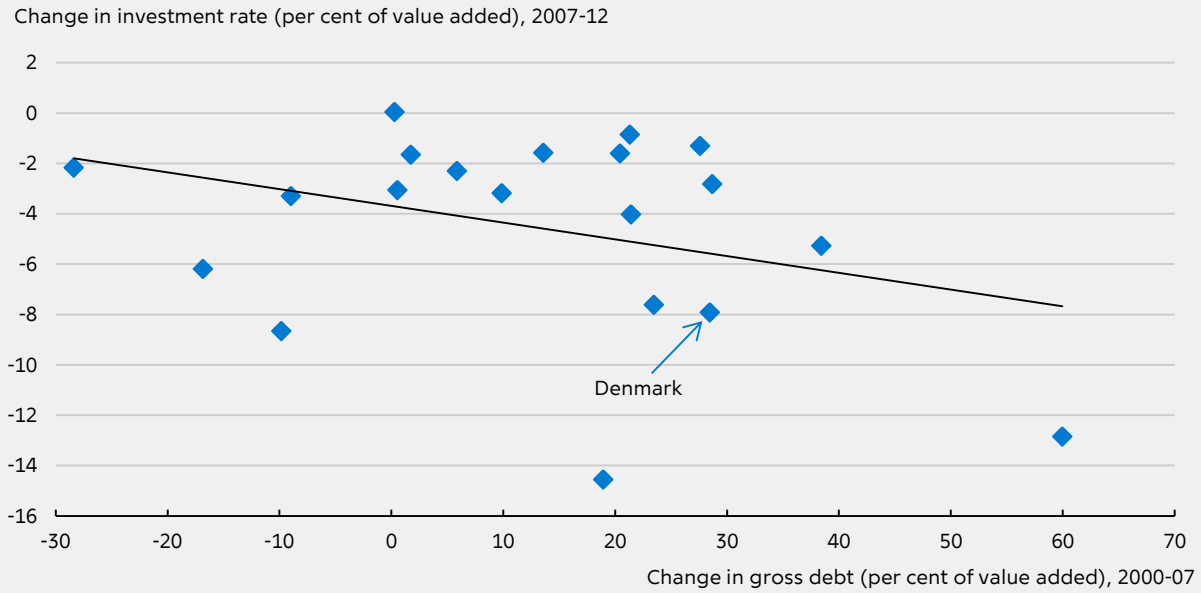
2. BACKGROUND AND LITERATURE

2.1 BACKGROUND AND CONTEXT

During the financial crisis, Danish firms reduced their investment substantially – also in comparison with other countries in which firm debt grew relatively strongly before the crisis, cf. chart 1 and Banerjee et al. (2015). The fact that Denmark is one of the countries in international comparison in which firms' response to the crisis in terms of investment has been relatively marked makes Denmark a relevant setting to study the effect of leverage on investment at the firm-level.

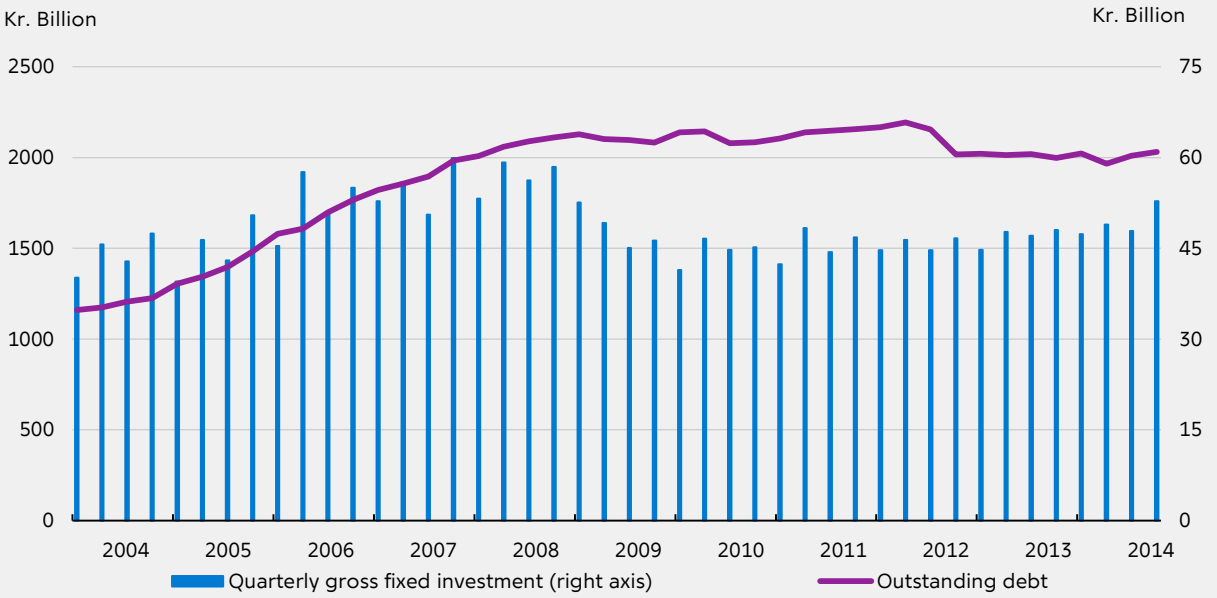
In 2000-2007, Danish firms expanded their financial balances substantially. On the liabilities side of balance sheets, firms increased their gross debt from 70 per cent of Gross Domestic Product (GDP) to almost 95 per cent, while on the assets side the expansion was reflected in increased placement in shares and other equity and an increase in stocks of liquid assets (Brandt et al., 2012). Most of the increase in gross debt was in the form of bank loans. The outstanding debt of non-financial corporations was in 2014 around 2,000 billion DKK, approximately the same as of end-2007, cf. chart 2. However, there has been a substantial shift from financing through commercial banks towards mortgage bank financing. This is in line with the pattern in previous periods of economic stress (Abildgren and Kuchler, 2013).

The build-up of debt 2000-07 and change in investment 2007-12, OECD countries Chart 1



Note: The investment rate is defined as gross fixed investment relative to value added. Gross debt includes loans, debt securities and insurance technical reserves. All OECD countries for which data are available are included.
Source: OECD.

Non-financial enterprises' debt and investment Chart 2



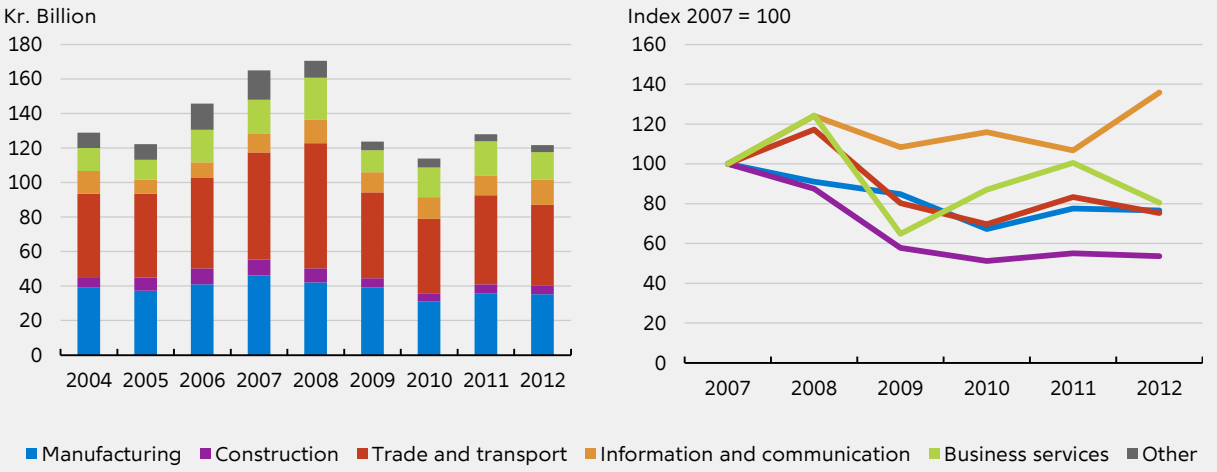
Note: Investment is defined as in the national accounts statistics. The break in the outstanding debt series in 4th quarter of 2012 is caused by migration to new national accounts standards.
Source: Statistics Denmark and Danmarks Nationalbank.

Firms in the non-primary industries have reduced their investment even further than reflected in chart 2. The reduction has been more marked in some industries than others, cf. chart 3. While the construction industry has seen a substantial reduction in investment, firms in the information and communication industry have increased their aggregate investment. Firms in large industries such as manufacturing and trade/transport have reduced their investment to around 80 per cent of the 2007-level. The industry variation in investment is in line with the result found for a range of advanced economies by the IMF (2015), namely that firms in industries, which are more sensitive to uncertainty, reduce their investment more relative to less-sensitive industries during times of high economy-wide uncertainty.

In line with cross-country results from the BIS (Banerjee et al., 2015) and IMF (2015), results from the Business Tendency Surveys indicate that also in Denmark, low demand has played a major role for the low economic activity during the crisis and, in particular, in the most recent years, cf. chart 4.

Investment in non-primary industries

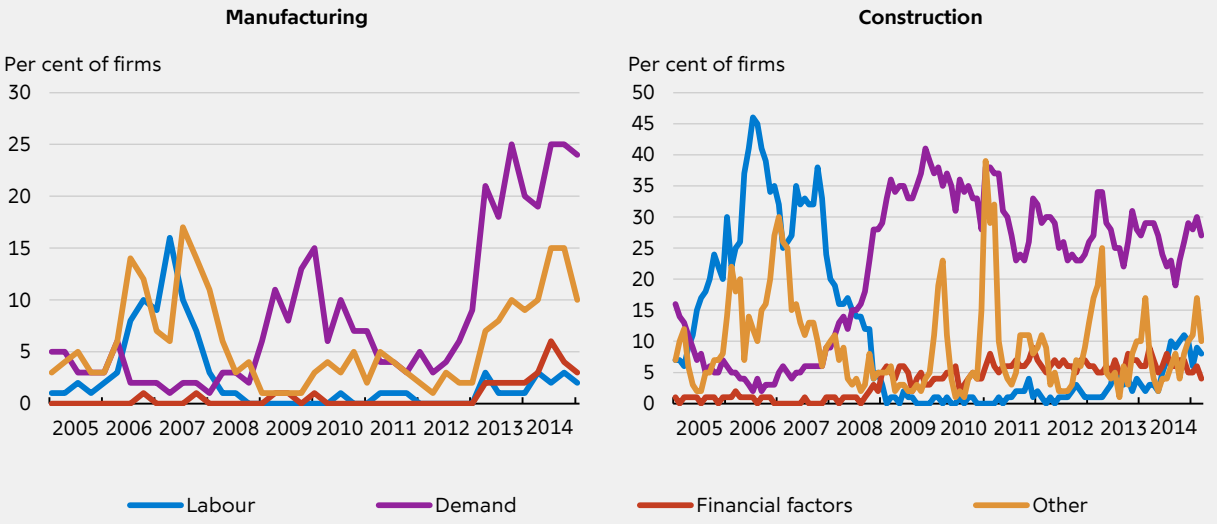
Chart 3



Note: All firms in the firm accounts statistics are included, except firms within the sub-industry 'renting of non-residential buildings' which are excluded due to data quality issues.
Source: Statistics Denmark.

Limits to production

Chart 4



Note: Data for manufacturing is quarterly, while data for construction is monthly. Other factors is the sum of 'weather related factors' (for construction only), 'equipment and raw material' and 'other factors'. The questionnaires were redesigned in 2013, contributing to a fall in the 'no constraints' response in favour of responses stating constraints. A Business Tendency Survey for the service industries is also available from 2011, i.e. not during the crisis. Results from the service industries in the common period are broadly in line with those presented here, although a larger fraction of firms report that demand and financial factors are limits to production.
Source: Statistics Denmark.

2.2 PREVIOUS RESEARCH ON THE ROLE OF LEVERAGE IN INVESTMENT DECISIONS

The literature has suggested several reasons for a negative empirical relation between leverage and investment at the firm-level. Relatively few studies have focused on this relation for non-financial firms during the recent financial crisis, while consequences of household and bank leverage have received a larger focus. For example, Andersen et al. (2014) find that households with high leverage reduced their consumption more during the crisis than similar households in terms of net wealth and other characteristics, but low leverage.

One line of reasoning points to investment below the optimal level for highly leveraged firms. This could arise because of a worsened outlook or because of liquidity constraints, since firms with high leverage may not to the same extent as firms with low leverage be able to take advantage of investment opportunities as they need to raise outside funds (Lang et al. 1996). A related theory for highly leveraged firms posits that high leverage reduces the incentives of the management to invest in positive NPV projects as the benefits, at least partly, accrue to the creditors (Myers, 1977).

The implication of these theories may not only be that we should expect a negative empirical relation between leverage and investment. Firms which expect future valuable investment opportunities may take measures to reduce leverage ex ante in order to retain flexibility in future financing and investment choices (Aivazian et al., 2005). Such an incentive is likely to be reiterated by an economic downturn with increased uncertainty regarding not only future demand but also future credit conditions.

In contrast to the 'low investment' hypotheses mentioned above, an overinvestment problem has also been discussed in the literature (Jensen, 1986). The reasoning is that management may have a propensity to expand the size of the firm even if it implies that the firm undertakes poor investment projects. The ability of the management to follow such a strategy might be more constrained for highly leveraged firms because of the cash flow needed to service the debt. The implication is also here that we should expect a negative relation between leverage and investment, but mainly for firms with weak growth opportunities, as firms with good growth opportunities should still be able to obtain financing for their investment even if they are highly leveraged.

Empirically, the relation between debt and investment has been the focus of a number of recent studies in the academic literature as well as in policy circles. IMF (2015) find that the large contraction in investment since 2007 is broadly based, and that low demand is the main explanation. In some countries, limited access to finance and increased uncertainty has also played a role. Banerjee et al. (2015) also conclude that uncertainty about expected profits and the future state of the economy are main drivers of the development in investment. While financing conditions in general have been favorable in the crisis and post-crisis years, with low interest rates and accessible capital markets, investment has evolved broadly in line with what could be expected based on past relations – in which uncertainty is found to be the main explanatory factor. One of the reasons why uncertainty may potentially play such a large role in holding back investment is that it increases real option values, which makes firms more cautious in their investment decisions (Bloom et al., 2007).

Another related strand of literature is concerned with the concept of 'balance sheet recession', arguing that a downward pressure on asset prices may create an imbalance between the preferred and actual leverage of both firms and banks (Koo, 2008). In response, firms may prefer to reduce leverage instead of investing, while the pressure on banks' balance sheets at the same time may reduce their willingness to extend credit. Both developments imply negative shocks to the economy, and if strong enough, the result may be a balance sheet recession.

The use of microdata enables insights into issues which may be invisible in aggregate data. Previous micro-based empirical evidence points to the existence of a negative relation between leverage and investment at the firm-level (Aivazian et al., 2005; Cai and Zhang, 2011; Dang, 2011; Lang et al., 1996; Magud and Sosa, 2015). Martinez-Carrascal and Ferrando (2008), using data from 6 different countries, find this relation to be present only in some countries (Belgium, France, and to a lesser extent Italy and Spain, while not in Germany and the Netherlands), while Holmberg (2013) find that Swedish firms with low credit reserves (unused credit on lines of credit) reduced their investment more than other firms, but did not find evidence that the decline in investment was exacerbated by a contraction in credit supply. Evidence of a balance sheet channel has also been found for other outcomes than investment, e.g. employment (Giroud and Mueller, 2015) and wage level (Akyol and Verwijmeren, 2013).

The present paper is most closely related to the micro-based empirical literature. We complement the existing literature in a number of important ways. First, in contrast to previous literature, our focus is specifically on the effect of high leverage during a crisis period. This focus enables a better assessment of the extent to which measures to reduce leverage (in boom years) may be an effective tool to reduce macroeconomic volatility. Second, we use a large, nationally representative dataset. This is important as it means that sample selection issues are not impacting our results, but also because the wide coverage enables a wide range of possible subsample splits, which we utilize to gain further insights into the nature of the estimated effects. Third, the panel dimension of data enables a cleaner estimate of the investment response to the crisis at the firm-level by considering the change in investment from its pre-crisis level at the individual firm. Firm behavior can therefore be directly analyzed. And finally, we are able to control for pre-crisis investment behavior, and thereby ensure that the estimated effects are not only a consequence of a 'regression to the mean'-effect – i.e. that it is normal for firms to cut back on investment after a period of large investment, irrespective of whether or not a crisis occur.

3. DATA

3.1 DATA AND SOURCES

We use firm-level data from Statistics Denmark's Firm Accounts Database covering all private non-primary and non-financial firms, excluding firms in energy and water supply and parts of the transport sector (ports etc. and railway and bus transport), in the period 2000-2012. Firms are identified at the enterprise level (i.e. legal units). The database is primarily based on questionnaires administered to a sample of firms (covering approximately 70 per cent of total sales). In addition, some data, e.g. investment, employment, turnover, net income, capital and total assets (and thereby leverage) is available for most firms (around 90 per cent of total sales) via tax reportings. For the non-sampled firms, data for some of the variables used here have been imputed by Statistics Denmark based on a matching algorithm using data on e.g. firm size, industry etc. The quality of the imputation is likely to be relatively high since the sample includes firms of all sizes and types. We use the full dataset, and not only the sampled firms, in order to be able to relate the results to the full population of Danish firms. In essence, this approach is an alternative to a weighted regression using sampling weights. A robustness check using only observations where no data has been imputed (at the cost of the sample being non-representative) yields similar results as those using the full dataset, cf. section 5.6.

Furthermore, we exclude sole proprietorships from the dataset for three reasons. First, for these firms, the owner's private finances are not sufficiently separated from those of the firm to enable a comparison between the data for this group and the remaining firms. Second, the fact that sole proprietorships are disproportionately represented in the sample might cast some doubt about the reliability of data for this group of firms. Third, data on investment is incomplete for these small firms. And fourth, although they only represent a limited fraction of total turnover, sole proprietorships outnumber the rest of the firms. Naturally, this would impact the results, possibly in some cases to such a large degree that results may be driven by sole proprietorships, which may in many ways not be comparable to larger firms.

A few more restrictions have been imposed. We exclude inactive firms, defined as firms with an employment less than 0.5 full-time employed, as well as firms registered with no assets. From the regressions, we also exclude firms with an investment rate of more than 200 per cent, which approximately corresponds to the 99th percentile. Finally, we restrict the analysis to firms which exist in the full period 2006-2012. This is mainly in order to counter the effect that firms, which cease to exist in the period, may otherwise have had between e.g. the bankruptcy date (or the date on which a firm's management become aware that the firm will not survive) and until the firm no longer submits an annual report which is included in the statistics.[1]

A comparison of fixed investment as defined in the firm accounts statistics with fixed investment as defined in the national accounts statistics shows a substantial lack of correspondence for firms classified in the subindustry 'renting of non-residential buildings'. Firms in this subindustry have therefore been excluded from the analysis.[2] Having excluded these firms, the development in investment in the national accounts statistics and the firm accounts statistics is relatively comparable in spite of differences in the level due to e.g. industries not covered by the accounts statistics and different sector classifications of firms in the national accounts and the firm accounts statistics, cf.

[1] Abildgren et al. (2014a) demonstrate that firms with high leverage have a lower survival probability than firms with low leverage.
[2] Results with this subsector included are broadly similar to those presented in this paper.

Comparison of total investment in national accounts statistics, firm accounts statistics and analysis sample Table 1

	2005	2006	2007	2008	2009	2010	2011	2012
Investment (kr. billion)								
Non-financial enterprises, national accounts statistics	179.4	209.0	219.2	227.1	193.2	178.0	181.9	182.4
Firm accounts statistics excl. renting of non-residential buildings	116.8	136.2	158.0	168.6	122.1	112.0	125.1	118.7
Analysis sample	71.3	94.0	114.6	113.8	80.3	74.1	97.6	104.7
Investment rate (per cent of value added)								
Non-financial enterprises, national accounts statistics	22.5	24.4	24.8	24.7	23.2	20.1	20.0	19.9
Firm accounts statistics excl. renting of non-residential buildings	17.1	18.6	20.2	20.8	17.5	15.0	16.3	15.2
Analysis sample	15.8	18.3	19.7	18.2	14.6	12.6	15.1	15.6

Source: Statistics Denmark and own calculations

table 1. The additional restrictions imposed (e.g. exclusion of sole proprietorships) are responsible for the remaining differences between the firm accounts statistics and the analysis sample. Also here, the restrictions imposed mainly give rise to a difference in levels whereas the development over time is relatively comparable between the aggregate statistics and the analysis sample.

3.2 KEY VARIABLES

Our main variable of interest, the investment rate, is defined to most closely resemble the national accounts definition. Hence, it is defined as investment divided by value added. By investment, we refer to gross fixed investment, i.e. the gross flow of fixed assets. As a robustness check, alternative specifications use the definition most commonly used in the micro-based literature, namely the ratio of investment to capital (see section 5.6).

The measurement of investment may be less precise than other accounting variables, in part because a consistency check, such as the one performed on e.g. balance sheet variables, is not to the same extent possible, and in part because investment is subject to large inter-annual variation which hampers consistency checks based on reporting from previous periods. According to Statistics Denmark, any imprecision in the measurement of investment is likely to result in an underestimation of investment. There is no particular reason to believe that the precision with which investment is measured differs across e.g. leverage groups. However, in the regressions, we allow for misspecification caused by measurement error by computing robust standard errors.

Leverage is defined as the ratio of debt to total assets. To partly allow for a non-linear effect of leverage on investment, in graphics and most regressions, we define three categories of leverage, namely low (debt ratio 60 per cent or less), medium (debt ratio of 60-80 per cent) and high (debt ratio of more than 80 per cent). In separate robustness estimations, we instead specify the effect of leverage by linear, squared and non-linear terms.

As control variables in the econometric analysis, we include variables typically included in investment models. We include sales growth, and to control for capital costs we include the implied interest cost defined as the ratio of interest payments to total debt. We also include a measure of firm profitability, namely Return On Assets (ROA). Since exporting firms may be different than non-exporting, we include export share defined as the ratio of export to total sales. We also include equity divided by value added to partly control for different corporate risk profiles (see section 5.1). Finally, to control for firm size and age, we include the logarithm of the number of full-time employees and the firm age in years.

In the econometric analysis, we split the sample by industry, liquidity ratio and firm size. To allow for clarity in graphical representation, the industry classification used is based on the most aggregate industry level. Since the accounts statistics do not cover all industries, we end up with a 6-industries split, namely manufacturing, construction, trade and transportation, information and communication, business services, and other industries.

The liquidity ratio used here is a broad measure, defined as the value of securities, other equity, cash and deposits, divided by total assets[3]. For the purposes of splitting the sample, we define two liquidity categories, low (liquidity ratio 10 per cent or less – roughly corresponding to the sample median) and high (more than 10 per cent). And regarding firm size, we use 4 size groups, namely micro (less than 10 full-time employees), small (10-49), medium-sized (50-249) and large (250 or more full-time employees).

Descriptive statistics, 2007

Table 2

	Low leverage			Medium leverage			High leverage			All		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Investment rate	11.54	20.25	4.51	12.75	17.93	8.57	13.62	27.05	3.69	12.45	21.00	6.25
Leverage ratio	0.42	0.14	0.46	0.69	0.05	0.69	0.95	0.18	0.89	0.64	0.23	0.64
LN(employees)	1.64	1.39	1.50	1.82	1.34	1.75	1.89	1.21	1.82	1.76	1.34	1.67
Age	14.18	15.60	9.00	11.28	11.53	7.00	9.97	10.23	6.00	12.17	13.19	8.00
ROA	25.07	573.36	16.63	13.12	285.17	13.37	5.10	29.69	6.42	16.26	404.53	13.23
Sales growth	0.28	3.01	0.06	0.63	21.81	0.10	0.37	5.26	0.08	0.43	13.87	0.08
Implied interest rate	0.10	1.78	0.02	0.05	0.16	0.04	0.04	0.08	0.03	0.07	1.13	0.03
Export share	9.64	23.50	0.00	8.58	22.17	0.00	9.03	22.89	0.00	9.09	22.85	0.00
Equity/value added	2.59	20.88	0.84	0.64	2.21	0.46	0.07	1.60	0.11	1.30	13.32	0.50
Number of obs.		16,675			16,651			8,506			41,832	

Note: Only observations included in the regressions are included in this table.
Source: Own calculations based on firm-level data from Statistics Denmark.

[3] Results for a more narrow definition of liquidity, consisting of cash and deposits divided by total assets, are similar.

4. DESCRIPTIVE EVIDENCE

Non-financial enterprises reduced their investment substantially during the crisis. For firms in the non-primary industries, which are those covered by our micro-data, the reduction in investment was even more marked. The contraction in investment is mainly driven by the micro, small and medium-sized firms, whereas the investment level of large enterprises has remained largely unchanged, cf. chart 5.

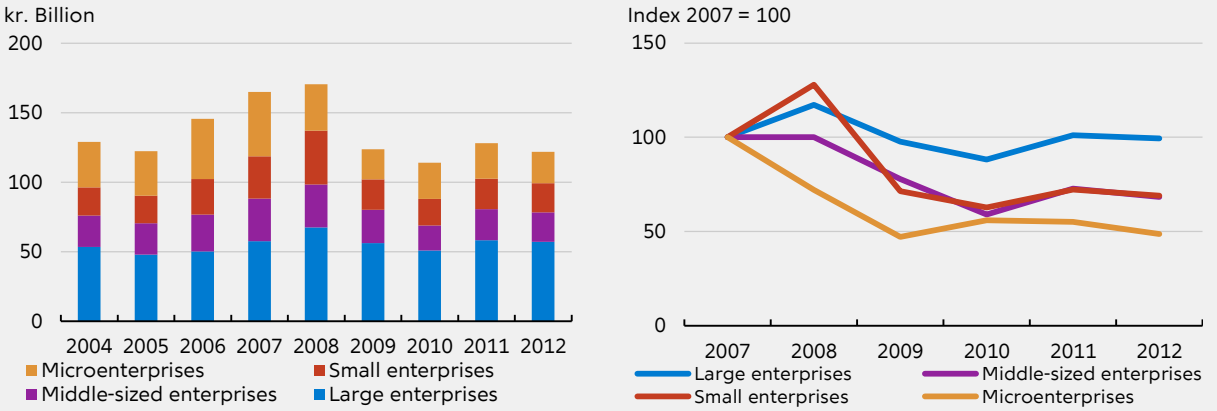
Splitting the sample by pre-crisis leverage, we see that firms with high pre-crisis leverage reduced their investment more during the crisis than firms with low pre-crisis leverage, cf. chart 6. A few observations deserve to be mentioned here, since the same methodology is used to construct the remaining charts in this section. First, the construction of the chart takes advantage of the panel dimension of the dataset, as we are able to observe the response of individual firms to the financial crisis controlling for their behaviour before the crisis. Therefore, the chart is constructed by comparing the investment rate at the individual firm in year t to the same firm's investment rate in 2007.

Second, the median firm reduced its investment substantially during the crisis (note the scale on the vertical axis). This reflects that the investment, which took place during the crisis, was concentrated at fewer firms than the investment which took place before the crisis. The result is also in line with a larger reduction in investment for smaller firms than for large firms, because the number of smaller firms is much greater than the number of large firms, and smaller firms therefore have a large weight in calculating median investment rates.

Finally, the chart points to a conclusion that much of the reduction in (median) investment took place in the period 2007-2010, whereas investment rates have been more or less unchanged from 2010 to 2012. This is largely in line with the aggregate investment development.

Aggregate investment distributed by firm size

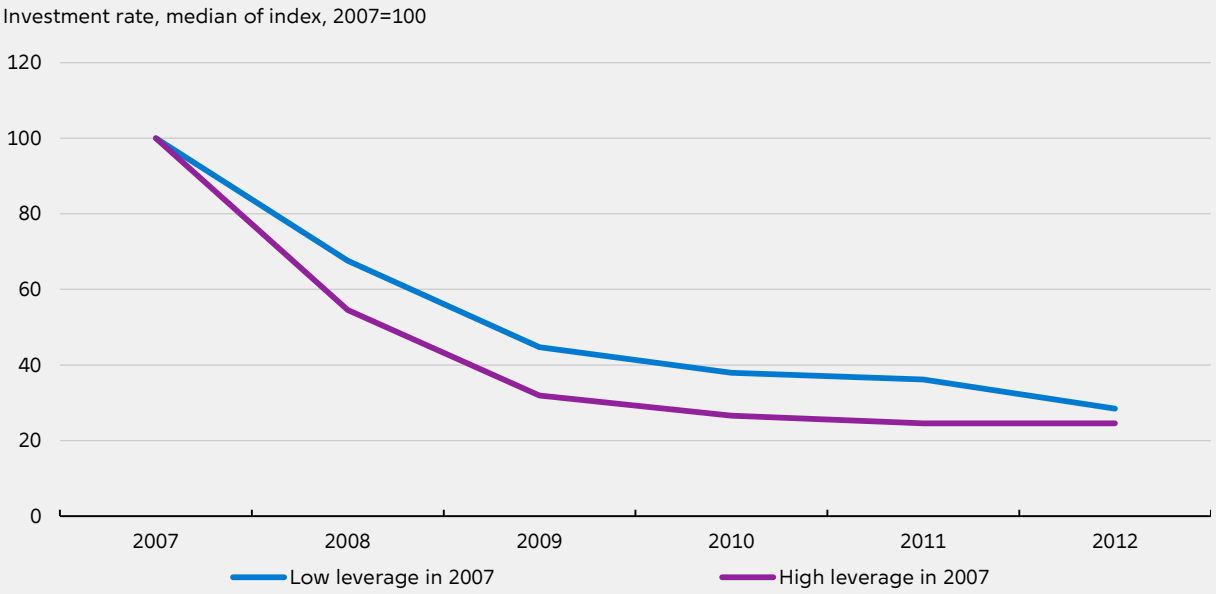
Chart 5



Note: Gross investment. Firm sizes: Micro: less than 10 (full-time) employees; Small: 10-49 employees, Middle-sized: 50-249 employees, Large: 250 or more employees.
Source: Own calculations based on firm-level data from Statistics Denmark.

The development in firms' investment rates

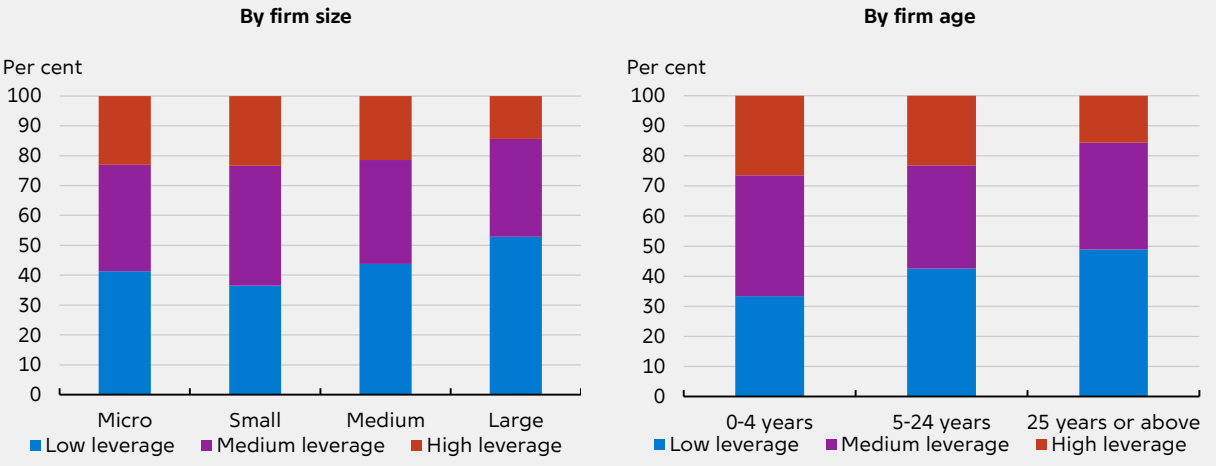
Chart 6



Note: Low leverage refers to leverage ratios up to 60 per cent; high leverage refers to leverage ratios above 80 per cent. The chart is constructed as follows: First, for each firm and each year, we calculate the investment rate. Second, for each firm, we divide by the investment rate in 2007 and multiply by 100 to obtain an index of the firm's investment rate relative to 2007. Third, for each year and each leverage group, we calculate the median of the index and plot it against the years.
Source: Own calculations based on firm-level data from Statistics Denmark.

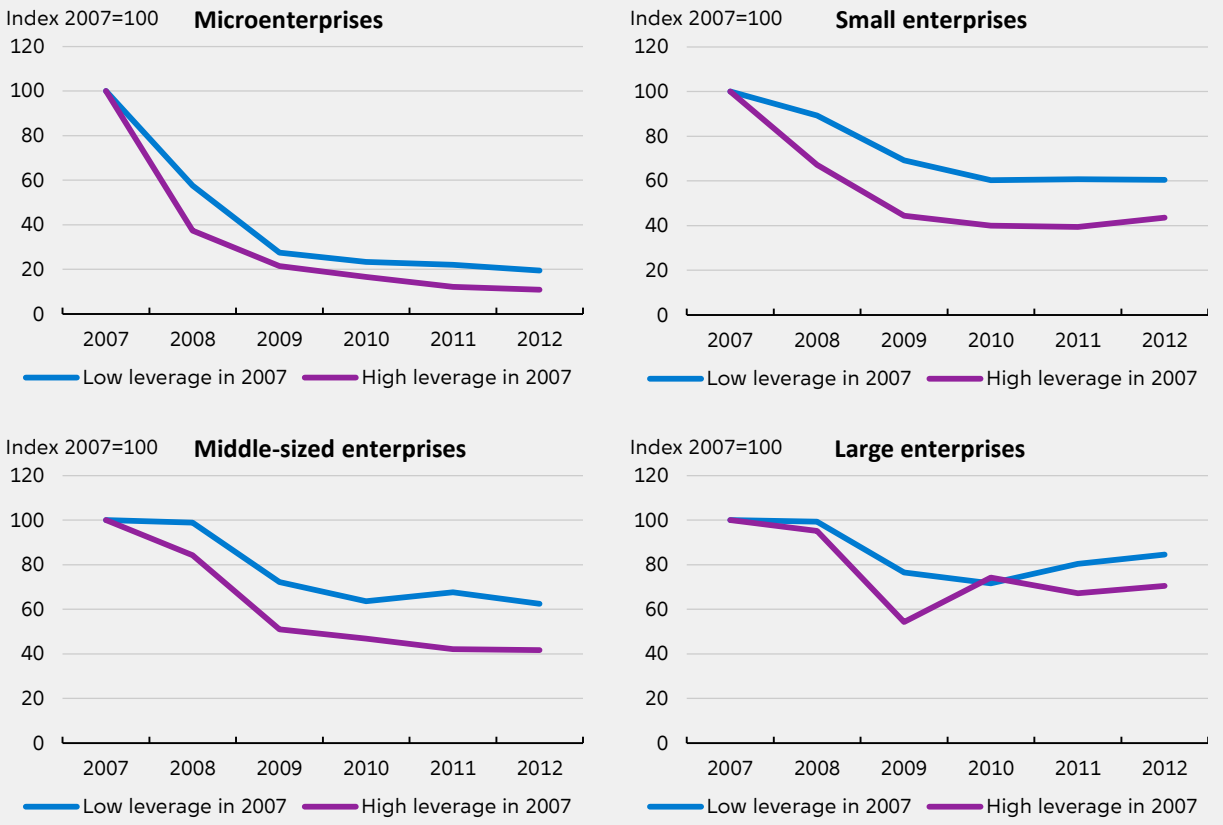
Leverage across firm sizes and age groups, 2007

Chart 7



Note: Low leverage: Leverage ratio up to 60 per cent; Medium leverage: Leverage ratio between 60 and 80 per cent; High leverage: Leverage ratio more than 80 per cent. The firm size classification is identical to that in chart 5.
Source: Own calculations based on firm-level data from Statistics Denmark.

The development in firms' investment rates – groups defined by firm size Chart 8



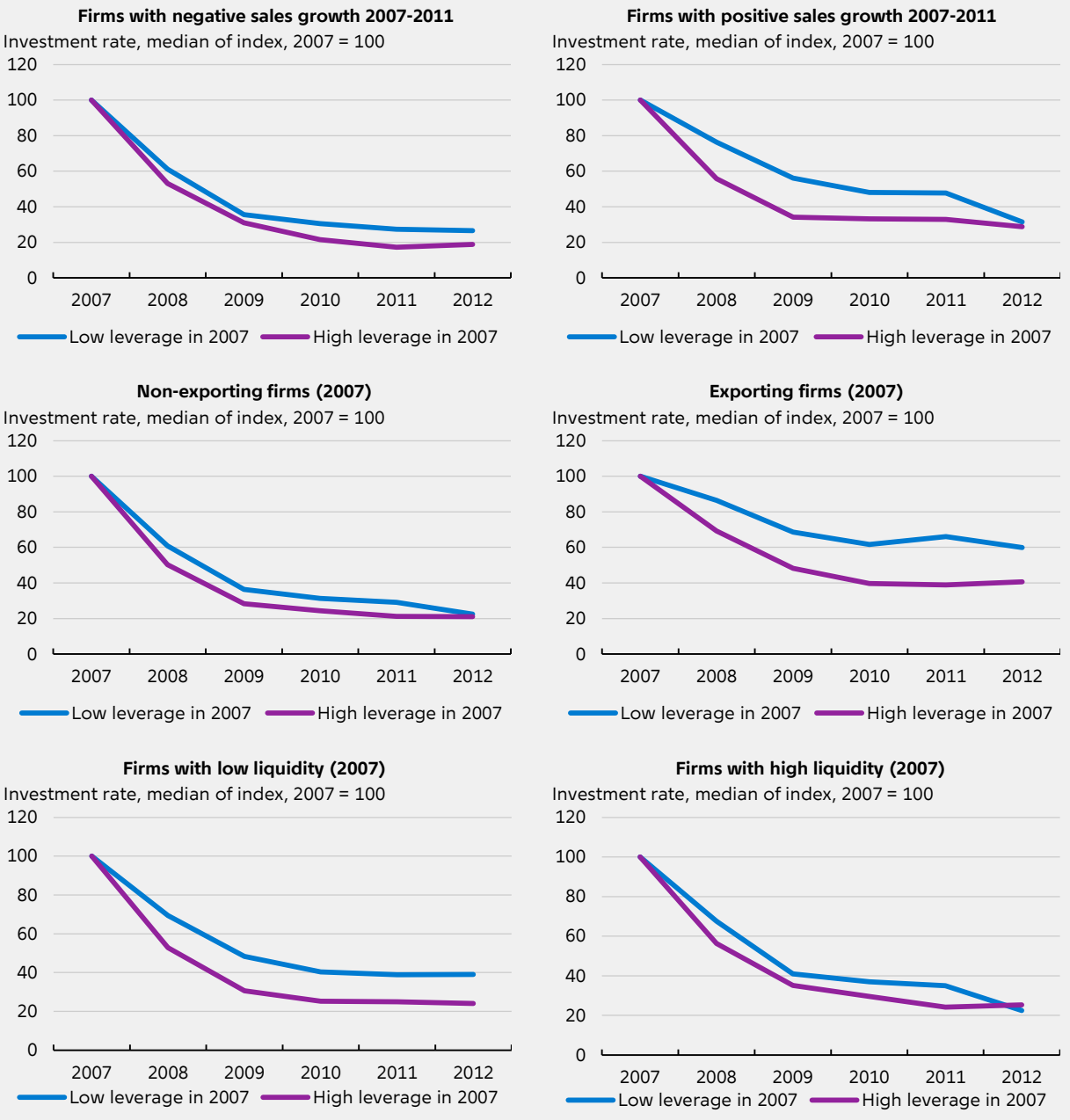
Note: See note to chart 6.
Source: Own calculations based on firm-level data from Statistics Denmark.

Micro and small enterprises and younger enterprises tend to have higher leverage than larger and older enterprises, cf. chart 7. Consistent with the evidence that smaller firms have reduced their investment more than larger firms during the crisis, the relationship between leverage and investment found in chart 6 could potentially be a size effect rather than a leverage effect. Of course, this issue is more fully investigated in the econometric analysis, but the relation between leverage and the development in investment during the crisis is found for both micro-, small and medium-sized enterprises, cf. chart 8. For large enterprises, however, there is no clear effect of leverage on investment in all years during the crisis. The group of large firms is a more heterogeneous group than the smaller firms, as well as their number is smaller. In addition, as already noted, large firms have not reduced their investment substantially during the crisis, which indicates that any effect of firm leverage on aggregate investment is more likely to be found among the smaller and medium-sized firms, rather than among the large.

Continuing our descriptive analysis, we split the sample by sales growth, export rate and liquidity. The split by sales growth is motivated by findings in previous studies of a stronger negative impact of leverage on investment for firms with low Tobin's Q (e.g. Lang et al., 1996; Aivazian et al., 2005). While not directly comparable to Tobin's Q, realised sales growth can be thought of as an ex ante (short run) measure of growth prospects.

Development in firms' investment rates, selected groups

Chart 9

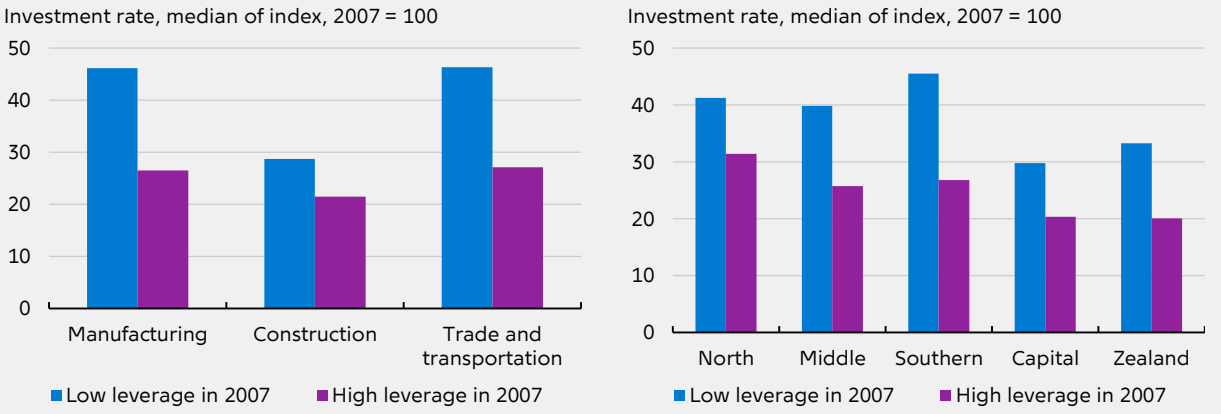


Note: Exporting firms are defined as firms which export more than 5 per cent of their turnover. Firms with high liquidity are defined as firms with liquidity ratio (liquid assets / total assets) higher than 10 per cent, and firms with low liquidity are defined as firms with liquidity ratio smaller than or equal to 10 per cent. Liquid assets are defined as the value of securities, other equity, cash and deposits.

Source: Own calculations based on firm-level data from Statistics Denmark.

We also split the sample by export rate, as exporting firms may differ in e.g. their dependence on bank finance and, more importantly, in the demand they faced during the crisis years. The larger reduction in investment for the highly leveraged firms is not likely to have been caused by the group of highly leveraged firms having lower growth potential or different export profiles on average. Although firms with positive sales growth and exporting firms reduced their investment less than other firms during the crisis, the difference in the investment development between firms with high

Median investment in selected industries and regions, 2011 compared to 2007 Chart 10



Note: Example of interpretation: The median reduction in investment from 2007 to 2011 in the group of manufacturing firms with low leverage was 54 per cent (as the median index value in 2011 for this group is 46 per cent).
Source: Own calculations based on firm-level data from Statistics Denmark.

and low leverage is larger for these groups than for firms with negative sales growth and non-exporters, cf. chart 9.

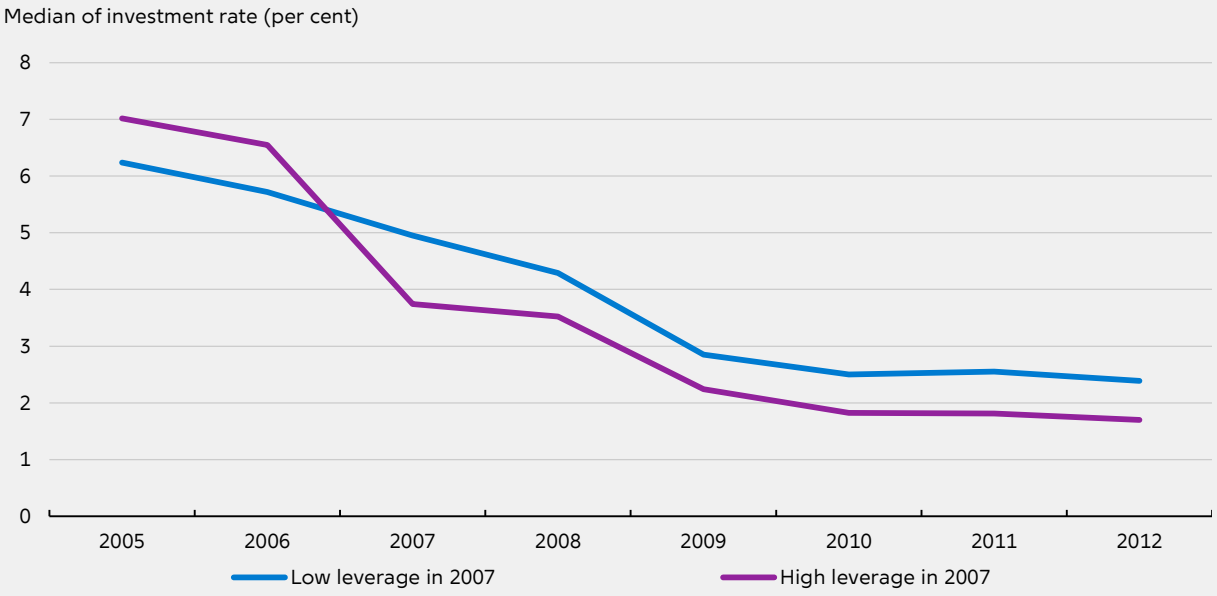
Subsequently, we split the sample by liquidity ratio, cf. chart 9. The effect of leverage on investment is stronger (at the median) among firms with low liquidity, but it is also present among firms with high liquidity. This is a point to which we will return in the interpretation of the regression results.

Finally, we split the sample into groups defined by industry and regions. The effect of leverage on the development in investment during the crisis is also present in subsamples of single industries and regions, cf. chart 10. The econometric analysis will shed more light on whether these bivariate relations in fact can be interpreted as a leverage effect on investment, or whether heterogeneity within the groups give rise to spurious correlations.

To conclude the descriptive analysis, we consider the extent to which the change in investment during the crisis reflects different pre-crisis levels of investment rates or differences in behaviour during the crisis. In chart 11, we consider the level of investment instead of the change. Both firms with high and low leverage reduced their investment substantially during the crisis. Before the crisis, firms with high leverage had a somewhat higher investment level, but during the crisis, highly leveraged firms reduced their investment substantially more than firms with low leverage, cf. chart 11. In fact, this reduction in investment was initiated already in 2007 for the highly leveraged firms. The differences in pre-crisis investment underlines the need for a formal econometric analysis to take into account the possibility of a regression-to-the-mean effect driving the higher reduction in investment observed for the more leveraged firms.

Median investment rates

Chart 11



Source: Own calculations based on firm-level data from Statistics Denmark.

5. RESULTS

5.1 ECONOMETRIC APPROACH

The following reduced form investment relation is used to model the relationship between pre-crisis leverage and investment:

$$\Delta I_{i;s;r;2007-t} = \alpha + \delta_M M_{i;s;r;2007} + \delta_H H_{i;s;r;2007} + \beta x_{i;s;r;2007} + \theta \Delta I_{i;s;r;2006-2007} + \sum_{s=1}^{6} \gamma_s S_s + \sum_{r=1}^{4} \gamma_r R_r + \varepsilon_{i;s;r;t} \quad (1)$$

where the subscripts refer to firm *i* in industry *s*, region *r* and year *t*, where $t \in (2008,2009,\ldots,2012)$. The dependent variable is defined for each firm as the change in investment from 2007 to year t. The variables *M* and *H* are dummy variables referring to firms having medium leverage (a leverage ratio of 60-80 per cent) and high leverage (leverage ratio of more than 80 per cent), respectively, so the coefficients δ_M and δ_H express the difference in the change in investment rates for two otherwise identical firms, where one has medium or high leverage, respectively, and the other has low leverage (less than 60 per cent).

In the vector of control variables, $x_{i;s;r;t}$, we include variables typically included in investment models. We include sales growth, and to control for capital costs we include the implicit interest rate defined as the ratio of interest payments to total debt. We also include a measure of firm profitability, namely Return On Assets (ROA). Since the investment behaviour of exporting firms may be different than that of non-exporting firms, we include export share defined as the ratio of export to total sales. To partly control for different corporate risk profiles, we include equity divided by value added (the same denominator as the dependent variable). The rationale behind this variable is, that if a firm has invested heavily in the recent past (reflected in the equity level) it may face larger risks, which may have impacts on subsequent investment. In addition, it serves to control for a wealth effect, although this is not as straightforward to define for firms compared to e.g. households.[4] Finally, to control for firm size and age, we include the logarithm of the number of full-time employees and the firm age in years.

Since the models are formulated in terms of the change in investment from 2007 to year *t*, we include the change in investment from 2006 to 2007, $\Delta I_{i;s;r;2006-2007}$, to ensure that results are not driven by firms having extraordinarily large, one-of investments in 2007 or a 'regression to the mean'-effect.[5] By a 'regression to the mean'-effect, we refer to the idea that firms are likely to have smaller investment needs and therefore cut back on investment after a period of large investment, irrespective of whether or not a crisis occurs. Inclusion of this variable is also important from a statistical viewpoint, as investment is a variable with substantial inter-annual variation. Finally, we include industry and region dummies in the model.

Because of the relatively loose credit standards leading up to the crisis, it has not been possible to find a suitable instrument for leverage. Abildgren et al. (2013) found that almost all firms which applied for bank loans in 2007 got their application approved. This may be an explanation why there is little correlation between tangible assets and debt level (as used to instrument leverage by

[4] We scale equity by value added in order to use the same scale as the dependent variable. Results are not sensitive to exclusion of the variable from the model.

[5] In a robustness check, we include more lags of this variable. See section 5.6.

Aivazian et al., 2005), and liquidity and debt level in 2007 (as liquidity may be another candidate for an instrument). While results from estimation of equation (1) are therefore in principle only interpretable as correlations, in later subsections, we strengthen the interpretation of the results by e.g. investigating the effects within subsamples and with alternative specifications of the central variables.

5.2 BASELINE RESULTS

Results from estimation of equation (1) are presented in table 3. Results indicate that firms with medium and high leverage reduced their investment more during the crisis than firms with low leverage. As an indication of the economic relevance of the results, it could be noted that the median investment rate in 2007 was 6.3 per cent, and that the median change from 2007 to year t (2008,…,2012) is between 0 and -2, increasingly negative over the years. As an example, consider the coefficient on 'high leverage' in 2008, -3.9. The interpretation of this coefficient estimate is that for two firms which are identical on all parameters except leverage, one having high leverage and

Results: Models of change in investment rate from 2007 to year t Table 3

	2008	2009	2010	2011	2012
Medium leverage (2007)	-2.328***	-3.764***	-2.443***	-2.245***	-2.058***
	(0.280)	(0.298)	(0.263)	(0.251)	(0.261)
High leverage (2007)	-3.877***	-5.321***	-3.710***	-3.267***	-2.946***
	(0.387)	(0.405)	(0.379)	(0.374)	(0.391)
LN (no. of full-time	-0.137	-0.489***	-0.255***	0.228**	0.200**
employees)	(0.104)	(0.110)	(0.099)	(0.096)	(0.101)
Age	0.062***	0.086***	0.025***	0.001	0.003
	(0.010)	(0.011)	(0.009)	(0.009)	(0.009)
ROA	0.004***	0.003***	0.003***	0.004***	0.004***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
Sales growth (per cent)	0.039	0.187	0.188***	0.004	-0.063
	(0.037)	(0.132)	(0.066)	(0.093)	(0.093)
Implied interest rate	-0.078	0.095	-0.509***	-0.537***	-0.571***
	(0.505)	(0.503)	(0.178)	(0.145)	(0.155)
Export share	0.007	0.019***	0.033***	0.027***	0.044***
	(0.005)	(0.006)	(0.006)	(0.005)	(0.007)
Equity / value added	-0.120	-0.137	-0.112	-0.106	-0.109
	(0.077)	(0.096)	(0.087)	(0.079)	(0.080)
Change in investment	-0.011	-0.011*	-0.011	-0.012*	-0.011*
rate in 2007	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes
No. of obs.	35,658	34,814	34,341	33,954	33,602
R-squared	0.085	0.108	0.022	0.018	0.022

Note: All control variables, except sales growth, are measured in 2007. Significance: ***p<0.01, **p<0.05, *p<0.10. Standard errors in parentheses.
Source: Own calculations based on firm-level data from Statistics Denmark.

the other having low, the firm with high leverage would in expectation have reduced its investment rate by 3.9 percentage points more than the firm with low leverage from 2007 to 2008. Considering that the median investment rate in 2007 was 6.3 per cent, the effect is sizeable. It should also be noted that the effect is not only a tail issue. 20 percent of the firms were classified in the high leverage category in 2007 and 38 per cent in the medium leverage category.

To further assess the macroeconomic implications of this 'balance sheet channel', a counterfactual exercise has been performed. The results from this exercise should only be taken as indicative. Since the purpose of the exercise is an estimate of the extent to which the reduction in investment can be explained by high leverage, we compare the predicted changes in the investment rate to predicted changes in a scenario with reduced leverage.

In particular, the counterfactual exercise builds on a scenario in which the firms with high pre-crisis leverage instead had medium pre-crisis leverage. All other variables are held constant. The approach requires an assumption that by the control variables, we have fully controlled for differences between firms (e.g. caused by firms being in different life cycle phases, etc.) – and hence that firms are similar conditional on the control variables. This will enable us to assess the effect of high leverage by predicting, for each firm with high leverage, how investment would have developed during the crisis if the firm had instead had medium leverage but otherwise been identical. By aggregating these individual firm effects, we obtain an estimate of how investment would have evolved during the crisis under this scenario. This estimate is compared to the predicted investment using actual leverage. The difference between these two estimates is our estimate of the effect of high leverage for the firms included in the regression. To obtain an estimate of the macroeconomic effect, then, this estimate is scaled up from the estimation sample to the population level.

According to this calculation, high pre-crisis leverage can explain approximately 15-20 per cent of the reduction in investment from 2007 to 2012. Hence, it is clear that the macroeconomic effect of high pre-crisis leverage exists, but also that the size of the effect is limited.

5.3 LINEAR VERSUS NON-LINEAR LEVERAGE EFFECTS

In our preferred specification, reported in the previous subsection, we specify the leverage effect through the inclusion of dummy variables for medium and high leverage. This is reasonable as the effect of leverage may not be linear, and in addition, as leverage generally may be expected to be less binding for investment if it is lower than a certain threshold (e.g. 60 per cent as used here), meaning that the leverage ratio relative to the threshold may be more important than the actual leverage ratio. To test whether this is a reasonable approach, we estimate a range of models with pre-crisis leverage modelled in distinct ways. First, we specify a linear leverage effect:

$$\Delta I_{i;s;r;2007-t} = \alpha + \delta L_{i;s;r;2007} + \beta x_{i;s;r;2007} + \theta \Delta I_{i;s;r;2007} + \sum_{s=1}^{6} \gamma_s S_s + \sum_{r=1}^{4} \gamma_r R_r + \varepsilon_{i;s;r;t} \quad (2)$$

and secondly, a quadratic effect:

$$\Delta I_{i;s;r;2007-t} = \alpha + \delta_1 L_{i;s;r;2007} + \delta_2 L^2_{i;s;r;2007} + \beta x_{i;s;r;2007} + \theta \Delta I_{i;s;r;2007} + \sum_{s=1}^{6} \gamma_s S_s + \sum_{r=1}^{4} \gamma_r R_r + \varepsilon_{i;s;r;t} \quad (3)$$

Results are presented in table 4. While pre-crisis leverage is significant in the linear specification, the magnitude is not large, considering that the leverage ratio is only defined in the interval [0;1]. The minimum point in the quadratic specification is well above a leverage ratio of 1, meaning that also the quadratic specification implies a downward sloping relation between pre-crisis leverage and investment.

The third specification lets pre-crisis leverage be represented by a more granular series of dummy-variables than those used in the basic model:

$$\Delta I_{i;s;r;2007-t} = \alpha + \sum_{l=65,70,\ldots}^{100} \delta_l 1\left[L_{i;s;r;2007} \in \{l-5; l\}\right] + \beta x_{i;s;r;2007} + \theta \Delta I_{i;s;r;2006-2007} + \sum_{s=1}^{6} \gamma_s S_s + \sum_{r=1}^{4} \gamma_r R_r + \varepsilon_{i;s;r;t} \quad (4)$$

, where 1[ ] denotes an indicator function taking a value of one if the expression in the brackets is true and zero otherwise. The intervals have been defined in this way to allow for a sufficient number of dummy variables to be included, while at the same time ensuring that enough observations are included in each category in order to ensure a certain precision of the estimates.

Results of estimation of this equation for each year are shown graphically in chart 12. To meaningfully interpret the charts, it should be noted that the scale on the y-axis is relative to the excluded category, that is, a pre-crisis leverage ratio of 0-60 per cent. Hence, the charts display the additional change in the investment rate since 2007 for firms with various leverage ratios, relative to a (similar) firm which has a leverage ratio of 0-60 per cent.

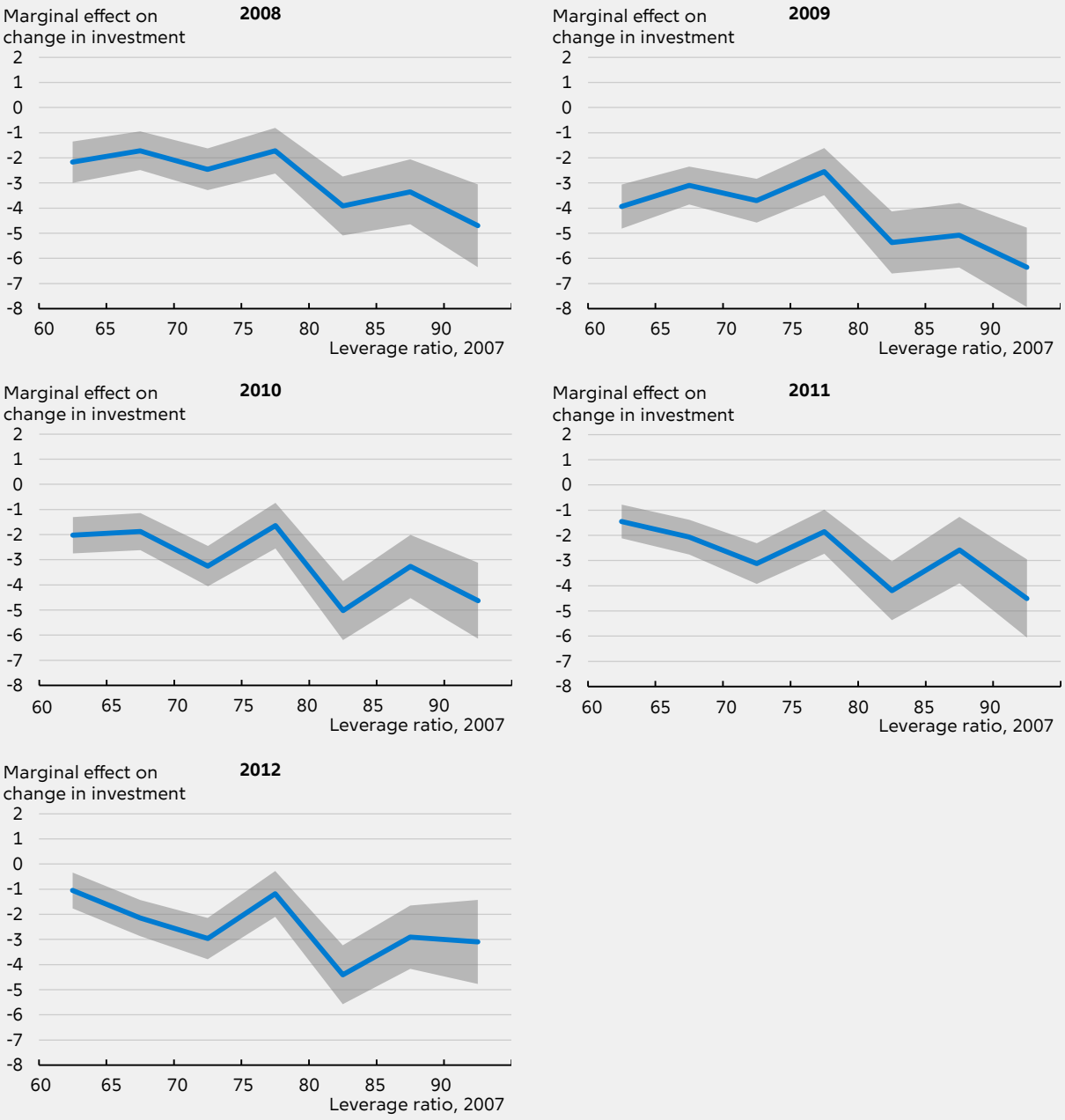
Results: Models of change in investment rate from 2007 to year t Table 4

	2008	2009	2010	2011	2012
Panel A: Linear specification					
Leverage ratio (2007)	-1.258***	-1.955***	-1.685***	-1.357**	-1.634***
	(0.403)	(0.580)	(0.590)	(0.558)	(0.565)
Panel B: Quadratic specification					
Leverage ratio (2007)	-2.263***	-3.649***	-3.361***	-2.895***	-3.320***
	(0.511)	(0.575)	(0.530)	(0.623)	(0.558)
Leverage ratio (2007) squared	0.071***	0.116***	0.117***	0.107***	0.112***
	(0.020)	(0.025)	(0.028)	(0.032)	(0.027)

Note: All control variables included in the model in table 3 are included but not reported here. Significance: ***p<0.01, **p<0.05, *p<0.10. Standard errors in parentheses.
Source: Own calculations based on firm-level data from Statistics Denmark.

We find non-linearities in the effect of pre-crisis leverage and investment in each year during the crisis. In line with the baseline results, we also here find the strongest effect of high leverage in the first years of the crisis. Overall, the charts underpin that modelling the pre-crisis leverage effect on investment as dummy variables capturing medium and high (in contrast to low) leverage is reasonable, in particular compared to a linear effect of pre-crisis leverage.

Non-linear effects of pre-crisis leverage on change in investment Chart 12



Note: The charts show the marginal effect on investment of leverage in 2007 (blue lines) and 95 per cent confidence intervals (grey areas), as estimated by equation (4). Since leverage 0-60 per cent is the excluded dummy variable, the scale on the vertical axis should be interpreted as the additional effect of leverage on the change in investment ratio from 2007 to year t, compared to a firm with a leverage ratio of 0-60 per cent in 2007.

Source: Own calculations based on firm-level data from Statistics Denmark.

5.4 SUBSAMPLE ESTIMATES

In order to investigate the extent to which the significant correlation between pre-crisis leverage and the subsequent development in investment is caused by differences between groups of firms, e.g. in terms of industries and size groups, in contrast to differences within groups, we estimate equation (1) using data for various subsamples. Subsample estimates may also be useful for interpretation of the mechanism through which the leverage effect works, a topic we will return to in section 6. We split the sample by industry, size group, liquidity, export share and sales growth. A split by region has also been performed, but is not reported here since results are similar to the full-country results.

Subsample estimates are presented in table 5. In terms of signs and significance, results are robust within all subsamples except for large firms. The magnitude of the estimated coefficients cannot be directly compared across subsamples, as the model is formulated in terms of changes (from 2007 to year t). This implies that magnitudes of changes will vary across subsamples with different pre-crisis investment levels.

Subsample estimates: The effect of medium and high leverage on change in investment Table 5

Year (t)	2008		2009		2010		2011		2012	
Leverage in 2007	M	H	M	H	M	H	M	H	M	H
Industry										
Manufacturing	-0.256	-3.345***	-1.443**	-5.341***	-2.543***	-5.230***	-1.493**	-3.443***	-2.792***	-5.699***
Construction	-1.784***	-2.536***	-2.578***	-3.261***	-2.755***	-3.276***	-2.308***	-3.031***	-1.999***	-2.966***
Trade / transport	-1.543***	-2.906***	-2.353***	-3.688***	-2.199***	-3.246***	-2.652***	-3.416***	-2.629***	-2.886***
Info. and comm.	-1.761*	-0.302	-1.961*	-2.250*	-0.299	-2.551**	-3.057***	-4.919***	-2.889***	-2.563*
Business services	0.551	-2.176**	-1.347**	-4.442***	-0.289	-3.894***	-1.373**	-4.080***	-0.881	-4.096***
Firm size										
Micro	-2.882***	-4.136***	-4.237***	-5.397***	-2.651***	-3.490***	-2.259***	-2.873***	-2.085***	-2.597***
Small	-1.369***	-3.091***	-3.161***	-5.249***	-2.373***	-4.425***	-2.542***	-4.596***	-2.436***	-4.005***
Medium	-0.502	-0.466	-2.266**	-4.966***	-1.993*	-4.907***	-2.615**	-3.350*	-2.112*	-5.286***
Large	2.207	-0.992	-1.287	-3.869	-1.901	-0.461	-1.000	-2.749	-4.259*	-3.461
Liquidity										
Low	-0.823*	-2.838***	-3.894***	-6.784***	-3.141***	-5.372***	-2.952***	-5.071***	-1.923***	-2.814***
High	-3.158***	-3.393***	-2.265***	-2.453***	-1.649***	-1.897***	-1.834***	-1.540***	-2.192***	-2.743***
Export										
Non-exporters	-3.398***	-5.208***	-4.884***	-6.676***	-2.766***	-4.542***	-2.576***	-3.799***	-2.164***	-3.765***
Exporters	-0.531	-1.121*	-1.965***	-2.565***	-2.177***	-2.184***	-1.761***	-2.087***	-1.938***	-0.960
Sales growth 2007-11										
Negative	-1.554***	-3.036***	-2.419***	-3.732***	-2.318***	-3.697***	-2.491***	-3.071***	-2.424***	-3.208***
Positive	-2.502***	-3.674***	-4.225***	-5.820***	-2.319***	-3.540***	-1.904***	-3.180***	-1.572***	-2.207***

Note: Regression estimates of dummy variable coefficients for medium (M) and high (H) leverage in 2007. Dependent variable: Change in investment in the period 2007 to year t. Separate regressions have been performed for each year and each subsample as indicated in first column. Results can be interpreted in a similar way as results presented in section 5.2, i.e. as the additional change induced by firms having medium (M) or high (L) leverage compared to a similar firm having low leverage. All control variables included in the model from section 5.2 are included in each of the regressions. Significance: ***p<0.01, **p<0.05, *p<0.10.

Source: Own calculations based on firm-level data from Statistics Denmark.

The industry dimension is particularly interesting in light of the differential development in aggregate investment across industries evidenced in section 2. The relation between pre-crisis leverage and investment during the crisis is present in all industries, although in the business services and information and communication industries, the effect of leverage on investment is mainly found for the group of firms with high leverage. These two industries are those which were least impacted by the crisis in terms of investment, possibly because the crisis has not hit those industries as marked as other industries in terms of reduced demand and increased uncertainty.

Chart 13 compares the estimated effects of high leverage compared to low leverage, i.e. the coefficients of high leverage reported in table 5, across industries. Median pre-crisis investment rates vary between 4 and 9 per cent across industries. The investment response to the crisis may therefore also vary across industries. The effects of leverage on change in investment are sizeable compared to the level of pre-crisis investment rates, and relatively comparable across industries. However, highly leveraged firms in the manufacturing industry have reduced their investment level somewhat more compared to firms with low leverage than is the case for firms in other industries.

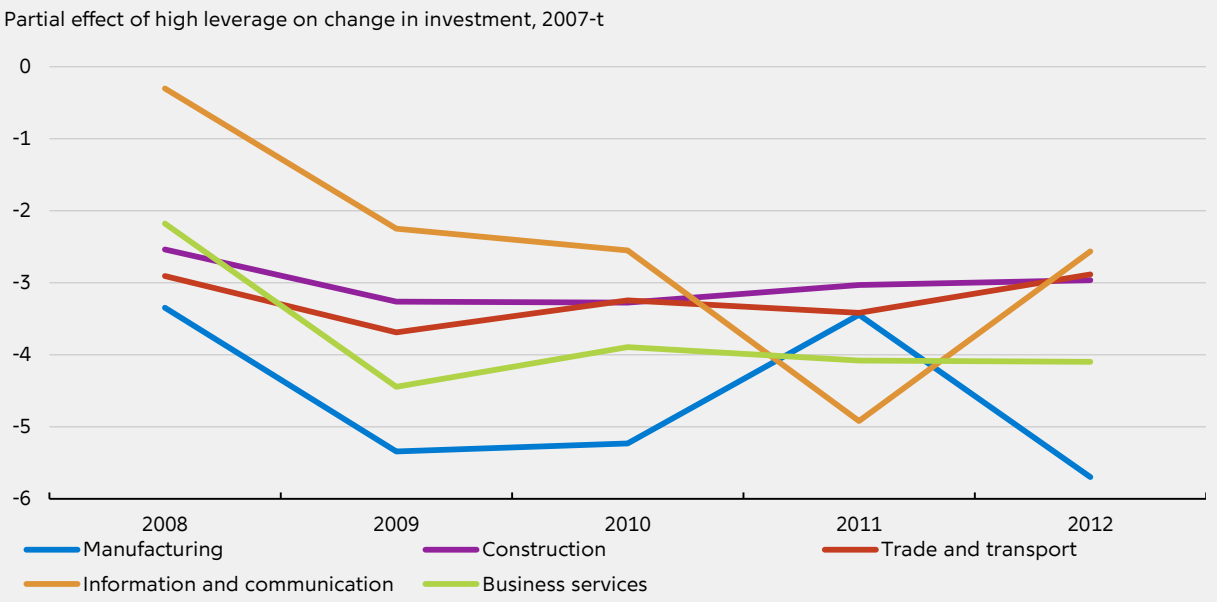
The leverage effect is found for various firm sizes, although it is not statistically significant for large firms (point estimates have the same sign as in the other firm sizes). Large firms are a more heterogenous group than smaller firms, and in addition, the number of large firms is substantially smaller than the number of firms in the other groups.

In terms of liquidity, we find a significant effect among firms with high as well as low liquidity. We will return to this point in section 6. We also find a significant effect for both exporters and non-exporters – even though the effect for exporting firms was not so significant in the beginning of the crisis period in 2008, and it has vanished when comparing investment in 2007 to 2012.

Finally, as previously noted, inspired by the literature we search for a differential effect among groups with different growth prospects by splitting the sample in groups defined by sales growth in the crisis period. However, in contrast to previous literature, we find no difference across firms, which had positive and negative sales growth during the crisis. The relation between leverage and change in investment is similar in the two groups.

At a first glance, the fact that we find a significant impact of high leverage within all subsamples (except large firms) may not appear to be fully consistent with the overinvestment hypothesis discussed previously. However, it is consistent with the 'low investment' hypotheses to the extent that firms respond to the increased uncertainty brought about by the crisis by taking measures to reduce leverage in order to retain flexibility in future financing and investment choices. Our results may be fully consistent with both types of hypotheses, if, during a crisis, the desire to (voluntarily) reduce leverage as a response to increased uncertainty is also present among the firms for which the theories otherwise would have predicted no effect of leverage on investment, e.g. firms with good growth prospects and firms with high liquidity (the significant effect for firms with high liquidity is also found when a more narrow measure of liquidity is used, cf. section 3.2).

The effect of high leverage on change in investment during the crisis Chart 13



Note: The chart depicts the partial effect of high leverage in 2007 on the change in investment since 2007 resulting from an estimation of equation (1) using data for each industry. The base category is low leverage, meaning that the effects depicted can be interpreted as the extra increase in investment resulting from a firm having high leverage instead of low leverage. Example: Consider two otherwise identical firms in the manufacturing industry, one having low leverage and one having high leverage in 2007. The firm with high leverage would on average have reduced its investment rate by 3.3 percentage points more than the firm with low leverage in 2008 compared to 2007.

Source: Own calculations based on firm-level data from Statistics Denmark.

5.5 A CRISIS EFFECT?

A natural next question is whether the estimated effect of high leverage on investment is a crisis effect, or, at least, whether it is reiterated by the crisis. However, even if the effect is unrelated to the crisis, the fact that more firms increased their leverage in the period running up to the crisis would in itself warrant a subsequent larger reduction in investment compared to a situation in which fewer firms build up high leverage.

To investigate this issue, we estimate the following relation:

$$\Delta I_{i;s;r;t-1,t} = \alpha + \delta_M M_{i;s;r;t-1} + \delta_H H_{i;s;r;t-1} + \beta x_{i;s;r;t-1} + \theta \Delta I_{i;s;r;t-2,t-1} + \sum_{s=1}^{6} \gamma_s S_s + \sum_{r=1}^{4} \gamma_r R_r + \varepsilon_{i;s;r;t} \quad , t \in \{2002,2003,\dots,2012\} \tag{5}$$

, i.e. in contrast to the baseline model, for each year, we estimate the relation between change in investment in year t and leverage in year t-1. Compared to the baseline model, this equation is more focused on the short run relation. Results are presented in table 6.

The relation between leverage (t-1) and change in investment (t) Table 6

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Medium leverage	-0.579**	-0.592**	-0.626**	-1.135***	1.920***	0.401*	-0.892***	-1.752***	1.280***	0.573***	0.473***
(t-1)	(0.290)	(0.261)	(0.252)	(0.248)	(0.285)	(0.238)	(0.225)	(0.206)	(0.173)	(0.151)	(0.161)
High leverage	-1.712***	-0.435	-0.627**	-1.801***	0.095	-0.740**	-1.845***	-3.015***	-1.321***	-0.834***	-1.211***
(t-1)	(0.330)	(0.313)	(0.306)	(0.289)	(0.343)	(0.293)	(0.275)	(0.246)	(0.176)	(0.156)	(0.165)
Observations	22,111	24,477	26,439	28,682	31,112	33,548	36,370	40,148	45,604	49,459	53,677
R-squared	0.484	0.298	0.346	0.551	0.243	0.387	0.363	0.411	0.525	0.440	0.273

Note: Regression estimates of dummy variable coefficients for medium (M) and high (H) leverage. Dependent variable: Change in investment from year t-1 to year t. Separate regressions have been performed for each year. All control variables included in the model from section 5.2 are included in each of the regressions. Significance: ***p<0.01, **p<0.05, *p<0.10. Standard errors in parentheses.
Source: Own calculations based on firm-level data from Statistics Denmark.

The relation between leverage and investment is to some extent present in most years.[6] However, the negative effect of medium and high leverage is more pronounced in the crisis years (in particular in 2009, where most of the reduction in investment during the crisis took place). The effect of leverage on investment is not only a crisis effect, but it is reiterated by the crisis. In assessing the impact of leverage on aggregate investment during the crisis based on table 6, three separate effects should be taken into account. First, the negative impact of leverage on investment at the firm-level is stronger in the crisis years (in particular 2007-2010) than in most non-crisis years.

Second, while a firm's leverage is in general quite persistent from year to year, the persistency increased during the crisis. For example, in 2005, the probability of a firm having high leverage conditional on high leverage in the previous year was 55 per cent, while in 2010 it was 60 per cent. The mechanism is likely to reflect that deleveraging was more difficult for many firms during the crisis because of a weaker development in sales and because the value of many assets was reduced. In terms of implications of the short run models presented in table 6, this means that firms, which had high leverage (just) before the crisis, are likely to have had high leverage for a longer duration than they would have had if the crisis had not occurred, and hence, the investment response will also be stronger during the crisis than before as firms on average are 'treated' with high leverage for a longer period.

Third, a larger number of firms build up leverage in the years before the crisis, which, even if the effect on investment was the same in crisis and non-crisis years (i.e. a 'regression to the mean'-effect), would warrant a larger reduction in aggregate investment during the subsequent years, which coincided with the financial crisis. Only the first effect is reflected in the results in table 6, while the first and second effects are reflected in our baseline approach due to the longer time horizon. All three effects are reflected in the counterfactual exercise presented in section 5.2.

5.6 SPECIFICATION IN LEVELS AND OTHER ROBUSTNESS CHECKS

The models presented in sections 5.1-5.4 are specified in terms of the change in investment rate from 2007 to year t. This is the most relevant specification for assessing macroeconomic volatility during the crisis, as it relatively directly enables us to address the investment response at the firm-

[6] In subsample estimates (not reported here), in non-crisis times we mainly find the effect among non-exporting firms. Estimates based on various subsamples show there is no difference in significance across subsamples defined by liquidity and subsequent sales growth.

level. While we do control for unusual investment growth in 2007, the larger reduction in investment for firms with higher leverage may still potentially be impacted by different investment levels in 2007. Chart 11 points to a conclusion that firms with high leverage had somewhat higher investment rates before the crisis than firms with low leverage, while the highly leveraged firms reduced their investment more during the crisis. To assess the significance of this differential investment development, we estimate model (1) in terms of investment rates (levels) instead of changes in investment rates.

To achieve a consistent estimate of the coefficients, we need to take into account that a sizeable fraction of firms have no investment in some of the years during the crisis.[7] This is done in a Tobit-framework.[8] For this, we assume that there exists a latent variable, $I^*_{i;s;r;t}$, expressing the investment choice of firm *i* in year *t*. The model of interest is then similar to that of equation (1), only now modelled in terms of the latent investment level instead of the change since 2007:

$$I^*_{i;s;r;t} = \alpha + \delta_M M_{i;s;r;2007} + \delta_H H_{i;s;r;2007} + \beta x_{i;s;r;t} + \sum_{s=1}^{6} \gamma_s S_s + \sum_{r=1}^{4} \gamma_r R_r + \varepsilon_{i;s;r;t} \quad (6)$$

where x is a vector of control variables corresponding to those included in equation (1) and ε is a normally distributed error term. However, we only observe investment when it is positive, that is

$$I_{i;s;r;t} = \begin{Bmatrix} I^*_{i;s;r;t} \text{ if } I^*_{i;s;r;t} > 0 \\ 0 \quad \text{if } I^*_{i;s;r;t} \leq 0 \end{Bmatrix} \quad (7)$$

To estimate the model, we use the maximum-likelihood estimator suggested by Tobin (1958). Results are presented in table 7. Also measured in levels, we find a significant negative effect of high pre-crisis leverage on the level of investment in each of the years 2008-12. The probability of positive (gross) investment in 2009 for a firm which had high leverage in 2007 was around 5 percentage points lower than a similar firm which had low leverage (table 7, panel B). The effect gradually decreases, but is still 1 percentage point in 2012. The size of the effect could be compared to the unconditional probability of positive investment, which vary between 64 and 73 per cent over the years.

Furthermore, conditional on investment being positive, firms with high leverage in 2007 have significantly lower investment rates throughout the period 2008-2012 (table 7, panel C). Compared to median investment rates in the range of 5-7 per cent, high pre-crisis leverage is associated with an investment rate which is 0.2-1.3 percentage points lower, varying over the years with the largest effect in 2009.

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7 The share of firms which do not invest at all in a given year ranges between 20 per cent and 37 per cent during the crisis. However, transition probabilities between the groups of firms with no investment and with positive investment are relatively large, so that it does not impact the models specified in terms of changes in investment since 2007. Only a small fraction (around 7-10 per cent varying over the years) of firms have reported zero investment in both 2007 and each of the subsequent years; a fact which justifies the linear specification used to estimate the model specified in terms of changes.

8 Although a standard linear regression estimator is inconsistent, results from it are similar to the Tobit model in terms of significance. Hence, the choice of the Tobit-model is not driving the results.

Tobit models of investment rates (specification in levels) Table 7

	2008	2009	2010	2011	2012
Panel A: Tobit estimates					
Medium leverage (2007)	0.363	-1.747***	-0.077	0.137	0.155
	(0.302)	(0.319)	(0.248)	(0.228)	(0.254)
High leverage (2007)	-1.891***	-3.361***	-1.221***	-0.766***	-0.695**
	(0.366)	(0.386)	(0.301)	(0.277)	(0.309)
LN (no. of full-time	1.428***	1.821***	1.831***	2.099***	2.366***
employees)	(0.108)	(0.115)	(0.090)	(0.083)	(0.091)
Age	0.089***	0.142***	0.077***	0.061***	0.067***
	(0.011)	(0.011)	(0.008)	(0.008)	(0.009)
ROA	0.002**	0.004***	0.012***	0.002**	-0.000
	(0.001)	(0.002)	(0.003)	(0.001)	(0.000)
Sales growth (per cent)	0.111***	0.345***	0.155***	0.184***	0.396***
	(0.027)	(0.058)	(0.035)	(0.034)	(0.058)
Implied interest rate	0.207	-0.290	-0.250	-0.677**	-0.073
	(0.268)	(0.219)	(0.184)	(0.298)	(0.193)
Export share	-0.009	0.006	0.013***	0.010***	0.000
	(0.006)	(0.006)	(0.003)	(0.002)	(0.001)
Equity / value added	0.062***	-0.058***	0.037***	0.063***	0.024***
	(0.010)	(0.017)	(0.004)	(0.008)	(0.009)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes
No. of obs.	40,396	39,331	38,785	38,325	37,945
Panel B: Extensive margin: Marginal effects on the probability of positive investment					
Medium leverage (2007)	0.006	-0.027***	-0.002	-0.003	0.003
High leverage (2007)	-0.029***	-0.052***	-0.024***	-0.017***	-0.014**
Unconditional probability	73.2%	67.9%	65.6%	65.2%	64.1%
Panel C: Intensive margin: Marginal effects on investment conditional on positive investment					
Medium leverage (2007)	0.152	-0.672***	-0.030	0.053	0.058
High leverage (2007)	-0.781***	-1.269***	-0.465***	-0.292***	-0.258**
Median investment rate	7.351	6.248	5.750	5.839	5.686
(conditional on positive)					

Note: The marginal effects presented are partial effects of a change in the dummy variable from 0 to 1. Marginal effects are evaluated at the mean of the explanatory variables, using the Stata command dtobit. Significance: ***p<0.01, **p<0.05, *p<0.10. Standard errors in parentheses (Panel A).

Source: Own calculations based on firm-level data from Statistics Denmark.

Robustness estimates Table 8

	2008	2009	2010	2011	2012
Panel A: Dependent variable: Change in gross investment divided by value added in 2007					
Medium leverage (2007)	-0.009***	-0.024***	-0.021***	-0.019***	-0.016***
High leverage (2007)	-0.019***	-0.033***	-0.030***	-0.029***	-0.024***
Controls included	Yes	Yes	Yes	Yes	Yes
Panel B: Dependent variable: Change from 2007 to t in ratio of gross investment to capital					
Medium leverage (2007)	-7.516*	-7.813*	-14.746***	-12.255**	-8.919**
High leverage (2007)	-19.115***	-27.332***	-26.097***	-23.970***	-15.436**
Controls included	Yes	Yes	Yes	Yes	Yes
Panel C: Baseline model estimated using only surveyed firms					
Medium leverage (2007)	-0.607	-2.243***	-3.011***	-2.270***	-2.969***
High leverage (2007)	-2.151**	-5.146***	-5.684***	-3.637***	-4.325***
Controls included	Yes	Yes	Yes	Yes	Yes
Panel D: 3 lags of change in investment up to 2007 included as controls					
Medium leverage (2007)	-1.840***	-3.119***	-1.408***	-1.127**	-0.856*
High leverage (2007)	-3.419***	-6.352***	-4.290***	-3.964***	-3.644***
Controls included	Yes	Yes	Yes	Yes	Yes

Note: The scale of the dependent variable is different in each of the panels so coefficient estimates cannot be compared. Due to data quality considerations (tangible assets are not reported to the tax authorities, but imputed by Statistics Denmark for non-surveyed firms), the results in panel B are based only on surveyed firms. Significance: ***p<0.01, **p<0.05, *p<0.10.
Source: Own calculations based on firm-level data from Statistics Denmark.

Turning back to the original model specified in changes, a number of further robustness checks have been performed, cf. table 8. First, we use an alternative specification of the dependent variable, namely the change in gross investment from 2007 to year t divided by value added in 2007. The motivation for using this measure is that we can then more specifically ensure that the change in investment rate is caused by the change in investment (the nominator) rather than changes in value added (the denominator). On the other hand, the advantage of the original measure is that it takes into account the fact that value added, and hence loosely speaking the capital available for investment, was also impacted by the crisis. In terms of significance, the relative sizes and the temporal development of coefficients, results are robust to this alternative specification.

Secondly, we define the investment ratio as gross investment divided by capital (where capital is defined as tangible assets). This is a more common measure used in investment relations. In our main specifications, we prefer the original measure due to its closer correspondence with the macroeconomic definition of the investment rate, a more intuitive appeal from a flow-of-funds perspective and the fact that it is not to the same extent sensitive to changes in the book value of tangible assets caused by e.g. revaluations. Due to data quality considerations, these results are based only on the subsample of firms, for which no data has been imputed. Results are robust to this alternative specification.

Thirdly, we reestimate the model using the (non-representative) subsample of firms which have been sampled by Statistics Denmark, that is, firms for which no data has been imputed. Results are robust to being based only on this subsample. The fact that the size of the effects are even

somewhat larger in this non-representative subsample than those estimated from the full dataset points to a conclusion that results are not driven by the decision to base our estimations on the full population of firms.

Finally, we include as explanatory variables two further 'lags' of the change in investment in the period before 2007, such that the model in addition to $\Delta I_{i;s;r;2006-2007}$ also includes $\Delta I_{i;s;r;2005-2007}$ and $\Delta I_{i;s;r;2004-2007}$. While these additional variables are intended to better capture unusual or high investment levels in 2007 or the years just before (e.g. large one-of investments or 'regression to the mean'-effects), their inclusion comes at the cost of a reduction in the number of observations since firms, which started (or was included in the dataset for the first time) in the lagged period, cannot be included in the estimation. Therefore, the specification with the additional variables is used as a robustness check and the baseline model restricted to one lag. Results are qualitatively the same. Point estimates of the leverage variable coefficients are, except for 2008, even larger than in the baseline model. Overall, results are quite robust to changes in specifications in both dependent and independent variables.

6. HOW DOES THE LEVERAGE CHANNEL WORK?

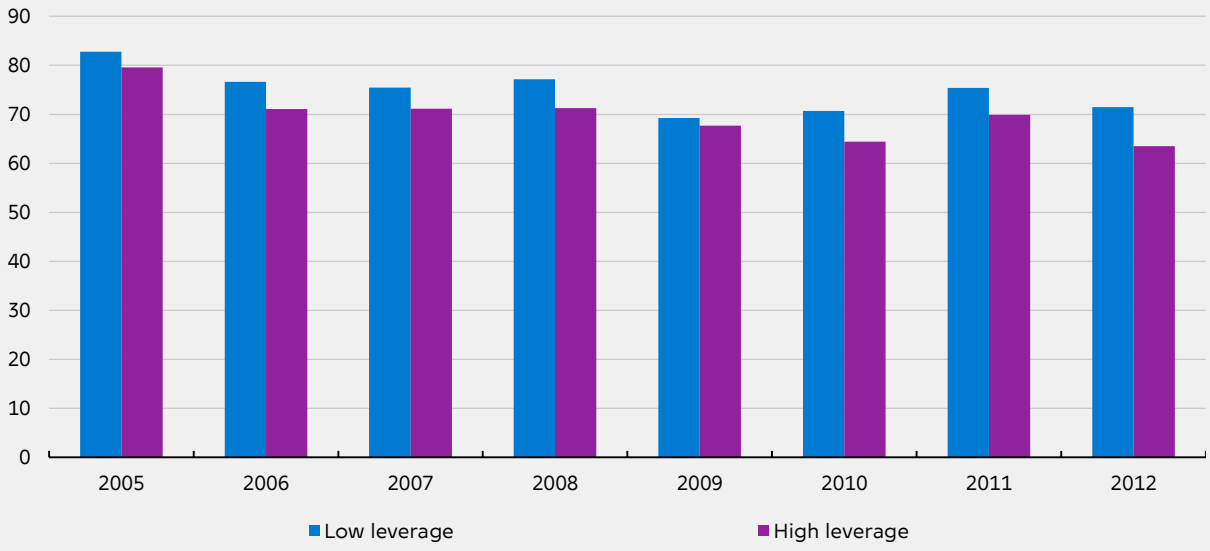
Evidence of a leverage channel may be sufficient for the purpose of establishing whether leverage impacts macroeconomic volatility, and the mechanism through which it works may be of less importance. However, policy assessment would benefit from a better understanding of how the leverage channel works. A number of possible explanations for the negative relation between leverage and investment during the crisis have been discussed already, including leverage dependent access to credit and voluntary deleveraging with the aim to retain flexibility in future financing choices. Although our results cannot provide conclusive evidence regarding the mechanisms at play, this section argues that our results are not consistent with credit conditions being the sole mechanism through which the leverage channel works in crisis times.

To begin the discussion, we consider the fraction of firms, which increased their debt level before and during the crisis. Highly leveraged firms have to a smaller degree than firms with low leverage increased their debt level during the crisis, cf. chart 14. This was, however, also the case before the crisis. Although the smaller tendency to take on new debt for the highly leveraged firms may be the result of either lower demand for or lower supply of credit, earlier evidence points to lower acceptance rates for highly leveraged firms being at least part of the explanation, also before the crisis (Abildgren et al., 2013; Abildgren et al., 2014b).

Debt uptake

Chart 14

Percentage of firms, which increased their debt level

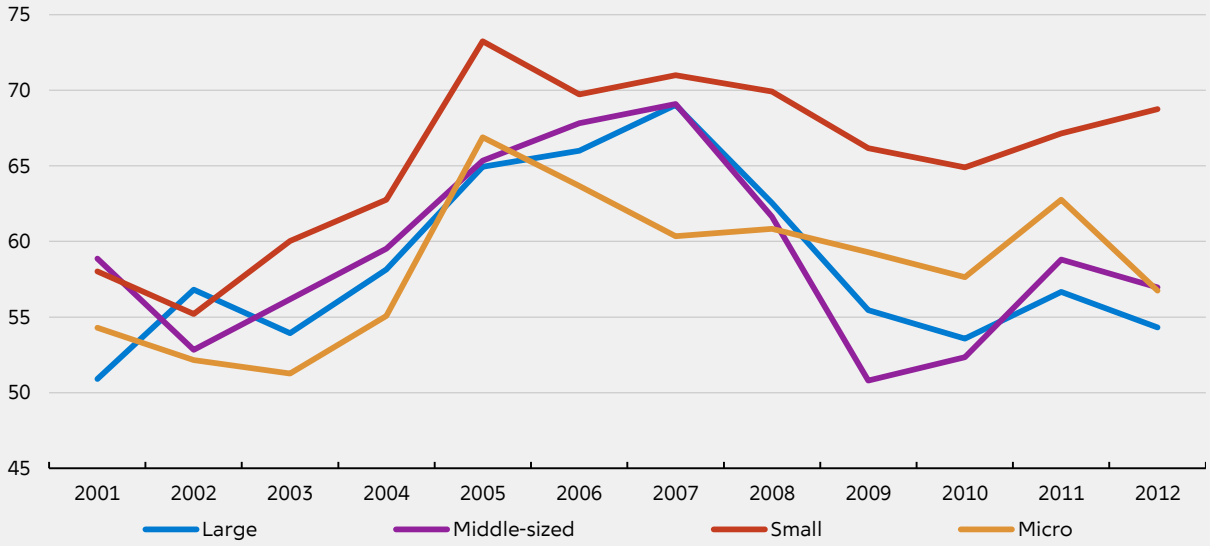


Note: Increase in debt level is defined as an increase of at least 5 per cent in outstanding debt (excluding trade credits) since the previous year.
Source: Own calculations based on firm-level data from Statistics Denmark.

Debt uptake across firm sizes

Chart 15

Percentage of firms, which increased their debt level

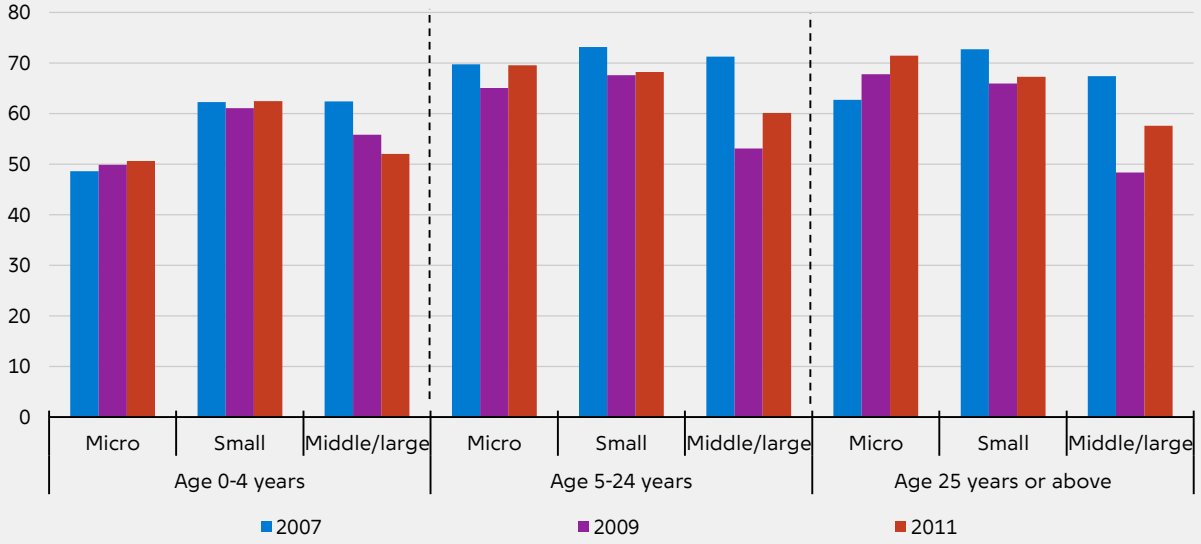


Note: The size classification follows that used in chart 5. Increase in debt level is defined as an increase of at least 5 per cent in outstanding debt (excluding trade credits) since the previous year. The chart is based on all firms, which existed in 2012.
Source: Own calculations based on firm-level data from Statistics Denmark.

Firms' debt uptake across the life cycle

Chart 16

Percentage of firms, which increased their debt level



Note: The size classification follows that used in chart 5. Increase in debt level is defined as an increase of at least 5 per cent in outstanding debt (excluding trade credits) since the previous year.
Source: Own calculations based on firm-level data from Statistics Denmark.

Micro and small firms did not to the same degree as medium sized and large firms reduce their credit uptake during the crisis, cf. chart 15. This could indicate that access to finance has not in general been a major constraint for smaller firms, while the reduction in investment was mainly driven precisely by the smaller firms. Also, younger fast-growing firms have a higher probability of taking up debt than young firms which are still small, cf. chart 16. Such firms are important for employment and investment, and the proportion of these firms which have taken up debt during the crisis has been similar to or larger than that of younger micro-firms.

To further investigate the potential role of credit access, we estimate a probit model of the probability that a firm has increased its debt level in a given year, using the same explanatory variables as in the investment relations. Results are presented in table 9. Based on the model and the results presented in section 5, the following arguments point to 1) the existence of a 'balance sheet channel' on investment, and 2) that the mechanism through which this balance sheet channel works is not only through more limited access to credit for highly leveraged firms.

First, the effect of high leverage (t-1) on the probability of uptake of debt (t) is similar before and during the crisis, which in itself indicates that limitations on access to finance for highly leveraged firms may also have been present before the crisis, while investment started to contract more heavily only during the crisis.

Second, firms' liquidity becomes significant for uptake of debt during the crisis, possibly because banks' have tightened their credit standards in the form of increased liquidity requirements. Even among the highly liquid firms, which – in addition to better access to finance during the crisis – should, *ceteris paribus*, have a smaller need for external finance for investment purposes, we find a significant effect of high leverage on investment as described in section 5.4. The effect is also found within all other subgroups defined by industry affiliation and firm size (except for large firms), also subgroups which would be expected to have relatively good access to finance.

Third, there is no evidence that the proportion of smaller or younger firms which have taken up debt in a given year decreased more during the crisis compared to larger and older firms – in fact, the data points in the opposite direction. This could have been expected if banks tightened their credit standards disproportionately towards smaller or younger firms. Since the reduction in aggregate investment during the crisis was mainly driven by smaller firms, this points to a conclusion that limitations in access to credit are not the only mechanism through which the balance sheet channel works.

In sum, these results are likely to reflect that the mechanism through which the balance sheet channel works is a combination of more difficult access to finance for highly leveraged firms (an effect which is present both in crisis and non-crisis periods), and that the crisis reiterated the tendency of some firms to hold back investment and reduce their leverage in order to increase their resilience to future shocks and retain flexibility in future financing choices. Furthermore, the limited role of access to finance reiterates macro-based findings, which point to a limited role of financing conditions in explaining the development in investment across countries (Banerjee et al., 2015).

Results: Probit models of probability of uptake of debt (marginal effects)

Table 9

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Medium	-0.097***	-0.135***	-0.055***	-0.086***	-0.111***	-0.092***	-0.078***	-0.088***	-0.100***
leverage (t-1)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
High leverage	-0.153***	-0.203***	-0.123***	-0.137***	-0.141***	-0.133***	-0.149***	-0.138***	-0.152***
(t-1)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.005)
LN (employees)	0.005**	0.008***	0.020***	0.024***	0.001	-0.012***	-0.004**	0.006***	0.007***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Age	-0.003***	-0.002***	-0.002***	-0.002***	-0.000	-0.002***	-0.003***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	0.001***	0.000*	-0.000	0.000	-0.000	-0.000	-0.001***	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sales growth	-0.004***	-0.009***	-0.002**	-0.003***	-0.002**	-0.001	-0.001	-0.002**	-0.002***
(per cent)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Implied interest	0.033	0.089*	0.025**	0.005	0.010	0.003	0.034***	0.012**	0.003*
rate	(0.030)	(0.049)	(0.012)	(0.009)	(0.006)	(0.003)	(0.007)	(0.006)	(0.002)
Liquidity ratio	-0.106***	-0.006	-0.046*	0.038*	0.016	-0.025	0.123***	0.048**	0.298***
	(0.025)	(0.024)	(0.027)	(0.022)	(0.022)	(0.022)	(0.019)	(0.021)	(0.021)
Export share	0.000	0.001***	0.001***	0.001***	0.000***	0.000*	0.001***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Equity / value	0.001	-0.001**	-0.000	-0.000	-0.001***	-0.001***	0.000	-0.000	-0.000
added	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry									
dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	26,106	28,288	30,709	33,438	36,383	40,073	44,764	48,452	52,581

Note: Marginal effects from probit models of the probability of a firm increasing its debt level. The marginal effects are evaluated at the mean of the explanatory variables. For the leverage variables, the figures are partial effects of a change from 0 to 1. The excluded category is low leverage. Significance: ***p<0.01, **p<0.05, *p<0.10. Standard errors in parentheses.

Source: Own calculations based on firm-level data from Statistics Denmark.

7. CONCLUDING REMARKS

The analysis has demonstrated a statistically and economically significant negative effect of pre-crisis leverage on change in investment rates at the firm-level during and after the most recent financial crisis. While firms with high leverage had somewhat higher investment rates before the crisis, they reduced their investment rates substantially more than firms with low leverage during the crisis. The effect is significant within all subsamples (except for large firms), also in subsamples in which theory predicts that the relation should be weak or non-existing. This, in combination with the result that highly leveraged firms both before and during the crisis to a smaller extent were able to increase their debt level points to (at least part of) the mechanism being a voluntary deleveraging aimed at increasing resilience to future shocks and retaining flexibility in future financing choices.

While the contraction in aggregate investment is likely to mainly be a result of weak demand and increased uncertainty, our results point to a non-negligible macroeconomic effect of the balance sheet channel. In particular, results indicate that high leverage contributed to the reduction in investment during the recent crisis. In sum, we therefore conclude that leverage, or in aggregate terms, the level of gross debt, may have implications for macroeconomic volatility.

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